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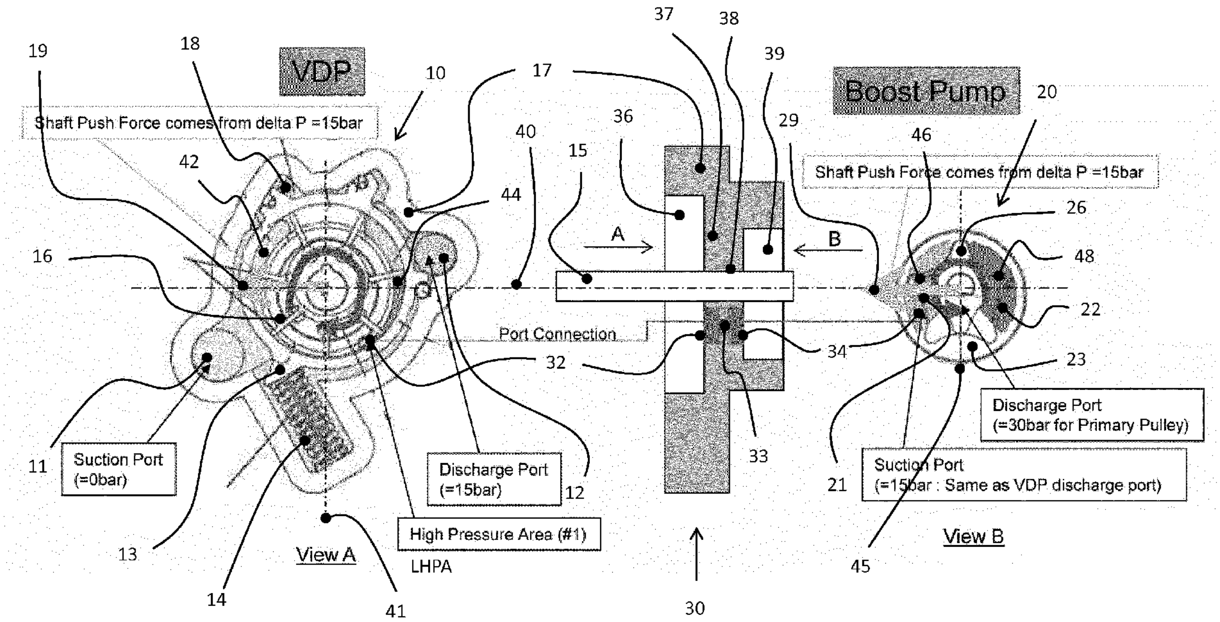
(54) **Balanced pressure dual pump**

(57) A dual outlet pressure pump comprising a first pump entity (10) and a second pump entity (20), whereby a dual pump housing (17) comprises a first pump rotor cavity (36) and a second pump rotor cavity (39) separated by a diaphragm (37) with a bore and whereby a first pump rotor (16) and a second pump rotor (26) are operatively arranged on a common drive shaft (15) to convey a fluid, whereby the angular placement of elements of the first pump entity (10) relative to elements of the second pump entity (20) about a pump axis (40) is such, that the radial force exerted by the fluid pressure in a first pump discharge region (44) of the first pump rotor cavity (36) upon the first pump rotor (16) is opposed in direction to the radial force exerted by the fluid pressure in a second pump discharge region (48) of the second pump rotor cavity (39) upon the second pump rotor (26).

A hydraulic control system for a continuously variable transmission of a vehicle, comprising a dual outlet pressure pump.

Fig. 1



EP 2 716 912 A1

Description

Field of the Invention

[0001] The present invention concerns a dual outlet pressure pump comprising a first pump entity and a second pump entity and more particularly a dual outlet pressure pump whereby a first pump rotor and a second pump rotor are operatively arranged on a common drive shaft to convey a fluid. The present invention further concerns a hydraulic control system for a continuously variable transmission of a vehicle, comprising a dual outlet pressure pump.

Description of Related Art

[0002] It is well known to utilize one or more fixed displacement pumps in continuously variable and other automated transmissions of vehicles. More recently, also variable displacement vane pumps have been considered for use as oil pumps for vehicle transmissions and engines. By providing a suitable control mechanism to alter the capacity of the pump to provide only the amount of pressurized lubrication oil necessary for proper operation of the engine, energy required to pressurize unneeded oil can be saved and thus energy efficiency of the pump, and the entire vehicle, can be improved.

[0003] Single pump hydraulic systems are particularly inefficient in applications requiring high-pressure fluid because the single pump continues to deliver high flow, high pressure fluid even when only low flow is needed. This results in unnecessary consumption of power from the vehicle engine or battery and may tend to reduce the overall life of the pump.

[0004] Multiple pump systems are designed to minimize this undesirable behavior by providing an additional pump that can be activated to deliver a required fluid flow rate or pressure depending upon the operating conditions.

[0005] In US 8 128 377 B2 a hydraulic fluid supply system is disclosed that utilizes a split-pressure configuration in cooperation with first and second pumps to continuously deliver variable flow, high-pressure fluid and fixed flow, low-pressure fluid, depending on the individual needs of two independent hydraulic circuits. In one embodiment of the disclosed invention, a split-pressure hydraulic fluid supply circuit for supplying pressurized fluid to a multi-speed transmission is provided. The split-pressure hydraulic fluid supply circuit includes a first pump, a second pump, a low-pressure circuit portion, and a high-pressure circuit portion. The first pump has both inlet and outlet ports, and is driven by the power source to provide a continuous flow of pressurized hydraulic fluid at a fixed rate. The second pump has an inlet port, an outlet port, and a regulator port, and is driven by the power source to provide a continuous flow of pressurized hydraulic fluid at variable rates. The low-pressure circuit portion includes a work circuit fluidly coupled to the first pump. The low-pressure circuit portion is adapted to supply all of the low-pressure hydraulic fluid needed by the multi-speed transmission. The high-pressure circuit portion includes a high-pressure work circuit fluidly coupled to the second pump. The high-pressure circuit portion is adapted to supply all of the high-pressure hydraulic fluid needed by the multi-speed transmission. No fluid coupling is provided between the high-pressure work circuit and the low-pressure work circuit.

[0006] EP 2 441 985 A2 provides a hydraulic system for an automatic transmission which supplies oil from an oil reservoir to a high-pressure part and a low-pressure part, using a cascaded pump arrangement, which includes a first oil pump pumping up oil from the oil reservoir and supplying the oil to the low-pressure part, and a low-pressure regulating valve connected to a low-pressure part channel connecting the first oil pump with the low-pressure part, and controlling the pressure of the oil discharged from the first oil pump. A second oil pump receives the oil and supplies it to the high-pressure part of the hydraulic system.

[0007] The known systems using multiple pumps to provide hydraulic fluid at different pressure levels and flow rates help to save energy but are often complicated in design and expensive to manufacture. Simplified and more affordable designs suffer from increased wear on components.

[0008] Object of the present invention is to provide pumps with the capability to provide fluids simultaneously at multiple pressure levels and flow rates. The pumps should combine improved wear resistance and longer service life with simplified construction and low cost and thereby improve known hydraulic control systems of said type in this respect.

Summary of the Invention

[0009] The object is achieved by a dual outlet pressure pump with the features of claim 1.

[0010] According to the invention, a dual outlet pressure pump comprising a first pump entity and a second pump entity, whereby a dual pump housing comprises a first pump rotor cavity and a second pump rotor cavity separated by a diaphragm with a bore and whereby a first pump rotor and a second pump rotor are operatively arranged on a common drive shaft to convey a fluid is provided. Angular placement of elements of the first pump entity relative to elements of the second pump entity about a pump axis is such, that the radial force exerted by the fluid pressure in a first pump discharge region of the first pump rotor cavity upon the first pump rotor is opposed in direction to the radial force exerted by the fluid pressure in a second pump discharge region of the second pump rotor cavity upon the second pump rotor.

[0011] By not simply stacking pump entities of known design onto a common drive shaft, but instead consciously placing and aligning pump elements such as pump suction ports and pump discharge ports or eccentric pump rotor cavities, vibrations and wear of dual outlet pressure pump components can be significantly reduced. Many different types and of asymmetric pumps of widely differing capacities can be successfully combined by following the principles outlined in the present invention.

[0012] The object is further achieved by a hydraulic control system for a continuously variable transmission of a vehicle, comprising a dual outlet pressure pump.

[0013] The directional terms "axial" and "radial" in the context of the present invention always relate to the axis of the rotating pump shaft.

[0014] Refinements of the invention are given in the subclaims, the description and the enclosed drawings.

[0015] Preferably the dual outlet pressure pump comprises a first pump entity and a second pump entity which are any combination of either a hydraulic rotary vane pump or a hydraulic gear pump.

[0016] Rotary vane pumps and gear pumps are known in many designs and can be configured in many combinations to adapt to specific requirements of hydraulic control system applications. Combinations of two pump entities of the same type, such as rotary vane pump with rotary vane pump or gear pump with gear pump are useful. Preferred are combinations of a rotary vane pump and a gear pump as either the first or second pump entity. This allows a pump designer to combine complementary strengths of both pump types.

[0017] Many of the abovementioned rotary vane pumps and gear pumps can be said to comprise an "operational plane of symmetry". In an internal gear pump such as a gerotor pump an imagined plane through the axis of rotation of a gerotor pump inner rotor and the axis of rotation of a gerotor pump outer rotor is fixed with respect to the gerotor pump housing. This imagined "operational plane of symmetry" divides the pump rotor cavity into a lower pressure pump suction region comprising the pump suction port and a higher pressure pump discharge region comprising the pump discharge port. It is the fluid pressure in the higher pressure pump discharge region that exerts a significant radial force on the gerotor pump inner rotor and thus on the pump shaft supporting the gerotor pump inner rotor.

[0018] In the case of a rotary vane pump having a circular cylindrical pump rotor cavity an analogous "operational plane of symmetry" is an imagined plane through the axis of rotation of the pump rotor and the axis of said circular cylindrical pump rotor cavity. In this example again the imagined "operational plane of symmetry" divides the pump rotor cavity into a lower pressure pump suction region comprising the pump suction port and a higher pressure pump discharge region comprising the pump discharge port. But here it is the combined fluid pressure of the moving compartments formed between vanes of the rotary vane pump in the higher pressure pump discharge region that exerts a significant radial force on the rotary vane pump rotor and thus on the pump shaft supporting the rotary vane pump rotor.

[0019] A preferred embodiment of the dual outlet pressure pump comprising either a hydraulic rotary vane pump and/or a hydraulic gear pump as the first pump entity and the second pump entity, said first and second pump entities are angularly aligned about the pump axis such that a first pump "operational plane of symmetry" and the second pump "operational plane of symmetry" intersect at a pointed angle and the first pump discharge region of the first pump rotor cavity and the second pump discharge region of the second pump rotor cavity are provided in opposite larger quadrants of the intersecting first and second pump "operational planes of symmetry".

[0020] In a further preferred embodiment of the inventive dual outlet pressure pump the first pump discharge region of the first pump rotor cavity and the second pump suction region of the second pump rotor cavity are hydraulically connected through a connection passage.

[0021] Said connection passage allows pump fluid to pass from the lower pressure pump directly to the higher pressure pump. The internal pressure drops of the two pumps are adding up and the maximum pressure level achievable with the same first and second pump entities is higher than in the embodiment without said connection passage.

[0022] In a preferred embodiment of the dual outlet pressure pump said connection passage comprises a connection passage inlet which is located in the area of highest pressure of the first pump discharge region of the first pump rotor cavity. By locating the connection passage inlet close to the point of highest pressure of said connection passage inlet flow characteristics of the first pump entity can be significantly improved. Zones of reverting flow of high pressure fluid are minimized whereby pump friction is reduced. Guiding pump fluid through a streamlined connection passage inlet right through the diaphragm of the dual pump housing solves many common problems in hydraulic pump outlet design and allows for a very compact dual outlet pressure pump scheme.

[0023] According to a further embodiment of the invention either the first pump entity or the second pump entity of the dual outlet pressure pump is a variable displacement pump. This allows the relative pumping capacity of the first and second pump entities to be altered although both are driven by the same drive shaft.

[0024] In a further embodiment of the invention either the first pump entity or the second pump entity is a fixed displacement pump. Fixed displacement pumps feature simple construction and reliable operation.

[0025] In another preferred embodiment of the dual outlet pressure pump the first pump entity is a lower pressure higher capacity pump and the second pump entity is a higher pressure lower capacity pump. This combination of pump entities is particularly useful as in many hydraulic systems there is a relatively large and variable need for fluid at low pressure and an often intermittent and limited need for fluid at high pressure.

[0026] Preferably the first pump entity is a rotary vane pump. Rotary vane pumps are available as variable capacity and low pressure types. Also preferably is the second pump entity is a gerotor pump. A small gerotor pump is a nearly perfect choice for a higher pressure lower capacity pump.

[0027] The axial bore of diaphragm of the dual pump housing of the dual outlet pressure pump according to the invention may comprise a bearing for additional performance and increased operating life.

Brief Description of Drawings

[0028] The invention is described below as an example with reference to the drawings.

Fig. 1 shows multiple sectional views of a dual pump according to the present invention.

Fig. 2 is a schematic view of a hydraulic control system for a continuously variable transmission in an "Idle" state.

Fig. 3 is a schematic view of a hydraulic control system for a continuously variable transmission in a "Speed UP" state of operation.

Fig. 4 is a schematic view of a hydraulic control system for a continuously variable transmission in a "Constant Speed" state of operation.

Fig. 5 is a schematic view of a hydraulic control system for a continuously variable transmission in a "Speed DOWN" state of operation.

Fig. 6 shows several embodiments of a variable displacement vane pump with enhanced discharge port as known in the prior art.

Detailed Description of the Invention

[0029] Figure 1 shows schematically multiple sectional views of an exemplary preferred embodiment of the dual outlet pressure pump comprising a variable displacement vane pump (VDVP) as a first pump entity 10 and a small gerotor pump (designated as boost pump BP in Figures 2 to 5) as second pump entity 20. Three schematic sectional views are aligned along a pump axis 40. The sectional view 30 in the center of Fig. 1 shows the dual pump housing 17 comprising a first pump rotor cavity 36, a second pump rotor cavity 39 and diaphragm 37 having a bore 38. Pump shaft 15 is arranged to extend through the bore 38. Also shown is a connection passage 33 fluidly connecting first pump rotor cavity 36 and second pump rotor cavity 39. Connection passage 33 has a carefully designed connection passage inlet 32 and connection passage outlet 34.

[0030] View A of Fig. 1 shows the variable displacement vane pump in a sectional view. The pump has a first pump suction port 11 arranged in a low pressure (0 bar) first pump suction region 42. First pump rotor 16 is equipped with several vanes to fit into slide 13 which is tensioned by spring 14. Slide 13 is movably arranged inside dual pump housing 17. By varying a fluid pressure in control port 18 the position of slide 13 can be changed and thus the volumetric pumping capacity of the VDP can be varied according to hydraulic control system requirements.

[0031] Assumed is a rotary motion of pump shaft 15 whereby the upper part of shaft 15 moves into the plane of Fig. 1 in view 30. This rotation of pump shaft 15 appears as clockwise rotation of rotor 16 in view A. Fluid is transported from first pump suction region to first pump discharge region 44 (15 bar) and may be discharged through first pump discharge port 12. Alternatively or simultaneously the fluid is transported through connection port 33 to a second pump suction port 21 and a second pump suction region 46 by the combined action of first pump entity 10 and second pump entity 20. Second pump entity 20 is shown in sectional view B. A second pump inner rotor 26 is operatively arranged on pump shaft 15 and thus forced to rotate with the pump shaft. This rotation entrains rotation of a second pump outer rotor in the same direction, which appears as counterclockwise rotation of both second pump rotors in view B. Said rotation transports fluid from second pump suction region 46 (15 bar) to second pump discharge region 48 where it is discharged at high pressure (30 bar) through second pump discharge port 22.

[0032] The high pressure fluid in second pump discharge region 48 exerts a force on second pump inner rotor 26 whereby the force is determined by the pressure difference between second pump discharge region 48 and second pump suction region 46 (30 bar - 15 bar = 15 bar) and the diameter of second pump inner rotor 26. Said force is transmitted to pump shaft 15 and is shown as second pump shaft force vector 29 normal to a second pump operational plane of symmetry 45 in view B and points into the plane of Fig. 1 in view 30 (not shown).

[0033] The force exerted by intermediate pressure (15 bar) fluid in the discharge region 44 of the first pump is shown as first pump shaft force vector 19 normal to a first pump operational plane of symmetry 41 in view A and points out of the plane of Fig. 1 in view 30 (also not shown).

[0034] Figs. 2 - 4 show a dual outlet pressure pump operatively arranged in a hydraulic control system according to the invention. The hydraulic control system controls a continuously variable transmission in various operating modes. Arrows indicate oil flow in a hydraulic line. Crosses on oil line indicate that oil pressure in the line is maintained at low to medium level by the VDP - typically no significant flow of oil from the pumps.

[0035] Figure 2 shows a schematic view of a hydraulic control system for a continuously variable transmission in an "Idle" state. A first pump entity 10 (in this example a variable displacement pump VDP) and a second pump entity 20 (in this example designated as boost pump BP) are operatively arranged on a common pump shaft 15 which is driven by a drive unit 80 which is typically the crankshaft of a combustion engine of a vehicle. In "Idle" mode drive unit 80 is supposed to run at 600 rpm. The 600 rpm rotation of pump shaft 15 drives the VDP at approximately 50% of theoretical pump capacity V_{th}. The VDP transports oil from oil reservoir 90 through oil filter 91 and oil intake line 92 into low pressure oil line 94. A small fraction of the oil passes through connection passage 33 to boost pump BP and is transported by the boost pump into high pressure oil line 96. In "Idle" state all of the oil of high pressure oil line 96 is recycled through oil bypass line 98 to oil intake line 92 because no high pressure oil is needed by primary pulley (PP) 65 and thus ratio control valve 55 is completely closed as shown in detail in insert 56.

[0036] In "Idle" state part of the low pressure oil flow passes through valve compartment 50 through torque converter 85 into lubrication section 87 and back to oil reservoir 90. Part of the low pressure oil passes through check valve 54 and oil return line 99 to the oil reservoir 90. A small amount of low pressure oil maintains belt cramping pressure in secondary pulley 66. Another small part of the low pressure oil is recycled to the VDP under control of bypass valve 52 from where it is directed to control port 18 of the VDP which in turn controls flow rate of the VDP.

[0037] Fig. 3 is a schematic view of a hydraulic control system for a continuously variable transmission in a "Speed UP" state of operation. Drive unit 80 is assumed to run at 1500 rpm. During "Speed UP" the VDP runs at 100% of V_{th}. The ratio control valve 55 is now partially open and the VDP is filling the primary pulley 65 to increase the gear ratio. The boost pump assists the VDP in reaching and maintaining a desired (medium) pressure level in the primary pulley 65.

[0038] Fig. 4 shows schematically the hydraulic control system of Figs. 2 and 3 in a "Constant Speed" state of operation. The VDP runs at a fraction of its V_{th} and at a relatively low pressure. The primary and secondary pulleys are maintained at the appropriate level and lockup clutch 86 is engaged. Most of the oil is recycled over the bypass lines 98.

[0039] Fig. 5 shows the hydraulic control system of Figs. 2, 3 and 4 in a "Speed DOWN" state of operation. The VDP runs at a significant fraction of its theoretical pump capacity and part of the oil (at medium pressure) is recycled through bypass lines 98. The VDP fills the secondary pulley 66 through the cramping pressure control valve 58 to gradually decrease the gear ratio. The ratio control valve 55 controls the oil flow out of the primary pulley 65.

[0040] Figure 6 is a series of sectional views showing different embodiments of a variable displacement vane pump with enhanced discharge port as disclosed in US 8 118 575 B2. "Gen I" designates an original design and "Gen II" and "Gen III" show proposed alternative designs of an enhanced discharge port of said variable displacement vane pump. The most preferable solution shown in "Gen III" requires much extra space in the pump discharge region. By using a variable displacement vane pump and providing a connection passage and a connection passage inlet according to the present invention flow behavior and friction is improved significantly without the extra space requirement of the "Gen III" solution.

[0041] The invention thus allows a particularly compact construction and relatively low production costs for a dual outlet pressure pump in a hydraulic control system for a continuously variable transmission of a vehicle.

List of Reference Numerals

[0042]

10	First Pump Entity
11	First Pump Suction Port
12	First Pump Discharge Port
13	Slide
14	Spring
15	Pump Shaft
16	First Pump Rotor
17	Dual Pump Housing
18	Control Port (of VDP)
19	First Pump Shaft Force Vector
20	Second Pump Entity / Boost Pump (BP)
21	Second Pump Suction Port
22	Second Pump Discharge Port (30 bar)
23	Second Pump (GeRotor) Outer Rotor
26	Second Pump (GeRotor Inner) Rotor
29	Second Pump Shaft Force Vector
30	Sectional View of Dual Pump
32	Connection Passage Inlet
33	Connection Passage
34	Connection Passage Outlet
36	First Pump Rotor Cavity
37	Diaphragm
38	Axial Bore
39	Second Pump Rotor Cavity
40	Pump Axis
41	First Pump Operational Plane of Symmetry
42	First Pump Suction Region
44	First Pump Discharge Region
45	Second Pump Operational Plane of Symmetry
46	Second Pump Suction Region
48	Second Pump Discharge Region
50	Valve Compartment
52	Bypass Valve
54	Check Valve
55	Ratio Control Valve
56	Expanded Sectional View of Ratio Control Valve
58	Cramping Pressure Control Valve
65	Primary Pulley (PP)
66	Secondary Pulley (SP)
80	Drive Unit
85	Torque Converter (T/C)
86	Lockup Clutch

87 Lubrication Section
90 Oil Reservoir
91 Oil Filter
92 Oil Intake Line
94 Low Pressure Oil Line (P_{low})
96 High Pressure Oil Line (P_{high})
98 Oil Bypass Lines
99 Oil Return/Dump Lines

CVT Continuously Variable Transmission
LHPA Local High Pressure Area
NEDC New European Driving Cycle (Standard/Richtlinie ECE)
TCU Transmission Control Unit
VD(V)P Variable Displacement (Vane) Pump
V_{th} Percentage of Theoretical Pump Capacity

Claims

1. A dual outlet pressure pump comprising a first pump entity (10) and a second pump entity (20), whereby a dual pump housing (17) comprises a first pump rotor cavity (36) and a second pump rotor cavity (39) separated by a diaphragm (37) with an axial bore (38) and whereby a first pump rotor (16) and a second pump rotor (26) are operatively arranged on a common drive shaft (15) to convey a fluid,
characterized in that
the angular placement of elements of the first pump entity (10) relative to elements of the second pump entity (20) about a pump axis (40) is such, that the radial force exerted by the fluid pressure in a first pump discharge region (44) of the first pump rotor cavity (36) upon the first pump rotor (16) is opposed in direction to the radial force exerted by the fluid pressure in a second pump discharge region (48) of the second pump rotor cavity (39) upon the second pump rotor (26).

2. The dual outlet pressure pump as claimed in claim 1,
characterized in that
the first pump entity (10) and the second pump entity (20) are any combination of either a hydraulic rotary vane pump or a hydraulic gear pump.

3. The dual outlet pressure pump as claimed in claim 2,
characterized in that
the first pump entity (10) and the second pump entity (20) are angularly aligned about the pump axis (40) such that a first pump operational plane of symmetry (41) and a second pump operational plane of symmetry (45) intersect at a pointed angle and the first pump discharge region (44) of the first pump rotor cavity (36) and the second pump discharge region (48) of the second pump rotor cavity (39) are provided in opposite larger quadrants of the intersecting first and second pump operational planes of symmetry.

4. The dual outlet pressure pump as claimed in any of the preceding claims,
characterized in that
the first pump discharge region (44) of the first pump rotor cavity (36) and a second pump suction region (46) of the second pump rotor cavity (39) are hydraulically connected through a connection passage (33).

5. The dual outlet pressure pump as claimed in claim 4,
characterized in that
said connection passage (33) comprises a connection passage inlet (32) which is located in the area of highest pressure of the first pump discharge region (44) of the first pump rotor cavity (36).

6. The dual outlet pressure pump as claimed in any of the preceding claims,
characterized in that
the first pump entity (10) is a lower pressure pump and the second pump entity (20) is a higher pressure pump.

7. The dual outlet pressure pump as claimed in any of the preceding claims,
characterized in that
either the first pump entity (10) or the second pump entity (20) is a variable displacement pump.

8. The dual outlet pressure pump as claimed in any of the preceding claims,
characterized in that
either the first pump entity (10) or the second pump entity (20) is a fixed displacement pump.

9. The dual outlet pressure pump as claimed in any of the preceding claims,
characterized in that
the first pump entity (10) is a lower pressure higher capacity pump and the second pump entity (20) is a higher pressure lower capacity pump.

10. The dual outlet pressure pump as claimed in any of the preceding claims,
characterized in that
the first pump entity (10) is a rotary vane pump.

11. The dual outlet pressure pump as claimed in any of the preceding claims,
characterized in that
the second pump entity (20) is a gerotor pump.

12. The dual outlet pressure pump as claimed in any of the preceding claims,
characterized in that
the axial bore (38) of diaphragm (37) of the dual pump housing (17) comprises a bearing.

13. A hydraulic control system for a continuously variable transmission of a vehicle, comprising a dual outlet pressure pump as claimed in claim 1.

Fig. 1

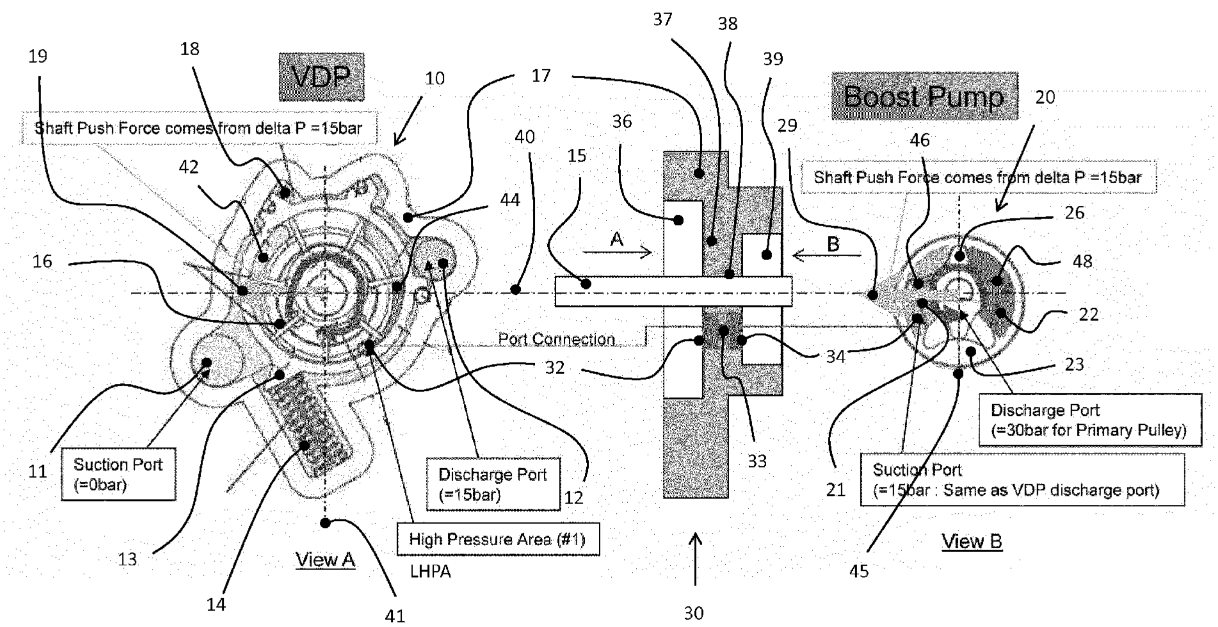

VDP
Shaft Push Force comes from delta P =15bar
Suction Port
(=0bar)
Discharge Port
(=15bar)
High Pressure Area (#1)
LHPA
View A
Port Connection
A
B
Boost Pump
Shaft Push Force comes from delta P =15bar
Discharge Port
(=30bar for Primary Pulley)
Suction Port
(=15bar : Same as VDP discharge port)
View B
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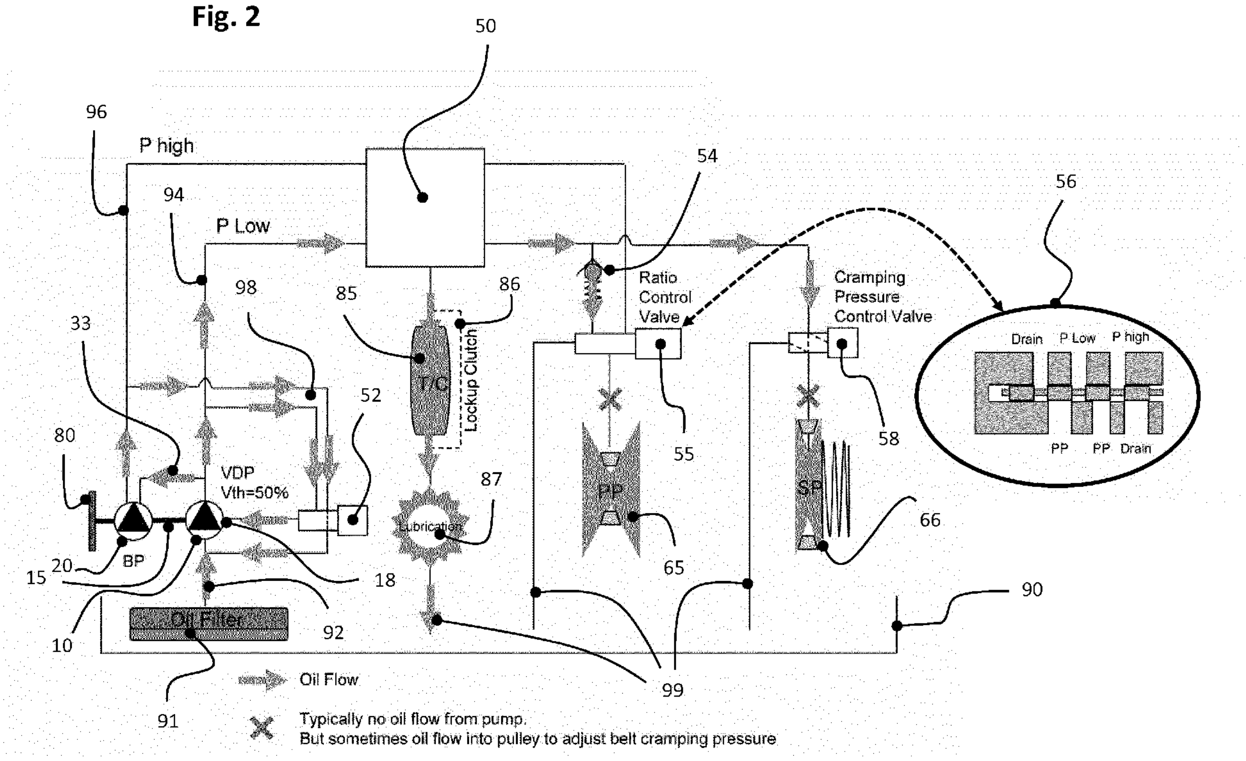
Fig. 2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Lockup Clutch
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80
VDP
Vth=50%
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Lubrication
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BP
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Oil Filter
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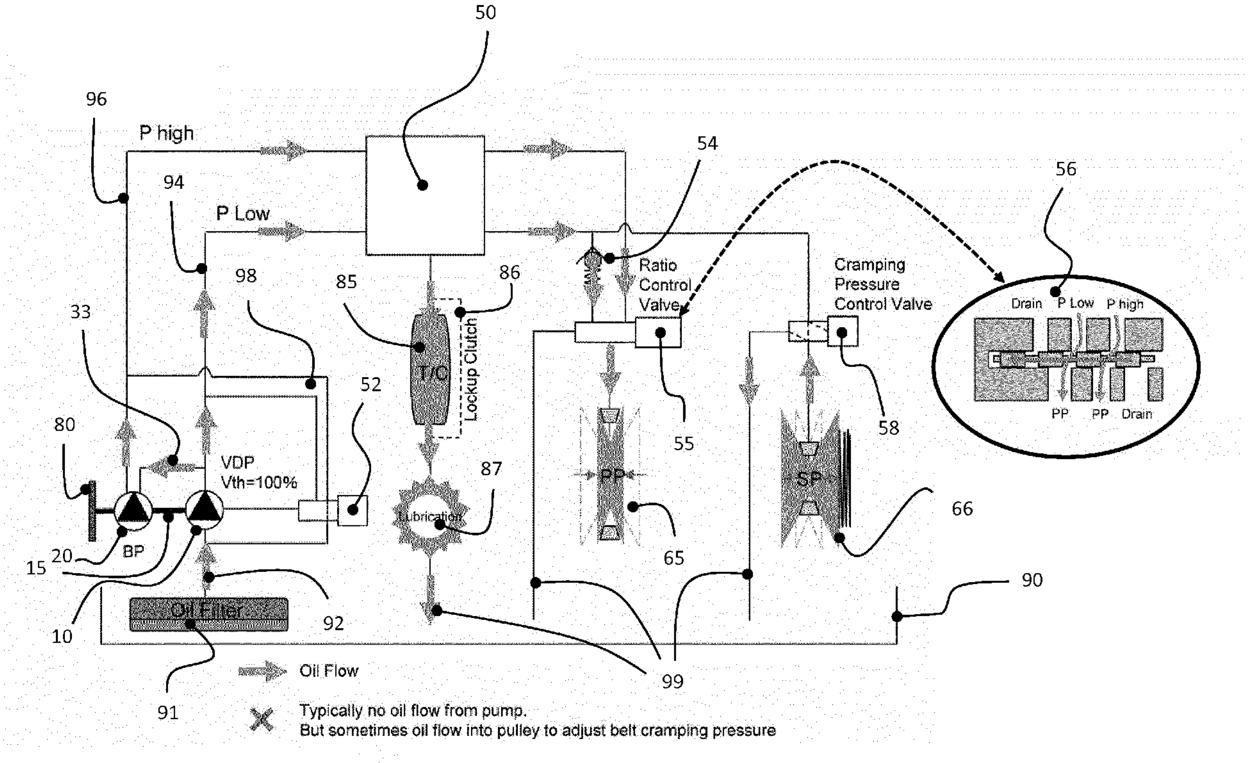
Oil Flow
Typically no oil flow from pump.
But sometimes oil flow into pulley to adjust belt cramping pressure

Fig. 3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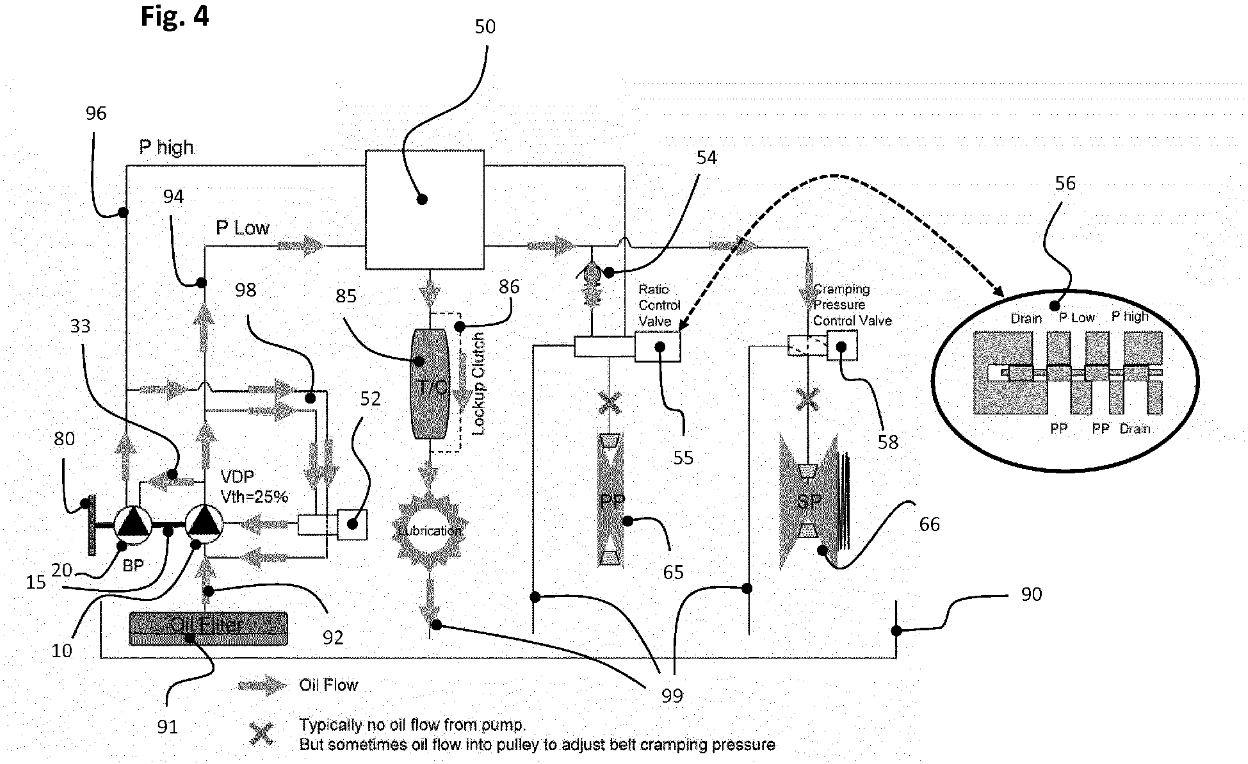
Typically no oil flow from pump.
But sometimes oil flow into pulley to adjust belt cramping pressure

Fig. 4



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Lockup Clutch
T/C
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PP
Drain
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VDP
Vth=25%
Lubrication
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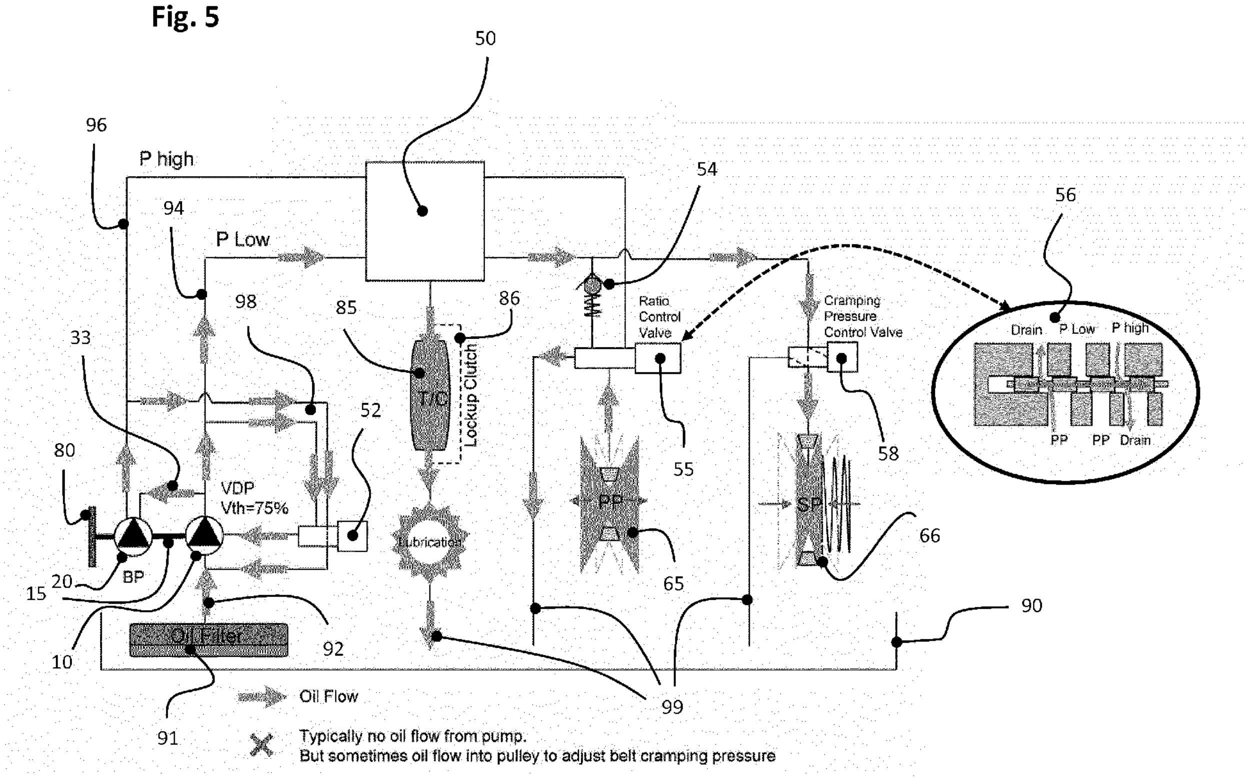
Fig. 5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Ratio Control Valve
Cramping Pressure Control Valve
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Oil Flow
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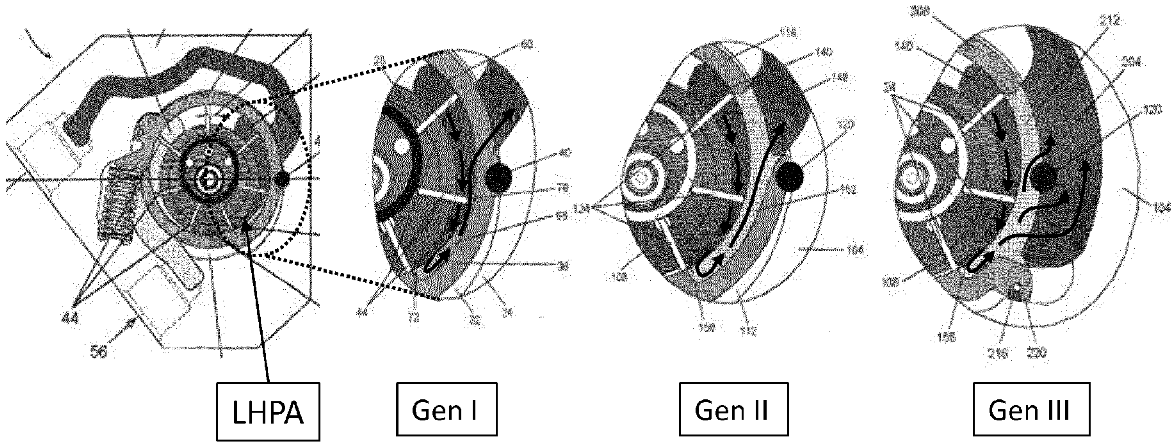
Typically no oil flow from pump.
But sometimes oil flow into pulley to adjust belt cramping pressure

Fig. 6

(Prior Art)



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EUROPEAN SEARCH REPORT

Application Number
EP 12 18 7673

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2001/026767 A1 (TAKAGI MASATOSHI [JP] ET AL) 4 October 2001 (2001-10-04) * the whole document * * paragraphs [0060], [0069] *	1-6,8,9, 11 1-13	INV. F04C2/10 F04C2/344 F04C11/00 F04C15/00 F04C14/02 F04C15/06
X Y	US 2002/053829 A1 (MURAYAMA TAKASHI [JP] ET AL) 9 May 2002 (2002-05-09) * the whole document * * figures 2-5B,7-8D,15 * * paragraph [0089] - paragraph [0100] *	1-4,8, 11,12 1-13	
Y,D	US 8 128 377 B2 (EARHART DAVID EARL [US] ET AL EARHART DAVID E [US] ET AL) 6 March 2012 (2012-03-06) * the whole document *	1-13	

TECHNICAL FIELDS SEARCHED (IPC)

F04C
F01C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 February 2013	Sbresny, Heiko

CATEGORY OF CITED DOCUMENTS

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The members are as contained in the European Patent Office EDP file on
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15-02-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2001026767 A1	04-10-2001	US 2001026767 A1	04-10-2001
		US 2003026722 A1	06-02-2003
US 2002053829 A1	09-05-2002	DE 19918390 A1	25-11-1999
		US 6347843 B1	19-02-2002
		US 2002053829 A1	09-05-2002
US 8128377 B2	06-03-2012	CN 101280845 A	08-10-2008
		DE 102008016499 A1	30-10-2008
		US 2008247882 A1	09-10-2008

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 8128377 B2 **[0005]**
- EP 2441985 A2 **[0006]**
- US 8118575 B2 **[0040]**