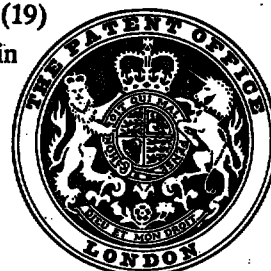


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(54) ROTARY SLIDING VANE-TYPE DOUBLE-LOBE HYDRAULIC PUMPS

(71) We, SUNDSTRAND CORPORATION, a corporation organised and existing under the laws of the State of Delaware, United States of America, of 4751 Harrison Avenue, Rockford, Illinois 61101, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement: -

The invention relates to rotary sliding-vane-type double-lobe pumps for hydraulic fluid having a variable volume capacity.

A pump according to the invention comprises a rotor having a number of radial slots each with a vane movably mounted therein, a cam ring surrounding the rotor and vanes and having lobes of different contour, first pumping chambers beneath the vanes and second pumping chambers defined by spaces between the vanes, the first and second pumping chambers having respective inner and outer outlet ports leading to at least two outlet passages.

The different contours provide different pumping volumes, and hence different pumping capacity. With such a pump four different output volumes are possible: two derived from pumping chambers defined by the intervane spaces when the vane coact with the two lobes, and two derived from pumping chambers defined by the under-vane spaces when the vanes similarly coact.

There may also be provided a common outlet for the intervane and under-vane pumping spaces when the vanes coact with one lobe of the cam ring, and a common outlet for the intervane and under-vane spaces when the vanes coact with the other lobe of the cam ring. Control means may also be provided for the utilization of the total volume derived from both of the common outlets, or of less than the total flow from one or both of the common outlets,

including zero utilization of the flow from at least one of the common outlets. To this end, the flow through one common outlet may be reduced by returning part or all of the flow to an inlet of the pump. Control may be derived from valve means responsive to pressure in the circuit which utilizes the fluid. Thus, variations in pressure in the utilization circuit cause variations in the return of fluid to the inlet for the pump, and thus change the total volume supplied to the utilization circuit.

The invention is illustrated by way of example in the drawings in which:

Figure 1 is a section of a pump transverse to this axis of rotation of the rotor and along the line 1-1 in Figure 2;

Figure 2 is a section along the line 2-2 in Figure 1; and

Figure 3 is a schematic view of another pump and control circuit associated therewith for obtaining a variable volume output from the pump.

Figures 1 and 2, a pump casing 10 has an internal chamber with a shaft 11 extending therethrough. A generally cylindrical rotor 12 is mounted on the pump shaft 11, and has a number of rotor slots 15 extending radially outward to the surface of the rotor. Each of the slots 15 has an enlarged base region 34 and reciprocally mounts a movable vane 16. On rotation of the rotor 12, the vanes 16 track a cam ring 20 mounted within the casing 10 and having port plates 21 and 22 (Figure 2) positioned one to each side thereof. The port plates 21 and 22 are held in association with the rotor 12 and against the cam ring 20 by hydraulic clamping between an end cap 25 and a pressure-loaded member 26. Pressure fluid may be fed in through a passage 26a. Alternatively, the port plates 21 and 22 might be held in assembled relation to the cam ring 20 by bolts extending therethrough.

The cam ring 20 has two generally port-

10 elliptical lobes of different contour. The internal surface of the cam ring 20 has a pair of crossover points 30, 31 between an upper lobe 32 and a lower lobe 33. The lower lobe 33 is larger than the upper lobe 32. The pump utilizes pumping chambers provided by the spaces between vanes, which provide a swept volume, and pumping chambers provided by the undervane spaces and the reciprocal action of the vanes 16 in the rotor slots 15.

15 The port plate 21 provides four arcuate inlet ports to the pump; two being inner inlet ports 47, 48 selectively communicating with the first pumping chambers defined by the enlarged outer inlet ports 42, 43 selectively communicating with second pumping chambers defined by the intervane spaces. Alternatively, these outer inlet ports might be provided in both the port plates 21 and 22 or in the cam ring 20. Inlet passages 40 and 41 supply fluid to the outer inlet ports 42 and 43 respectively. Fluid passages 45 and 46 supply fluid to the inner inlet ports 47 and 48.

25 Inner outlet ports 50, 51 for the undervane chambers and outer outlet ports 52, 53 for the intervane chambers are provided in the port plate 21. Inner outlet ports might also be provided in the port plate 22 and the outlet ports 52, 53 might alternatively be in the cam ring 20. Similar ports 52a and 53a in the port plate 22 are connected thereto by a pair of slots 54 and 55 in the cam ring 20. The end cap 25 has four outlet passages 60, 61, 62 and 63 communicating respectively with the outlet ports 50, 51, 52, 53. Thus, the pump has the capability of separate utilization of pumped volume from intervane and undervane pumping spaces, and all four volumes differ in amount because of the different contour of the cam ring lobes 32, 33.

40 With the rotor 12 rotating in the direction of the arrow shown in Figure 1, hydraulic fluid, such as jet engine fuel is delivered through inlet passages 40, 41 to the outer inlet ports 42, 43, and through passages 45, 46 to the inner inlet ports 47, 48. In the lobe 33 of the cam ring, the vanes 16 track past the lower dead centre position of maximum extension of the vane, and pumping action occurs beyond. The swept volume of fluid from the intervane spaces is pumped to the outer outlet port 53, and the undervane pumping chambers pump fluid to the outlet port 51 by inward movement of the vanes in the rotor slots caused by the cam ring 20. As the vanes 16 coast with the lobe 32 of the cam ring, the pumping action commences beyond the top dead centre position for the vane, the intervane spaces pumping to the outer outlet port 52 and the undervane spaces pumping to the inner outlet port 50. As the lobe 32 is smaller than the lobe 33, each of the intervane spaces has less volume

when the vanes are tracking the lobe 32 than when the vanes are tracking the lobe 33, so less fluid is carried to the outlet port 52 than to the outlet port 53. Similarly, the stroke of the vanes is less when they are coasting with the lobe 32 than with lobe 33, and so a smaller volume of fluid is received in the rotor slots beneath the vanes, and less fluid is delivered to the inner outlet port 50 than to the inner outlet port 51. Any bearing loads that may be generated may be accounted for in the specific structural design of the pump.

70 In Figure 3, a pump 160 is of the same basic configuration as in Figures 1 and 2. A cam ring 161 has a pair of lobes 162 and 163 corresponding to lobes 32 and 33 in Figure 1. The pump 160 has a first inlet 65 and a second inlet 66 both supplied from a line 67 leading from a boost pump 68 having an inlet line 69 from a source of fluid. The inlet 65 serves both an outer inlet port 70 and an inner inlet port 71 corresponding to inlet ports 42 and 47 in Figure 1. The inlet 66 supplies an outer inlet port 72 and an inner inlet port 73 which are comparable to the inlet ports 43 and 48 in Figure 1. The inlet ports of each set are interconnected by a channel shown in broken lines 74 and 75.

80 The output of the pump is delivered to a line 80 leading to a fluid utilization circuit, such as the fuel control for a jet engine, the supply to the line 80 being through a pair of common outlets 81 and 82 extending from the pump 160. The common outlet 81 connects to an outer outlet port 85 and an inner outlet port 86 through a connecting channel 87. The common outlet 82 connects to an outer outlet port 90 and an inner outlet port 91 through a connecting channel 92. Thus, with rotation of the pump rotor in a clockwise direction, there is both intervane and undervane pumping action between the fluid inlet 65 and the common outlet 81 and, similarly between the fluid inlet 66 and the common outlet 82. The flow to each outlet is a sum of the intervane and undervane pumping and the volume of fluid delivered to the common outlet 81 is less than that delivered to common outlet 82 because of the differing contours of the lobes 162 and 163.

110 The common outlets 81 and 82 join together and connect to the line 80. Fluid flows past a check valve 96 in the common outlet 82 which prevents flow from the common outlet 81 to the common outlet 82 when the pressure is low.

120 Fluid in the line 80 flows perpendicular to the exposed surface of the filter element of a wash flow filter 95 at an end of a line 121.

125 The pump 160 has additional alternative fluid flow paths. One alternative path is from the fluid outlet ports 85 and 86 back to the fluid inlet 65 through a passage 97. This is under the control of a modulating valve 100 urged to a closed position by a spring 130

101. When the modulating valve 100 opens, fluid may flow back to the inlet 65 for recycling through the pump. The second alternative path is from outlet ports 90, 91 back to the inlet 66 through a passage 110 under the control of a second modulating valve 105 urged to a close position by a spring 106 of less force than the spring 101. The modulating valve 105 blocks flow from the outlet ports 90 and 91, but, when open, permits flow from along the passage 110 back to the fluid inlet 66 for recycling through the pump. This passage 110 also communicates, through a line 111, with the downstream side of a relief valve 112 which may be set to establish a maximum pressure on the outlet flow line 80. The different force values of the springs 101 and 106 provide for opening of the modulating valve 105 prior to opening of the modulating valve 100. The two modulating valves are of a different size. The valve 100 is smaller because it is associated with the lower volume section of the pump.

An additional control is put on the opening of the modulating valves by means of a control circuit, including a servo control valve 120. The control valve 120 is supplied with a control pressure from pumped fluid at the wash flow filter 95 through the line 121, and the valve has a line 122 to tank. A valve spool 123 of the control valve 120 has a land 124 which throttles the flow of pressure fluid from a branch line 121a of line 121 and thus delivers and intermediate pressure to a line 125 which has branches 126 and 127 leading respectively to the modulating valves 105 and 100. A second branch 121b of the control pressure line 121 leads to the control valve between a land 128 and a land 129. The pressure differential prevents impurities in the fuel from moving downwardly past the land 129 into the control area of the valve.

The position of the valve spool 123 is controlled by a pressure differential applied to a diaphragm 130. The diaphragm 130 is of relatively large area and so amplifies the effect of the pressure on the spool 123. A pair of lines 131 and 132 connect to opposite sides of the diaphragm and extend from opposite sides of a variable geometry orifice in a fuel control whereby a predetermined difference in pressure results in a downward shift of the diaphragm to lower the valve spool 123. The valve spool 123 is in an upper position (as shown) in which the intermediate pressure in the line 125 is relatively high and is applied to the back side of both of the modulating valves to assist the springs and maintain the modulating valves closed. When the pressure differential between lines 131 and 132 is sufficient to deflect the diaphragm 130 downwardly, the valve spool land 124 moves to a position to throttle the flow to

line 124 to reduce the intermediate pressure. At a certain value, the modulating valve 105 opens and part of the pump flow passes through the passage 110 and back to the fluid inlet 66. If the intermediate pressure reduces further, the modulating valve 105 opens further, and ultimately the intermediate pressure may be reduced to a value whereby the modulating valve 100 may also open.

At start up, there will be no intermediate pressure, since there is no pressure in line 121. A spring 140 urges the valve spool 123 to the upper position shown. A branch line 141 from line 132 extends to the lower side of the valve spool 123 whereby the force of the pressure in line 132 directed to the underside of the diaphragm and acting against valve land 129 is balanced out so as to not affect valve positioning.

The circuit of Figure 3 may be used in supplying an aircraft engine fuel system in which there are ranges of flow requirements from a minimum flow at flight idel descent to a maximum flow at maximum rate thrust. In such an application, the flow from the common outlet 81 would be of such a volume as to provide the lower flow engine requirements, and the flow would be from both common outlets 81 and 82 at full flow for maximum flow at maximum rate thrust. This system provides for a variable volume delivery with high overall efficiency without requiring the use of a variable volume pump with an adjustable cam ring. High volumetric efficiency is obtained as there is always pumping the intervane spaces at the same time that there is pumping in the associated undervane spaces. This avoids a substantial pressure differential between the undervane spaces and the intervane spaces, and leakage around the vane edges from the base of the rotor slots to the spaces between vanes is reduced. This volumetric efficiency makes it possible to pump at high pressures.

WHAT WE CLAIM IS:-

1. A rotary sliding-vane-type double-lobe hydraulic pump comprising a rotor having a number of radial slots each with a vane movably mounted therein, a cam ring surrounding the rotor and vanes and having lobes of different contour, first pumping chambers beneath the vanes and second pumping chambers defined by spaces between the vanes, the first and second pumping chambers having respective inner and outer outlet ports leading to at least two outlet passages.

2. A pump as defined in claim 1 including a fluid utilization circuit connected to the outlet passages and means in the circuit for controlling the flow from one or more of the outlet passages.

3. A pump as defined in claim 2 wherein the said means provides for delivery from



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An additional control is put on the opening of the modulating valves by means of a control circuit, including a servo control valve 120. The control valve 120 is supplied with a control pressure from pumped fluid at the wash flow filter 95 through the line 121, and the valve has a line 122 to tank. A valve spool 123 of the control valve 120 has a land 124 which throttles the flow of pressure fluid from a branch line 121a of line 121 and thus delivers and intermediate pressure to a line 125 which has branches 126 and 127 leading respectively to the modulating valves 105 and 100. A second branch 121b of the control pressure line 121 leads to the control valve between a land 128 and a land 129. The pressure differential prevents impurities in the fuel from moving downwardly past the land 129 into the control area of the valve.

The position of the valve spool 123 is controlled by a pressure differential applied to a diaphragm 130. The diaphragm 30 is of relatively large area and so amplifies the effect of the pressure on the spool 123. A pair of lines 131 and 132 connect to opposite sides of the diaphragm and extend from opposite sides of a variable geometry orifice in a fuel control whereby a predetermined difference in pressure results in a downward shift of the diaphragm to lower the valve spool 123. The valve spool 123 is in an upper position (as shown) in which the intermediate pressure in the liner 125 is relatively high and is applied to the back side of both of the modulating valves to assist the springs and maintain the modulating valves closed. When the pressure differential between lines 131 and 132 is sufficient to deflect the diaphragm 130 downwardly, the valve spool land 124 moves to a position to throttle the flow to

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1. A rotary sliding-vane-type double-lobe hydraulic pump comprising a rotor having a number of radial slots each with a vane movably mounted therein, a cam ring surrounding the rotor and vanes and having lobes of different contour, first pumping chambers beneath the vanes and second pumping chambers defined by spaces between the vanes, the first and second pumping chambers having respective inner and outer outlet ports leading to at least two outlet passages.

2. A pump as defined in claim 1 including a fluid utilization circuit connected to the outlet passages and means in the circuit for controlling the flow from one or more of the outlet passages.

3. A pump as defined in claim 2 wherein the said means provides for delivery from

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one outlet passage and for full or partial delivery from another outlet passage.

4. A pump as defined in claim 2 or claim 3 wherein the said means includes a modulating valve associated with the other outlet passage, and means for setting a pump pressure value for the opening of the modulating valve.

5. A pump as defined in claim 4 wherein a passage downstream of the modulating valve leads to inlet ports through which fluid returns to the inlet side of the pump when the valve opens.

6. A pump as defined in claim 4 or claim 5 wherein the setting means includes a spring and means for varying fluid pressure urging the modulating valve closed.

7. A pump as defined in claim 3 wherein the said means includes a modulating valve associated with each outlet passage means for setting different fluid pressure values for the operating of said modulating valves, and a passage leading from downstream of the associated modulating valve to a pump inlet port for the return of fluid to the pump.

8. A pump as defined in claim 7 wherein the means for setting different fluid pressure values includes a spring engaging

each valve, one spring having a relatively light spring force and the other a relatively heavy spring force and means for applying a variable pressure to the modulating valves.

9. A pump as defined in claim 6 wherein the means for applying the variable pressure to the modulating valve includes a control valve for metering a control pressure providing the variable pressure, and means for positioning the control valve in response to a device receiving fluid from the pump.

10. A pump as defined in any preceding claim including a port plate providing first and second inlet ports, the first and second outlet ports communicating alternately with the rotor slot spaces beneath the vanes and with the inter-vane spaces during rotation of the rotor.

11. A rotary sliding-vane-type double-lobe pump as herein described with reference to Figures 1 and 2 of the drawings.

12. A pump according to claim 11 including circuitry as in Figure 3 of the drawings.

SERJEANTS

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