A pump for a machine hydraulic system is disclosed. The pump has a housing, a first plurality of pumping elements, and a second plurality of pumping elements. The housing has a central bore with a first end and a second end. The housing also has a first high pressure port for fluid communication with a first external circuit and a second high pressure port for fluid communication with a second external circuit. The first plurality of pumping elements is disposed within the housing and is in fluid communication with the first high pressure port. The second plurality of pumping elements is disposed with the housing, axially aligned in opposition to the first plurality of pumping elements, and is in fluid communication with the second high pressure port.
DUAL FLOW AXIAL PISTON PUMP

TECHNICAL FIELD

[0001] The present disclosure is directed to an axial piston pump and, more particularly, to an axial piston pump capable of simultaneously pressurizing separate flows of fluid.

BACKGROUND

[0002] Machines such as loaders, motor graders, backhoes, excavators, and other heavy equipment often include multiple separate hydraulic circuits. For example, one machine circuit typically provides pressurized fluid to a brake mechanism that decelerates the machine, while another circuit separate from the first typically provides pressurized fluid to a hydraulic actuator associated with a tool such as a bucket or a shovel. Each of these separate circuits generally includes a fluid pressurizing pump that derives power from the machine’s engine and generates an associated efficiency loss for the engine. Each of these pumps increases the cost of the machine and take up space on the machine.

[0003] One attempt to reduce the space on a machine consumed by fluid pressurizing pumps is described in U.S. Patent Publication No. 2005/0201879 (the ’879 publication) by Achten published on Sep. 15, 2005. The ’879 publication describes a hydraulic device having, in a housing, a rotor with pistons connected to either side of the rotor. Each side of the rotor interacts with an inclined drum plate having drum sleeves. Each piston is surrounded by a drum sleeve to form a chamber, the volume of which changes when the rotor rotates. The change in volume causes oil flow into and out of the chamber via an opening in the drum plate. There are two face plates in contact with the drum plates to distribute fluid from a single low pressure line entering the housing to the chambers, and to direct fluid pressurized by motion of the rotor from the chambers to a single high pressure line exiting the housing. In other words, fluid pressurized in the chambers on either side of the rotor flows together within the single high pressure line to exit the housing from a single exit port.

[0004] Although the hydraulic device of the ’879 publication may be compact in size, multiple devices may still be required to supply pressurized fluid to the multiple circuits of a machine. That is, because each of the hydraulic devices of the ’879 patent provides only a single flow of pressurized fluid, each different circuit may still require its own dedicated device. A machine having multiple such hydraulic devices, regardless of the compactness of the devices, may still consume considerable space, have low efficiency, and be costly.

[0005] The pump of the present disclosure solves one or more of the problems set forth above.

SUMMARY OF THE INVENTION

[0006] One aspect of the present disclosure is directed to a pump. The pump includes a housing, a first plurality of pumping elements, and a second plurality of pumping elements. The housing includes a central bore with a first end and a second end. The housing also includes a first high pressure port for fluid communication with a first external circuit, and a second high pressure port for fluid communication with a second external circuit. The first plurality of pumping elements is disposed within the housing and is in fluid communication with the first high pressure port. The second plurality of pumping elements is disposed with the housing, axially aligned in opposition to the first plurality of pumping elements, and is in fluid communication with the second high pressure port.

[0007] Another aspect of the present disclosure is directed to a method of pressurizing dual streams of fluid. The method includes directing low pressure fluid through at least one port into a housing to separate axial ends of the housing. The method also includes working the fluid at a first end of the housing in an axial direction of the housing to pressurize the fluid. The method also includes working the fluid at a second end of the housing in an axial direction of the housing to pressurize the fluid. The method further includes expelling pressurized fluid from the first end of the housing through a high pressure port to a first external circuit. The method additionally includes simultaneously expelling pressurized fluid from the second end of the housing through a high pressure port to a second external circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a schematic and diagrammatic illustration of an exemplary disclosed machine hydraulic system;

[0009] FIG. 2 is a cutaway view illustration of an exemplary disclosed hydraulic pump for the machine hydraulic system of FIG. 1;

[0010] FIG. 3 is an exploded view illustration of the hydraulic pump of FIG. 2; and

[0011] FIG. 4 is a cutaway view illustration of another exemplary disclosed hydraulic pump for the machine hydraulic system of FIG. 1.

DETAILED DESCRIPTION

[0012] FIG. 1 illustrates an exemplary machine 10. Machine 10 may be stationary or mobile and perform some type of operation associated with an industry such as mining, construction, farming, transportation, power generation, or any other industry known in the art. For example, machine 10 may embody a wheel loader configured to move earth at a construction site, a passenger vehicle configured to transport people or goods, a generator set configured to produce electrical power, or any other type of machine known in the art. Machine 10 may include, among other things, a power source 12, a first hydraulic circuit 14, a second hydraulic circuit 16, a tank 18, and a pump 20.

[0013] Power source 12 may embody an engine such as, for example, a diesel engine, a gasoline engine, a gaseous fuel-powered engine such as a natural gas engine, or any other type of combustion engine apparent to one skilled in the art. Power source 12 may alternatively embody a non-combustion source of power such as a fuel cell, a power storage device, or any other suitable source of power. Power source 12 may produce a mechanical or electrical power output that drives pump 20 to pressurize fluid.

[0014] First hydraulic circuit 14 may receive pressurized fluid from pump 20 and direct the pressurized fluid to one or more actuator devices. In one example, first hydraulic circuit
14 may be associated with a brake mechanism 22. It is contemplated, however, that first hydraulic circuit 14 may alternatively or additionally be associated with other actuator devices, if desired, such as a steering mechanism, a cooling component, a pilot operated control device, and other devices known in the art.

0015] Brake mechanism 22 may be operatively associated with one or more wheels 24 of machine 10 to retard the motion of machine 10. In one embodiment, brake mechanism 22 may include a hydraulic pressure-actuated wheel brake such as, for example, a disk brake or a drum brake that is disposed intermediate wheel 24 and a final drive assembly (not shown) of machine 10. When actuated, pressurized fluid within brake mechanism 22 may be utilized to increase the rolling friction of machine 10.

0016] Similar to first hydraulic circuit 14, second hydraulic circuit 16 may also receive pressurized fluid from pump 20 and direct the pressurized fluid to one or more actuator devices. In one example, second hydraulic circuit 16 may be associated with a fluid cylinder 26 that assists movement of a machine tool 28. It is contemplated, however, that second hydraulic circuit 16 may alternatively or additionally be associated with other actuator devices, if desired, such as a drive motor, a swing motor, and other devices known in the art. The pressure and/or flow rate of fluid supplied by pump 20 to second hydraulic circuit 16 may be different than the pressure and/or flow rate of fluid simultaneously supplied by pump 20 to first hydraulic circuit 14.

0017] Fluid cylinder 26 may be connected to a frame of machine 10 via a direct pivot, via a linkage system with fluid cylinder 26 forming a member in the linkage system, or in any other appropriate manner. Fluid cylinder 26 may include a tube and a piston assembly disposed within the tube. The tube may be divided by the piston assembly into opposing pressure chambers selectively supplied with pressurized fluid from pump 20 and selectively connected with tank 18 to cause the piston assembly to displace within the tube, thereby changing the effective length of fluid cylinder 26. The expansion and retraction of fluid cylinder 26 may assist in moving tool 28.

0018] Tank 18 may constitute a reservoir configured to hold a supply of low pressure fluid. The fluid may include, for example, a dedicated hydraulic oil, an engine lubrication oil, a transmission lubrication oil, an engine fuel, or any other fluid known in the art. One or more hydraulic systems within machine 10 may draw fluid from and return fluid to tank 18. It is also contemplated that machine 10 may alternatively be connected to multiple separate fluid tanks.

0019] Pump 20 may simultaneously produce dual flows of pressurized fluid and may embody an axial piston type-pump. Pump 20 may be drivably connected to power source 12 by, for example, a gear train (not shown), a belt (not shown), an electrical circuit (not shown), or in any other suitable manner. Alternatively, pump 20 may be indirectly connected to power source 12 via a torque converter (not shown) or in any other appropriate manner.

0020] As illustrated in the embodiment of FIG. 2, pump 20 may be an assembly of multiple components that interact to pressurize fluid from tank 18. In particular, pump 20 may include a housing 30, a shaft 32 supported within the housing 30 by way of bearings 34, a rotor 36, a plurality of pumping elements 38, and a second plurality of pumping elements 40.

0021] Housing 30 may retain first and second plurality of pumping elements 38, 40 and fluidly interconnect first and second plurality of pumping elements 38, 40, tank 18, and first and second hydraulic circuits 14, 16. Specifically, housing 30 may include a central bore 42 having a first axial end 44 and a second axial end 45. Shaft 32 may extend through at least first axial end 44 and be substantially axially aligned with central bore 42. Bearings 34 may engage interior walls of central bore 42 to support the rotation of shaft 32 therein. Housing 30 may also include a low pressure inlet port 46 in fluid communication with tank 18, a first high pressure outlet port 48 in communication with first hydraulic circuit 14, and a second high pressure outlet port 50 in communication with second hydraulic circuit 16. An internal fluid passageway 52 may connect low pressure inlet port 46 with first and second pluralities of pumping elements 38, 40. An internal fluid passageway 54 may connect first plurality of pumping elements 38 with first high pressure outlet port 48. An internal fluid passageway 56 may connect second plurality of pumping elements 40 with second high pressure outlet port 50.

0022] Rotor 36 may embody a plate-like member fixedly connected to shaft 32 such that a rotation of shaft 32 results in a direct rotation of rotor 36. Rotor 36 may be integral to shaft 32 or, alternatively, joined to shaft 32 through a welding, sintering, or other known metal joining process. Rotor 36 may include opposing faces 58, 60 oriented substantially orthogonal to the axial direction of shaft 32.

0023] Each of first and second plurality of pumping elements 38, 40 may include numerous components that interact to simultaneously work the fluid from tank 18 in the axial direction of shaft 32 and produce two separately pressurized streams of fluid. For example, each of the first and second plurality of pumping elements 38, 40 may include a plurality of cup-like piston members 62 fixedly connected to opposing faces 58 and 60 of rotor 36. Each piston member 62 may engage a corresponding drum sleeve 64 to form a chamber 66.

0024] Each of drum sleeves 64 associated with those piston members 62 extending from face 58 may be connected to an inclined drum plate 68, while each of drum sleeves 64 associated with those piston members 62 extending from face 60 may be connected to a similar opposing inclined drum plate 70. Drum plates 68 and 70 may be connected to rotate with shaft 32 and configured to direct low pressure fluid into chambers 66 and high pressure fluid from chambers 66. As shaft 32, rotor 36, and drum plates 68, 70 rotate, piston members 62 may move into and out of drum sleeves 64, thereby changing the volume of chambers 66. As the volume of chambers 66 increases, fluid from internal passageway 52 may flow into chambers 66 through a plurality of distribution holes 72 in drum plates 68 and 70. As the volume of chambers 66 decreases, fluid from chambers 66 may be forced back through distribution holes 72 to internal fluid passageways 54 and 56.

0025] At each of first and second axial ends 44, 45 of housing 30, internal fluid passageway 52 may be in communication with only half of distribution holes 72 at one time via a plurality of distribution passageways 52a, while internal fluid passageways 54, 56 may be in communication with the remaining distribution holes 72 via distribution passageways 54a and 56a, respectively. Although illustrated
Drum plates 68, 70 may be inclined to an angle \( \beta \) defined by the geometry of first and second axial ends 44, 45 (or face plates 74, if implemented). In particular, first and second axial ends 44, 45 (and face plates 74) may be located during manufacture at a particular tilt angle \( \beta \) relative to the axial direction of shaft 32. Because of the assembled relationship between first and second axial ends 44, 45 and drum plates 68, 70, this tilt angle \( \beta \) may correspond to the volume change of chambers 66 during a revolution of shaft 32. In fact, the tilt angle \( \beta \), associated with first plurality of pumping elements 38 may be different from the tilt angle \( \beta \), associated with second pumping elements 40. In this manner, the volume change of chambers 66 associated with first plurality of pumping elements 38 during a single revolution of shaft 32 may be different from the volume change of chambers 66 associated with second plurality of pumping elements 40 during the same revolution of shaft 32. For this reason, first plurality of pumping elements 38 may produce a stream of pressurized fluid having a different flow characteristic (e.g., rate and/or pressure) than the stream of pressurized fluid produced by second plurality of pumping elements 40.

FIG. 4 illustrates an alternative embodiment of pump 20. Similar to pump 20 of FIGS. 2 and 3, pump 20 of FIG. 4 includes housing 30, shaft 32, bearings 34, rotor 36, first plurality of pumping elements 38, and second plurality of pumping elements 40. However, in contrast to pump 20 of FIGS. 2 and 3, first plurality of pumping elements 38 and/or second plurality of pumping elements 40 of FIG. 4 may produce streams of pressurized fluid having variable flow characteristics. In particular, pump 20 of FIG. 4 may include a variable displacement actuator 76 located at first axial end 44 and/or second axial end 45 of housing 30.

Variable displacement actuator 76 may include components that adjust the tilt angle \( \beta \) of face plate 74 and subsequently the volume change of chambers 66. Specifically, variable displacement actuator 76 may include one or more control pistons 78 that directly or indirectly press against a portion of face plate 74 to urge face plate 74 to tilt relative to the axial direction of shaft 32. Control pistons 78 may be hydraulically actuated, pneumatically actuated, electrically actuated, or actuactuated in any other known manner such that face plate 74 may be tilted to a specific desired tilt angle corresponding to a desired characteristic (e.g., flow rate and/or pressure) of the resulting stream of pressurized fluid. The control pistons 78 associated with face plate 74 at first axial end 44 may be operated independent of the control pistons 78 at the opposing second axial end 45 such that tilt angle \( \beta \), may be varied independent of tilt angle \( \beta \).

It is contemplated that pump 20 may include multiple low pressure inlet ports, if desired. In particular, as illustrated in FIG. 4, housing 30 may include a second low pressure inlet port 80 fluidly connected to drum plate 70 by way of low pressure passageway 82. As a result, first plurality of pumping elements 38 may be supplied with low pressure fluid from tank 18 via low pressure inlet port 46 and internal fluid passageway 52, while second plurality of pumping elements 40 may be supplied with low pressure fluid from tank 18 via low pressure inlet port 80 and low pressure passageway 82. In this manner, fluid fluctuations within internal fluid passageway 52 may have little or no affect on the fluid drawn through low pressure passageway 82.

INDUSTRIAL APPLICABILITY

The disclosed pump and associated hydraulic circuits find potential application in any machine where it is desirable to reduce the cost, size, and efficiency loss of the machine. The disclosed pump and hydraulic circuits may reduce the cost, size, and efficiency of the machine by integrating multiple pumping functions within a single pumping device. Operation of pump 20 will now be described.

Referring to FIGS. 2-4, as shaft 32 is rotated, low pressure fluid from tank 18 may be drawn into chambers 66 by way of low pressure inlet port 46 (and 80, if dual inlet ports are implemented, as in FIG. 4) in response to the expanding volume of chambers 66. As shaft 32 continues to rotate, piston members 62 may be driven into drum sleeves 64 to reduce the volume of chambers 66, pressurize the fluid therein, and force the fluid from chambers 66 via distribution holes 72 in drum plate 68. As the fluid leaves distribution holes 72, the fluid may be directed via internal fluid passageway 54 and first high pressure outlet port 48 to first hydraulic circuit 14. Similarly, as the fluid leaves distribution holes 72 in drum plate 70, the fluid may be directed via internal fluid passageway 56 and second high pressure outlet port 50 to second hydraulic circuit 16. Because the tilt angles \( \beta \) and \( \beta \) may be different, the flow rate and/or pressure of the fluid exiting first and second high pressure outlet ports 48, 50 may likewise be different.

During operation of pump 20, the displacement of piston members 62 into drum sleeves 64 may be varied to simultaneously and independently change the flow rate and/or pressure of fluid exiting first and second high pressure outlet ports 48, 50. Specifically, control pistons 78 may be selectively actuated to urge face plates 74 to a desired tilt angle \( \beta \) relative to the axial direction of shaft 32. The desired tilt angle may correspond to a desired characteristic of the fluid flowing from first and second high pressure outlet ports 48, 50.

Because multiple independent streams of fluid may be pressurized with a single pump 20, cost, space, and efficiency loss of machine 10 may be reduced. In particular, by reducing the number of components required to produce the separate streams of fluid, the component cost of the machine may be reduced. In addition, the space consumed by separate pumps may be eliminated. Further, because the two streams of pressurized fluid may be tailored to meet specific flow demands of separate hydraulic circuits 14 and 16, pump 20 may be operated in a highly efficient manner.

It will be apparent to those skilled in the art that various modifications and variations can be made in the pump of the present disclosure without departing from the scope of the disclosure. Other embodiments will be apparent to those skilled in the art from consideration of the specification and practice of the pump disclosed herein. It is intended that the specification and examples be considered
as exemplary only, with a true scope of the disclosure being indicated by the following claims and their equivalents.

What is claimed is:

1. A pump, comprising:
   a housing having:
   a central bore with a first end and a second end;
   a first high pressure port for fluid communication with a first external circuit; and
   a second high pressure port for fluid communication with a second external circuit;
   a first plurality of pumping elements disposed within the housing and being in fluid communication with the first high pressure port; and
   a second plurality of pumping elements disposed with the housing, axially aligned in opposition to the first plurality of pumping elements, and being in fluid communication with the second high pressure port.

2. The pump of claim 1, further including:
   a shaft rotatably disposed within the housing and having an axial direction; and
   a rotor fixedly connected to the shaft and having a first face and an opposing second face, wherein:
   the first plurality of pumping elements includes:
   a first plurality of piston members extending from the first face; and
   a first plurality of cylinders located within the first end of the central bore to receive the first plurality of piston members; and
   the second plurality of pumping elements includes:
   a second plurality of piston members extending from the second face; and
   a second plurality of cylinders located within the second end of the central bore to receive the second plurality of piston members.

3. The pump of claim 2, wherein the housing further includes a low pressure port in communication with an external supply of fluid and both of the first and second pluralities of cylinders.

4. The pump of claim 2, wherein the housing further includes:
   a first low pressure port in fluid communication with an external supply of fluid and the first plurality of cylinders; and
   a second low pressure port in fluid communication with the external supply of fluid and the second plurality of cylinders.

5. The pump of claim 2, wherein the first and second plurality of piston members are fixedly connected to the rotor.

6. The pump of claim 2, further including:
   a first drum plate operatively connected to the first plurality of cylinders; and
   a second drum plate operatively connected to the second plurality of cylinders.

7. The pump of claim 6, wherein the first and second drum plates are tilted at an angle relative to the axial direction.

8. The pump of claim 7, wherein the first drum plate is fixed at a different angle than the second drum plate to pressurize the fluid flowing from the first high pressure port to a different level relative to the fluid flowing from the second high pressure port.

9. The pump of claim 7, wherein the tilt angle is variable during operation of the pump to vary a pressure of fluid exiting the first and second high pressure ports.

10. The pump of claim 9, wherein the tilt angle of the first drum plate is separately and simultaneously variable relative to the tilt angle of the second drum plate.

11. The pump of claim 2, wherein the first and second plurality of piston members are substantially aligned with the axial direction.

12. A method of pressurizing dual streams of fluid, comprising:
   directing low pressure fluid through at least one port into a housing to separate axial ends of the housing;
   working the fluid at a first end of the housing in an axial direction of the housing to pressurize the fluid;
   working the fluid at a second end of the housing in an axial direction of the housing to pressurize the fluid;
   expelling pressurized fluid from the first end of the housing through a high pressure port to a first external circuit; and
   simultaneously expelling pressurized fluid from the second end of the housing through a high pressure port to a second external circuit.

13. The method of claim 12, wherein directing low pressure fluid through at least one port includes directing low pressure fluid through a first port to the first end of the housing and directing low pressure fluid through a second port to the second end of the housing.

14. The method of claim 12, further including distributing the fluid from the at least one port to a plurality of axial pumping elements located with the first end of the housing and to a plurality of axial pumping elements located within the second end of the housing.

15. The method of claim 14, further including varying a displacement of the first and second plurality of pumping elements.

16. The method of claim 15, wherein varying a displacement includes varying a displacement of the first plurality of pumping elements differently than the displacement of the second plurality of pumping elements.

17. A machine, comprising:
   a first hydraulic circuit;
   a second hydraulic circuit; and
   a pump configured to supply separate streams of pressurized fluid to the first and second hydraulic circuits, the pump including:
   a housing having:
   a central bore with a first end and a second end;
   a first high pressure port in fluid communication with the first external circuit;
a second high pressure port in fluid communication with the second external circuit; and
at least one low pressure port in communication with an external supply of fluid;
a shaft rotatably disposed within the housing and having an axial direction;
a rotor fixedly connected to the shaft and having a first face and an opposing second face;
a first plurality of piston members extending from the first face;
a first plurality of cylinders located within the first end of the central bore to receive the first plurality of piston members and being in fluid communication with the at least one low pressure port;
a second plurality of piston members extending from the second face;
a second plurality of cylinders located within the second end of the central bore to receive the second plurality of piston members and being in fluid communication with the at least one low pressure port.

18. The machine of claim 17, wherein:
the at least one low pressure port is a first low pressure port in fluid communication with the first plurality of cylinders; and
the housing further includes a second low pressure port in fluid communication with the external supply of fluid and the second plurality of cylinders.

19. The machine of claim 17, further including:
a first drum plate operatively connected to the first plurality of cylinders; and
a second drum plate operatively connected to the second plurality of cylinders,
wherein the first drum plate is fixed at a different angle relative to the axial direction than the second drum plate to pressurized the fluid flowing from the first high pressure port to a different level relative to the fluid flowing from the second high pressure port.

20. The machine of claim 17, further including:
a first drum plate operatively connected to the first plurality of cylinders; and
a second drum plate operatively connected to the second plurality of cylinders,
wherein a tilt angle of the first drum plate is separately and simultaneously variable relative to a tilt angle of the second drum plate to vary a pressure of fluid exiting the first and second high pressure ports.

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