HYDRAULIC DEVICE HAVING AN ALIGNMENT COMPONENT

Inventors: Bryan E. Nelson, Lacon, IL (US); Viral S. Mehta, Peoria, IL (US); Kirat Shah, Dunlap, IL (US)

Correspondence Address: CATERPILLAR/FINNEGAN, HENDERSON, L.L.P. 901 New York Avenue, NW WASHINGTON, DC 20001-4413 (US)

Assignee: Caterpillar Inc.

Filed: Jul. 31, 2008

Publication Classification

Publication Date: Feb. 4, 2010

Publication No.: US 2010/0028169 A1

Abstract

The present disclosure is directed towards a hydraulic device. The hydraulic device may include a rotor, a plurality of piston members extending from the rotor, and a plurality of piston sleeves receiving the plurality of piston members. Each piston sleeve may have a piston receiving end and a piston sleeve axis. The hydraulic device may further include a plate component supporting the plurality of piston sleeves. The plate component may have a plate component axis. The hydraulic device may also include an alignment component having a plurality of arms spaced in a non-contact relationship with a piston receiving end of a respective piston sleeve when the plate component axis is parallel with the piston sleeve axis of the respective piston sleeve.
HYDRAULIC DEVICE HAVING AN ALIGNMENT COMPONENT

TECHNICAL FIELD

[0001] The present disclosure is directed to a hydraulic device, and more particularly, to a hydraulic device having an alignment component.

BACKGROUND

[0002] Hydraulic devices based on the ‘floating cup principle’ generally include a shaft disposed within a housing and a rotor fixedly connected to the shaft. The rotor includes a plurality of pistons which interact with a plurality of piston sleeves supported by an inclined plate. Each piston and respective piston sleeve form a chamber, the volume of which varies during rotation of the shaft. The change in volume causes fluid flow into and out of the chamber via an opening in the inclined plate.

[0003] Each piston sleeve is designed to press against the inclined plate as a result of the fluid pressure in the chamber during operation of the device. Centrifugal forces can cause the piston sleeve to tilt relative to the inclined plate and form a gap at the piston sleeve-inclined plate interface. This gap can impede pressure from building in the chamber. Furthermore, fluid present in the chamber may leak through the gap.

[0004] A conventional apparatus used to prevent fuel leakage at the piston sleeve-inclined plate interface is disclosed in International Publication No. WO/2006/083163 A1 (“the ’163 publication”) to Achten published on Aug. 10, 2006. The ’163 publication discloses a system for clamping the piston sleeves against an inclined drum plate of a ‘floating cup’ hydraulic device. Specifically, the ’163 publication discloses a spring plate connected to a drum plate. The spring plate is provided with radial spring arms having contact surfaces which press against a top edge of the piston sleeve. As the two spring arms press against the top edge of the piston sleeve, the piston sleeve is pressed against the drum plate to prevent the piston sleeve from lifting during rotation of the shaft. The force of the spring plate on the piston sleeve is adjusted by varying the thickness of a washer disposed between the spring plate and the drum plate.

[0005] Although the ’163 publication may prevent the piston sleeves of the hydraulic device from excessively tipping, the limited contact area between the spring plate and piston sleeves may still allow a small amount of tilt as the drum plate rotates. Further, because of the constant spring force applied to the piston sleeves, any minor tilt or oscillation of the piston sleeves results in friction at the piston sleeve-drum plate interface. The energy required from a power source to overcome the friction may decrease the mechanical efficiency of the overall hydraulic device.

[0006] The present disclosure is directed to overcoming one or more of the shortcomings set forth above and/or other shortcomings in the existing technology.

SUMMARY

[0007] One aspect of the present disclosure is directed towards a hydraulic device. The hydraulic device may include a rotor, a plurality of piston members extending from the rotor, and a plurality of piston sleeves receiving the plurality of piston members. Each piston sleeve may have a piston receiving end and a piston sleeve axis. The hydraulic device may further include a plate component supporting the plurality of piston sleeves. The plate component may have a plate component axis. The hydraulic device may also include an alignment component having a plurality of arms spaced in a non-contact relationship with a piston receiving end of a respective piston sleeve when the plate component axis is parallel with the piston sleeve axis of the respective piston sleeve.

[0008] Another aspect of the present disclosure is directed towards a method of assembling a hydraulic device. The method includes positioning a plurality of piston sleeves on a plate component. The method further includes positioning an alignment component at a fixed distance from a piston receiving end of a respective piston sleeve. The method also includes engaging the alignment component with the plate component to partially enclose the plurality of piston sleeves.

[0009] Yet another aspect of the present disclosure is directed towards a floating-cup device. The floating-cup device may include a housing and a shaft rotatably disposed within the housing. The floating-cup device may also include a rotor fixedly connected to the shaft, and a plurality of piston members extending from the rotor. The floating-cup device may include a plurality of piston sleeves receiving the plurality of piston members, each piston sleeve may have a bottom sleeve and a piston receiving end. The floating-cup device may also include a plate component supporting the plurality of piston sleeves. The floating cup may further include an alignment component configured to abut against the plate component, the alignment component positioned to provide a variable gap with the receiving end of the respective piston sleeve, the gap varying as a function of the alignment of the respective piston sleeve to the inclined plate component.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a cutaway view illustration of an exemplary disclosed hydraulic device according to the present disclosure; and

[0011] FIG. 2 is a partial cross-section of the hydraulic device of FIG. 1 during a first operational conditions;

[0012] FIG. 3 is a partial cross-section of the hydraulic device of FIG. 1 during a second operational condition; and

[0013] FIG. 4 illustrates an alignment component of the hydraulic device of FIG. 1.

DETAILED DESCRIPTION

[0014] FIG. 1 illustrates an exemplary hydraulic device 10. In one embodiment, hydraulic device 10 may be a pump that is mechanically driven to produce a flow of pressurized fluid. In an alternate embodiment, hydraulic device 10 may be a fluid motor that receives a flow of pressurized fluid and responsively produces a mechanical output. In either embodiment, hydraulic device 10 may include an assembly of multiple components including a housing 12, a shaft 14 supported within housing 12, a rotor 16, a barrel plate component 40, and an alignment component 20.

[0015] Housing 12 may include a central bore 22 having a first end 24 and a second end 26. Shaft 14 may extend through, for example, second end 26 and be substantially axially aligned with central bore 22. Bearings 28 may engage interior walls of central bore 22 to support the rotation of the shaft 14 therein. Shaft 14 may be sealed to the housing 12 at first end 24. Shaft 14 may further include an opposing end protruding from housing 12. A motor may be coupled to the protruding end of shaft 14 if, for example, hydraulic device 10 is a
hydraulic pump. Alternatively, a driving component may be coupled to the protruding end of shaft 14 if, for example, hydraulic device 10 is a motor.

Rotor 16 of hydraulic device 10 may embody a plate-like member fixedly connected to shaft 14 such that a rotation of shaft 14 results in a direct rotation of rotor 16. Rotor 16 may be integral to shaft 14 or, alternatively, joined to shaft 14 through welding, sintering, or other known metal joining processes. Rotor 16 may include a first face 30 and a second opposing face 32 oriented substantially orthogonal to the axial direction of shaft 14.

A plurality of piston members 34 may be fixedly connected to the outer radial portion of first face 30 and second face 32 of rotor 16 in a circular pattern. Each piston member 34 may be received in a respective piston sleeve 36. Specifically, each piston sleeve 36 may be coupled in a sealing manner around a spherical seal (not shown) of piston member 34.

The plurality of piston sleeves 36 may be connected to barrel plate components 40 disposed in, for example, first end 24 and second end 26 of central bore 22. Barrel plate components 40 disposed in first end 24 and second end 26 of central bore 22 may be coupled to rotate with shaft 14. Specifically, barrel plate components 40 may be fitted around shaft 14 by a ball hinge and coupled to the shaft 14 by, for example, a key connection. The ball hinge allows the barrel plate components 40 to wobble or tilt during rotation of shaft 14 as barrel plate components 40 ride against an axial cam formed by face plates 42 disposed at first end 24 and second end 26. As shaft 14, rotor 16, and barrel plate components 40 rotate, each piston sleeve 36 may move toward and away from a respective piston member 34 as barrel plate components 40 wobble or tilt. This reciprocation of piston sleeves 36 with respect to the piston members 34 causes an expansion and contraction of a pumping chamber located in piston sleeves 36. As the volume of the pumping chamber changes, fluid may either flow into or out of the pumping chamber by way of various ports 45 in face plates 42 and into a plurality of distribution passages 44 located within housing 12.

As noted above, barrel plate component 40 may be inclined to an angle β defined by the geometry of face plates 42. In particular, face plates 42 may be fixed during manufacturing at a particular tilt angle β relative to the axis of shaft 14. Because of the assembly relationship between face plates 42 and barrel plate components 40, the tilt angle β may correspond to the volume change within piston sleeves 36 during a revolution of shaft 14. It is to be understood that face plates 42 could be omitted and the axial cam and ports 45 may be designed directly in housing 12 of hydraulic device 10.

In an alternative embodiment, hydraulic device 10 may include a variable displacement actuator (not shown) to adjust the tilt angle β of face plates 42. Specifically, the variable displacement actuator may include one or more control pistons that press against a portion of face plates 42 to urge face plates 42 to tilt relative to the axial direction of shaft 14. The control pistons associated with face plate 42 at first end 24 may be independently controlled of the control pistons at the opposing second end 26 such that tilt angle β associated with first end 24 may be varied simultaneously to and independent of tilt angle β associated with second end 26.

Referring to FIG. 2, sleeve bottom 50 of piston sleeve 36 may be supported by barrel plate component 40. Sleeve bottom 50 of piston sleeve 36 may additionally have an opening 52 configured to fit around a positioning sleeve 54 of barrel plate component 40. Opening 52 may be larger than positioning sleeve 54, enabling piston sleeve 36 to move relative to barrel plate component 40 during rotation of shaft 14. Additionally or alternatively, sleeve bottom 50 may have a supporting surface 56 that may seal against a sealing surface on barrel plate component 40 under the influence of fluid pressure in pumping chamber 38.

Alignement component 20 may be located to face a piston receiving end 60 of piston sleeve 36. More particularly, alignment component 20 may be spaced in a non-contact relationship with piston receiving end 60 of piston sleeve 36 when a piston sleeve axis 66 is generally parallel to a barrel plate component axis 64. As indicated by axial gap 62, alignment component 20 may be positioned at least 0.0002 inches (0.00508 mm) from piston receiving end 60, and for example between 0.0002 inches (0.00508 mm) to 0.01 inches (0.254 mm) from piston receiving end 60.

The axial gap 62 will vary when piston sleeve axis 66 forms an angle relative to barrel plate component axis 64 during, for example, rotation of shaft 14. More particularly, as piston receiving end 60 of piston sleeve 36 approaches alignment component 20, the angle between the piston sleeve axis 66 and barrel plate component axis 64 may increase and the size of gap 62 may decrease. A maximum angle may be defined as the angle between piston sleeve axis 66 and barrel plate component axis 64 when piston receiving end 60 of piston sleeve 36 contacts alignment component 20. Alignment component 20 may be configured to prevent piston sleeve 36 from tilting beyond alignment component 20. With this configuration alignment component 20 may selectively contact piston sleeve 36 without urging piston sleeve 36 into barrel plate component 40. In this manner, frictional losses at the piston sleeve-barrel plate component interface may be avoided. FIG. 3 shows piston sleeve 36 tilting to the maximum angle and contacting alignment component 20.

As shown in FIG. 4, alignment component 20 may embody a plate-like member substantially parallel to barrel plate component 40. Alignment component 20 may embody, for example, a disc having a plurality of arms 72 extending from the outer perimeter of the disc. Arms 72 may form a plurality of semi-circles in the outer perimeter of alignment component 20. The semi-circles may have a radius greater than the radius sized to partially receive piston members 34. Arms 72 of alignment component 20 may be parallel to barrel plate component 40 and may partially or completely extend over piston receiving end 60 of piston sleeve 36. As noted above, alignment component 20 may be configured to contact piston receiving end 60 of piston sleeve 36 when sleeve sleeve 36 is tilted. The contacting surface area of alignment component 20 may depend on, for example, the orientation of piston sleeve 36 when piston sleeve 36 is tilted. Alignment component 20 may form a rigid stop for the tilted piston sleeves 36 without applying a force onto piston sleeve 36 to urge piston sleeve 36 into barrel plate component 40. It is contemplated that alignment component 20 may have any other shape known by one skilled in the art that may be used to maintain alignment of piston sleeves 36.

Referring back to FIG. 2, alignment component 20 may be coupled to barrel plate component 40. For example, an inner opening of alignment component 20 may form an interference fit with barrel plate component 40. It is contemplated that alignment component 20 may be alternatively welded onto barrel plate component 40, formed as one-piece with barrel plate component 40, or keyed to barrel plate component 40.
component 40 to prevent relative rotation of alignment component 20 and barrel plate component 40. In yet another embodiment, alignment component 20 may be fastened to barrel plate component 40 using a threaded nut. In an alternative arrangement, alignment component 20 may be coupled to shaft 14 using any of the means described above and/or any other conventional fastening arrangement known to one skilled in the art.

[0026] In one embodiment, alignment component 20 may abut a radially extending shoulder 69 of barrel plate component 40. More particularly, alignment component 20 may frictionally engage barrel plate component 40 and rest on shoulder 69 of barrel plate component 40. Shoulder 69 of barrel plate component 40 may prevent alignment component 20 from moving toward piston receiving end 60 of piston sleeve 36 during operation of hydraulic device 10. It will be understood by one skilled in the art that the height of shoulder 69 may determine the position of alignment component 20 relative to piston sleeve 36.

[0027] A retaining mechanism 68 may be attached to alignment component 20 opposing shoulder 69. Retaining mechanism 68 may be configured to constrain axial movement of alignment component 20. More particularly, retaining mechanism 68 may prevent alignment component 20 from moving in a direction away from piston receiving end 60 of piston sleeve 36. Retaining mechanism 68 may be, for example, a snap ring held in a groove 79 located in barrel plate component 40. It is contemplated that multiple retaining mechanisms may, alternatively, be used to constrain alignment component 20.

INDUSTRIAL APPLICABILITY

[0028] The present disclosure may find application in a hydraulic device such as, for example, a floating-cup device. Floating-cup device may be a doubled-sided (FIG. 1) or single-sided pump, motor, or transformer having a plurality of piston sleeves that interact with a plurality of cup-like piston sleeves hydrostatically supported by a barrel plate component. Operation of the disclosed hydraulic device is explained below.

[0029] Referring to FIG. 1, as shaft 14 is rotated, rotor 16 and barrel plate component 40 may rotate therewith. Each piston member 34 extending from first face 30 and second face 32 of rotor 16 may engage a respective piston sleeve 36 supported by a respective barrel plate component 40, and alter the volume of pumping chamber 38 within each piston sleeve 36. Alignment component 20 may selectively contact piston sleeve 36 to maintain alignment of piston sleeve 36 during rotation of shaft 14.

[0030] More particularly, when shaft 14 is rotated, sealing surface 56 of piston sleeve 36 may press against barrel plate component 40 in a manner such that piston sleeve axis 66 may be substantially parallel to barrel plate component axis 64. During such instances, alignment component 20 may form a non-contact relationship with piston receiving end 60 of piston sleeve 36.

[0031] During rotation of shaft 14 or, alternatively, when pressurized fluid in chamber 38 is low, piston sleeve 36 may tilt relative to barrel plate component 40. Specifically, piston sleeve axis 66 may form an angle relative to barrel plate component axis 64. In such instances, axial gap 62 between alignment component 20 and piston receiving end 60 of piston sleeve 36 may change. Gap 62 may vary as a function of the alignment of piston sleeve 36. When piston sleeve 36 tilts beyond a predetermined angle, i.e., maximum angle between piston sleeve axis 66 and barrel plate component axis 64, alignment component 20 is contacted by piston receiving end 60 of piston sleeve 36. The contact can take place at any point on the alignment component 20 depending on the orientation of tilt of piston sleeve 36.

[0032] Gap 62 between alignment component 20 and piston receiving end 60 of piston sleeve 36 may allow for minor tilting of piston sleeve 36. Alignment component 20, however, may prevent piston sleeve 36 from tilting beyond a predetermined angle and, in this manner, may prevent fluid leakage at the interface between piston sleeve 36 and barrel plate component 40. Thus, piston sleeve 36 may selectively contact alignment component 20 with such selective contact minimizing frictional losses at the piston sleeve 36-barrel plate component 40 interface. This may improve the overall efficiency of hydraulic device 10.

[0033] Application of the disclosed alignment component 20 may also provide for a simple assembly of hydraulic device 10 by, for example, removing the necessity for a plurality of fasteners and springs. Furthermore, the disclosed device may reducing manufacturing costs of the associated components. For example, barrel plate component 40 of the present device may be formed by lathe turning and lapping operations, and alignment component 20 may be formed by stamping and finished by grinding/lapping.

[0034] It will be apparent to those skilled in the art that various modifications and variations can be made in the hydraulic device 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 hydraulic device 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 hydraulic device, comprising:
   a rotor;
   a plurality of piston members extending from the rotor;
   a plurality of piston sleeves receiving the plurality of piston members, each piston sleeve having a piston receiving end and a piston sleeve axis;
   a plate component supporting the plurality of piston sleeves, the plate component having a plate component axis; and
   an alignment component having a plurality of arms spaced in a non-contact relationship with the piston receiving end of a respective piston sleeve when the plate component axis is parallel with the piston sleeve axis of the respective piston sleeve.

2. The hydraulic device of claim 1, wherein the plurality of arms form a variable gap with the piston receiving end of the respective piston sleeve, the gap varying as a function of a tilt of the piston sleeve axis relative to the plate component axis.

3. The hydraulic device of claim 1, wherein the plurality of arms form a rigid stop for the piston receiving end of the respective piston sleeve.

4. The hydraulic device of claim 1, wherein the plurality of arms form a plurality of openings that receive the piston members.

5. The hydraulic device of claim 3, wherein the plurality of arms partially extend over the respective piston sleeve.
6. The hydraulic device of claim 1, wherein the alignment component contacts a radially extending shoulder of the plate component.

7. The hydraulic device of claim 6, wherein an inner circumference of the alignment component forms an interference fit with the radially extending shoulder of the plate component.

8. The hydraulic device of claim 7, further including a mechanism configured to retain the alignment component.

9. The hydraulic device of claim 1, wherein the hydraulic device is a floating-cup device.

10. A method of assembling a hydraulic device, comprising:
    positioning a plurality of piston sleeves on a plate component;
    positioning an alignment component at a fixed distance from a piston receiving end of a respective piston sleeve; and
    engaging the alignment component with the plate component solely at the inner circumference of the alignment component.

11. The method of claim 9, further including receiving a plurality of piston members in a plurality of openings disposed within the alignment component to maintain the position of the plurality of piston members within the plurality of piston sleeves.

12. The method of claim 11, wherein engaging the alignment component with the plate component includes frictionally engaging an inner circumference of the alignment component with a groove disposed within a wall of the plate component.

13. The method of claim 12, wherein engaging the alignment component with the plate component further includes retaining the alignment component with a snap ring.

14. The method of claim 10, wherein engaging the alignment component with the plate component includes keying the alignment component to the plate component so that the alignment component rotates with the plate component during operation of the hydraulic device.

15. A floating-cup device, comprising:
    a housing;
    a shaft rotatably disposed within the housing;
    a rotor fixedly connected to the shaft;
    a plurality of piston members extending from the rotor;
    a plurality of piston sleeves receiving the plurality of piston members, each piston sleeve having a piston receiving end;
    a plate component supporting the plurality of piston sleeves; and
    an alignment component configured to abut against the plate component and provide a variable gap with the piston receiving end of the respective piston sleeve, the gap varying as a function of the alignment of the respective piston sleeve to the plate component.

16. The floating-cup device of claim 15, wherein the alignment component partially extends over the respective piston sleeve.

17. The floating-cup device of claim 15, wherein the alignment component includes a plurality of openings in a circumference of the alignment component for receiving the plurality of piston members.

18. The floating-cup device of claim 15, further including a retaining mechanism configured to constrain axial movement of the alignment component.

19. The floating-cup device of claim 15, wherein the alignment component is positioned between 0.0002 inches to 0.01 inches from the piston receiving end of the respective piston sleeve when the respective piston sleeve is in alignment with the plate component.

20. The floating-cup device of claim 19, wherein the alignment component is positioned to form a rigid stop for the piston sleeve when an axis of the respective piston sleeve tilts to a predetermined angle relative to an axis of the plate component.