

June 9, 1964

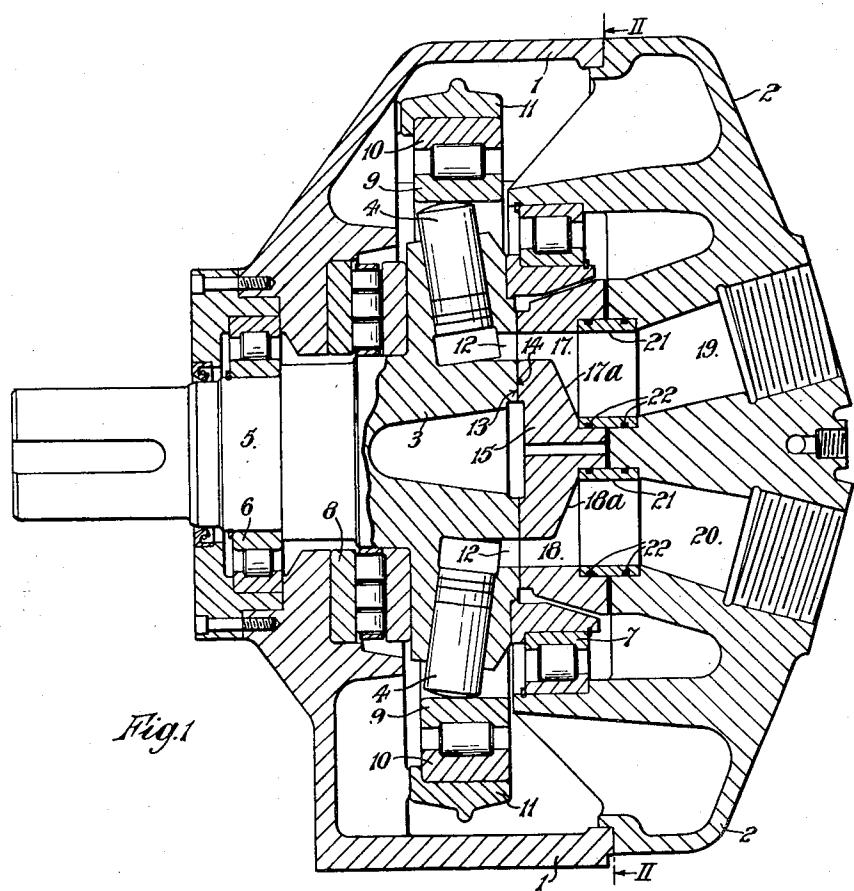
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HYDRAULIC PUMP OR MOTOR APPARATUS

Filed Nov. 2, 1961

2 Sheets-Sheet 1



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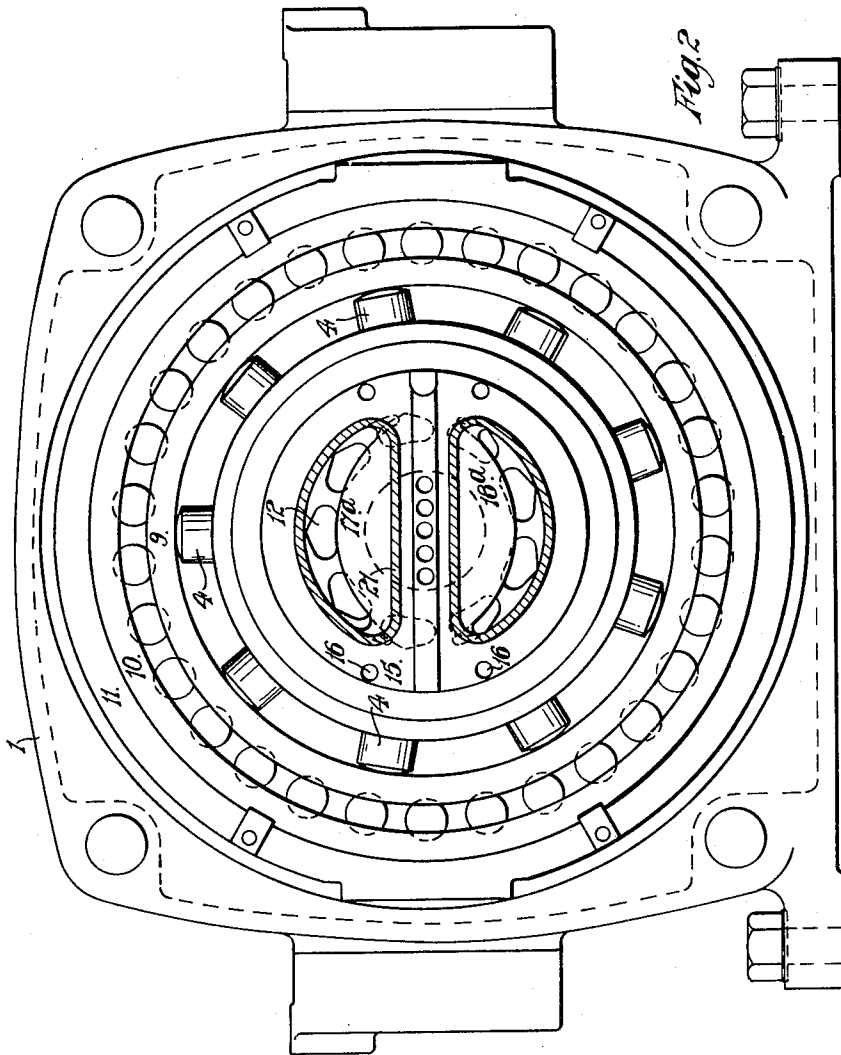
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## HYDRAULIC PUMP OR MOTOR APPARATUS

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4 Claims. (Cl. 103—161)

This invention relates to hydraulic pump or motor apparatus of the kind in which substantially the same apparatus will pump if driven mechanically or act as a motor if supplied with liquid under pressure.

The invention is applied to such apparatus in which a rotary cylinder barrel, such as a multiple radial-cylinder barrel, has axially-directed liquid-transfer ports with which co-operates a non-rotary face valve which is thrust axially against a port face of the cylinder barrel.

The hydraulic liquid has access between the opposed faces of the cylinder barrel and valve, thus lubricating these faces for the cylinder barrel to rotate, but the liquid which passes between these faces escapes from the hydraulic circuit and shows a loss in the hydraulic efficiency of the apparatus. The clearance between the cylinder barrel and valve faces must therefore be kept as small as possible and the liquid in this small clearance is at high pressure, with a reducing gradient in the direction of escape, usually radially inward and outward. The liquid in the clearance consequently exerts an axial separating thrust which is not uniform across the clearance and this separating thrust must be opposed by axial balancing thrust on the valve sufficient to limit the clearance and applied so as not to distort the valve when high pressures are used, e.g. 2000 p.s.i. and upwards.

It has previously been proposed to effect the axial balancing thrust on the valve by hollow pistons and hollow piston rods, thrusting mechanically on the valve, the pistons and rods forming part of the hydraulic circuit through which liquid is led to and from the valve and the liquid acting on the hollow pistons to produce the required axial balancing thrust.

An object of the present invention is to provide an improved way of utilising the pressure of the hydraulic liquid to achieve the required axial balanced thrust on the valve.

For the above purpose, in hydraulic pump or motor apparatus having a rotary cylinder barrel with an axially-directed face through which liquid-transfer ports open against an opposed face of a non-rotating face valve thrust axially against the barrel face and having at least one passageway to lead liquid under pressure to or from the ports, there being a leakage path for the liquid under pressure between the opposed faces of the barrel and valve, according to the invention each passageway in the valve has a wall surface directed substantially axially away from the barrel face, the axial projected area of the passageway wall surface is such that the resultant effect of liquid under pressure in the passageway has an axial component thrusting the valve against the barrel face and the shape and location of the axially-directed wall surface in each passageway are such that the consequent axial thrust on the valve is symmetrically distributed with respect to the opposing axial thrust of liquid between the opposed faces of the barrel and valve.

In a preferred embodiment, in a reversible pump or motor apparatus, the valve has two similar passageways, both capable of serving for either direction of liquid flow, and the two passageways are arranged symmetrically on opposite sides of the rotary axis.

An effective shape for the axially-directed wall surface of each passageway is an arcuate shape, such as a kidney,

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sickle or circular segment, subtending at the rotary axis an angle as near as possible to 180°. The subtended angle in a valve with two passageways is limited to less than 180° by the need to keep the two passageways separate and leave enough material between their ends for the valve to have a strong structure.

The valve must be connected for liquid flow through the pump casing, or equivalent fixed part, at the opposite side from the cylinder barrel and each valve passageway therefore has a corresponding casing passageway to which it is connected by a joint which is liquid-tight but permits the small axial movement of the valve necessary to permit the valve to be thrust against the cylinder barrel. The valve is also held against rotation, such as by axial dowels between the valve and casing allowing small axial movement of the valve.

Each joint between the valve and casing passageways can be sealed by a liner or internal sleeve, telescoping into enlargements of the two opposed passageway ends so that the bore of the liner conforms locally to the bore of the passageways.

In the preferred form of the invention, each valve passageway, at the end remote from the valve face, has a mouth which is of arcuate shape, is opposed to a casing passageway end of the same shape and is joined thereto by a tubular liner of corresponding arcuate cross-sectional shape.

An arcuate tubular liner, such as of kidney shape, can be made from a circular tubular blank of resiliently deformable material, such as nylon, which is thermo-plastic at a temperature higher than the maximum working temperature which the liner is intended to encounter, the blank being placed in the working position of the liner, or in a former providing the same shape as is required in the working position, and being moulded to shape under internal fluid pressure at a temperature at which it is thermo-plastic. The liner blank may be initially formed with circumferential grooves for the eventual reception of O-rings, to seal the liner when finally placed in working position.

One example of hydraulic apparatus according to the invention is shown on the accompanying drawings, in which:

FIG. 1 is an axial section through a pump and FIG. 2 is a cross-section on the line II—II of FIG. 1, some parts being omitted to facilitate illustration.

The pump as shown by the drawings operates on a well-known principle as regards its pumping action but includes new features of construction included within the present invention.

The pump has a casing, made in two main parts 1 and 2, in which a multiple, inclined radial, cylinder barrel 3, with pistons 4, is mounted on a shaft 5 by radial bearings 6 and 7 and an axial thrust bearing 8.

The pistons 4 bear, by their outer spherically-shaped heads, against the inner cylindrical surface of the inner race 9 of a large diameter roller bearing, surrounding the cylinder barrel 3, and of which the outer race 10 is held against rotation by a frame 11 in the casing part 1. The bearing race 10 either has a constant eccentricity to the cylinder barrel axis or the frame 11 is mounted for such eccentricity to be variable. When the cylinder barrel 3 is rotated, by a drive applied to the shaft 5, the pistons 4 tend to move outward in their cylinders, under centrifugal force, and to the extent to which the surrounding roller bearing 9, 10 is eccentric, the pistons are successively thrust inwards as they sweep the closer arc of the race 9. As the pistons move outwards, sweeping the further arc of the race 9, they each make a suction stroke in their respective cylinders, drawing liquid through a port 12 in each respective cylinder, and as they are thrust

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inwards they each discharge liquid through the same port 12. The bearing 9, 10 thus provides, in a simple and robust construction, a reaction ring as known in apparatus of this kind.

The ports 12 emerge at a transverse face 13 of the cylinder barrel 3 in axial opposition, with a small working clearance, to the transverse face 14 of a valve 15 held against rotation, with a small freedom for axial movement, by dowels in holes 16 in the valve 15 (see FIG. 2) and opposed holes in the casing part 2. The valve 15 has two passageways 17 and 18, one for suction and the other for delivery of liquid according to the direction of eccentricity of the reaction ring (the bearing 9, 10), and the casing part 2 has two corresponding passageways 19 and 20. The two pairs of passageways 17, 19 and 18, 20 are each joined by a liner 21, sealed by O-rings 22, and the opposed mouths of the passageways and the liners all have the same arcuate cross-sectional shape as can be seen in FIG. 2. The liners 21 are of nylon and are made as described above.

Within each valve passageway 17 and 18 an inclined transverse part 17<sup>a</sup> or 18<sup>a</sup> of the wall surface is directed substantially axially away from the cylinder barrel face 13 and the area of each such surface part is calculated so that the effect of the pressure of liquid in the respective passageway has an axial component sufficient to balance the separating effect of the pressure of liquid between the faces 13 and 14.

The shape and location of each passageway wall surface part 17<sup>a</sup> and 18<sup>a</sup> also is calculated such that the liquid pressure thereon is distributed appropriately with regard to the distribution of pressure between the faces 13 and 14 and the valve 15 is not subjected to undue asymmetrically opposed pressure forces which would cause distortion of the valve or spoil the uniformity of clearance between the faces 13 and 14.

In designing a valve for any particular apparatus, it is necessary to determine the area required for the valve ports and the area available for the sealing face of the valve against the cylinder barrel. The value, as a function of the working pressure, and the line of action of the axial force tending to separate the opposed valve and cylinder barrel faces can then be calculated on the basis of the pressure distribution across these faces due to the liquid leaking between and lubricating them.

To oppose the axial separating force, it is necessary to apply to the valve a coaxial balancing force of slightly greater value and the area, shape and position of the valve passageway wall surfaces required for the fluid pressure to produce the balancing force can be calculated.

On the above basis it is possible to design a valve with axially-directed wall surfaces of arcuate shape on

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which the fluid pressure will produce a balancing force preventing more than the desired minimum separation of the valve and cylinder barrel faces without causing the valve to tilt or distort under the opposing forces to which it is subjected.

I claim:

1. In hydraulic apparatus operable as a pump or a motor and having a casing, a rotary cylinder barrel in said casing, and axially directed face of said barrel having liquid-transfer ports, a non-rotating face valve opposed axially against said barrel face, said casing and said valve each having therethrough two passageways arranged symmetrically on opposite sides of the rotary axis of said barrel and in operative communication with said ports, the improvement comprising mutually opposed ends of said passageways in said casing and said valve being of the same arcuate cross-sectional shape subtending an angle of nearly 180° to said axis and said passageways in said valve each having a wall surface directed substantially axially away from said barrel face and being of arcuate shape subtending an angle of nearly 180° to said axis.

2. In hydraulic apparatus as claimed by claim 1, a liner in each two mutually opposed ends of said passageways in telescopic interconnection therewith and of the same cross-sectional shape as said ends of said passageways.

3. In hydraulic apparatus as claimed by claim 2, said liner and said mutually opposed ends of said passageways being of circular segmental cross-sectional shape centered on said rotary axis.

4. In hydraulic apparatus as claimed by claim 1, said mutually opposed ends of said passageways being of circular segmental cross-sectional shape centered on said rotary axis.

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