Sept. 27, 1966 F. BERRY 3,274,943

ROTARY POWER DEVICE

Filed Dec. 11, 1964 3 Sheets-Sheet 1

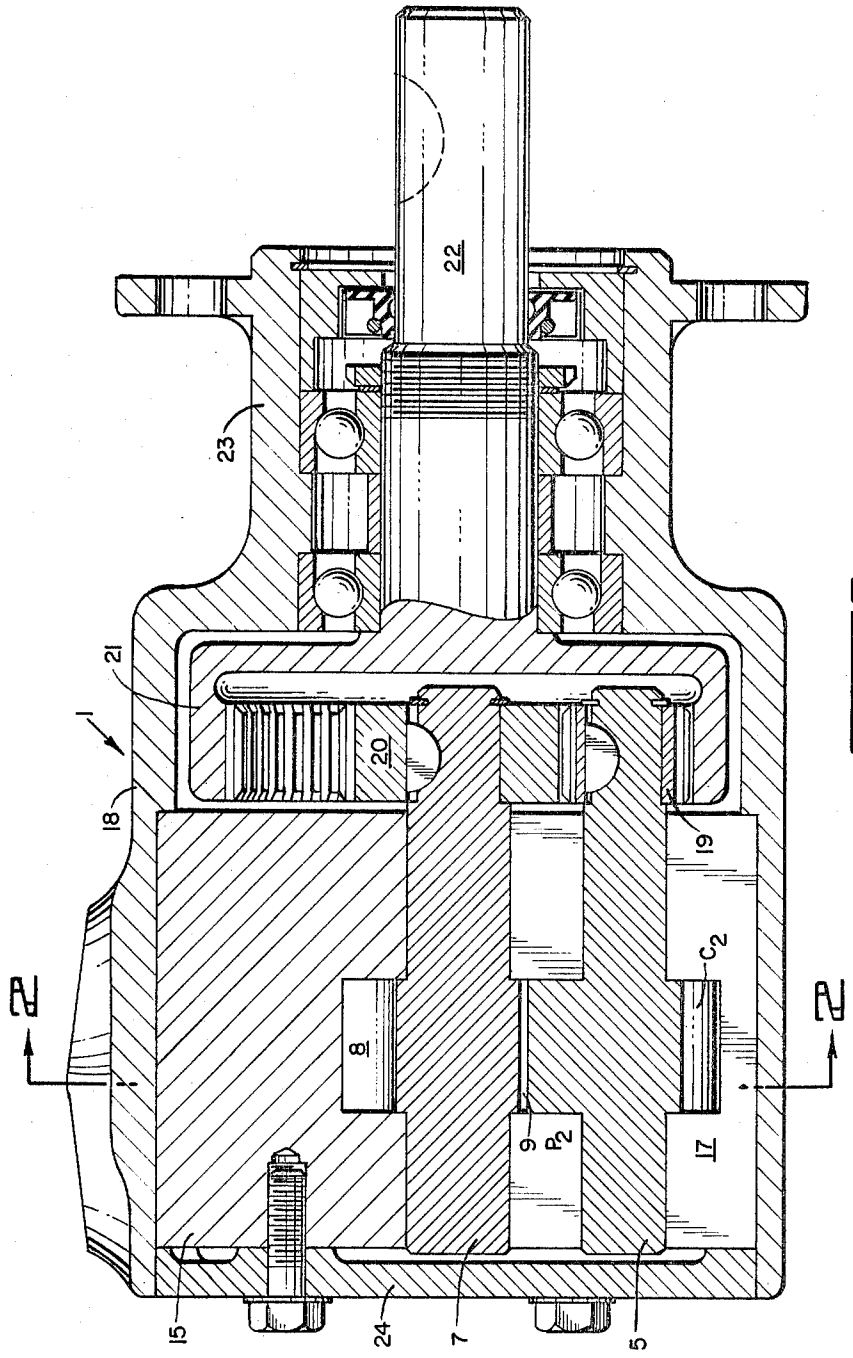


FIG. 1

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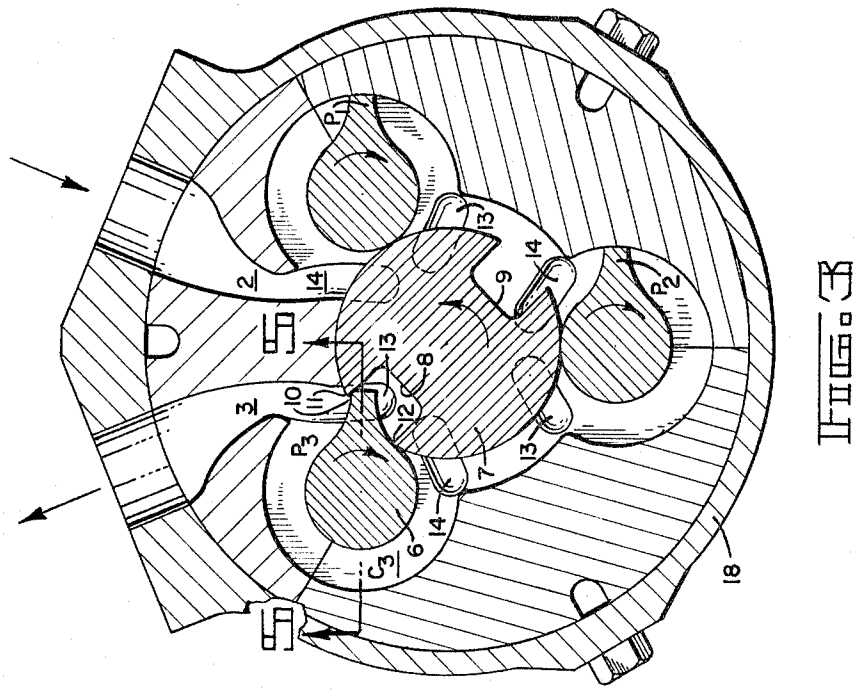


FIG. 3

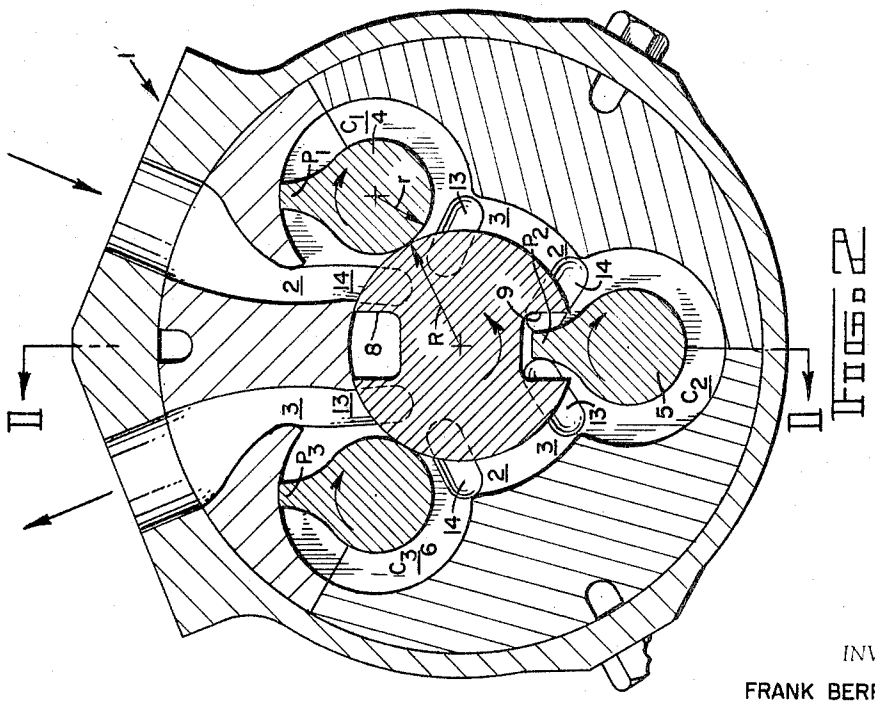


FIG. 2

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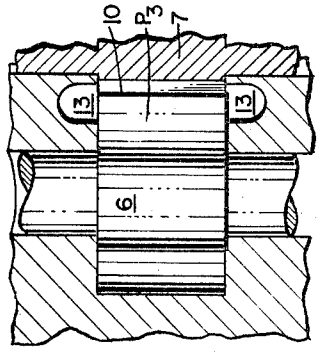


FIG. 5

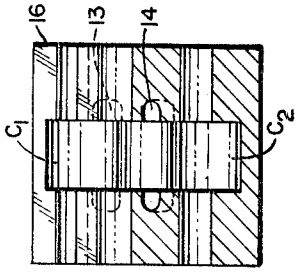


FIG. 6

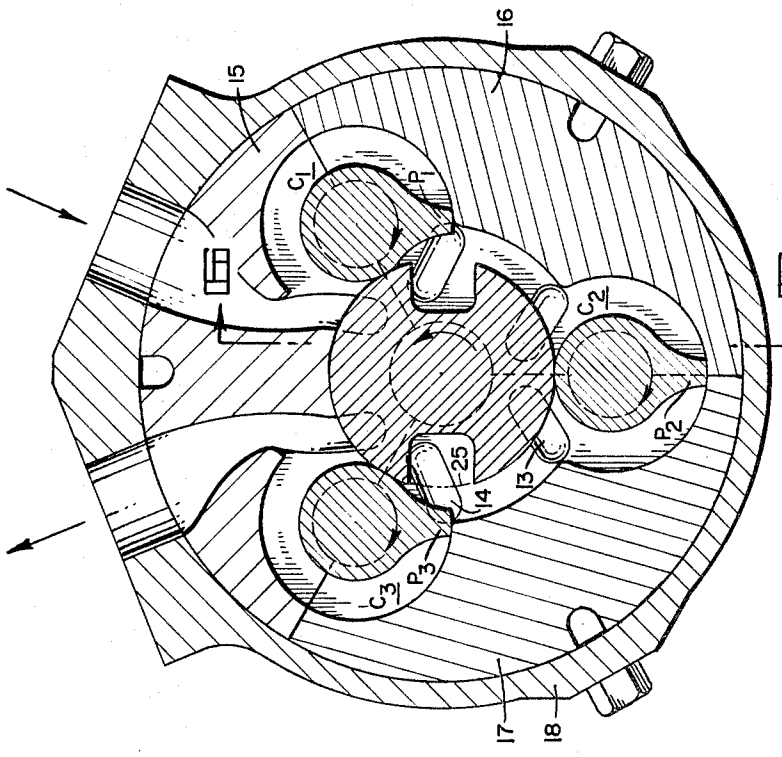


FIG. 4

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ROTARY POWER DEVICE

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6 Claims. (Cl. 103—125)

The invention relates to rotary power units and is primarily applicable to hydraulic pumps, motors and transmissions.

The capacity of rotary hydraulic power units of the rotary abutment type, considered in relation to the size and weight of the unit, has been circumscribed by various recognized design limitations. Taking the rotary hydraulic pump for illustration, it is axiomatic that if one could increase the size of the piston within a given overall size of unit, the volume of liquid pumped per revolution of the piston would be increased, thereby producing a more favorable capacity-size ratio. It the piston size is to be increased without increasing the size of the unit, such increase must be sought in the direction of increasing the radial height thereof, since to increase the width in the axial direction would proportionately increase the size of the unit. Immediately an attempt is made to increase radial height of the piston, other limiting factors are encountered such as the minimum size of piston rotor shaft and minimum size of rotary abutment to meet given load specifications.

Another problem which has plagued designers of rotary hydraulic pumps and motors of the rotary abutment type is that in attempting to increase the height of the piston it becomes necessary to increase the size of the valving recess in the rotary abutment through which the piston must pass. Here we run into another limiting factor, for the size of the valving recess in the abutment cannot be so large as to span the seal between the inlet and outlet of the pump or motor. Again, if the abutment recess is made to fit the piston too closely, the result will be to create a partial liquid lock between the piston and abutment, with a resultant intolerable level of pulsation. This problem has been solved as well as it could be until now by keeping enough clearance between the piston and the valving recess of the abutment to permit liquid flow around the tip of the piston and thus gain freedom from pulsation. I say "as well as it could be," because in providing free liquid flow around the tip of the piston it has been necessary to sacrifice piston height. Thus prior to my present invention a favorable capacity-weight ratio has had to be sacrified for freedom from pulsation, or vice versa.

Speaking of rotary abutment type units generally, it should be helpful at this point to observe that various constructions are possible in terms of the relationship between the pistons and the valving abutment. A single rotary piston may be used with a rotary abutment having a single valving recess, or there may be two or more rotary pistons disposed around a single rotary abutment and valving through one, two or more recesses in such abutment. In the most widely used hydraulic pump and motor there are two co-planar rotary pistons valving through a single abutment having a single valving recess. If it is desired to use three-coplanar rotary pistons valving through two abutment recesses of a single rotary abutment, the problems discussed hereinabove are in at least one respect increased for the reason that the pumping inlet and outlet of the unit must be crowded together between two of the three rotary pistons in such a way as to decrease the effective seal between the rotary abutment and the casing. This in turn decreases the size of the valving recess which can be used without breaking the seal between the inlet and outlet. This is unfortunate, because with such a combination of three piston rotors valving through two recesses of a common abutment, it would be possible to obtain a unit in which two pistons are at work while the third is valving, one of the two working pistons serving to back up the other and minimize leakage. My invention has especial reference to obtaining increased capacity in such a co-planar three-piston arrangement without breaking the seal between the inlet and outlet and with a low level of pulsation. What I have discovered is how to use a piston of increased height and obtain a more favorable capacity-weight ratio without running into the pulsation problem. My solution is to have the abutment recesses mesh closely with the pistons so that the tips of the pistons substantially close with the edges of the abutment recesses as the pistons pass through them, and to provide ducts leading from one or both ends of the abutment at points which are in communication with the abutment recesses when the pistons are valving, such ducts extending into communication with the inlets and outlets of the cylinders to accommodate flow of liquid prevented from flowing around the tips of the pistons.

With reference to the accompanying drawings, I shall now describe the best mode contemplated by me for carrying out my invention.

FIG. 1 is a vertical longitudinal cross-sectional view of a hydraulic pump or motor embodying my invention.

FIG. 2 is a vertical transverse sectional view taken as indicated at 2—2 in FIG. 1.

FIG. 3 is a transverse sectional view similar to FIG. 2, pistons advanced 90 degrees from the FIG. 2 position.

FIG. 4 is a similar view, pistons advanced 90 degrees from the FIG. 3 position.

FIG. 5 is a detail sectional view taken as indicated at 5—5 in FIG. 3.

FIG. 6 is a detail vertical sectional view of one of the segmental members in which the annular cylinders are formed, drawn to a reduced scale.

My invention comprises in its general arrangement, a rotary hydraulic power unit of the rotary abutment type including a casing 1 having three annular cylinders C_1, C_2, C_3, each having an inlet 2 and an outlet 3, and a rotor shaft carrying a piston rotor 4, 5 and 6, respectively, with a piston P_1, P_2, P_3, respectively, slidably arranged in the cylinder to traverse the cylinder in rotary movement. A rotary abutment 7 is arranged in the casing with its axis parallel to the rotor shafts, the annular cylinders C_1, C_2, C_3 being distributed around the abutment shaft and lying in a common plane. The abutment has a pair of recesses 8 and 9 to clear each of the three pistons as it passes the abutment, the pistons having a base radius r (FIG. 2) which is one-half the radius R of the abutment and the piston rotors rotating in 2:1 relation to the abutment. One of the characteristics of my construction is that the abutment recesses 8 and 9 mesh closely with the pistons P_1, P_2, P_3 so that the tips 10 of the pistons (FIG. 3) substantially close with the edges 11 of the abutment recesses as the pistons pass through the recesses. It will be observed as the piston P_3 begins to valve through recess 8, a volume of liquid is trapped within the recess between the conjunctive edges of the piston tip 10 and edge 11 of the recess and the edge 12 of the recess which is conjunctive with the piston rotor 6. The liquid is restrained from flowing around the tips of the pistons in sufficient quantity to alleviate the pulsation created by the close meshing of the piston and its valving recess. However, reference to FIG. 2 will reveal why the piston recess cannot be further enlarged since to do so would break the seal between the inlet 2 and outlet 3 of the unit. Instead of trying to solve the pulsation problem in the usual way through providing for liquid flow around the

tips of the pistons, I have conceived the idea of providing the ducts **13** and **14** leading from one or both ends of the abutment at points which are in communication with the abutment recesses when the pistons are clearing through them, such ducts extending into communication with at least one of the inlets and outlets of the cylinders to accommodate flow of liquid prevented from flowing around the tips of the pistons. Thus as piston P_3 begins to valve through recess **8** of abutment **7**, as shown in FIG. 3, the liquid which cannot flow around the tip of the piston can nevertheless flow through the duct **13** into the outlet **3**. Similarly as the piston P_3 advances farther from the position shown in FIG. 3, it will reach a point at which recess **8** of the abutment is placed in communication with duct **14** so that liquid can then flow from the recess through duct **14** into the cylinder C_3.

It should be observed that the ducts **13** and **14** are not in communication with one another. Because of this, the seal between the inlet and outlet of the cylinder is not broken.

I have found that with the construction described, the height of the pistons for a given size of unit can be increased without creating objectionable pulsation due to restriction of flow around the piston tips. The increased piston height so accommodated yields a higher volume of liquid flow per stroke of the pistons. As an example of the measure of improvement thus obtainable, a hydraulic pump constructed without the use of my invention and having an output of 0.7488 cubic inch per piston revolution, when redesigned in accordance with the disclosure of this application and without increase in the size of the unit will have an output of 1.13 cubic inches per piston revolution, an increase in capacity of approximately 51%.

In my preferred construction, the ducts **13** and **14** lead from both ends of the abutment. This arrangement of the ducts as applied to the ducts **13** is illustrated in FIG. 5. Also in my preferred construction, the three annular cylinders C_1, C_2, C_3 are formed by three segmental members **15**, **16** and **17** (FIGS. 4 and 6) each containing one-half of each of two cylinders. Thus the segmental member **16** shown in FIG. 6 contains one-half of cylinder C_1 and one-half of cylinder C_2. The three segmental members fit within an outer casing member **18** bearing tightly against the three members to relieve them from tensional stresses and to hold the portions of the cylinders together against the outward pressure of the fluid within the power unit. With this construction, it becomes possible to make the segmental members **15**, **16** and **17** of bearing aluminum, the outer casing **18** being made of steel or nodular iron.

The piston rotors **4**, **5** and **6** are suitably geared in 2:1 ratio to the abutment **7** as by means of pinions **19** (FIG. 1) keyed to the shafts of piston rotors **4**, **5** and **6** and gear **20** keyed to the shaft of abutment rotor **7**. In the particular construction shown, pinions **19** mesh with a ring gear **21** fixed to the end of drive shaft **22**, the drive shaft having a suitable bearing in the extended portion **23** of casing **18** as provided by the ball bearings illustrated, and suitable sealing means being provided where the shaft **22** projects through the end of the casing.

In assembling the unit, it will be understood from FIG. 1 that the several parts are inserted from the left hand end of the casing **18**. The segmental members **15**, **16**, **17** are fitted closely within the casing **18** and may, if desired, have a pressed fit therewith. The open end of the casing is then closed with a cover plate **24** having a suitable sealing engagement with the casing and being secured to the cylinder segments as by means of the bolts shown. Other fastenings between the periphery of the cylinder segments and casing **18** may be employed as desired, such being conventional details of construction forming no part of the present invention.

The device which I have shown and described may be used either as a motor or a pump, and is reversible. When used as a pump, shaft **22** is an input shaft and the exterior

arrows in FIGS. 2, 3 and 4 show the low pressure inlets and high pressure outlets. When used as a motor, the high pressure inlet becomes the source of power and **22** of the output shaft, all of which will be well understood by those familar with the design of hydraulic power units.

In addition to providing a more favorable capacity-size ratio, devices constructed in accordance with my invention have a smoother and more efficient pumping action by reason of the conjoint action of the three rotary pistons, two of which are pumping while the third is valving. Referring to FIG. 2, we see pistons P_1 and P_3 pumping while piston P_2 is valving. Piston P_1 backs up the action of piston P_3, reducing leakage between the tips of the pistons and their cylinders. In the position shown in FIG. 3, following 90 degrees of rotation of the three pistons in the clockwise direction shown by the arrows, pistons P_1 and P_2 are pumping while piston P_3 is valving. In the position shown in FIG. 4 piston P_2 is pumping, piston P_3 is entering its working stroke and piston P_1 finishing its working stroke. A comparison of FIGS. 2 and 3 will reveal the effectiveness of ducts **13** and **14** for various positions of the pistons as they pass through the abutment recesses. FIG. 3 illustrates such effectiveness at the beginning of the valving action and FIG. 2 at the mid-point of such action. It will be observed with reference to FIG. 4 that the ducts **13** and **14** extend from within the circle **25** of the abutment recesses to a point substantially outside of such circle, such being requisite in order to provide an operative volume of flow through the ducts.

The terms and expressions which I have employed are used in a descriptive and not a limiting sense, and I have no intention of excluding equivalents of the invention described and claimed.

I claim:

1. A rotary hydraulic power unit of the rotary abutment type comprising a casing having three annular cylinders each having an inlet and an outlet and a rotor shaft carrying a piston rotor with a piston slidably arranged in the cylinder to traverse the cylinder in rotary movement, a rotary abutment arranged in said casing with its axis parallel to the rotor shafts, said annular cylinders being distributed around said abutment shaft and lying in a common plane, said abutment having a pair of recesses to clear each of the three pistons as it passes the abutment, the pistons having a base radius which is one-half the radius of the abutment and the piston rotors rotating in 2:1 relation to the abutment,

(a) the abutment recesses meshing closely with the pistons so that the tips of the pistons substantially close with the edges of the abutment recesses as the pistons pass through the recesses, and

(b) ducts leading from at least one end of the abutment at points which are in communication with the abutment recesses when the pistons are clearing through the recesses, said ducts extending into communication with at least one of said inlets and outlets of the cylinders to accommodate flow of liquid prevented from flowing around around the tips of the pistons by the construction defined in (a) above,

by virtue of all of which the height of the pistons for a given size of unit can be increased without creating objectionable pulsation due to restriction of flow around the piston tips, the increased piston height so accommodated yielding a higher volume of liquid flow per stroke of the pistons.

2. A rotary hydraulic power unit as defined in claim **1**, in which the ducts defined in sub-paragraph (b) lead from both ends of the abutment.

3. A rotary hydraulic power unit as defined in claim **1**, in which the ducts defined in sub-paragraph (b) extend into communication with both the inlets and outlets of the cylinders.

4. A rotary hydraulic power unit as defined in claim **1**, in which said three annular cylinders are formed by three segmental members each containing one-half of each of

two cylinders, said three segmental members fitting within an outer casing member bearing tightly against the three segmental members to relieve them from tensional stresses.

5. A rotary fluid power unit of the rotary abutment type comprising an outer casing, three segmental members fitting within said outer casing, each of said segmental members having a portion of each of two annular cylinders formed therein so that, when the three segmental members are fitted together within said outer casing, three annular cylinders are provided each having an inlet and an outlet, and a rotor shaft carrying a piston rotor with a piston slidably arranged in the cylinder to traverse the cylinder in rotary movement, a rotary abutment arranged in said casing with its axis parallel to the rotor shafts, said annular cylinders being distributed around said abutment shaft and lying in a common plane, said abutment having a pair of recesses to clear each of the three pistons as it passes the abutment, said outer casing member bearing tightly against said three segmental members to hold the portions of the cylinders together against the outward pressure of the fluid within the power unit.

6. A rotary hydraulic power unit as defined in claim 1, in which said ducts defined in sub-paragraph (b) extend from within the circle of abutment recesses to a point substantially outside of said circle.

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