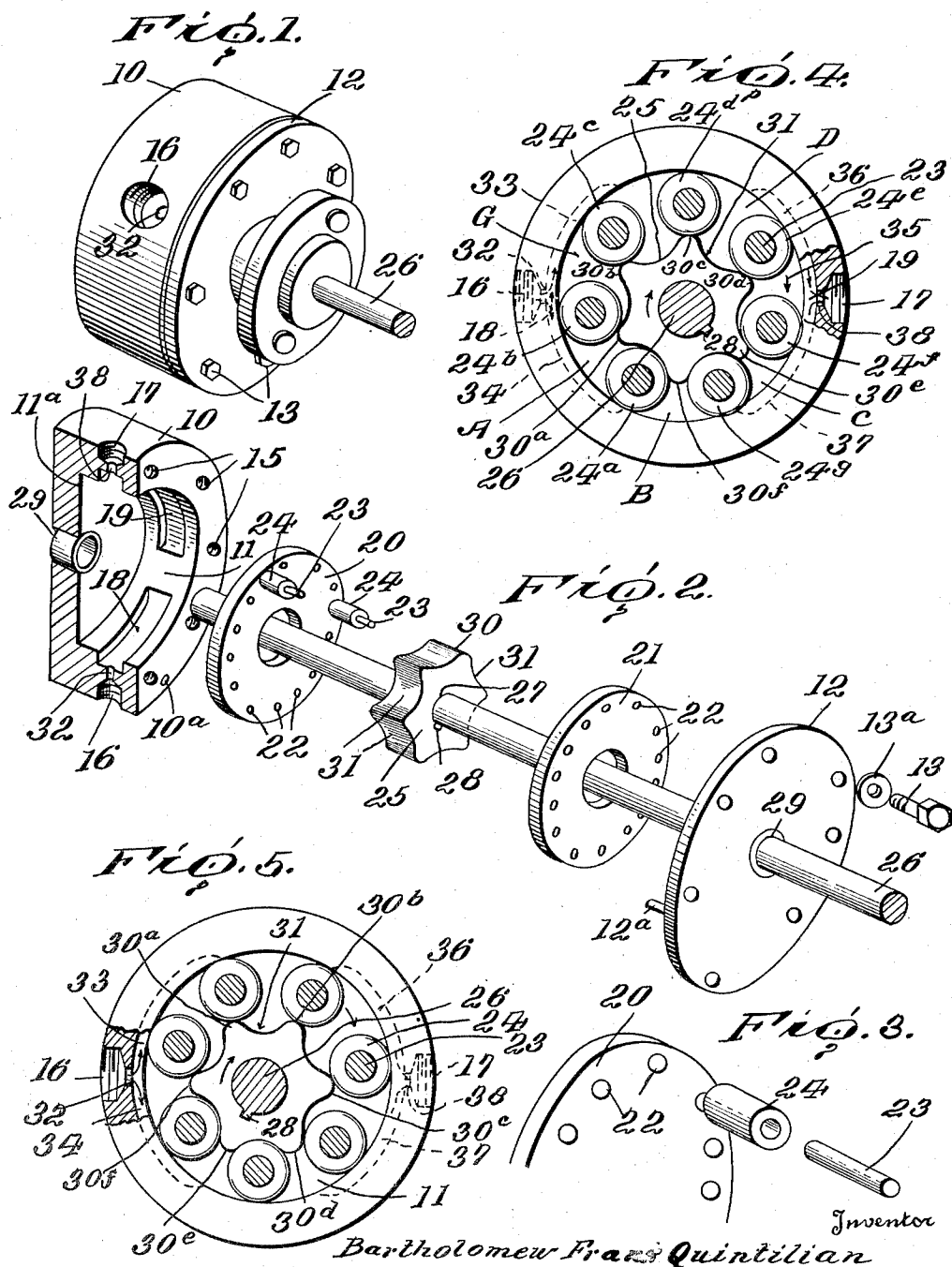


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HYDRAULIC PUMP OR MOTOR

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HYDRAULIC PUMP OR MOTOR

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My invention relates to rotary hydraulic pumps and motors in which rotatable elements provide a plurality of fluid compartments of continuously varying dimensions.

An object of my invention is to provide a rotary pump which is simple, small, compact, rugged, inexpensive and has long life and low wear even under conditions of continuous use; has both high volumetric and high mechanical efficiency, has smooth and uniform flow, requires minimum maintenance, supervision and repair, has only a minimum number of moving parts all of which are readily interchangeable, has low relative rotational speed between the component parts, and which requires no speed reducers.

Other objects will in part be obvious and in part pointed out hereinafter, in connection with the following description taken in the light of the appended claims.

Accordingly, my invention consists of the various parts, elements, combination of parts and features of construction, and in the relation of each of the same to one or more of the others as described herein and set forth in the following claims.

In the attached drawings, wherein is shown solely by way of illustration and not in any sense by way of limitation, a preferred embodiment of my invention.

Figure 1 discloses my new pump in perspective;

Figure 2 is an exploded perspective view of the pump, showing certain of the elements thereof in their relation to each other, the pump casing being in axial section, for clarity;

Figure 3 is a fragmentary exploded perspective view showing the manner in which the rollers are assembled in the corresponding end plates to form a cage-like outer rotor, while

Figures 4 and 5 are elevations showing the pump assembly in different phases of the same operating cycle, to facilitate ready understanding of the mode of operation.

To ensure thorough appreciation of the nature and extent of certain features of my invention consideration may be given briefly at this point to the development of hydraulic equipment of the general nature of that disclosed herein.

At an early date it was appreciated that rotary pumping could be achieved by rolling two generally cylindrical members such as gears against each other within a suitable casing. From a suitable intake reservoir, a fluid was supplied the two members on the forward side in the direction of rotation. The two rotating members dis-

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charged this fluid on the far side and brought about an increase in pressure in a fluid receiving reservoir, from which the fluid could be ejected through a discharge orifice, opening as when the interior pressure reached a pre-determined value. Such pump had many advantages, principal among which were long wear and simplicity.

From this relatively crude pump of comparatively low capacity—but which nevertheless received wide-spread acceptance in the industries—the art quickly developed to the point of providing a construction which had a plurality of separate compressor compartments defined between complementary parts of inner and outer pump rotors. These compartments operated separately as pumping compartments. By proper choice of the number and dimensions of the compartments the total capacity of the unit could be increased many times over that of the old compartment type of pump. This action was based fundamentally on the relative rotation occurring between the inner and outer rotors as a result of having teeth of the inner rotor one less in number than corresponding teeth and recesses of the outer rotor. A typical instance of this construction is shown for example in the United States patent to Hill, No. 2,011,338. The outer rotors in these earlier devices took the form of plates or discs, circular in outer periphery but annularly toothed, so as to form a plurality of inwardly projecting rounded teeth with intervening valley or concave portions.

With this outer rotor construction and with teeth of the inner rotor engaged about its periphery, then upon rotation of one of the rotors to drive the other, a constant but slow gain in revolutions occurred between the two rotors. The teeth of the inner rotor remained at all times in contact with the outer rotor and thus defined a plurality of compartments of continuously varying dimensions. With proper design, these compartments were sealed against the exterior so that when a fluid such as air or liquid was introduced through a suitable port into the compartments at a point where these latter had approximately their greatest dimensions, then in subsequent phases of any particular revolution of the driving rotor the several compartments decreased in dimensions to a minimum, thereby compressing the fluid contained therein. A suitable port was provided adjacent the region of minimum dimensions through which the compressed fluid was discharged.

Needless to say improved pumps of this type

have received widespread acceptance in the art. They are compact, simple and due to the small number of moving parts, display long wear and require but little maintenance, repair, and supervision. Properly designed, hydrostatic balance is experienced, so that to a certain extent at least a sort of floating action is occasioned between the moving parts of the construction.

Despite the manifest advantages of the construction just described, however, it will be noted that the contact between the cooperating parts of the inner and outer rotors is frictional and sliding in nature. Particularly when the fluid is being compressed as a gas, undue wear between the contacting parts is experienced, probably due to insufficient lubrication, so that readjustment and replacement of parts is required more frequently than is desired. Definite limitations are thus placed upon the range of utility of this type of pump. Expensive broaching and other constructional processes are required in producing the outer rotors.

An important object of my invention therefore is to provide a construction which in substantial measure eliminates the aforementioned disadvantages and defects, and which at the same time is characterized by the production of rolling, anti-friction contact between the moving parts, to the substantial exclusion of frictional or sliding contact, and by its extremely long life and low wear under substantially all conditions of usage and when handling substantially all types of fluids.

Referring now more particularly to a preferred embodiment of my invention, in Figures 1 and 2 there is shown a rotary pump having an outer body portion 10, illustratively cylindrical in form, and having an inner cylindrical recess or bore indicated generally at 11, terminating at its inner end in a machined wall 11a which for example is a plane surface perpendicular to the axis of the bore. A cover plate or head 12 in the form of a circular disc seals the open end of the bore 11 in any suitable manner as by bolts 13 which extend through washers 13a and holes 14 in the head 12 and seat in corresponding threaded apertures 15 in the adjacent end of the body member 10. Preferably holes 14 are shouldered to receive the washers 13a. Dowel pin 12a is provided on the inner face of head 12 and is received in a cooperating positioning opening 10a in the adjacent face of body 10, thus automatically assuring ready and proper positioning of the head 12 relative to the body 10 during the process of assembling the several parts. The body 10 and head 12 together comprise the casing of my new constructions.

Ports 16, 17, generally circular in cross-section, are disposed on diametrically opposite sides of body 10, and extend from the exterior through and into the bore 11. At the inner ends the ports 16, 17 terminate in corresponding manifolds 18, 19, relatively shallow but extending from the ports for a substantial distance in each direction away from the ports along the walls of the bore 11. In the embodiment undergoing description these manifolds extend approximately 60 degrees in each direction from the ports, each for a total extent of approximately 120 degrees of the circular extent of the bore. The utility of these manifolds will be developed hereinafter.

I provide an outer rotor (see also Figs. 4 and 5) which snugly fits within the casing defined by body 10 and head 12, and which includes a plurality of elongated rollers 24 that bridge the

manifolds 18 and 19 and roll on the bore surface 11. This outer rotor, in the form of a cage now to be described, is received in sealed relation against cooperating machined surfaces of the bore 11 and the head 12.

The cage, or outer rotor, comprises paired, like circular end-plates 20, 21, having diameter somewhat smaller than the smallest diameter of bore 11. End plate 20 is received snugly against the machined inner wall 11a of bore 11 while end plate 21 is received snugly against the machined inner wall of head 12. A plurality of preferably uniformly spaced openings 22 are provided in each end-plate 20, 21, disposed with their centers lying in a circle struck from the center of each end plate. The number of holes 22, and their position relative to adjacent holes, is the same in each end-plate. Preferably the end-plates are struck from the same die so that the positions of the holes in one end plate will be identical with those in the other. These holes 22 serve as journal bearings for studs 23, which extend between and are carried by the end-plates. Rollers 24 of substantial radius extend for rolling contact slightly beyond the outer edges of plates 20 and 21. The rollers are axially bored in whole or in part and are mounted for rotation on the studs 23 or are made with bore omitted so as to have integral axial studs at the ends thereof. These rollers preferably are formed of case-hardened metal, ground to size. They are comparatively simple and inexpensive to produce and inherently have extremely long life. Wear is reduced to a minimum.

The cage comprising the outer rotor is thus seen to consist of the end plates 20, 21 which are held separate along the length of the bore by the rollers 24 disposed on the studs 23. It has already been stated that the fit between the end plates 20, 21 and the corresponding walls of the body 10 and head 12 is as snug as can be achieved, consistent with the rotation of the cage relative to the casing. The purpose of this, as was explained, is to insure a seal between these parts. To contribute to this sealed relation, the rollers 23 are dimensioned so that they fit snugly against the inner surfaces of end plates 20, 21 and roll firmly on bore 11. Reliance is placed upon an oil film of microscopic thickness to lubricate the rollers and to permit them to rotate on their studs 20 without disturbing or breaking the inner rotor seal which will later be described.

An inner rotor, movable relative to the outer rotor, is disposed within the outer rotor cage. It is toothed in such manner that it has the general appearance of a fluted star wheel. This inner rotor is indicated generally at 25.

Both the end plates 20, 21 of the outer rotor and the inner rotor 25 are disposed on a drive shaft 26. End plates 20, 21 are disposed comparatively loosely thereon so that shaft 26 imparts no direct rotational impetus thereto. Inner rotor 25, however, is disposed on shaft 26 and is made fast thereto. Rotor 25 is fast thereto in any desired manner, as by a key and keyway 28 (Figs. 4 and 5).

The shaft 26 is carried in suitable anti-friction bearings 29 provided in body 10 and head 12, which bearings are mounted in a hole bored eccentric to bore 11. These bearings may be of any suitable type. In the present instance I employ ball-bearings. One such bearing is shown in Figure 2 in the head 12, but is omitted in the disclosure of the body 10, for simplicity and convenience.

While I have disclosed the rotors as being powered through shaft 20 to which inner rotor 25 is made fast, it is of course equally feasible to power the outer rotor through any suitable means as by a spider, and to permit the outer rotor to drive the inner rotor 25. In point of fact, I have found that perhaps smother action is obtained in this manner than when the inner rotor 25 is employed as the driving means.

The inner rotor 25 comprises a plurality of radially-disposed teeth 30 between which are formed recesses or valleys 31 of cycloidal or other suitable configuration. The teeth are preferably of uniform contour and spacing. In number, teeth 30 amount to one less than the number of rollers 24 in the outer rotor. Keeping in mind that, as shown, the rotor 26 is eccentrically disposed with respect to the outer rotor, it will be seen that at any given time one tooth 30 of the inner rotor is substantially fully enmeshed and engaged momentarily with two adjacent ones of the rollers 24 of the outer rotor while the remaining inner rotor teeth are in various stages of mesh or contact with the remaining outer rotor rolls. Upon rotation imparted to one or the other of the inner or outer rotors these rotors will be moved at high speed relative to the casing comprised by parts 10 and 12, and will undergo a slow change of phase relative to each other inasmuch as the outer rotor will rotate at slightly lower speed than does the inner rotor. In the embodiment shown wherein the outer rotor has seven rollers 24, while the inner rotor has six teeth 30, it will be seen that the outer rotor rotates at a speed which is $\frac{1}{7}$ that of the inner rotor.

Considered from another aspect, it will be understood that this outer rotor loses one revolution in the course of every seven revolutions of the inner rotor. That is, during the time that it takes for the inner rotor to accomplish seven revolutions, the outer rotor will pass through six revolutions. To illustrate, with the inner rotor as the driving rotor and operating at say 1200 revolutions per minute, it is clear by simple calculation that the outer rotor revolves at 1028.5 revolutions per minute. By subtraction, the outer and inner rotors, under such conditions, differ in number of rotations by but 171.5 revolutions per minute.

It is to be noted that the number and size of teeth 30 and rollers 24 determines in large measure the ultimate capacity of the pump. It is equally notable that proper choice of tooth contour has appreciable bearing on pump efficiency. As suggested in an earlier part of this discussion, these factors have all been the subject of careful study and investigation by earlier workers in the field. Their findings comprise the subject of earlier patents as well as articles in the general technical literature. Since such design does not per se comprise part of this invention, no effort will be devoted herein to a development of such constructional details. By the use of proper epicycloidal and hypocycloidal contours, or other suitable shapes, it is insured that tight, yet rolling and anti-frictional contact is maintained between the cusps 30 and bases 31 of the teeth of the inner rotor and the several rollers 24 of the outer rotor.

Figures 4 and 5, wherein are disclosed the momentary relation of the inner and outer rotors for different phases of the same cycle of rotation, tend to facilitate an understanding of the operation of my device. Fluid enters through

port 18, serving as the intake port. This fluid may be either gas, vapor or liquid or any mixture thereof. The fluid follows the small arrows in separating at the throat 32, to course along upper and lower parts 33, 34 of manifold 18. With the two rotors revolving at different speeds, there is a continuous opening and closing of spaces or compartments defined between the two rotors. The constant contact of the teeth of the inner rotor with the rollers of the outer rotor create a series of small spaces filled with fluid. During any small increment of time, some of these spaces are increasing in size. This creates a suction and draws fluid from the intake manifold into these spaces. Others of these spaces are decreasing in size causing pressure. These spaces discharge as they pass the exhaust manifold.

At the lowermost edge of manifold portion 34, some of the fluid enters compartment A defined at the moment by roller 24a, tooth 30f, tooth 30a, roller 24b and bore 11. The contact of teeth 30f and 30a with rollers 24a and 24b, respectively, is such that the volumetric dimensions of the compartment A are at a substantial minimum. An ensuing increase in volume up to maximum creates a suction drawing in fluid from manifold 18.

The fluid continues to enter compartment A during rotation of the two rotors upward through the arc adjacent manifold 18, until the compartment A is substantially filled. Meanwhile as compartment A sweeps rapidly in a clockwise direction, indicated by the arrow 35, it is sequentially replaced at the lower edge of manifold portion 34 by successive compartments B, C, etc., which in turn follow through the same cycle as compartment A. It is to be noted that as the rotor 25 continues in its clockwise rotation, compartment A, having reached a condition of approximate maximum volume adjacent the lower tip of the lower portion 37 of exhaust manifold 19 during which time fluid from the compartment is expelled through port 41.

It should be noted that the compartment A is entirely sealed, from the other compartments B, C, etc., except through the intake and exhaust manifolds. The seal is accomplished by snug fit of the end plates 20, 21 against body 10 and head 12; by the snug rolling contact of the rollers 25 against the cylindrical wall of bore 11; by the snug fit of these rollers against the end plates; and by the snug contact of the rotor 25, both with the rollers 24 and with the inside surfaces of the end plates 20, 21. Each roller 24 is at all times in engagement with some one or the other of the teeth 30 of the inner rotor 25.

Returning now to further and somewhat more detailed consideration of the volumetric capacity of the several compartments, it will be seen that when the compartment A travels from the position shown in Figure 4 to the momentary position now occupied by compartment G (see also Fig. 5), a considerable increase in volume takes place. Compartment G, which corresponds to a successive phase or position of compartment A, is seen momentarily to be comprised between roller 24b, tooth 30a, tooth 30b, roller 24c, and bore 11. Subsequently, during the rotational movement, compartment A reaches station D. This is just opposite the uppermost edge of manifold portion 36. It represents the position of approximate maximum volume of the compartment. Compression is just beginning. It will be observed that compartment D for the moment is

comprised of roller 24d, tooth 30c, tooth 30d, roller 34e and bore 11. The fluid begins to discharge through manifold portion 36 along the direction indicated by the small arrows, and exits through throat 38 and port 17. Pressure discharge continues during the travel of compartment A down past the extent of manifold 19. What has been described with respect to compartment A is true of all of the other compartments such as B and C. As the rotors continue past the position D of approximate maximum volumetric capacity, the compartments defined at this position decrease in volume with further clockwise rotation until a position of minimum volume is reached at the lower end of the exhaust manifold.

It is the eccentric relation of the inner rotor 25 with respect to the outer rotor, and the design of rotor 25 with one less tooth than there are rolls 24, which give rise to the formation of compartments of continuously varying dimensions. While the rotors rotate at high velocity relative to the casing, nevertheless their phase change relative to each other is comparatively small. Ample time is provided by the long manifolds 18, 19, for charging fluid into the compartments and for discharging the fluid therefrom. Moreover, the long sweep of the manifolds effectively distribute the intake and discharge impulses in such manner that smooth, uniform, non-pulsating pumping action is achieved. The teeth and rollers comprising each compartment are constantly in a process of change and replacement, due to the relative rotation of the outer and inner rotors, and the teeth defining any given compartment will be entirely different from one revolution to another.

A construction of the type which I have disclosed is comparatively simple and inexpensive to produce. The various component elements are themselves of low first cost and require no expensive manufacturing process. The rollers 24 when constructed of extremely hard steel, ground to size, inherently tend toward long wear. This tendency toward long life and a low rate of wear is contributed to by the slow change of phase between the rotors. The rolling contact between the moving parts in the substantial absence of sliding friction conduces to small change in dimensions during use. Machined parts remain in close engagement. A tight and effective seal is had. Retention of the seal between the several compartments is maintained over long periods of service. Inasmuch, as the relative rotational speed of the inner and outer rotors is comparatively low, it is entirely practicable to operate the pump at motor speed, ranging as between 900 to 1800 revolutions per minute. The necessity of expensive auxiliaries in the form of speed reducers is effectively avoided. Lubrication is achieved in simple manner by a microscopic film of oil.

While I have described my new device as a pump, and while therein lies its principal sphere of utility, it is of course possible to achieve motor action by reversing the coursing of fluid through the ports of the casing and by permitting the fluid, under pressure, to enter into the compartments of minimum volume, and thereafter to expand the compartment causing a moving and change of rotor position. In such instance power take-off can be achieved through either the inner or outer rotor.

I claim:

1. A hydraulic pump comprising the combination of a cylindrical casing having inlet and outlet ports therein; nested inner and outer rotors disposed snugly in said cylindrical casing eccentrically of each other, said outer rotor comprising a pair of end plates having corresponding peripherally arranged bearing points and fitting snugly against the faces of said bore; studs extending between bearing points of said end plates, the said end plates and studs comprising a cage; and rollers mounted for rotation on said studs opposite the ports of said casing, the inner rotor having one less peripheral tooth than the number of said rollers, said rollers and teeth being in constant anti-friction rolling contact with each other to provide, together with the cylindrical inner surface of said casing, a series of sealed compartments of continuously varying dimensions.

2. A hydraulic pump comprising in combination, a casing having a bored body portion with cylindrical inner surface, a head portion adapted to be bolted thereto, dowel positioning means on said body and head for insuring proper assembly thereof, opposed annular ports extending from the exterior through said body portion to said bore, and means for securing said body and head portions together in fluid tight manner; and nested inner and outer rotors disposed snugly in said cylindrical bore eccentrically of each other, said outer rotor comprising a series of rollers mounted on a cage-like bearing frame and opposite the ports of said casing, said inner rotor having one less peripheral tooth than the number of said rollers, said rollers and teeth being in constant anti-friction rolling contact with each other to provide, together with the cylindrical surface of said bore, a series of sealed compartments of continuously varying dimensions.

3. A hydraulic pump comprising a ported casing having an interior cylindrical bore having annular ports on opposite sides thereof each communicating with a separate manifold in said casing which extends through an angle of approximately 120°; end plates fitting snugly against the faces of said bore in fluid-tight manner for rotation relative thereto, the said end plates each having a corresponding set of holes disposed in a circle near its periphery; corresponding studs interfitted corresponding holes of said end plates; rollers disposed for rotation on said studs and bearing snugly against said end plates; a pump drive shaft; and an inner, peripherally toothed rotor keyed to said drive shaft and disposed within and eccentrically of said outer rotor and fitting snugly between said end plates, the number of teeth on said inner rotor being one less than the number of rollers, the said teeth and rollers being constantly in fluid-tight contact with each other, and the said teeth, rollers and end plates defining, together with the cylindrical surface of said bore, a plurality of compartments each sealed against the others and each having continuously varying dimensions during the eccentric rotation of the rotors relative to and eccentrically of each other.

4. In a rotary pump of the character described, a housing, a cylindrical chamber within said housing, a pair of oppositely-arranged ports for said housing and chamber, a cam rotor in said chamber, said rotor having a plurality of identical, rounded, symmetrically-arranged cam surfaces, the axis of said rotor being parallel to but not concentric with the axis of said cy-

lindrical chamber, a roller cage in said chamber between said rotor and said housing, said roller cage supporting a plurality of rollers, the axes of said rollers being parallel to the axes of said chamber and rotor, said roller cage being rotatable on an axis concentric with the axis of said chamber and the rollers of said cage being supported by said cage at fixed radial distances from said cage axis, each of said rollers having rolling contact with the cylindrical wall of said chamber and the cam surfaces of said rotor at all times, and means for rotating said roller cage and therewith said rotor in said housing.

5. In a rotary pump of the character described, a stationary housing, a cylindrical chamber within said housing, a pair of ports for said housing and chamber, a cam pump element in said chamber, said pump element having a plurality of identical, rounded, symmetrically-arranged cam surfaces, said element mounted for rotation on an axis extending parallel to but not concentric with the axis of said cylindrical chamber, rollers interposed between said cam element and the cylindrical wall of said chamber, and means for keeping said rollers spaced a constant, arcuate distance apart from each other, said rollers being in constant rolling contact with said cam surfaces and with the cylindrical wall of said chamber, the number of rollers being one more than the number of cam surfaces on said pump element.

6. In a rotary pump of the character described, a housing, a cylindrical chamber within said housing, a pair of oppositely arranged ports for said housing and chamber, a cam pump element in said chamber, said pump element having a plurality of identical, rounded, symmetrically-arranged cam surfaces, said element mounted for rotation on an axis extending parallel to but not concentric with the axis of said cylindrical chamber, a roller supporting element in said chamber between said pump element and said housing, said roller supporting element having a plurality of rollers, the axes of said rollers being parallel to the axes of said chamber and pump element, said roller supporting element being rotatable on an axis concentric with the axis of said chamber, said rollers being positioned by said roller supporting element spaced apart at equal distances around said cylindrical wall, the number of rollers being one more than the number of said cam surfaces on said cam pump element, each of said rollers having constant rolling contact with the cylindrical wall of said chamber and with said cam surfaces of said pump element at all times, and means for producing relative rotational movement of said pump element and said rollers supporting element with respect to said housing.

7. A rotary pump including a stationary housing, a cylindrical chamber within said housing, a pair of diametrically opposite ports for said housing and chamber, a cam pump element in said chamber, said pump element having a plurality of identical rounded, symmetrically-arranged cam surfaces, said element mounted for rotation on an axis extending parallel to

but not concentric with the axis of said cylindrical chamber, a roller supporting element in said chamber between said pump element and said housing, said roller supporting element supporting a plurality of rollers, the axes of said rollers being parallel to the axes of said chamber and pump element, said roller supporting element being rotatable on an axis concentric with the axis of said chamber and the rollers of said roller supporting element being supported by said roller supporting element at fixed radial distances from said roller supporting element axis, said rollers having rolling contact with the cylindrical wall of said chamber and with said cam surfaces of said pump element at all times, and means for rotating one of said elements.

8. Apparatus of the character described comprising in combination, a casing having a cylindrical bore therein and inlet and outlet passages therefrom, an outer rotor disposed within the bore of said casing comprising spider means carrying a plurality of substantially uniformly spaced rollers continuously contacting the cylindrical wall thereof, a peripherally toothed inner rotor disposed eccentrically within said outer rotor with the teeth thereof contacting the spaced rollers of said outer rotor to provide a plurality of separate compartments each of continuously variable dimensions with those of the increasing dimensions cooperating with one passage and those of decreasing dimensions with the other passage, and shaft means extending from said rotor spider exteriorly of said casing.

9. Apparatus of the character described comprising in combination, a casing having a cylindrical bore therein and inlet and outlet passages therefrom, shaft means within said casing eccentric to the axis thereof, a peripherally toothed inner rotor secured to said shaft and eccentric to said bore axis, and a plurality of substantially uniformly spaced rollers exceeding the number of teeth of said inner rotor by at least one and as a group forming an outer rotor concentric with said casing bore and continuously contacting the cylindrical wall of the bore of said casing and the teeth of said eccentrically disposed inner rotor to provide a plurality of separate compartments, each of continuously varying dimensions with those of the increasing dimensions cooperating with one passage and those of decreasing dimensions with the other passage.

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