Sept. 3, 1957 G. E. RYDBERG 2,804,827

VARIABLE CAPACITY ROTARY PUMP

Filed June 9, 1953 6 Sheets-Sheet 1

Fig. 1

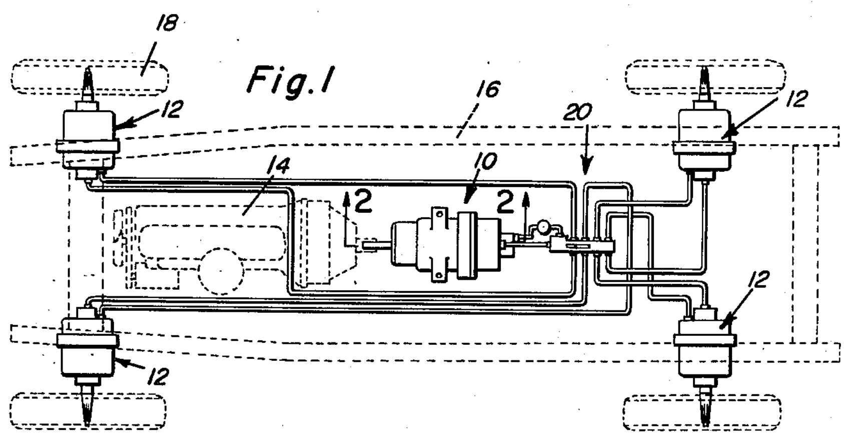
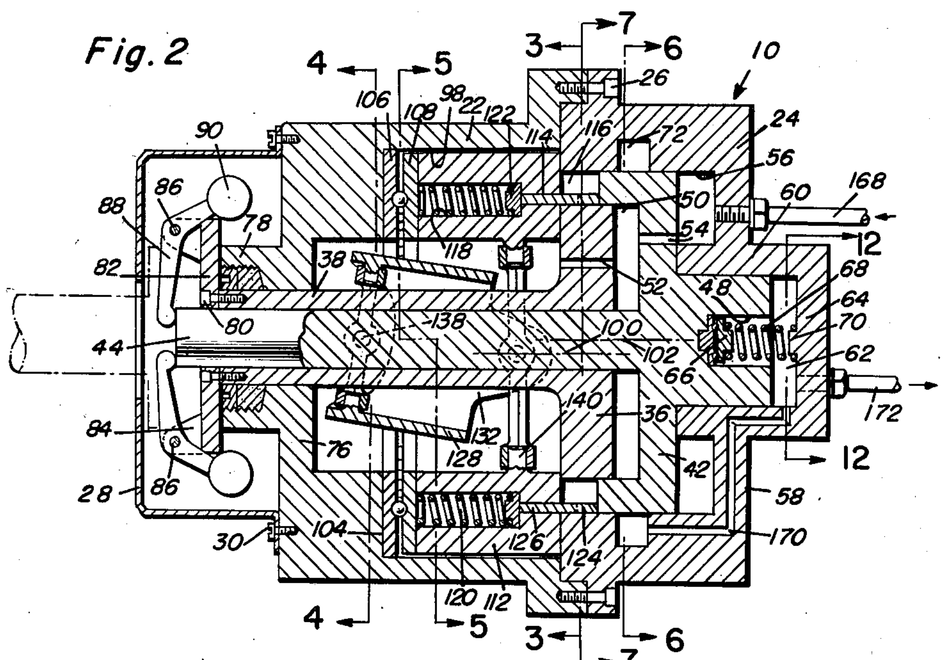


Fig. 2



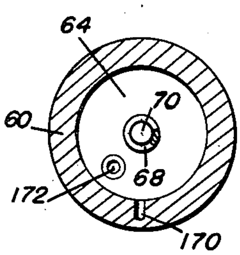


Fig. 12

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Fig.3

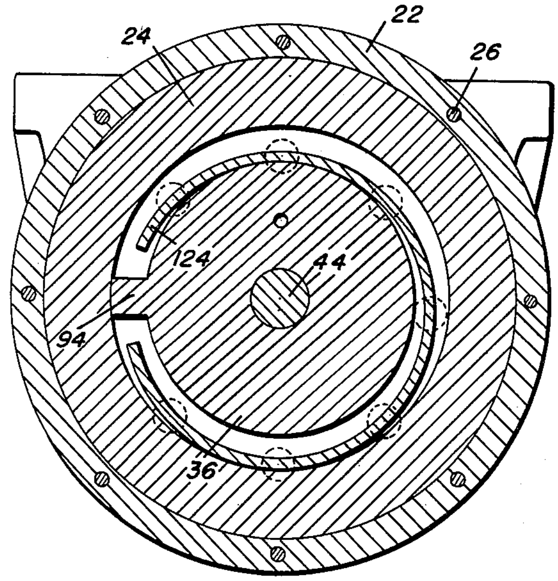

Fig. 4

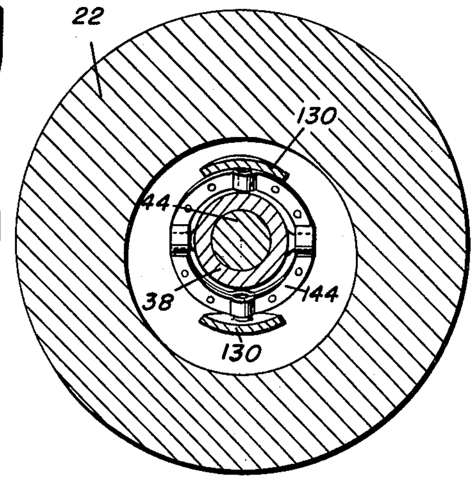

Fig.5

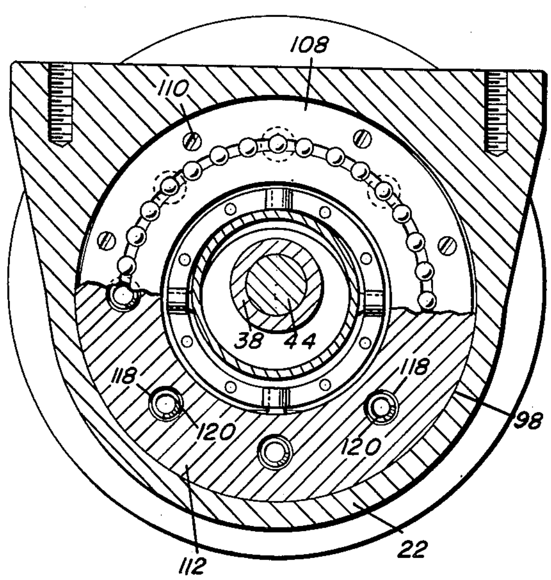

Fig.6

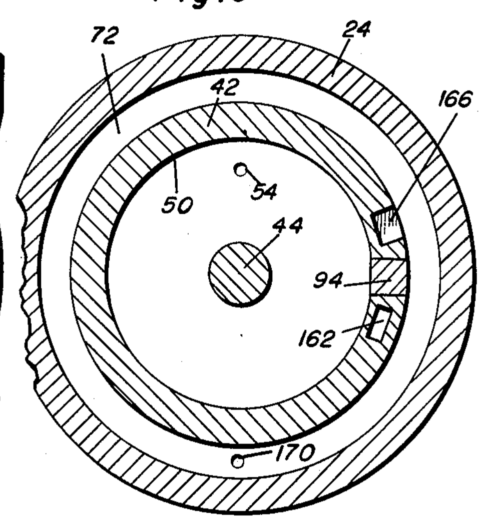

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Fig.7

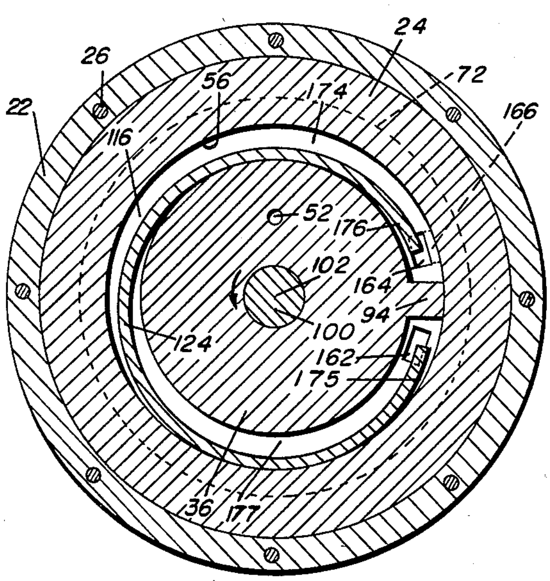


Fig.11

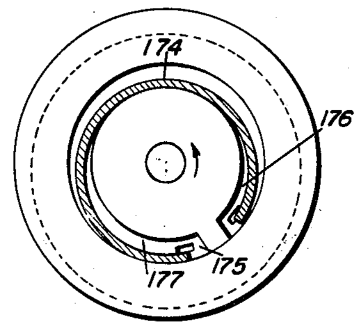


Fig.10

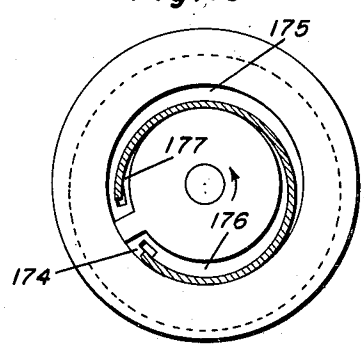


Fig.8

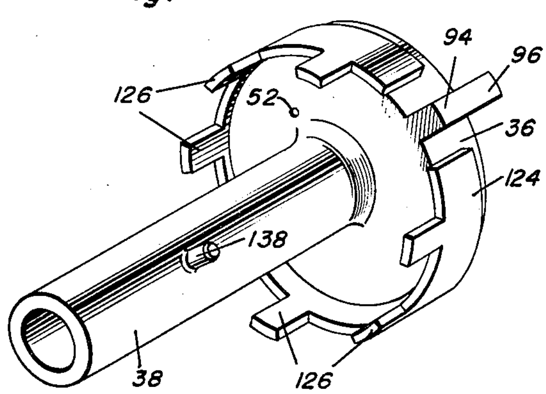
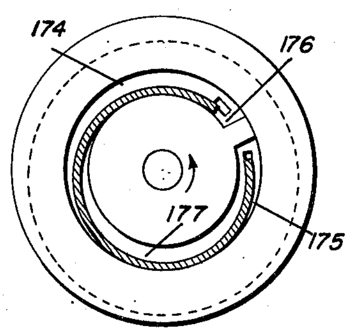


Fig.9



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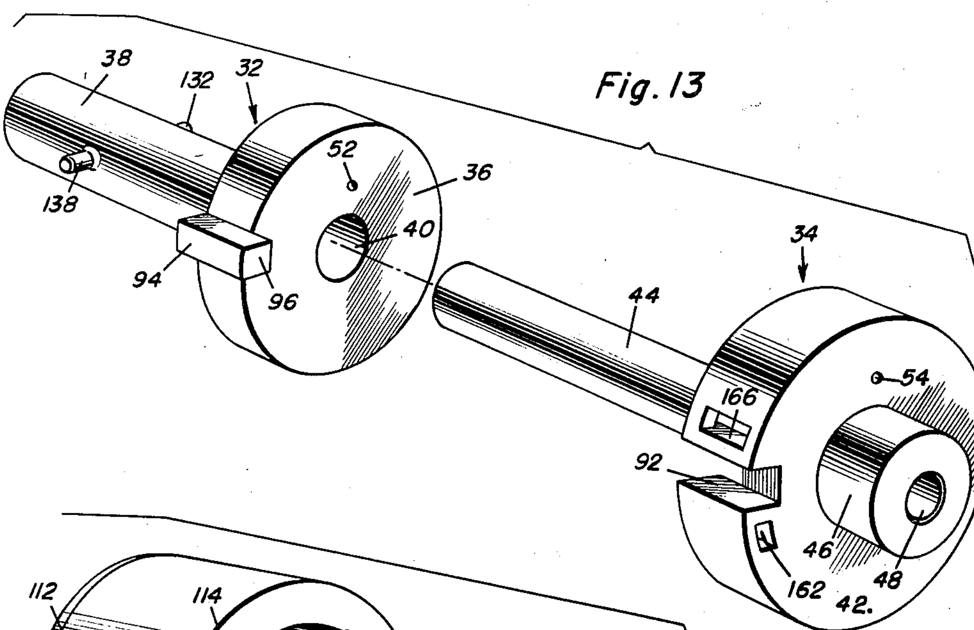

Fig. 13

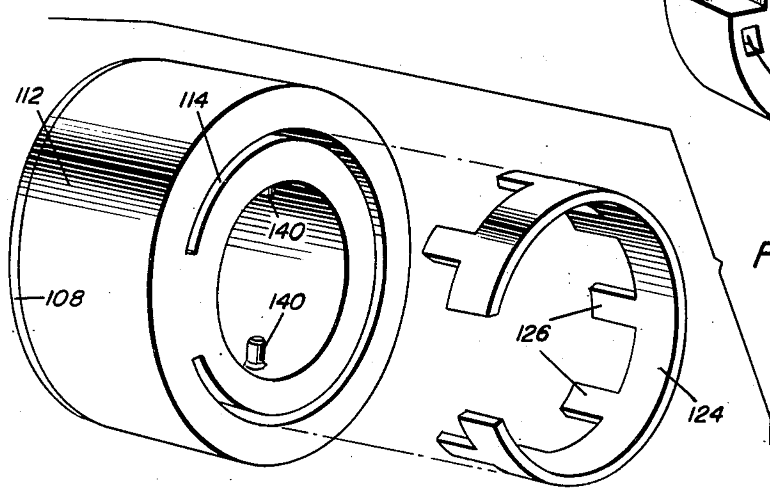

Fig. 14

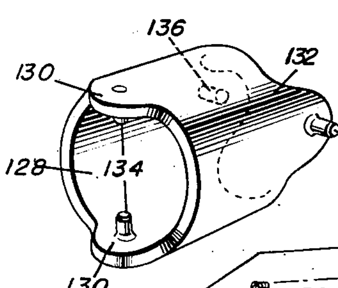

Fig. 15

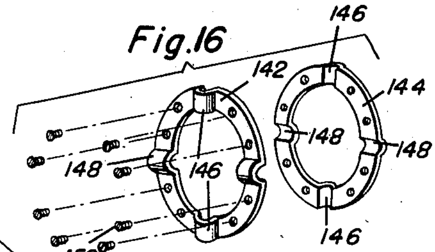

Fig. 16

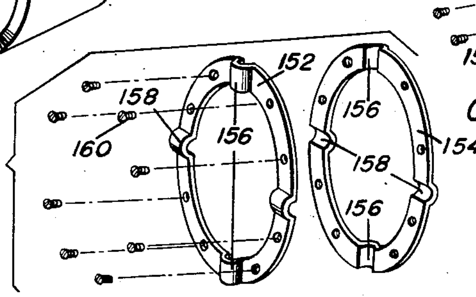

Fig. 17

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Fig. 18

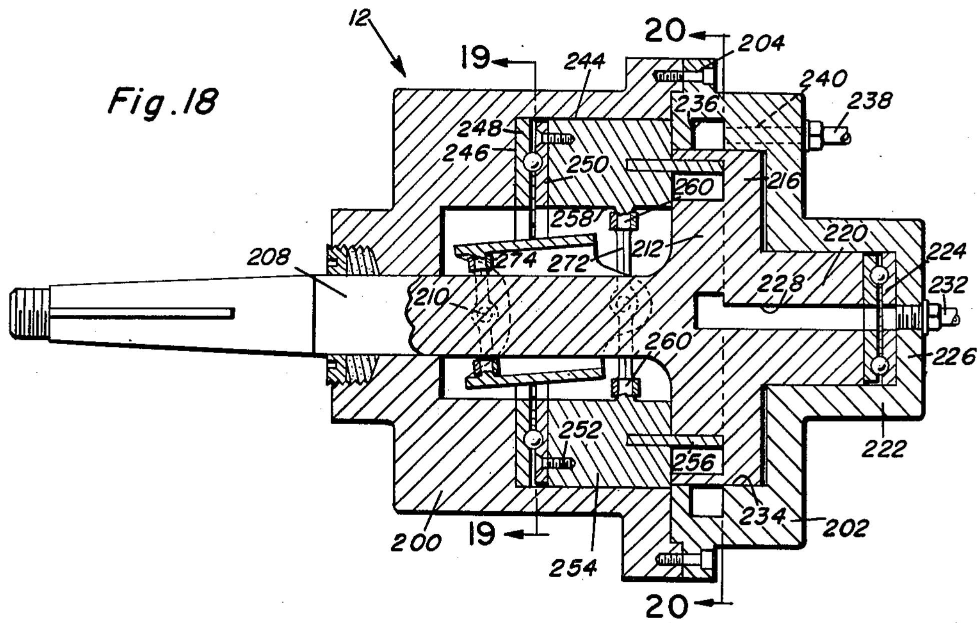

Fig. 22

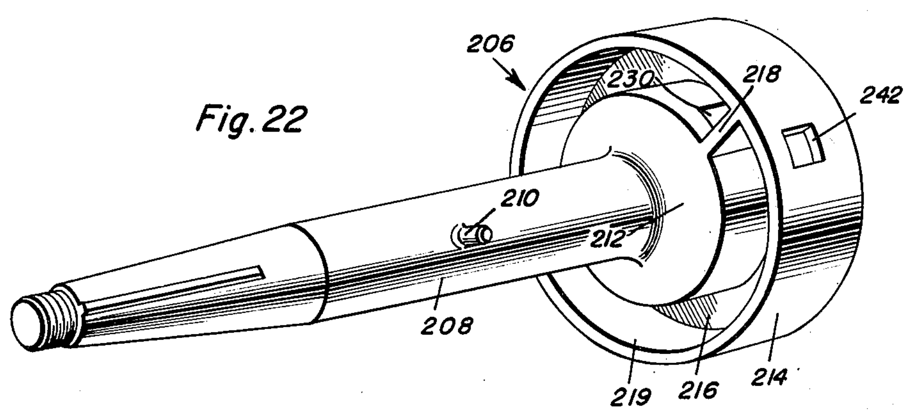

Fig. 23

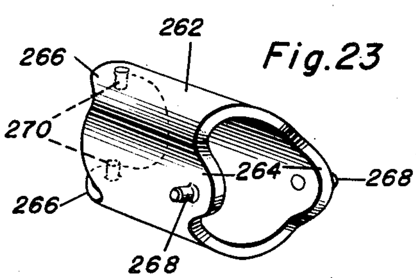

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Fig. 19

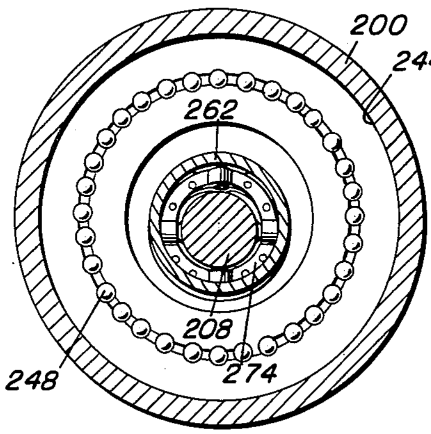


Fig. 20

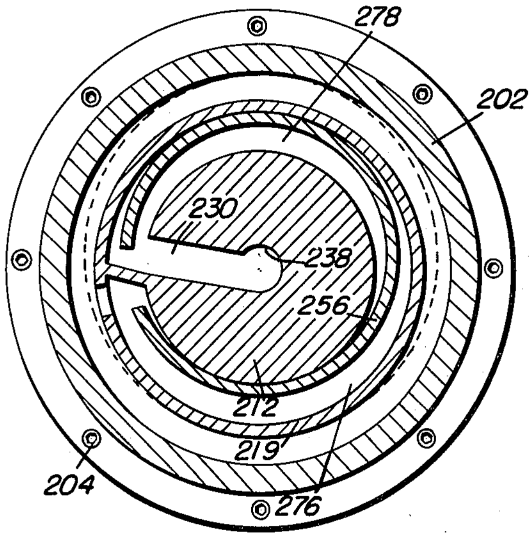
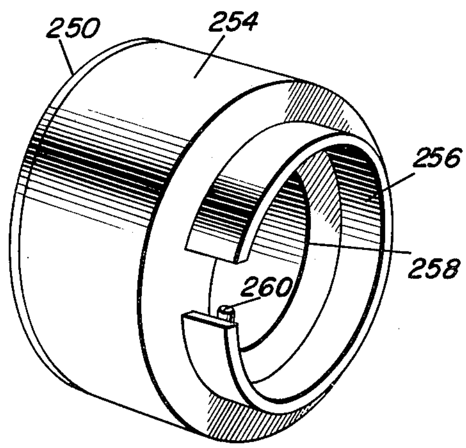


Fig. 21



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United States Patent Office

2,804,827
Patented Sept. 3, 1957

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2,804,827

VARIABLE CAPACITY ROTARY PUMP

George Emil Rydberg, Calgary, Alberta, Canada

Application June 9, 1953, Serial No. 360,530

23 Claims. (Cl. 103—120)

This invention pertains to novel and useful improvements in rotary pumps and motors for use with fluid pressure mediums, and more specifically pertains to an improved rotary pump having a controllable variable capacity which is varied in accordance with its speed of rotation.

The principal object of this invention is to provide a rotary pump or motor unit for operating with fluid pressure mediums and wherein the construction thereof shall be simplified by reducing the number of parts, by eliminating the rotational unbalance caused by reciprocating masses, as in the customary cylinder, piston and crankshaft constructions; and wherein a positive displacement is obtained in the use of a fluid pressure medium.

A further important object of the invention is to provide a rotary pump or motor unit in accordance with the foregoing object in which the parts of the device are reduced to a minimum and are compactly assembled.

A further important object of the invention is to provide a rotary unit in conformity with the above-mentioned objects in which the fluid pressures are effectively balanced in the construction of the apparatus in order to reduce the wear and strain upon the various parts of the mechanism.

Yet another important object of the invention is to provide a rotary unit in accordance with the preceding objects together with means for obtaining any desired variation of the capacity of the unit while readily controlling such variation.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

Figure 1 is a diagrammatic plan view illustrating the manner in which the rotary pump and motor units in accordance with this invention may be employed as part of a fluid drive of an automotive vehicle, certain parts being indicated in dotted lines therein;

Figure 2 is a vertical central longitudinal sectional view taken substantially upon the plane indicated by the section line 2—2 of Figure 1 and showing the internal construction of a variable capacity pump unit in accordance with this invention, the position of certain concealed parts being indicated in dotted lines therein;

Figure 3 is a vertical transverse sectional view taken substantially upon the plane indicated by the section line 3—3 of Figure 2 and showing the operating chamber of the unit;

Figure 4 is a vertical transverse sectional view taken substantially upon the plane indicated by the section line 4—4 of Figure 2 and showing a part of a connecting member comprising an element of the invention;

Figure 5 is a vertical transverse sectional view taken substantially upon the plane indicated by the broken section line 5—5 of Figure 2, this view being taken at substantially the same place but looking in the reverse direction from that of Figure 4;

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Figure 6 is a vertical transverse sectional view taken substantially upon the plane indicated by the section line 6—6 of Figure 2, parts being broken away;

Figure 7 is a vertical transverse sectional view taken substantially upon the plane indicated by the section line 7—7 of Figure 2, this view being taken upon the same plane as Figure 3 but looking in the reverse direction;

Figure 8 is a perspective view of a rotor forming a part of the invention and of a ring associated therewith;

Figures 9–11 are diagrammatic views similar to Figure 7 and showing in connection with that figure successive positions assumed by the rotor and ring during the operation of the unit;

Figure 12 is a vertical transverse sectional view taken substantially upon the plane indicated by the section line 12—12 of Figure 2 and showing certain details of the fluid pressure exhaust chamber of the unit;

Figure 13 is an exploded perspective view of two rotor elements forming a part of the working chamber of the invention;

Figure 14 is an exploded perspective view of a ring and the sleeve carrier therefor;

Figure 15 is a perspective view of a connecting member for securing the sleeve carrier to a rotor of the invention;

Figures 16 and 17 are exploded perspective views of two universal joint connecting assemblies for connecting the connecting sleeve to the ring carrier and to a rotor of the unit;

Figure 18 is a vertical longitudinal sectional view, similar to Figure 2, but showing a simplified and modified construction of the unit when the same is adapted to function as a constant capacity unit;

Figure 19 is a vertical transverse sectional view taken substantially upon the plane indicated by the section line 19—19 of Figure 18;

Figure 20 is a vertical transverse sectional view taken substantially upon the plane indicated by the section line 20—20 of Figure 18;

Figure 21 is a perspective view of the modified form of ring carrier and ring forming an integral assembly in the modified construction of Figure 18;

Figure 22 is a perspective view of a rotor unit forming a part of Figure 18; and

Figure 23 is a perspective view of a connecting sleeve for operatively connecting the unitary ring and ring holder with the rotor of Figure 18.

This invention relates to a rotary unit which may be optionally employed as either a fluid pressure pump or a fluid pressure motor, depending upon the manner in which it is employed. This unit may be either a variable capacity pump or a variable capacitor motor, and it is this variable capacity unit which has been illustrated in Figures 1–17. In some instances the unit may be constructed and employed as a constant capacity unit, and when intended for such functioning the unit's construction may be simplified in accordance with the modified embodiment illustrated in Figures 18–23.

In Figure 1 is shown in diagrammatic form a system wherein a plurality of the units may be employed as a part of a hydraulic transmission for automotive vehicles. The assembly of Figure 1 is to be understood as being an illustration only of the principles of the invention and a possible use for the invention, and not as a limitation thereof. In Figure 1 a variable capacity unit indicated generally by the numeral 10 is shown in operative relationship to a plurality units each indicated generally by the numeral 12, and the unit 10 is preferably of the variable capacity construction illustrated in Figures 1–17, while the units 12 may conveniently be of the constant capacity form of the invention illustrated in Figures 19–23.

As illustrated in Figure 1, the unit 10 is drivingly connected to the power plant 14 of an automotive vehicle, a portion of the framework of which is indicated in dotted lines as at 16. Each of the wheels 18 of the vehicle has associated therewith one of the motor units 12 for driving the respective or associated wheels.

A suitable conduit system indicated generally by the numeral 20 interconnects the pump driving unit 10 with each of the driven motor units 12, in any desired manner, whereby the power from the engine 14 will be delivered to the pump 10 and from thence by means of a fluid medium under pressure to the individual driven units 12 and each of the wheels of the vehicle.

Since the present invention is not concerned with the actual use of the units 10 or 12, nor the connecting and control system of conduits therebetween, a further description and explanation of the same is deemed to be unnecessary.

As shown in Figure 2, the variable capacity pump or driving unit 10 comprises a pair of casing sections 22 and 24 which are detachably secured together as by fastening bolts 26. At the free end of the section 22 there is removably secured a further housing 28 as by means of fasteners 30.

Disposed within the casing are the movable elements of the variable capacity pump. These elements include a pair of rotors, the numeral 32 indicating generally the driving rotor or piston of the unit, while the numeral 34 designates a volume varying rotor.

Referring particularly to Figure 13, the driving rotor includes a cylindrical or drum-like member 36 having an axially extending tubular sleeve 38 extending from what may be termed its rear face. An axial bore 40 disposed through the drum 36 constitutes a continuation of the internal bore of the stem 38.

The volume varying rotor 34 likewise includes a cylindrical drum 42 which has an axially extending stem or rod 44 extending from its rear face and adapted to be slidably received within the bore 40 and stem 38 of the rotor 32.

Extending forwardly from the front face of the rotor drum 42 is a cylindrical projection 46 having an axial recess or socket 48 in the forward end of the same. As will be more readily apparent from Figure 2, the rear face of the rotor drum 42 is provided with a cylindrical recess or chamber 50 which slidably receives therein the rotor drum 36. The rotor drums 36 and 42 are respectively provided with bores or passages 52 and 54 respectively whereby a fluid medium may freely pass from one side to the other side of these rotor drums.

The casing section 24 is provided with a cylindrical chamber 56 which extends inwardly from the open face of the section to the end wall 58 thereof and in which is slidably received the rotor drum 42. The end wall 58 is provided with an integral centrally disposed cylinder 60 having a chamber 62 having its inner end extending into the chamber 56 lying within the cylindrical section 24, and which has its outer end extending outwardly of the end wall 58, being provided with an integral closure 64. The sleeve 60 receives for sliding and rotating movement the cylindrical projection 46 of the rotor 34.

An anti-friction bearing assembly 66 is seated in the bottom of the recess or socket 48 and constitutes a seat for one end of a compression spring 68, the other end of this spring seating upon a boss 70 extending inwardly from the end wall 64. The spring thus serves to urge the volume varying rotor 34 towards the left as viewed in Figure 2, and thus tends to slidably urge the rotor drum 42 outwardly from the chamber 62.

Intermediate the opposite ends of the cylindrical wall 56 there is provided a circumferentially extending groove 72 which is covered at all times by the periphery of the rotor drum 42.

As will be apparent from Figure 2, the stem 38 of the rotor 32 is slidably received upon the shaft or stem 44 of the rotor 34, while the rotor drum 36 is slidably received within the chamber 50 within the drum 42. The casing section 22 has an end wall 76 which is axially bored to slidably and rotatably receive the stem 38 therein, the ends of the stems 38 and 44 being disposed within the housing 28. A conventional sealing assembly is provided for the projecting ends of the stems 38 and 44, such assembly being designated generally by the numeral 78. Fixedly secured to the projecting end of the stem 38 as by fasteners 80 is a plate 82 having pairs of lugs or ears 84 thereon which are provided with fulcrum pins 86 whereby a pair of lever arms 88 are pivoted. These lever arms at one end are provided with fly wheel governor weights 90 and at their other ends engage the extremity of the shaft 44 whereby the governor weights 90 will urge the levers 88 in a direction to move the stem 44 to the right against resistance of the spring 68 as the speed of rotation of the two stems increases. This movement of the stem 44 relative to the stem 38 under the influence of increases in speed is relied upon as a means for increasing the capacity or volume of delivery of the variable capacity pump.

It is contemplated that the stem 38 will be connected in any desired manner to the engine 14, in the assembly shown in Figure 1, or to any other power source in order to impart rotary movement to the variable capacity pump unit.

The rotor 32 is keyed to the rotor 34 whereby relative sliding or axial movement is permitted, but the two rotors revolve as a unit. For this purpose, as will be clearly apparent from Figure 13, the rotor drum 42 is provided with a radially extending slot or notch 92 extending radially inwardly from the cylindrical periphery of the drum 42, and extending axially across the entire width of the same. The rotor drum 36 is provided with a radially extending key or block 94 which extends entirely across the width of the rotor drum 36, and overhangs the forward end of the same. This key 94 is adapted to slidably move in the slot 92 and fills the cross-sectional area of the same, but the overhanging or forward portion 96 of the key extends into the slot 92 for varying distances in accordance with the relative axial positions of the rotor assemblies 32 and 34.

Disposed within the casing section 22 is a cylindrical chamber 98. The chamber 98 has a central axis 100 which is displaced vertically from the axis 102 of the stems 38 and 44 and the peripheral surfaces of the rotor blocks 36 and 42 as well as the cylindrical surface 56 of the chamber 62. This eccentricity for displacement of the axes 102 is clearly shown in Figure 2, as well as in Figure 7.

The rearward or outer end of the chamber 98 has an annular shoulder 104 upon which is seated an anti-friction bearing assembly indicated generally by the numeral 106 whose inner bearing race 108, see also Figure 5, is secured as by fasteners 110 to the rear end of a cylindrical annulus or rotor 112 which constitutes a ring holder as set forth hereinafter and which thus revolves about the axis 100.

Referring now to Figure 14 it will be seen that the cylindrical annulus 112 which constitutes the ring carrier is provided upon its forward face with a circumferential groove or recess 114 which extends throughout almost a complete circle, having its ends spaced.

The forward face of the annulus 112, which is the face having the groove 114, is adapted to abut against the adjacent plane face of the extremity of the casing section 24, as clearly shown in Figure 2.

As so far described, it will now be seen that an annular chamber 116, constituting the working chamber of the unit 10, is formed having a cylindrical concave wall formed by the wall 56; a convex cylindrical wall formed by the periphery of the rotor drum 36; and a pair of annular end walls formed by the adjacent parallel plane faces of the ring holder **112** and the annular rim of the rotor **42** which is axially slidable between the convex and concave cylindrical surfaces just mentioned.

Extending from the rear face of the ring holder **112** are a plurality of parallel wells or recesses **118** each of which intersects the bottom of the circular groove **114**. These recesses, have their open rear ends, shown also in Figure 5, closed by the plate **108** constituting the inner race of the bearing assembly **106** as previously mentioned. A compression spring **120** is seated in each of the recesses **118** and has one extremity bearing against the closure plate **108** and has its other extremity engaging a spring seat in the form of a disk or plug **122**, which is slidable in the recess **118**. A ring **124**, is provided, which is slidable axially of the annulus or ring keeper **112** within the ring groove **114**, this ring having a plurality of parallel axially extending and rearwardly extending projections or fingers **126**, each of which is adapted to extend into and be slidable in one of the wells **118**. The spring seats **122** engage the extremitites of the fingers **126** and thus the force of the springs **118** yieldingly urges the ring towards the right as viewed in Figures 14 and 2 to thus yieldingly urge the ring **124** from the recess **114** and into and across the chamber **116** and into contact with the annular face upon the rim of the rotor drum **42**.

Since the ring **124** and the ring groove **114** are concentric with respect to the axis of the ring holder **112**, being concentric with respect to the axis **100**, they are eccentric with respect to the axis **102**. Consequently, upon rotation of the ring holder and ring, and the two rotor drums about their parallel axes, the ring will have an eccentric motion in the chamber **116**.

The eccentric travel of the ring within the chamber **116** between the concave and convex cylindrical surfaces will be more readily perceived from a comparison of Figures 7, 9–11 which show sequential positions during a complete revolution of these members.

Although the stems **38**, **44** and the ring holder **112** rotate about different axes, a connecting means is provided between these members whereby the stems will constitute a driving means for the ring holder to cause rotation of the latter. This connecting means as shown especially in Figures 2, 15–17 consists of a sleeve **128** which has a pair of axially extending parallel lugs or ears **130** and **132** at its opposite extremities. The ears **130** have inwardly extending diametrically opposed connecting pins **134** while a similar pair of outwardly diametrically disposed pins **136** is provided upon the other pair of ears **132**. The pins **134** and **136** are respectively connected to the sleeve **38** and to the ring holder **112**.

The pins **134** and the stem **38** are connected by the coupling means shown in Figure 16, while the pins **136** and the ring holder **112** are secured by the coupling means of Figure 17. Referring to Figures 13 and 14, it will be seen that the stem **38** is provided with a pair of diametrically disposed outwardly extending coupling pins **138**, while the annulus **112** is provided adjacent its right end with a pair of diametrically disposed inwardly extending pins **140**.

The coupling means of Figure 16 includes a pair of rings **142** and **144** having complementary faces provided with two pairs of diametrically disposed semi-cylindrical bearing recesses **146** and **148**. Suitable fasteners **150** serve to removably couple and secure the rings **142** and **144** together. The pair of bearing recesses **146** are adapted to receive and journal the pair of pins **134** of the connecting sleeve **128**, while the other pair of bearing recesses **148** are connected to and journaled upon the pair of pins **138** of the stem **38**. Thus the stem **38** is rotatably connected to the sleeve **128** whereby the former will rotate the latter despite the displacement of their axes of rotation, the axis of the sleeve being inclined with respect to the axis of the stem **38** as will be apparent from Figure 2.

The other coupling member of Figure 17 is of similar construction, comprising a pair of coupling rings **152** and **154**, each of which is provided with two pairs of diametrically disposed semi-cylindrical bearing recesses **156** and **158**. As in the other coupling member, suitable fasteners **160** serve to removably secure the coupling rings together and upon the connecting sleeve **128** and the ring holder **112**.

The diametrically disposed pair of bearing recesses **156** of the coupling rings **152** and **154** are adapted to be connected to and journaled upon the pair of pins **140** of the ring holder **112**, while the other pair of bearing recesses **158** are adapted to journal and embrace the pins **136** upon the connecting sleeve **128**. It will thus be apparent that the connecting sleeve together with the two coupling members constitutes a universal joint coupling which drivingly connects the sleeve **38** to the ring holder **112** whereby rotation of the former will cause rotation of the latter about parallel axes of rotation, **100** and **102**.

Referring now again to Figure 13 and to Figures 6 and 7, it will be seen that the rotor drum **42** is provided on one side of the slot **92** with a passage or bore **162** which is parallel to the axis of the stem **44** and which extends entirely through the rotor drum. This passage establishes communication between the chamber **56** and the chamber **116**, at all times, and when the unit functions as a pump constitutes the inlet passage to the pump.

Upon the other side of the notch **92** the rotor drum **42** is provided with an axially extending passage **164** which is L-shaped, having a radially outwardly extending leg **166** opening to the periphery of the rotor drum and registering at all times with the annular groove or channel **72**. The L-shaped channel **164**, **166**, when the unit functions as a pump, constitutes a fluid outlet means from the chamber **116**, with which the horizontal or axial leg of the passage at all times communicates.

The chamber **56** thus constitutes a fluid inlet chamber for the pump and fluid is supplied to this chamber by means of a pipe or conduit **168** from any suitable source. The chamber **72** which is the exhaust chamber for the pumping chamber **116**, is connected by a passage means **170**, see Figure 2, with the chamber **62** formed between the end wall **64** and the outer extremity of the rotor drum **42** within the sleeve or cylinder **60**. This chamber in turn is connected with a discharge conduit **172** which delivers the fluid under the pressure generated with the pump to any suitable destination, as for example, one of the rotor motor units **12**.

It will be seen that the vent passages **52** and **54** serve to equalize the fluid pressure applied to the opposite faces of the rotor drums **36** and **42** to facilitate their axial adjustment under the influence of the governor mechanism previously described.

Referring now to Figures 3, 7, 9–11, it will be seen that the ring **124** divides the annular chamber **116**, into two concentric chambers. Thus, the adjacent ends of the ring are disposed on opposite sides of and are spaced from the key member **94**. Further, since the ring is eccentric with respect to the chamber **116**, it will be seen from Figure 7 that the ring is tangent to the rotor drum **36** and to the concave cylindrical wall of the chamber **56** upon a vertical diameter through these elements. During operation of the device, this point of tangency remains upon the vertical diameter. There is thus provided an outer chamber **174** which lies radially outwardly of the ring **124** and radially inwardly of the cylindrical wall of the chamber **56**. The ring also provides an inner chamber **176** which lies within the ring and between the ring and the exterior surface of the rotor drum **36**.

The key **94**, which functions as a piston or impeller in the chamber **116**, rotates in a counter-clockwise direction as shown by the arrows in Figures 7, 9–11. This rotation of the piston 94, and of the ring 124 with points of tangency of the ring with the adjacent surfaces of the members 36 and 56 remaining stationary upon a vertical diameter, constantly decreases the volume of the chambers 174 and 176 on the forward or advance side of the piston 94, and increases the volume of the chamber 175 and 177 on the rear or trailing side of the piston 94.

As the piston 94 and ring 124 rotate in the chamber 116 in the direction of the arrows and as shown in sequence in Figures 7, 9–11, the motive fluid is forced from the decreasing chambers 174, 176 and discharged from the passages 164, 166, into the annular channel 72 and from thence to the chamber 62 by the passage 170 and from thence to the discharge conduit 172.

At the same time, the enlarging chambers 175 and 177 receive or intake a charge of the motive fluid through the inlet conduit 168, chamber 56 and the intake passage 162.

When the piston is at either the upper or lower positions of tangency of the ring 124, the volume of the chambers 174, 176 in advance of the piston is equal to that of the chambers 175, 177 at the rear of the piston.

It will also be observed that the pressure at which the fluid will be applied to the outer or righthand end of the projection 46 of the rotor drum 42, thereby tending to urge the rotor 34 toward the left. This sliding movement of the rotor 34 toward the rotor 32 will cause the rim of the rotor drum 42 to penetrate further into the chamber 116, this inward movement causing the ring to be driven into the ring groove against the resistance of the springs 118, thereby contracting or reducing the volume of the chamber 116 and therefore the capacity of the pump.

As the speed of the unit increases, the governor members 90 and 88 will tend to separate the drums thereby increasing the volume of the working chamber of the device.

In the modification described hereinabove, the device is of the variable capacity type. Where it is not desired to vary the capacity, but to obtain a constant volume or capacity, as when the device is to be employed as a fluid motor such as the units 12, a simplification of the above described construction is possible by omitting the volume varying means and combining previously distinct elements. For such a construction, attention is directed to the embodiment of Figures 18–23 wherein the same principle of construction and operation except for the volume varying feature is disclosed.

Thus, the unit 12 includes a pair of casing sections 200 and 202 which are detachably connected as by fasteners 204.

The member 200 as illustrated is identical with the member 22, the member 202 is similar to but slightly modified from the construction of the member 24, while the two sections are coupled together by the fasteners 204 in the same manner as the previously described sections were connected by the fasteners 26. However, in place of the two separate rotors 32 and 34, there is provided a single rotor 206. As shown more clearly in Figure 22, the rotor 206 consists of a stem 208 having thereon a pair of diametrically disposed oppositely extending pins 210 which correspond to the previously mentioned pins 138. At one extremity the stem 208 is provided with an integral cylindrical drum 212 which is surrounded by a cylindrical rim or flange 214 integrally connected to the drum at the forward edges of both these members by the annular integral flange or plate 216. A radial rib or web 218 connects the exterior peripheral surface of the drum 212 with the interior cylindrical surface of the member 214 and serves as a partition in the annular space therebetween. This annular space comprises a chamber 219 which corresponds to the chamber 116 in the preceding embodiment.

As shown in Figure 18, the members 212 and 216 have a cylindrical axial extension 220' which corresponds to the projection or extension 46 of the motor drum 42.

The casing section 202 is provided with a centrally disposed axially and outwardly extending cylinder 222 in which is journaled the extension 220, an anti-friction bearing assembly 224 being disposed between the adjacent ends of the extension and of the wall 226 of the sleeve 220. An axial passage 228 extends through the wall 226, the bearing assembly 224, the projection 220, the flange or plate 216, and the drum 212, the passage having a radially extending leg at its inner end, as at 230 which opens into the chamber 219 upon the periphery of the rotor drum 212. This passage means communicates with a conduit 232 and therewith constitutes the inlet means for the unit 12.

As in the preceding embodiment, the casing section is provided with a cylindrical bore or chamber 234 in which is rotatably received the member 214, this chamber having an annular groove or channel 236 therein corresponding to the previously described channel 72. A conduit 238 is connected to a passage 240 communicating with the interior of the channel 236, this conduit and channel corresponding to the previously described passage 170 and conduit 172. Communication is established between the channel 236 and the chamber 219 by means of the outlet passage or port 242 formed in the member 214 and registering with the channel 236.

The casing section 200 has a cylindrical but eccentrically disposed chamber or bore 244 corresponding to the bore 98 and having an annular bottom wall 246 corresponding to the shoulder or wall 104, with a bearing assembly 248 resting against this bottom wall. The bearing assembly includes a plate 250 comprising one race of the bearing and which plate is removably secured as by fasteners 252 to the rear end of a ring holder 254. As shown in Figure 21, the ring holder 254 has an integral axially extending concentric ring 256 at one end, this ring corresponding to the ring 124. It will thus be seen that the ring holder of Figure 21 combines as a single element the ring holder 112 and ring 124 previously described, the ring holder having an axial bore 258 therethrough.

The ring extends into the chamber 219 and operates therein in the same manner, since the ring rotates about an axis which is eccentric to that of the rotor carrying the chamber.

The same connecting means previously described is utilized to establish a driving connection between the rotor stem 208 and the ring holder. For this purpose, there are provided a pair of diametrically disposed inwardly extending coupling pins 260 upon the ring holder 254 within the bore 258 thereof, which are connected to a connecting sleeve 262, see Figure 23, which in turn is connected to the pins 210 upon the stem 208.

The connecting sleeve 262 has pairs of oppositely disposed lugs 264 and 266 extending from opposite ends of the same, these lugs having pairs of diametrically disposed outwardly and inwardly extending pins 268 and 270, respectively. Coupling rings indicated generally by the numerals 272 and 274, and which may be substantially identical with the coupling rings of Figures 17 and 16, respectively, of the previously described embodiment are utilized to connect the pins 268 and 270 to the pins 260 and 210, respectively.

The operation of this form of the invention is identical with that previously described except that there is no variation in the volume of the working chamber 219, the ring 256 extending into this chamber 219 dividing the same into concentric chambers 276 and 278, as shown in Figure 20.

Since the operation of this form of the invention is identical with that previously described except that the chamber is of constant instead of variable volume a further description of the same appears to be unnecessary.

From the foregoing, the construction and operation of the device will be readily understood and further explanation is believed to be unnecessary. However, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the appended claims.

What is claimed as new is as follows:

ing an annular pump chamber therein, said pump chamber

1. A variable capacity pump comprising a stator hav- having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first and second rotors having a common axis of rotation displaced from that of said third rotor, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a ring disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, the displacement of said axes being sufficient to bring the concave and convex surfaces of the ring into sealing engagement with the convex surfaces of the second rotor and the concave surface of the stator.

2. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, a ring carried by said third rotor, said ring having a sealing engagement with the surface of said second rotor.

3. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, a ring carried by said third rotor, said ring having a sealing engagement with the surface of said second rotor, said third rotor having a groove in said surface, said ring being movably seated in said groove, means resiliently urging said ring outwardly of said groove and into sealing engagement with the surface of said second rotor.

4. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, said last mentioned means being operatively connected with the fluid outlet means for varying the capacity of the pump chamber in response to pressure variations of the fluid discharge from the pump chamber.

5. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, means drivingly connecting said first rotor to said third rotor for simultaneous rotation at the same speed.

6. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, means drivingly connecting said first and second rotor for simultaneous rotation at the same speed.

7. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer wall and constituting one of said annular side walls, said third rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, said last mentioned means including an actuator responsive to speed of said first rotor.

8. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, said last mentioned means including an actuator responsive to speed of said first rotor, said actuator being mounted upon said first rotor and operatively engaging said second rotor.

9. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the

other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, means drivingly connecting said first rotor to said third rotor for simultaneous rotation at the same speed, said third rotor having a central chamber, said first rotor having a portion extending into said central chamber said connecting means being disposed in said central chamber and being fastened to said portion and to said third rotor.

10. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, means drivingly connecting said first rotor to said third rotor for simultaneous rotation at the same speed, said third rotor having a central chamber, said first rotor having a portion extending into said central chamber said connecting means being disposed in said central chamber and being fastened to said portion and to said third rotor, said connecting means comprising a sleeve surrounding said portion, a pair of universal joint couplings secured to the ends of said sleeve, one coupling engaging said portion and the other coupling engaging said third rotor.

11. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, a ring carried by said third rotor, said ring having a sealing engagement with the surface of said second rotor, said third rotor having a groove in said surface, said ring being movably seated in said groove, means resiliently urging said ring outwardly of said groove and into sealing engagement with the surface of said groove and into sealing engagement with the surface of said second rotor, said third rotor having recesses therein each communicating with the bottom of said groove, said resilient means comprising a spring seated in each recess, means connecting said springs to said ring.

12. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, a ring carried by said third rotor, said ring having a sealing engagement with the surface of said second rotor, said third rotor having a groove in said surface, said ring being movably seated in said groove, means resiliently urging said ring outwardly of said groove and into sealing engagement with the surface of said second rotor, said third rotor having recesses therein each communicating with the bottom of said groove, said resilient means comprising a spring seated in each recess, means connecting said springs to said ring, said last mentioned means including fingers on said ring and each extending into said recesses.

13. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, means drivingly connecting said first and second rotor for simultaneous rotation at the same speed, said connecting means comprising a radial notch in said second rotor and a radial and axial projection on said first rotor extending into said notch.

14. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, said inlet and outlet means including passages in said second rotor communicating with said pump chamber.

15. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, means for balancing the fluid pressure on opposite sides of said first and second rotors.

16. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, said inlet and outlet means including passages in said second rotor communicating with said pump chamber, a pressure inlet chamber in said stator at one side of said second rotor, one of said passages communicating with said inlet chamber.

17. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third

rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, said inlet and outlet means including passages in said second rotor communicating with said pump chamber, a pressure inlet chamber in said stator at one side of said second rotor, one of said passages communicating with said inlet chamber, a pressure exhaust chamber in said stator surrounding said second rotor, another of said passages extending to the periphery of said second rotor and communicating with said exhaust chamber.

18. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner wall, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, said first and second rotors having axial stem portions rotatably journaled one in the other.

19. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner walls, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, said first and second rotors having axial stem portions rotatably journaled one in the other, said third rotor having a central chamber receiving said stem portions therein.

20. A variable capacity pump comprising a stator having an annular pump chamber therein, said pump chamber having concentric cylindrical inner and outer walls together with annular side walls, first, second and third

rotors journaled in said stator, said first rotor having a peripheral surface constituting said inner walls, said second rotor having a surface disposed between said inner and outer walls and constituting one of said annular side walls, said third rotor having a surface constituting the other of said side walls, a pump impeller disposed in said pump chamber, fluid inlet and outlet means for said pump chamber, means for moving said second rotor to vary the volume of said pump chamber, said first and second rotors having axial stem portions rotatably journaled one in the other, said third rotor having a central chamber receiving said stem portions therein, a sleeve in said central chamber surrounding said stem portions, said sleeve having a connection with said third rotor and with the stem portion of said first rotor.

21. The combination of claim 1 wherein the peripheral surface of the first rotor has a block firmly attached thereto, said block constituting an impeller for said pumping chamber and having a rear overhanging portion slidably received in the drum of the second rotor whereby to allow horizontal movement of the second rotor but causing the first and second rotors to revolve as a unit about their common axis of rotation.

22. The combination of claim 21 wherein the second rotor has openings in its annular surface on each side of said impeller constituting inlet and exhaust ports, said third rotor having a surface comprising the other of said side walls.

23. The combination of claim 1 wherein the peripheral surface of said first rotor has an impeller extending therefrom and into said pumping chamber, said ring revolving about the axis of rotation of said third rotor and is slidably received therein, said ring having a cut away portion with the impeller located in the latter whereby said ring and impeller effect a pumping action.

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