Jan. 9, 1962 C. S. PRENDERGAST 3,016,017

ROTARY PUMPS AND MOTORS

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FIG. 2.

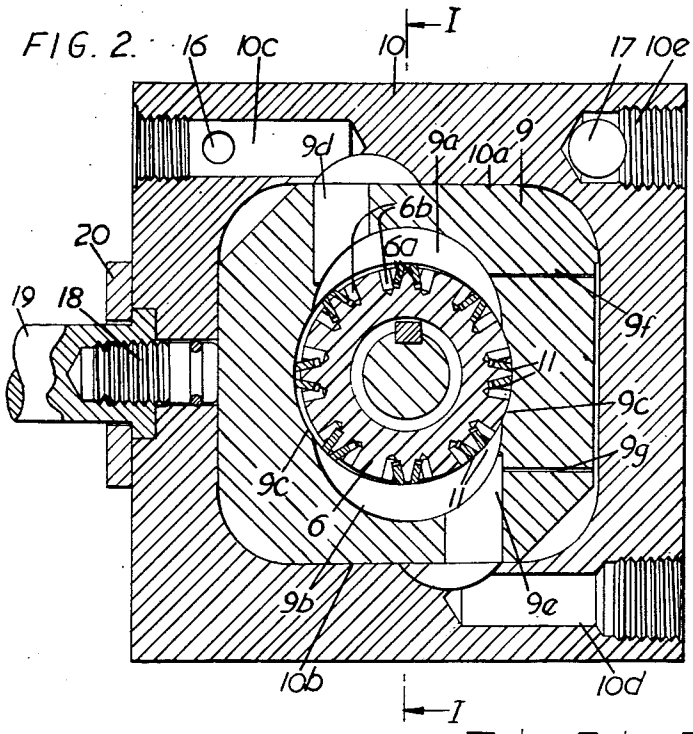
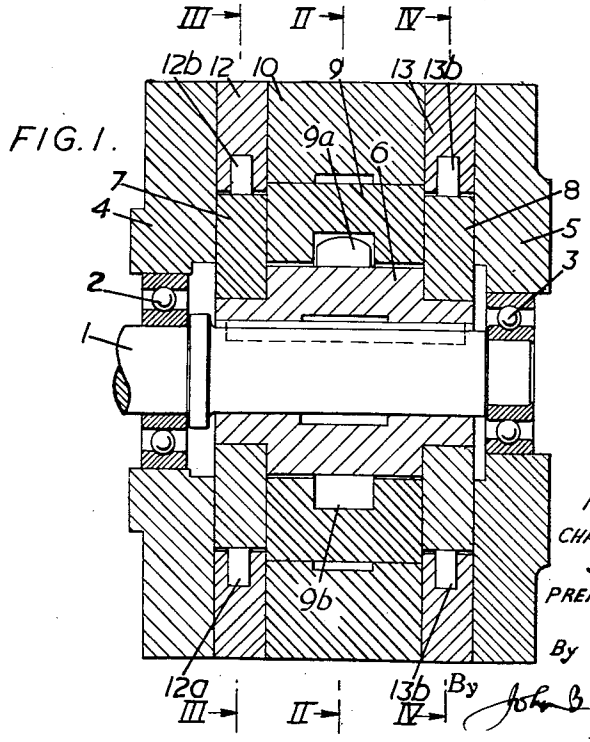


FIG. 1.



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FIG. 3.

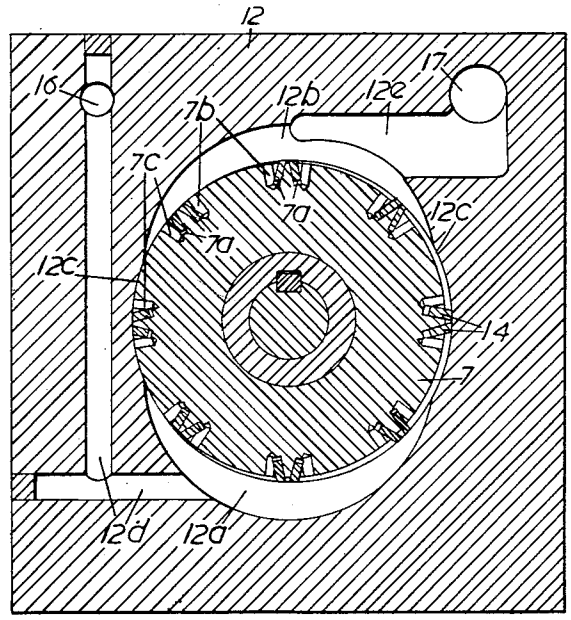
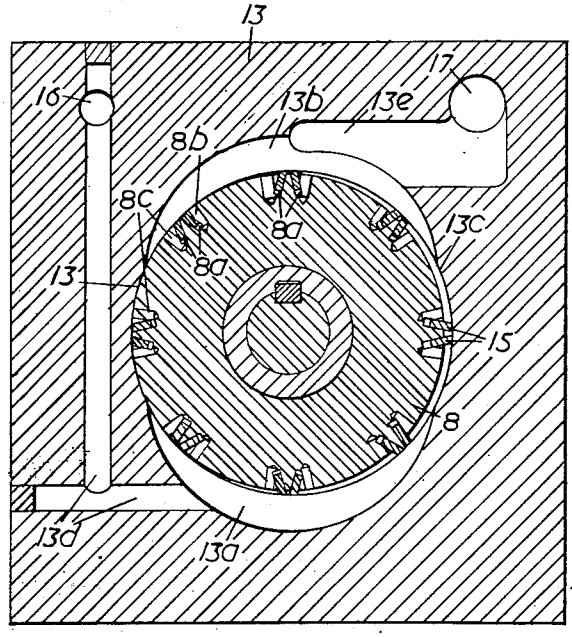


FIG. 4.



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FIG. 5.

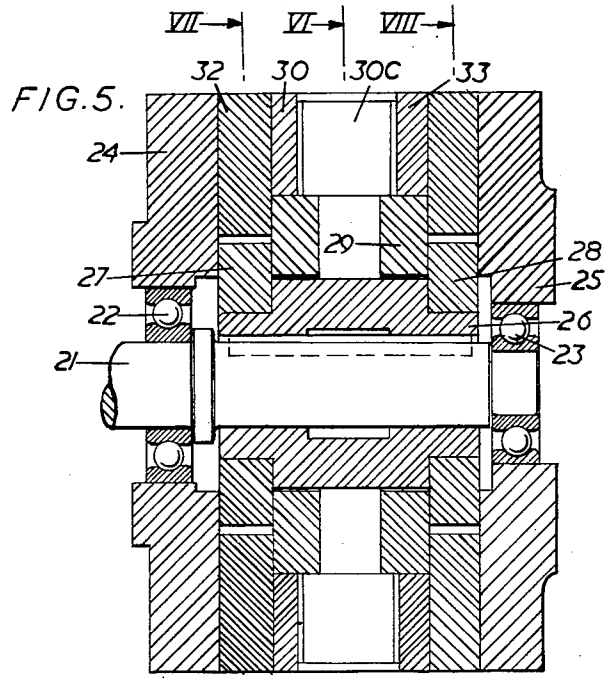
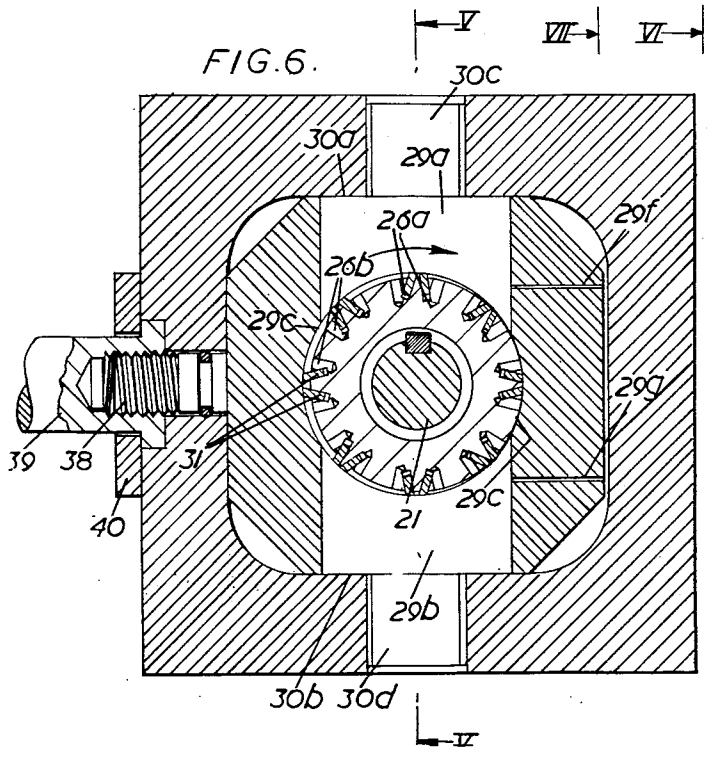


FIG. 6.



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ROTARY PUMPS AND MOTORS

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FIG. 7.

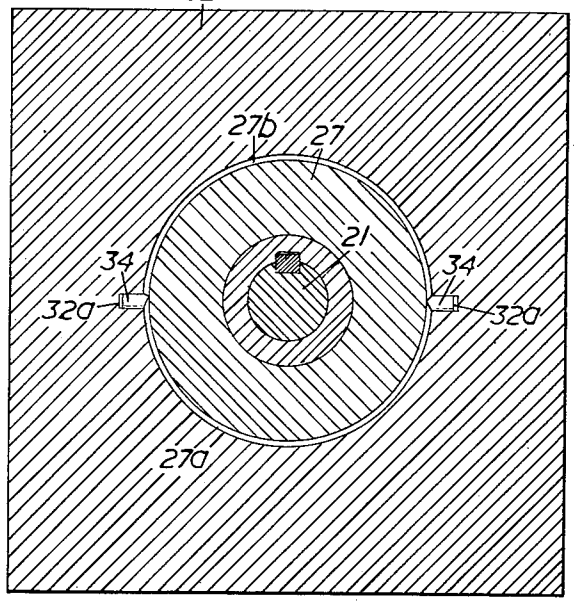
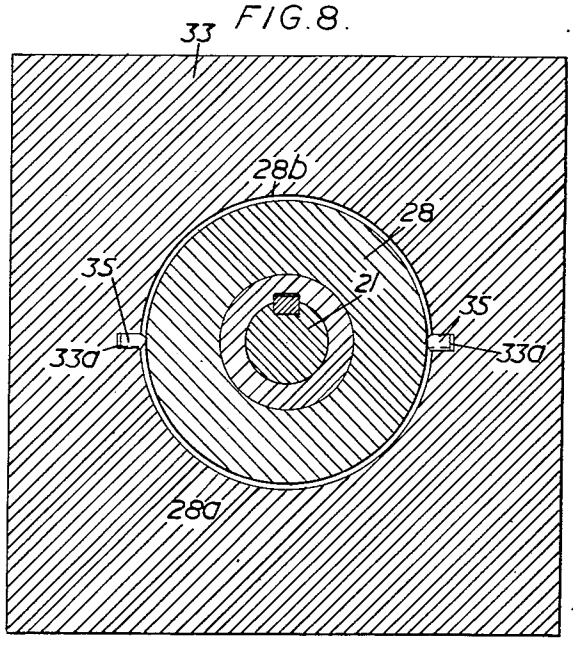


FIG. 8.



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United States Patent Office 3,016,017 Patented Jan. 9, 1962

3,016,017

ROTARY PUMPS AND MOTORS

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Filed Aug. 21, 1959, Ser. No. 835,301
Claims priority, application Great Britain Dec. 23, 1958
6 Claims. (Cl. 103—4)

This invention relates to pumps and motors of the kind having three rotors concentrically mounted and rotatable with a central shaft, a similar number of bored stators surrounding said rotors at least the centre one of which stators is or may be set eccentrically in relation to the axis of the shaft, and vanes slidable in radial grooves in each rotor having an eccentric stator.

An object of the invention is to eliminate the previous necessity in machines of this kind for separating or partitioning plates or like members between the respective fluid chambers.

According to the invention and to the attainment of this object I provide a pump or motor of the aforesaid kind in which the diameter of the centre rotor differs from that of the two end rotors and the product of the diameter and axial width of either of the two end rotors is approximately equal to half the product of the diameter and axial width of the centre rotor. This arrangement provides sealing surfaces between the respective fluid chambers without the necessity for separating or partitioning plates or equivalent members.

The invention is applicable to a pump or motor in which the bores of the stators for all three rotors are eccentric to the shaft axis and in which all three rotors are equipped with vanes slidable in radial grooves therein.

However, the invention is also applicable to a pump or motor in which the bore of the centre stator alone is eccentric to the shaft axis and its rotor is equipped with vanes slidable in radial grooves therein, while the bore of each of the end stators is concentric to the shaft axis and carries two abutments (which may be radially slidable) on approximately the same centre line as the eccentricity of the centre stator, these abutments making sealing contact with the unbroken periphery of the pertaining rotor.

In either case the pump or motor may be so constructed that the eccentricity of the bore of the centre stator is capable of being varied at will as in accordance with my patent application Ser. No. 710,573, now Patent No. 2,972,953.

In order that the invention may be better understood two embodiments thereof as applied to pumps are illustrated by way of example on the accompanying drawings to which reference is now made.

FIG. 1 is a longitudinal section on I—I of FIG. 2.
FIG. 2 is a transverse section on II—II of FIG. 1.
FIG. 3 is a transverse section on III—III of FIG. 1.
FIG. 4 is a transverse section on IV—IV of FIG. 1.
FIG. 5 is a longitudinal section on V—V of FIG. 6.
FIG. 6 is a transverse section on VI—VI of FIG. 5.
FIG. 7 is a transverse section on VII—VII of FIG. 5.
FIG. 8 is a transverse section on VIII—VIII of FIG. 5.

Referring first to FIGURES 1 to 4, a shaft **1** is carried in ball-bearings **2** and **3** mounted in end housings **4** and **5**. Keyed to the shaft but free to slide axially on it is a rotor **6**, and rigidly and concentrically mounted on extensions at opposite ends of the rotor **6** are two other rotors **7** and **8**, all three rotors forming one rotatable unit concentric with the axis of the shaft **1**. The rotors **7** and **8** are identical; they are considerably larger in diameter and shorter in axial width than the central rotor **6**. In fact the diameter of the rotor **7** or **8** multiplied by that rotor's axial width is equal to half the product of the diameter and the axial width of the rotor **6**.

Each of the three rotors **6**, **7**, **8** is provided with eight pairs of equidistant grooves **6***a*, **7***a*, **8***a* respectively, these grooves being of equal depth and extending inwardly from the rotor periphery and their bottoms being connected by ducts **6***b*, **7***b*, **8***b* respectively to said periphery between adjacent pairs of grooves. The construction of each rotor is in accordance with my Patent No. 2,928,350.

Surrounding the rotor **6** is an adjustable stator **9**, approximately the same axial width as this rotor and having a circular bore which is substantially greater in diameter than the rotor but substantially less than a circle inscribed at the bottoms of the grooves **7***a* and **8***a*; surrounding the rotors **7** and **8** are stators **12** and **13** of approximately the same axial width as these rotors and having circular bores which are substantially greater in diameter than the rotors. The described arrangement of the rotors and their stators forms sealing surfaces between the respective fluid chambers without the necessity for separating or partitioning plates thereby simplifying the construction.

The adjustable stator **9** is carried in slides **10***a* and **10***b* in an outer member **10** and has freedom to move transversely in these slides in relation to the rotor **6** from a position where the centre of the stator bore is a predetermined distance on one side of the shaft axis to a position in which it is a predetermined distance on the other side of the shaft axis. Sixteen vanes **11**, approximately the same axial width as the rotor **6**, are free to slide radially in the grooves **6***a*; they maintain contact with the bore of the stator **9** by centrifugal force when the rotor is rotated (with or without the aid of springs). Chambers **9***a* and **9***b* extend radially outwards from the bore of the stator **9** and are separated by equal unbroken portions **9***c* of the stator bore, each of these portions having a greater angular length than the angular distance between adjacent pairs of vanes **11**. The chambers **9***a* and **9***b* are situated on a transverse plane at right angles to that on which the adjustable stator **9** moves. Chamber **9***a* is a pressure chamber and is connected by a duct **9***d* to the pump outlet port **10***c* in the outer member **10**. Chamber **9***b* is a non-pressure chamber and is connected by a duct **9***e* to a non-pressure port **10***d* connected to the fluid reservoir.

The stators **12** and **13** are fixed radially in relation to the rotors **7** and **8**, their bores having a predetermined and identical eccentricity in relation to the shaft axis on the same transverse plane as that on which the adjustable stator **9** moves. Sixteen vanes **14** and sixteen vanes **15**, approximately the same axial width as the rotors **7** and **8**, are free to slide radially in the grooves **7***a* and **8***a* respectively; these vanes maintain contact with the bores of the stators **12** and **13** by centrifugal force when the rotors are rotated (with or without the aid of springs). Chambers **12***a*, **12***b* and **13***a*, **13***b* extend radially outwards from the bores of the stators **12** and **13** respectively, the chambers in each stator being separated by equal unbroken portions of the stator bore **12***c* or **13***c*, each of these portions having a greater angular length than the angular distance between adjacent pairs of the vanes. The chambers **12***a*, **12***b*, and **13***a*, **13***b*, are on transverse planes at right angles to the plane in which the adjustable stator **9** moves. The chambers **12***a* and **13***a* are pressure chambers and are respectively connected by ducts **12***d* and **13***d* to another duct **16** which is on a plane parallel to the shaft axis. Duct **16** connects to the output port **10***c*. The chambers **12***b* and **13***b* are non-pressure chambers and are respectively connected by ducts **12***e* and **13***e* to another duct **17** which is on a plane parallel to the shaft axis. Duct **17** connects to the inlet port **10***e* in the outer member **10**.

When the described pump is adjusted for full flow, the eccentricity of the adjustable stator **9** is at its maximum and is at 180° to the eccentricities of the stators **12** and **13**. There is then a gap between the adjustable stator and the outer member **10**. Small diameter holes **9***f* and **9***g* connect this gap to the pressure chamber **9***a* and the non-pressure chamber **9***b*, thus creating a fluid pressure at this side of the adjustable stator **9** which holds it in the full flow position. When the adjustable stator is in the full flow position and the rotors are rotated, the displacement thus created causes fluid to enter through the ports **10***d* and **10***e* and to be expelled through the outlet port **10***c*.

For the purpose of adjusting the stator **9** at will the outer member **10** is equipped with an adjusting screw **18** and an adjusting nut **19**, which are retained in position by a retaining plate **20**. By rotating the adjusting nut, the adjusting screw can be moved inwards against the adjustable stator **9** forcing it to move towards the other side of the outer member **10**.

When the adjustable stator **9** is moved towards the concentric position the displacement created between it and the rotor **6** is reduced and becomes zero when the stator reaches the concentric position, so that at this point the total displacement of the pump is created between the end rotors **7** and **8** and the end stators **12** and **13**. If the adjustable stator **9** is moved farther to become eccentric with the shaft axis in the same direction as the eccentricities of the stators **12** and **13**, the displacement created between it and the rotor **6** absorbs a proportion of the fluid displaced by the rotors **7** and **8** and this fluid is expelled through the non-pressure port **10***d* back to the reservoir. Under these conditions the rotor **6** is being driven by pressure fluid displaced by the rotors **7** and **8** and the energy represented by this displacement is being returned to the shaft **1**. By moving the adjustable stator **9** far enough in this direction all the fluid displacement by the rotors **7** and **8** is returned to the reservoir through the nonpressure port **10***d* and apart from volumetric and other losses no energy is absorbed by the pump.

Referring now to FIGS. 5 to 8, a shaft **21** is carried in ball-bearings **22** and **23** mounted in end housings **24** and **25**. Keyed to the shaft but free to slide axially on it is a vane-bearing rotor **26** and rigidly and concentrically mounted on extensions at opposite ends of the rotor **26** are two pressure re-action rotors **27** and **28**, all three rotors forming one rotatable unit concentric with the axis of the shaft **21**.

Rotors **27** and **28** are identical; they are larger in diameter and shorter in axial width than the vane-bearing rotor **26**. In fact the diameter of rotor **27** or **28** multiplied by the axial width of that rotor is equal to half the product of the diameter and the axial width of the rotor **26**.

The vane-bearing rotor **26** is provided with eight pairs of equidistant grooves **26***a* of equal depth and extending inwardly from the rotor periphery, and the bottoms of the grooves are connected by ducts **26***b* to said periphery between adjacent pairs of grooves. The construction of the rotor **26** is in accordance with my Patent No. 2,928,350.

Surrounding the rotor **26** is an adjustable stator **29**, approximately the same axial width as the rotor and having a circular bore which is substantially greater in diameter than the rotor but substantially less than the diameter of either of the pressure re-action rotors **27**, **28**; surrounding the pressure re-action rotors **27**, **28** are fixed stators **32**, **33** respectively, approximately the same axial width as the rotors and having circular bores which are concentric with and slightly greater in diameter than the rotors **27**, **28**. This arrangement of the rotors and their stators forms sealing surfaces between the respective fluid chambers without the necessity for separating or partitioning plates.

The adjustable stator **29** is carried in slides **30***a* and **30***b* in an outer member **30** and has freedom to move transversely in these slides in relation to the rotor **26** from a position where the centre of the stator bore is a predetermined distance on one side of the shaft axis to a position approximately concentric with the shaft axis. Sixteen vanes **31**, approximately the same axial width as the rotor **26**, are free to slide radially in the grooves **26***a*; they maintain contact with the bore of the stator **29** by centrifugal force when the rotor is rotated (with or without the aid of springs). Chambers **29***a* and **29***b* extend radially outwards from the bore of the stator **29** and are separated by equal unbroken portions **29***c* of the stator bore, each of these unbroken portions having a greater angular length than the angular distance between adjacent pairs of vanes **31**. The chambers **29***a* and **29***b* are situated on a transverse plane at right angles to that on which the adjustable stator **29** moves. Chamber **29***a* is the outlet chamber and is connected directly to the pump outlet port **30***c* in the outer member **30**. Chamber **29***b* is the inlet chamber and is connected directly to the inlet port **30***d*.

Each of the fixed stators **32** and **33** has two radial grooves **32***a* and **33***a* respectively, which extend radially outwards from the bores of the stators. Two abutments **34** and two abutments **35** are free to slide radially in the grooves **32***a* and **33***a* respectively, and these abutments are constrained to make sealing contact with the pressure reaction rotors **27** and **28** by hydraulic pressure (with or without the aid of springs). Abutments **34** and **35** are situated on a centre line parallel to the slides **30***a* and **30***b* in which the adjustable stator **29** moves. The annular spaces between the pressure reaction rotors **27** and **28** and the fixed stators **32** and **33** are divided into four chambers **27***a*, **27***b* and **28***a*, **28***b* by the abutments **34** and **35**. Chambers **27***a* and **28***a* are connected by ducting (not shown) to the outlet chamber **29***a* and are situated at 180° to it. Chambers **27***b* and **28***b* are connected by ducting (not shown) to the inlet chamber **29***b* and are situated at 180° to it.

Owing to the stated dimensional relationship between the pressure reaction rotors **27** and **28** and the vane-bearing rotor **26**, the sum of the cross-sectional areas of the rotors **27** and **28** is equal to the cross-sectional area of the rotor **26**. As the chambers **27***a* and **28***a* are at 180° to the outlet chamber **29***a* and are hydraulically connected to it, any hydraulic pressure developed in the output chamber **29***a* is balanced by the hydraulic pressures in the chambers **27***a* and **28***a* thus tending to eliminate bearing loading due to internal hydraulic pressure.

When the rotor **26** is rotated fluid is displaced between it and the adjustable stator **29** and by reason of this displacement fluid enters through the inlet port **30***d* and is expelled through the outlet port **30***c*. The volume of fluid displaced can be varied from zero to maximum by adjusting the position of the adjustable stator **29** between the position of concentricity with the shaft axis and the position of maximum eccentricity with the shaft axis.

When the pump is adjusted for full flow, the eccentricity of the adjustable stator **29** is at its maximum. There is then a gap between the adjustable stator and the outer member. Small diameter holes **29***f* and **29***g* connect this gap to the outlet chamber **29***a* and the inlet chamber **29***b* thus creating a fluid pressure at this side of the adjustable stator **29** which holds it in the full flow position. On the opposite side of the outer member **30** are an adjusting screw **38** and an adjusting nut **39** which are retained in position by a retaining plate **40**. By rotating the adjusting nut the adjusting screw can be moved inwards against the adjustable stator **29**, forcing it to move towards the concentric position.

It will be understood by those skilled in the art that although I have described the invention in detail in relation to pumps it is applicable to the construction of hydraulic motors. Further many constructional details

may be modified within the scope of the invention; for instance means other than described may be provided for adjusting the eccentricity of the centre stator.

I claim:

1. A pump or motor comprising end housings; a shaft journalled for rotation in said end housings; three rotors arranged side-by-side with their adjacent surfaces in sealing contact, mounted on and rotatable with said shaft; three bored stators each surrounding one of said rotors to form part annular fluid spaces of equal angular length therewith, at least the bore of the center stator being eccentric to the axis of said shaft; a plurality of vanes equally spaced and slidable in radial grooves formed in at least the center rotor to provide with its stator a series of fluid displacement chambers; fluid inlet and outlet chambers of equal angular length on opposite sides of the plane of eccentricity of at least the center stator bore, lands of equal angular length situated on the circumference of the stator bore separating said inlet and outlet chambers, each land having an angular length at least equal to the angular distance between adjacent rotor vanes; ducting connecting the part annular fluid space on each side of the plane of eccentricity of the center stator to the part annular fluid spaces contained by the end rotors and their stators on the opposite side of said plane; the diameter of the center rotor differing from that of the two end rotors in sealing contact with it, thereby affording sealing surfaces between the respective part annular fluid spaces contained by the three rotors and stators without partitioning members between the rotors, and the product of the diameter and the axial width of each of the end rotors being substantially equal to half the product of the diameter and the axial width of the center rotor thereby insuring that the area under radial hydraulic pressure of the center rotor is approximately equal and opposite to the sum of the areas under hydraulic radial pressure of the two end rotors.

2. A pump or motor as set forth in claim 1, including means for varying at will the eccentricity of the bore of the centre stator.

3. A pump or motor comprising end housings; a shaft journalled for rotation in said end housings; three rotors arranged, side-by-side, with their adjacent surfaces in sealing contact, mounted on said shaft and rotatable with said shaft; three bored stators each surrounding one of said rotors to form part annular fluid spaces of approximately equal angular length therewith, the bores of the stators being eccentric to the axis of said shaft; the eccentricities of the end stators being equal to one another and fixed on coincidental radii on the same plane of eccentricity as the central stator; a plurality of vanes equally spaced and slidable in radial grooves formed in each of said rotors to provide a series of displacement chambers with the bores of their stators; fluid inlet and outlet chambers of equal angular length on opposite sides of the plane of eccentricity of each stator bore, lands situated on the circumference of each stator bore separating said inlet and outlet chambers of each stator, each land having an angular length at least equal to the angular distance between adjacent rotor vanes, ducting connecting the part annular fluid space on each side of the plane of eccentricity of the center stator to the part annular fluid spaces contained by the end rotors and their stators on the opposite side of said plane; the diameter of the center rotor differing from that of the two end rotors in sealing contact with it, thereby affording sealing surfaces between the respective part annular fluid spaces contained by the three rotors and their stators without partitioning members between the rotors, and the product of the diameter and the axial width of each end rotor being substantially equal to half the product of the diameter and the axial width of the center rotor thereby ensuring that the area under radial hydraulic pressure of the center rotor is approximately equal and opposite to the sum of the areas under hydraulic radial pressure of the two end rotors.

4. A pump or motor as set forth in claim 3, including means for varying at will the eccentricity of the bore of the center stator on the same plane as the fixed eccentricities of the end stators.

5. A pump or motor comprising end housings; a shaft journalled for rotation in said end housings; three rotors arranged side-by-side with their adjacent surfaces in sealing contact, mounted on said shaft and rotatable with said shaft; three bored stators each surrounding one of said rotors to form part annular spaces of equal angular length therewith, the bore of the center stator being eccentric to the axis of said shaft and the bores of the end stators being concentric to said axis; a plurality of vanes equally spaced and slidable in radial grooves in the center rotor to form with its stator a series of displacement chambers; two abutments slidable in radial grooves formed in the concentric bore of each end stator and bearing on the pertaining rotor on approximately the same plane as the plane of eccentricity of the center stator bore with the shaft axis; fluid inlet and outlet chambers of equal angular length on opposite sides of the plane of eccentricity of the center stator bore, lands of equal angular length situated on the circumference of the stator bore separating said inlet and outlet chambers, the angular length of each land being at least equal to the angular distance between adjacent rotor vanes; ducting connecting the part annular fluid space on each side of the plane of eccentricity of the center stator to the part annular fluid spaces contained by the end rotors and their stators on the opposite side of said plane; the diameter of the center rotor differing from that of the end rotors in sealing contact with it, thereby affording sealing surfaces between the respective part annular fluid spaces contained by the three rotors and stators without partitioning members between the rotors, and the product of the diameter and the axial width of each of the end rotors being substantially equal to half the product of the diameter and the axial width of the center rotor thereby ensuring that the area under radial hydraulic pressure of the center rotor is approximately equal and opposite to the sum of the areas under hydraulic radial pressure of the two end rotors.

6. A pump or motor as set forth in claim 5, including means for varying at will the eccentricity of the bore of the centre stator.

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