July 22, 1969 O. E. ROSAEN 3,456,593

VARIABLE CAPACITY MECHANISM FOR FLUID PUMPS AND MOTORS

Filed June 26, 1967 4 Sheets-Sheet 1

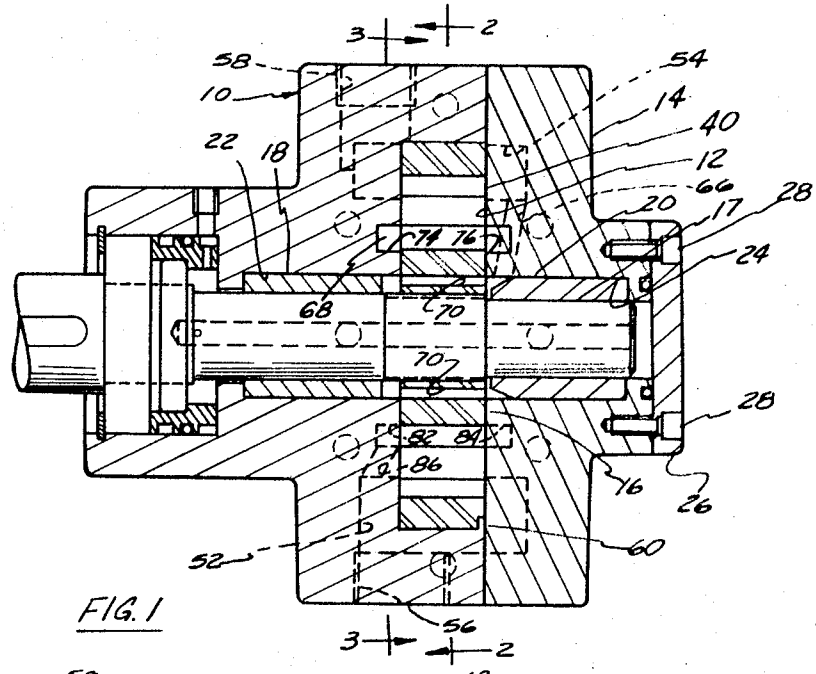


FIG. 1

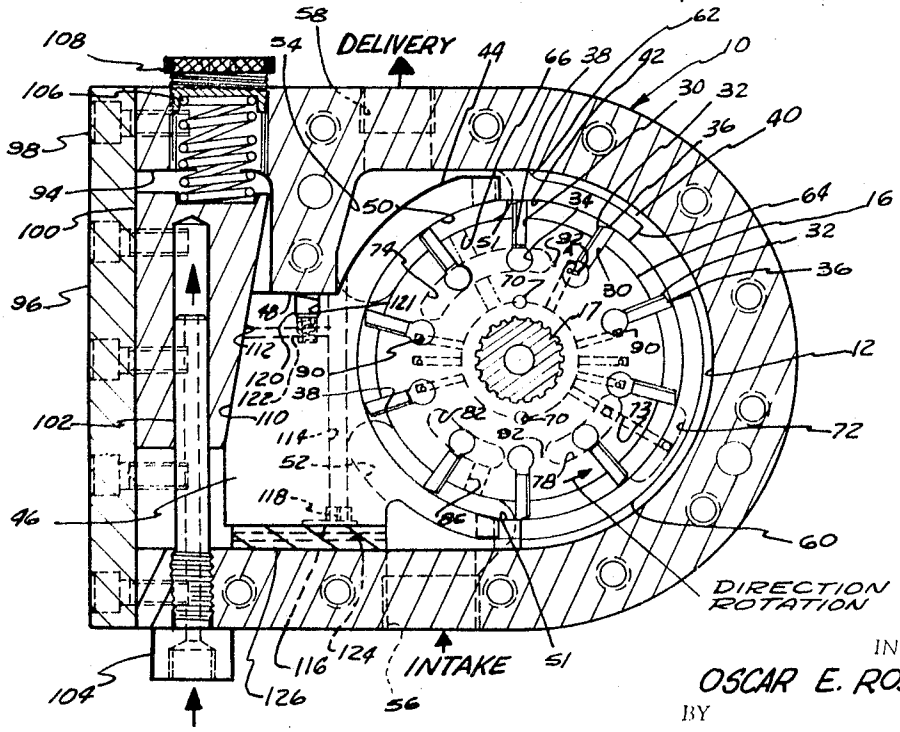


FIG. 2

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VARIABLE CAPACITY MECHANISM FOR FLUID PUMPS AND MOTORS

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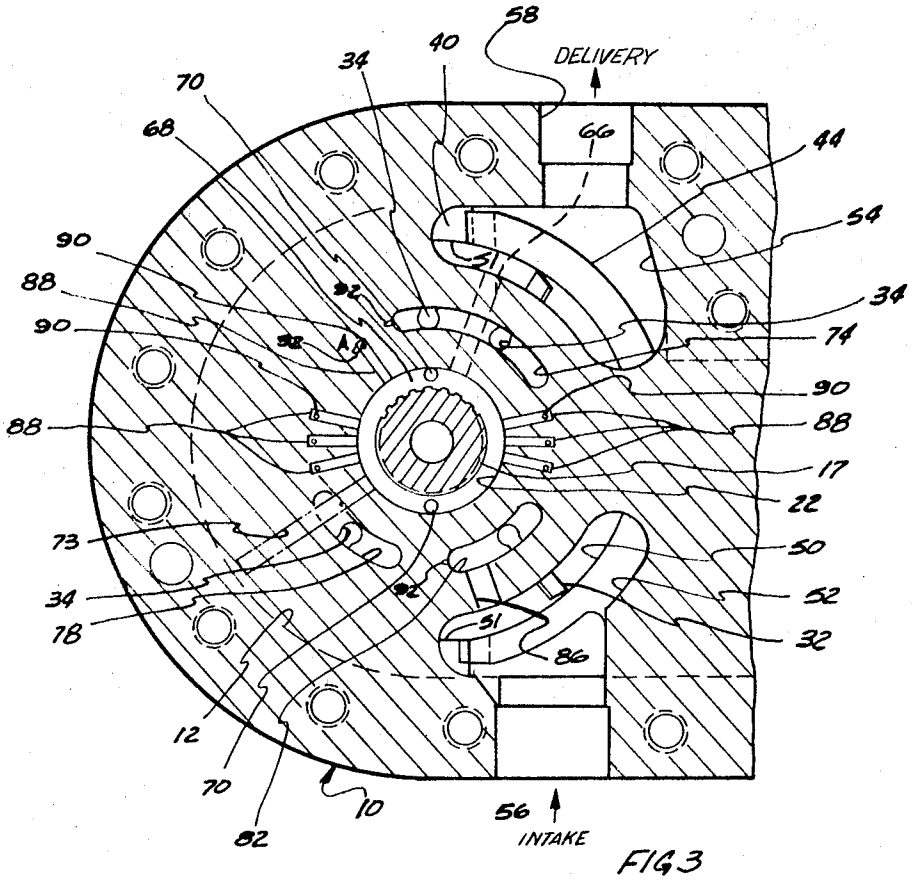


FIG 3

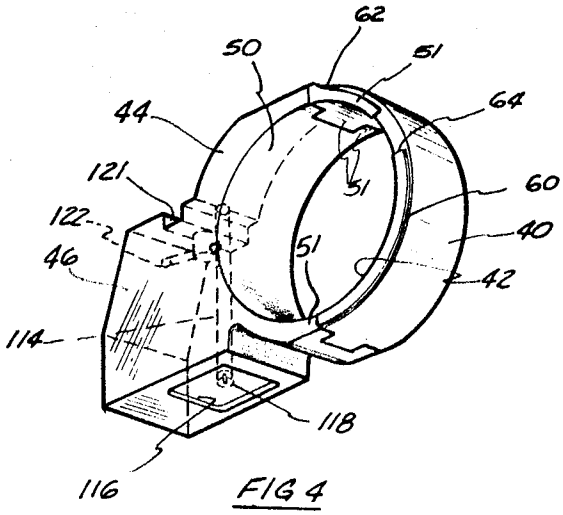


FIG 4

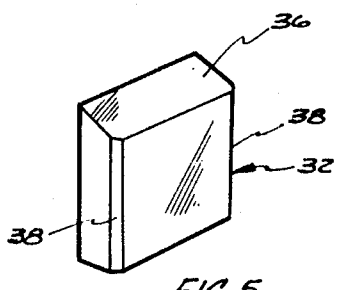


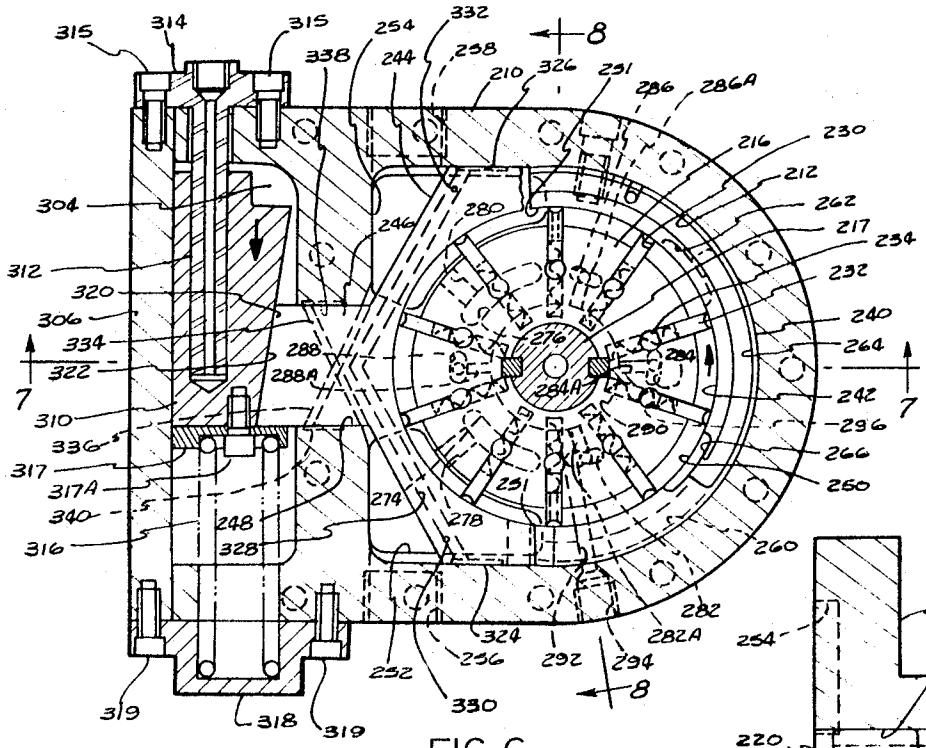
FIG 5

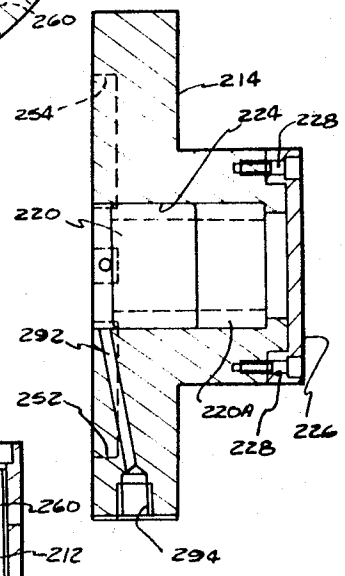
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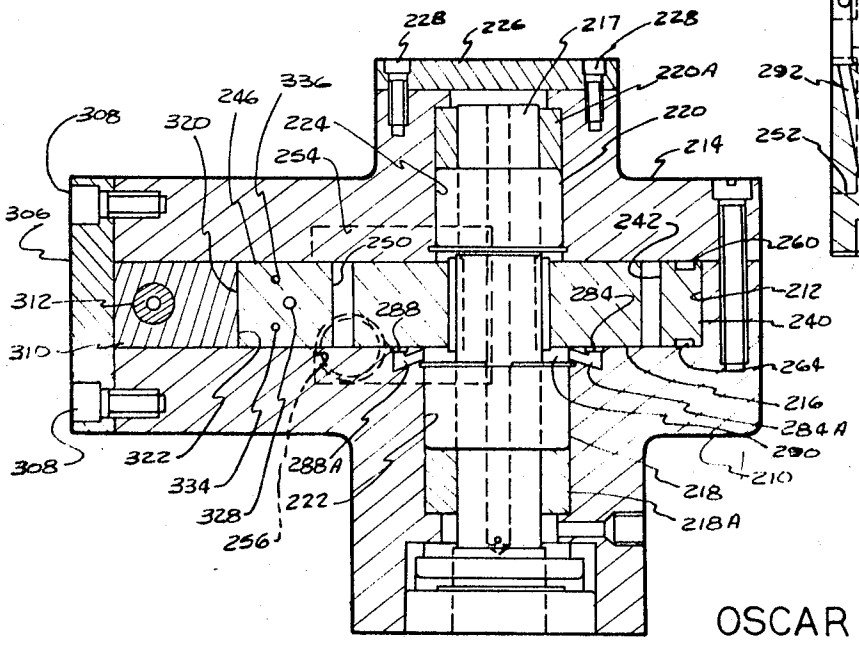
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VARIABLE CAPACITY MECHANISM FOR FLUID PUMPS AND MOTORS

Filed June 26, 1967 4 Sheets-Sheet 3







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VARIABLE CAPACITY MECHANISM FOR FLUID PUMPS AND MOTORS

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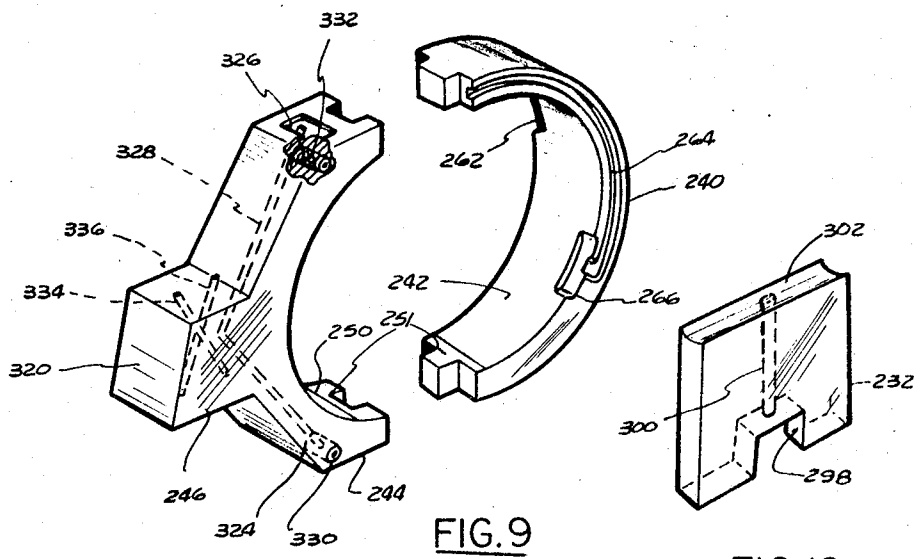


FIG. 9

FIG. 10

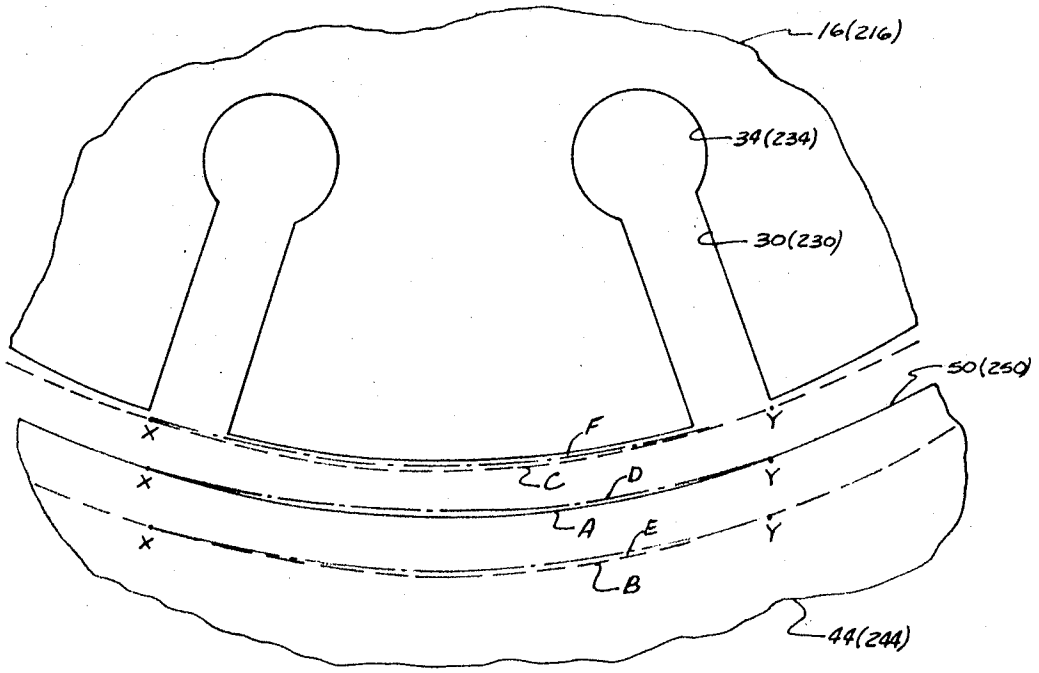


FIG. 11

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VARIABLE CAPACITY MECHANISM FOR FLUID PUMPS AND MOTORS

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Int. Cl. F04c *15/04, 3/00*
U.S. Cl. 103—120 12 Claims

ABSTRACT OF THE DISCLOSURE

A variable capacity mechanism for expansible chamber fluid pumps and motors of the rotary vane type in which the cam means which guide the vanes for extension and retraction in the pumping chamber is divided into two members having substantially semi-circular surfaces, one members being fixed with its cam surface at a substantially constant radius from the rotor, and the other member having a similar cam surface radius and being movable with respect to the rotor, the ends of the cam members having sliding tongue and groove engagement and shaped to be substantially tangent to arcs concentric with the cam for smooth transition of the vanes from the fixed to the movable member and vice-versa, and the movable member being cam actuated responsively to pump delivery or motor working pressure toward and away from said rotor, with means for pressure balancing the rotor, the movable cam member, and the individual vanes, with the cam surface contours and the pressure-balancing being such as will provide a smooth surge-free transition as the vanes move between pressure and suction areas of the pump or motor chamber.

BACKGROUND OF THE INVENTION

Field of the invention

The invention relates to expansible chamber, variable capacity, rotary vane pumps and motors, the pumps having delivery pressure responsive means adjustable to position the vane-guiding cam for maintaining or varying pump delivery volume according to downstream requirement with predetermined substantially constant pressure, and the motors having similarly functioning means for load-compensation depending upon variable working pressure.

Description of the prior art

Patents which indicate means for varying the capacity of a pump or motor of this general type by adjusting a portion of the vane-guiding cam member are the following: U.S. Patent Nos. 1,697,041; 2,031,749; 2,170,786; 2,222,144; 2,458,023; 1,693,540; Swiss Patent No. 101,021; German Patent Nos. 415,472 and 606,178; and Belgian Patent No. 502,418. Additionally, applicant's issued Patent No. 3,272,139 shows a specialized type of variable capacity pump in which a movable cam portion is connected with a fixed cam portion by means of hinged ramp elements, and is adjusted responsively to pump delivery pressure. Problems relating to the above patents include not merely the complexity of construction, but the difficulty in obtaining movable cam adjustment, relatively slower response times, the effects of surge-producing transitional pressures, and presence of other unbalanced forces which will adversely affect the operation of the pump or motor, all of which are corrected by the present variable capacity mechanism.

SUMMARY OF THE INVENTION

In the present pump or motor, the fixed and movable cam ring members have cam surfaces disposed on a radius which is larger than the rotor radius, with the movable cam member adjustable between a position where its radius is substantially concentric to and spaced from the rotor to a position at which the mid-section of the movable cam member is closely adjacent to the rotor, so that fluid moves from the inlet disposed on one side of said mid-section around to the outlet disposed on the other side of said mid-section, with the inlet and outlet respectively connected to diametrically opposite portions of the pump or motor chamber to substantially balance the rotor against unequal forces, and with the individual vanes substantially balanced at all times as they move between differing pressure areas of the chamber. In the case of a pump, there are special restricted orifice pressure ports to the inner ends of the vanes when in transition periods, the orifices admitting pressure proportionately as the same pressure is permitted to escape through passages formed between the vane slots and beveled edges of the vanes on the leading sides thereof. Adjustment of the movable cam member is accomplished through the means of a sliding cam actuator moved in response to pump delivery or motor working pressure as opposed by a spring or the like. Means are provided for balancing the movable cam member against unequal pressure forces acting thereon, so that it can be readily adjusted by the aforesaid actuator. The midsection of the movable cam member, in the chamber area intermediate the inlet and outlet, is contoured such that when it is adjusted to an optimum or normal operational position, the cam arc is substantially concentric with the rotor periphery, producing improved surge-free operation.

DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention may be had by reference to the accompanying drawings illustrating a preferred embodiment of the invention in which like reference characters refer to like parts throughout the several views, and in which:

FIG. 1 is a longitudinal cross-sectional view through a pump of the type described embodying the present invention;

FIG. 2 is a lateral cross-sectional view of the pump taken substantially on the line **2**—**2** of FIG. 1;

FIG. 3 is a fragmentary lateral cross-sectional view taken substantially on the line **3**—**3** of FIG. 1:

FIG. 4 is a perspective view of the cam members of the pump;

FIG. 5 is a perspective view of a preferred vane element for use in the present pump;

FIG. 6 is a lateral cross-sectional view of a fluid motor of the type described embodying the present invention;

FIG. 7 is a longitudinal cross-sectional view of the motor taken substantially on the line **7**—**7** of FIG. 6;

FIG. 8 is a cross-sectional view taken substantially on the line **8**—**8** of FIG. 6 but showing only the motor end cap;

FIG. 9 is a perspective view of the cam members of the motor;

FIG. 10 is a perspective view of a vane element used in the motor of FIGS. 1–9; and

FIG. 11 is an enlarged fragmentary view of the rotor and cam used in the present invention to show contour details.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1–5 illustrate the present invention as embodied in a pump comprising a housing structure **10** having a pumping chamber **12** closed by an end cap structure **14**. A rotor **16** is carried in the pumping chamber **12** and splined to a shaft **17** supported by bearings **18** and **20** respectively carried in coaxial bores **22** and **24** provided through the housing **10** and end cap structure **14**. The

open end of the bore 24 in the end cap 14 is closed by a plate 26 secured thereto by any means such as screws 28.

The periphery of the rotor 16 has a plurality of angularly spaced transverse slots 30 as shown in FIG. 2 in which are radially slidably carried a plurality of vane elements 32, with the inner ends of the vanes 32 being subjected to fluid pressures introduced into transverse bores 34 provided at the inner ends of the slots 30. A vane 32 is shown in FIG. 5 to have an outer beveled end 36 and beveled edges 38 on the leading side thereof (i.e. facing the direction in which the vanes are moving as the rotor rotates as indicated by the directional arrow in FIG. 2).

A fixed cam member 40 is secured in the pumping chamber 12 and encircles approximately one-half of the rotor 16. The cam member 40 has an inner cam surface 42 which is concentric with the rotor outer periphery and radially outwardly spaced therefrom. A movable cam member 44 is disposed in the pumping chamber 12 and has a portion 46 extending oppositely from the fixed cam member 40 and supported for sliding movement in an aperture 48 in the housing structure 10. The movable cam member 44 has an inner cam surface 50 formed on a radius substantially similar to the fixed cam member inner surface 42, except for a media portion to be described, and is adapted for adjustment toward and away from the rotor 16 to move the medial portion of the inner cam surface 50 between a zero or minimum expansion position (shown in FIG. 2), wherein the cam surface 50 is substantially concentric to and spaced from the periphery of the rotor 16 and fluid delivery is zero or minimum, to a maximum delivery position, indicated in FIG. 11, where the medial portion of the inner cam surface 50 is closely adjacent the rotor periphery, the cam surface 50 thereby forming adjacent slopes relative to the rotor periphery to provide adjacent contracting and expanding volumes between successive vanes in the pumping chamber 12 and to guide the vanes 32 for retraction and extension into and out of the slots 30, fluid delivery being at a maximum.

The ends of the cam members 40 and 44 have slidable tongue and groove engagement as seen in FIG. 4, and the ends of the cam surfaces 42 and 50 are flattened as at 51 to be substantially tangent to arcs concentric with the rotor 16, and parallel to the direction of cam member 44 adjustment, so that the vanes 32 will ride smoothly from one cam surface to the other as the rotor rotates, regardless of the adjusted position of the movable cam member 44.

The housing 10 and end cap 14 are arranged to provide an inlet recess 52 adjacent that portion of the movable cam member 44 on one side of its medial portion, and an outlet recess 54 adjacent the other portion of the movable cam member 44 on the other side of its medial portion. The inlet and outlet recesses 52 and 54 are connected through respective inlet and outlet ports 56 and 58 provided in the housing 10 with a source of fluid (not shown) and a fluid pressure user (not shown) respectively. Thus, when the movable cam member 44 has been adjusted toward the rotor 16, fluid will be drawn into the inlet recess 52, carried around the periphery of the rotor 16, to rotate same in a counterclockwise direction as seen in FIG. 2, and discharged through the outlet recess 54, the delivery volume being a function of the proximity of the movable cam member 44 to the rotor 16.

The fixed cam member 40 is provided with an outer peripheral groove 60 extending from the end adjacent and open to the inlet recess 52 to a point 62 closely adjacent and closed off from the outlet recess 54. A gap 64 connects the groove 60 with the pumping chamber 12 at a location adjacent the rotor 16 substantially diametrically opposite the portion of the rotor which is exposed to the inlet recess 52. Pump delivery pressure is introduced through a passage 66 connecting the outlet recess 54 with an annular space 68 adjacent the shaft 17 of the rotor 16, the opposite sides thereof being openly communicated through bores 70 extending through the rotor 16, and the pressure is connected by means of a passage 73 bored in the housing 10 radially outwardly to a small side recess 72 in the fixed cam member 40, the recess 72 being open to the pumping chamber 12 adjacent the rotor 16 at a location substantially diametrically opposite to the chamber portion adjacent the outlet recess 54. Admission of inlet and outlet pressures to these diametrically opposite portions of the rotor tend to balance the rotor against fluid pressure forces which would otherwise exert binding and wear-producing stresses on the rotor 16 and its shaft 17.

It will be seen that as the rotor 16 rotates, the outer ends of the vanes 32 will move between areas of different pressures. These pressures need to be balanced at the inner vane ends with substantially similar pressures to prevent the vanes from being forced against the cam surfaces 42 and 50 with too great a force, or from being retracted into their slots which would eliminate pumping. Therefore, arcuate recesses 74 and 76 respectively are provided in the housing 10 and cap 14 adjacent the pumping chamber 12 along an arc registering with the bores 34 at the inner ends of the vane slots 30, and in that area where the outer ends of the vanes 32 would be subjected directly to pump discharge pressure. The recesses 74 and 76 communicate with pump delivery pressure by means of the aforesaid passage 66 extending toward the hub of the rotor 16. Substantially diametrically opposite, a second set of arcuate recesses, namely recess 78 in the housing and a similar recess (not shown) in the end cap are provided adjacent the pumping chamber 12 on an arc registering with the bores 34 in that area where the outer ends of the vanes 32 are subjected to pressure from the recess 72 previously described. The recess 78 and the end cap recess (not shown) communicate with delivery pressure from the passage 73 extending between annular space 68 and the recess 72.

Other arcuate recesses 82 and 84 are provided respectively in the housing 10 and cap 14 adjacent the pumping chamber 12 on an arc registering with the bores 34 as the vanes move through the area directly adjacent the inlet recess 52. The recesses 82 and 84 are connected by means of a passage 86 with the inlet recess 52.

The aforesaid recesses introduce inlet and outlet pressures to the inner ends of the vanes 32 to provide proper end-to-end balancing thereof as they move.

Passages 88, all substantially the same, extend outwardly from the annular space 68 at the hub of the rotor and are connected through restricted orifices 90 with the pumping chamber 12 on an arcuate line registering with the bores 34 at the inner ends of the vane slots 30. A restricted pressure introduced at these points enables the vanes to move between areas of different pressure (that is, from an inlet pressure area to an outlet pressure area or vice-versa) without any sudden jump in balancing pressures which might tend to damage the vanes, cause noise, and produce undesirable surges of pressure. The orifice 90 at the location diametrically opposite the inlet recess 52 and designated by the letter A in FIGS. 2 and 3 is required to hold the vanes outwardly in an area where they might otherwise tend to part from contact with the cam surface. Also, small grooves 92 are provided at the leading ends of the arcuate recesses 74 and 78, and at the orifice 90 at location A. These grooves 92 serve the purpose of augmenting a smooth, surge-free transition from one balancing pressure to another. The vanes 32, as shown in FIG. 5, have the beveled edges 38 which are constructed to provide communication between the inner and the outer ends of the vanes 32 and are of a total cross-sectional area substantially equal to the cross-sectional area of each of the orifices 90. Thus, the pressure admitted through the orifices 90 will be permitted to escape with controlled flow.

The housing 10 has a side recess 94 closed by a cover plate 96 secured by any means such as screws 98. An

actuator member **100** is slidably supported in the recess **94** on a central tube **102** extending from a fluid fitting **104** as shown in FIG. 2. The tube **102** is hollow for the admission of pump delivery pressure which is conducted to the fitting **104** through a conduit (not shown) or the like connected with the outlet recess **54**. Pressure admitted throguh the tube to the interior of the actuator **100** tends to move the actuator in the direction of the arrow in FIG. 2, and is opposed by a spring **106** compressed between the inner end of the actuator **100** and the recess of an adjustable fitting **108** which can be adjusted to vary spring compression and thus determine the pressure change required to move the actuator member **100**.

The outer end surface **110** of the movable cam member portion **46** is sloped as shown in FIG. 2 at about a ten degree angle from the normal to direction of movement, and abuts a similarly sloped surface **112** of the actuator member **100**, so that as the actuator member **100** is moved laterally back and forth dependent on variations in pressure admitted to its interior, the movable cam member will be cammed toward or away from the rotor **16**. Thus, when the downstream fluid demand of the pump is decreased, for example by closing of a downstream valve, the delivery pressure will tend to increase, moving the actuator **100** against the force of the spring **106**, and the fluid pressure acting on the interior vane-guiding cam surface **50** of the movable cam member **44** will cause the movable cam member to move away from the rotor **16** toward or to the position shown in the drawings to thereby decrease fluid delivery from the pump. As the requirements for fluid pressure are increased, such as by opening a downstream valve, the pressure within the actuator **100** will correspondingly decrease, and the spring **106** will move the actuator to thereby cam the movable cam member **44** radially toward the rotor **16**, to increase pump fluid delivery.

It will be seen that the movable cam member portion **46** is subjected on one side to the delivery pressure of the pump, and therefore a passage **114** through the cam member portion **46** admits pressure fluid to a recess **116** on the other side of the cam member portion **46** through a restricted orifice **118**. The size of the recess **116** is such as will substantially balance the movable cam member portion **46** from side-to-side to prevent a tendency toward binding thereof.

A spring-loaded vane member **120** is provided in a slot **121** on the pressure side of the movable cam member portion **46** to engage the side of the aperture **48** and minimize leakage of pressure therethrough. The inner end of the slot **121** is recessed for the spring and connected with delivery pressure through a passage **122** extending between the pressure passage **114** and the face of the movable cam member sloped surface **110**. The pressure to this surface **110** tends to keep it and the actuator sloped surface **112** from sticking, so that response to pressure moving the actuator member **100** will be instantaneous. Fluid leakage into the side recess **94** will be returned to the inlet recess **52** through a passage **124** in a slide plate **126** secured to the side of the aperture **48** as seen in FIG. 2.

FIGS. 6–10 illustrate the present invention as embodied in a load compensating, expansible chamber fluid motor comprising a housing structure **210** having a working chamber **212** closed by an end cap structure **214**. A rotor **216** is carried in the working chamber **212** and keyed to a shaft **217** supported by roller bearings **218** and **220** along with bushings **218A** and **220A**, respectively carried in coaxial bores **222** and **224** provided through the housing structure **210** and the end cap structure **214**. The open end of the bore **224** in the end cap **214** is closed by a plate **226** secured thereto by any means such as screws **228**.

The periphery of the rotor **216** has a plurality of angularly spaced slots **230** as shown in FIG. 6, in which are radially slidably carried a plurality of vanes **232**, with the inner ends of the vanes **232** being subjected to fluid pressure introduced into transverse bores **234** provided at the inner ends of the slots **230**.

A fixed cam member **240** is secured in the working chamber **212** and encircles approximately one-half of the rotor **216**. The cam member **240** has an inner cam surface **242** which is concentric with the rotor outer periphery and radially outwardly spaced therefrom. A movable cam member **244** is disposed in the working chamber **212** and has a portion **246** extending oppositely from the fixed cam member **240** and supported for sliding movement in an aperture **248** in the housing structure **210**. The movable cam member **244** has an inner cam surface **250** formed on a radius substantially similar to the fixed cam member inner surface **242**, except for a medial portion to be described, and is adapted for adjustment toward and away from the rotor **216** to move the medial portion of the inner cam portion **250** between a zero or minimum expansion position (shown in FIG. 6), wherein the cam surface **250** is substantially concentric to and spaced from the periphery of the rotor **216**, and the motor is working at minimum load, to a maximum expansion position, indicated in FIG. 11, where the medial portion of the inner cam surface **250** is closely adjacent the rotor periphery, the came surface **250** thereby forming adjacent slopes relative to the rotor periphery to provide adjacent contracting and expanding volumes between successive vanes in the working chamber **212** and to guide the vanes **232** for retraction and extension into and out of the slots **230**, the motor working at maximum load.

The ends of the cam members **240** and **244** have slidable tongue and groove engagement as seen in the exploded view of FIG. 9, and the ends of the came surfaces **242** and **250** are flattened as at **251** to be substantially tangent to arcs concentric with the rotor **216**, and parallel to the direction of cam member **244** adjustment, so that the vanes **232** will ride smoothly from one cam surface to the other as the rotor **215** rotates, regardless of the adjusted position of the movable cam member **244**.

The housing **210** and end cap **214** are arranged to provide recesses **252** and **254** respectively adjacent portions of the movable cam member **244** on the two sides of its medial portion. These recesses **252** and **254** are connected through respective ports **256** and **258** provided in the housing **210** with a source of fluid under pressure (not shown) and a fluid reservoir (not shown). The motor is constructed symmetrically so that either of the ports **254** or **256** may serve as inlet or outlet ports, for operation of the rotor **216** in either direction.

For the purpose of the following discussion, the motor will be described by assuming that fluid under pressure is supplied to the port **256**, and the port **258** is connected with a reservoir. Thus the recess **252** will be described as the "inlet" recess and the recess **254** will be described as the "outlet" recess. Thus, with the movable cam member **244** adjusted toward the rotor **215**, fluid from the inlet recess **252** will move the vanes **232**, and consequently rotate the rotor **216** in a counterclockwise direction as seen in FIG. 6, the fluid moving around the periphery of the rotor **216** to be discharged through the outlet recess **254**, the volume of working fluid performing useful work being a function of the proximity of the movable cam member **244** to the rotor **216**.

The fixed cam member **240** is provided with an arcuate groove **260** on one side extending from the end adjacent and open to the inlet recess **252** to a recess **262** open to the working chamber **212** at a location adjacent the rotor **216** substantially diametrically opposite the portion of the rotor which is exposed to the inlet recess **252**. A second arcuate groove **264** extends from the end of the fixed cam member **240** adjacent and open to the end of the outlet recess **254** to a recess **266** opening to the working chamber **212** at a location adjacent the rotor **216** substantially diametrically opposite the portion of the rotor which is exposed to the outlet recess **254**. Admission of

the inlet and outlet pressure to these diametrically opposite portions of the rotor tends to balance the rotor against fluid pressure forces which would otherwise exert binding and wear producing stresses on the rotor **216** and its shaft **217**.

It will be seen that as the rotor **216** rotates, the outer ends of the vanes **232** will move between areas of different pressures. These pressures need to be balanced at the inner vane ends with substantially similar pressures to prevent the vanes from scoring the cam surfaces or from being retracted into their slots. Therefore, arcuate recesses **274** and **276** are provided in the housing **210** adjacent the working chamber **212** along arcs registering with the bores **234** at the inner ends of vane slots **230** and in those areas where the outer ends of the vanes **232** are subjected directly respectively to inlet and outlet pressures. The recesses **274** and **276** communicate respectively with the recesses **252** and **254** by means of passages **278** and **280** respectively provided in the housing **210**.

Other arcuate recesses **282**, **284**, **286**, and **288** are provided in the housing **210** adjacent the working chamber **212** on arcs registering with bores **234** as the vanes move through areas in which their ends are not subjected directly to pressures connected with either the inlet or the outlet. Radial passages **282A**, **284A**, **286A** and **288A** connect the respective recesses **282**, **284**, **286**, and **288** with an annular space **290** provided in the housing at the hub of the rotor **216** around the shaft **217**. This annular space **290** is provided with fluid, under pressure corresponding to the pressure of the working fluid at the inlet to the motor, through a passage **292** terminating in a port **294** adapted for connection with any suitable conduit or the like. Introduction of pressure fluid beneath the vanes in these areas will maintain the vanes in contact with the cam ring members. Additionally, each vane is at all time urged outwardly by lightweight springs **296** which are seated in holes extending radially inwardly from the bores **234**. These bores are axially aligned with the slots **230**, and the springs **296** engage in recesses **298** provided in the bases of the vanes **232** as shown in FIG. 10. This will insure that on starting the motor, and at any time that pressure may be interrupted, the vanes will remain in contact with the cam members. The vanes **232** are balanced end-to-end by the provision of passages **300** extending from the recess **298** outwardly to the ends of the vanes which are arcuately grooved as at **302** so that only the extreme leading and trailing edges of the outer ends of the vanes are contacting the cam surfaces and the outer ends of the vanes are therefore subjected to the pressures communicated thereto through the passages **300**.

The housing **210** has a centrally positioned side recess **304** closed with a cover plate **306** secured by screws **308** or the like. An actuator member **310** is slidably supported in the recess **304** on a tube **312** extending inwardly from a fluid fitting **314** secured to the housing **210** and the cover **306** by any means such as screws **315** as shown in FIG. 6. The tube **312** is hollow for the admission of motor working pressure which is conducted to the fitting **314** through a conduit (not shown) or the like connected with the source of working fluid. Pressure admitted through the tube **312** to the interior of the actuator **310** tends to move the actuator in the direction of the arrow shown on the actuator member **310** in FIG. 6, and is opposed by a spring **316** compressed between an abutment plate **317** secured to the inner end of the actuator **310** by a screw **317A** or the like and the recess of a closure cap **318** secured to the housing and cover plate **306** by any means such as screws **319**.

The outer end surface **320** of the movable cam member portion **246** is sloped as shown in FIG. 6 at about a ten degree angle from the normal to direction of movement, and abuts a similarly sloped surface **322** of the actuator member **310**, so that as the actuator member **310** is moved laterally back and forth dependent on variations in pressure admitted to its interior, the movable cam member will be cammed toward or away from the rotor **216**. Thus, when the load on the motor is increased tending to slow down the motor, the working pressure will tend to increase, moving the actuator **310** against the force of the spring **316** to thereby cam the member **244** radially toward the rotor, effecting an increase in the working force produced by the motor. Conversely, as the load on the motor decreases tending to permit the motor to speed up, the fluid working pressure will tend to decrease, and the pressure within the actuator **310** will correspondingly decrease so that the spring **316** will move the actuator in the opposite direction, and the fluid pressure acting on the interior vane-guiding cam surface **250** on the movable cam member **244** will cause the movable cam member to move away from the rotor **216** toward or to the position shown in FIG. 6, effecting a decrease in the working force produced by the motor. The movable cam member **244** will be prevented from moving to a fully unloaded position by having the abutment plate **317** adjusted to contact the cam member **244** just prior to the time it would become completely unloaded, to thereby keep some load so that the rotor will not overspeed.

It will be seen that the movable cam member **244** is subjected to pressures tending to force its end radially outward against the housing, and therefore the cam member portion **246** needs to be balanced against these pressures. As seen in FIGS. 6 and 9, recesses **324** and **326** are provided on the sides of the movable cam member **244** and are interconnected by a passage **328**. When the recess **252** is connected with working pressure, it is admitted to the passage **328** through a check valve **330**. When the recess **254** is connected with working pressure, the pressure is admitted to the passage **328** through a similar check valve **322** on the other side as shown in FIG. 6. This pressure admitted to both sides of the movable cam member **244** prevents binding thereof as it moves axially toward and away from the rotor **216**. Further, one side or the other of the extending portion **246** of movable cam member **244** is subjected to working pressure from the recess **252** or **254** (depending on which way the motor is working), and to compensate for this unbalancing, a pair of passages **334** and **336** extend from spaces communicating respectively with the recesses **252** and **254** to opposite sides of the extending portion **246** to admit the working pressure to respective recess **338** or **340** provided on the sides of the aperture **248** in the housing **210**.

FIG. 11 is a greatly enlarged view of the previously mentioned medial portion of the movable cam member **44** (or **244**) intermediate the inlet and outlet of the pump or motor, and a corresponding portion of the rotor **16** (or **216**), illustrating the cam surface **50** (or **250**) in a normal operating position (solid-line A) about half-way between the minimum expansion position (dash-line B) and the maximum expansion position (dash-line C), the enlargement illustrating an important feature of the invention. In the solid-line position shown, the actual contour of the medial portion between points X and Y is on a radius concentric with the peripheral surface of the rotor **16** (or **216**), so that in normal operation there will be no sudden transition between contraction and expansion of the fluid chamber which I have found will otherwise tend to produce disruptive surges in fluid pressures. The remainder of the cam surface **50** (or **250**) beyond the points X and Y is radiused similarly to the radius of the fixed cam member **40** (or **240**) so that the ends of the cams always meet. The dot-dash lines D, E and F indicated in FIG. 11 illustrate how the medial portion between points X and Y would appear respectively at the normal, minimum expansion, and maximum expansion positions if the cam surface **50** (or **250**) medial portion were radiused like the rest of the surface beyond the points X and Y. Thus it is apparent that this slight devia-

tion from constant radius in the medial portion will have little effect at either the minimum or maximum positions, yet in or near normal operating position the surge-free function will be effective.

Although I have described and shown only one modification of my invention, it will be apparent to one skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. A variable capacity mechanism for expansible chamber fluid pumps and motors comprising:

(a) a housing having a fluid chamber,

(b) a rotor in said chamber and angularly spaced radially slidable vanes carried by said rotor,

(c) cam means contacting and guiding said vanes for sliding operation as said rotor turns, said cam means having:

(1) a fixed cam member having an inner surface substantially concentric to and outwardly spaced from approximately one-half of said rotor,

(2) a movable cam member having an inner surface radius substantially similar to the fixed member inner surface radius and movable between a minimum expansion position substantially concentric to and outwardly spaced from the other approximately one-half of said rotor and a maximum expansion position in which the mid-section of the movable cam member inner surface is disposed closely adjacent the rotor,

(d) an inlet to said chamber adjacent said other one-half of said rotor at one side of said midsection of the movable cam member,

(e) an outlet connected to said chamber adjacent said other one-half of said rotor at the other side of said midsection of the movable cam member, and

(f) the separation between said inlet and outlet being greater than the spacing between any two successive vanes.

2. The mechanism as defined in claim **1** and in which the ends of said cam members have slidable tongue and groove engagement and in which the inner surfaces of the cam member ends are approximately tangent to arcs concentric to the rotor and extend parallel with the direction of movement of said movable cam member.

3. The mechanism as defined in claim **1** and in which:

(a) said housing has an aperture extending radially outward from said fluid chamber on the side opposite said fixed cam member,

(b) said movable cam member has a portion carried by and radially slidable in said aperture, and

(c) said housing carries means operatively connected with the movable cam member and adjusting same radially toward and away from said rotor responsive to fluid pressure.

4. The mechanism as defined in claim **3** and in which said last-mentioned means comprises an actuator having a camming surface slidably coacting with a cammed surface on said movable cam member, and pressure responsive means operable to adjust said actuator relative to said movable cam member for camming same toward and away from said rotor.

5. The mechanism as defined in claim **3** and in which:

(a) said movable cam member slidably carried portion has a cammed surface on the side opposite the inner surface which contacts said vanes and sloped at an angle to a plane extending normal to the movable cam direction of movement,

(b) an actuator having a camming surface slidably coacting with said movable cam member cammed surface, and

(c) pressure responsive means operable to adjust said actuator relative to said movable cam member for camming same toward and away from said rotor.

6. The mechanism as defined in claim **3** and in which:

(a) said movable cam member slidably carried portion has a cammed surface on the side opposite the inner surface which contacts said vanes and sloped at an angle of about ten degrees to a plane extending normal to the movable cam direction of movement,

(b) an actuator having a camming surface slidably coacting and complementary with said movable cam member cammed surface, and

(c) pressure responsive means operable to adjust said actuator relative to said movable cam member for camming same toward and away from said rotor.

7. The mechanism as defined in claim **5** when used in a pump and in which:

(a) said actuator has means resiliently urging same toward a direction camming the movable cam member toward said rotor for increasing pump delivery,

(b) means opposing said resilient urging means with a pressure proportional to tendencies of said pump to increase delivery pressure, and

(c) said movable cam portion is urged radially outwardly from said rotor by pump pressure directed against said inner cam surface.

8. The mechanism as defined in claim **5** when used in a motor and in which:

(a) said actuator has means resiliently urging same toward a direction permitting the movable cam member to move away from said rotor for decreasing the motor working force,

(b) means opposing said resilient urging means with a pressure proportional to motor inlet pressure as determined by the load on said motor, and

(c) said movable cam portion is urged radially outwardly from said rotor by working pressure directed against said inner cam surface.

9. A variable capacity mechanism for expansible chamber fluid pumps and motors comprising:

(a) a housing having a fluid chamber,

(b) a rotor in said chamber and angularly spaced radially slidable vanes carried by said rotor,

(c) cam means contacting and guiding said vanes for sliding operation as said rotor turns, said cam means having:

(1) a fixed cam member having an inner surface substantially concentric to and outwardly spaced from approximately one-half of said rotor,

(2) a movable cam member having an inner surface radius substantially similar to the fixed member inner surface radius and movable between a minimum expansion position substantially concentric to and outwardly spaced from the other approximately one-half of said rotor and a maximum expansion position in which the midsection of the movable cam member inner surface is disposed closely adjacent the rotor,

(d) an inlet to said chamber adjacent said other one-half of said rotor at one side of said midsection of the movable cam member,

(e) an outlet connected to said chamber adjacent said other one-half of said rotor at the other side of said midsection of the movable cam member, and

(f) means connecting said inlet and outlet with said fluid chamber diametrically opposite respectively said inlet and outlet to tend to balance pressures radially directed on said rotor.

10. A variable capacity mechanism for expansible chamber fluid pumps and motors comprising:

(a) a housing having a fluid chamber,

(b) a rotor in said chamber and angularly spaced radially slidable vanes carried by said rotor,

(c) cam means contacting and guiding said vanes for sliding operation as said rotor turns, said cam means having:

(1) a fixed cam member having an inner surface substantially concentric to and outwardly spaced from approximately one-half of said rotor,

(2) a movable cam member having an inner surface radius substantially similar to the fixed member inner surface radius and movable between a minimum expansion position substantially concentric to and outwardly spaced from the other approximately one-half of said rotor and a maximum expansion position in which the midsection of the movable cam member inner surface is disposed closely adjacent the rotor,

(d) an inlet to said chamber adjacent said other one-half of said rotor at one side of said midsection of the movable cam member,

(e) an outlet connected to said chamber adjacent said other one-half of said rotor at the other side of said midsection of the movable cam member, and

(f) said rotor having angularly spaced slots in its periphery carrying said vanes for radial extension and retraction thereof as guided by said cam means,

(g) means connecting the inner ends of said vanes to inlet and outlet pressures varying to effect balancing of said vanes as they move into areas of different pressures,

(h) said vanes having means restrictingly connecting the inner ends to the outer leading side ends, and

(i) means connecting the inner vane ends to pressure restricted proportionately with the aforesaid restrictingly connecting means as said vanes move from outlet-connected to inlet-connected areas of said chamber whereby to provide gradual changes in balancing pressures.

11. The mechanism as defined in claim **1** and including means pressure balancing said movable cam member normally with respect to the direction of cam member movement and to the axis of said rotor.

12. A variable capacity mechanism for expansible chamber fluid pumps and motors comprising:

(a) a housing having a fluid chamber,

(b) a rotor in said chamber and angularly spaced radially slidable vanes carried by said rotor,

(c) cam means contacting and guiding said vanes for sliding operation as said rotor turns, said cam means having:

(1) a fixed cam member having an inner surface substantially concentric to and outwardly spaced from approximately one-half of said rotor,

(2) a movable cam member having an inner surface radius substantially similar to the fixed member inner surface radius and movable between a minimum expansion position substantially concentric to and outwardly spaced from the other approximately one-half of said rotor and a maximum expansion position in which the midsection of the movable cam member inner surface is disposed closely adjacent the rotor,

(d) an inlet to said chamber adjacent said other one-half of said rotor at one side of said midsection of the movable cam member,

(e) an outlet connected to said chamber adjacent said other one-half of said rotor at the other side of said midsection of the movable cam member, and

(f) said movable cam member inner surface having a medial portion extending between the inlet and outlet and radiused to be concentric with the rotor periphery only when the movable cam member is positioned about midway between its minimum and maximum expansion positions, the remainder of said movable cam member inner surface being substantially concentric with the rotor periphery only when the movable cam member is positioned at its minimum expansion position.

References Cited

UNITED STATES PATENTS

1,693,540	11/1928	Balsiger.
2,170,786	8/1939	McElroy et al.
2,238,786	4/1941	Warman.
3,117,528	1/1964	Rosaen.
3,272,139	9/1966	Rosaen.

FOREIGN PATENTS

502,418	4/1951	Belgium.
415,472	6/1925	Germany.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,456,593 Dated July 22, 1969

Inventor(s) Oscar E. Rosaen

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

IN THE SPECIFICATIONS:

Column,1,line 16, change "members"to --member--.

Column 6, line 25, change "came" to --cam--.

Column 6, line 33, change "came" to --cam--.

SIGNED AND
SEALED
APR 28 1970

(SEAL)
Attest:

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