June 14, 1960 C. V. ZIEG ET AL 2,940,399

HYDRO-BALANCED PUMP

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Fig. 1.

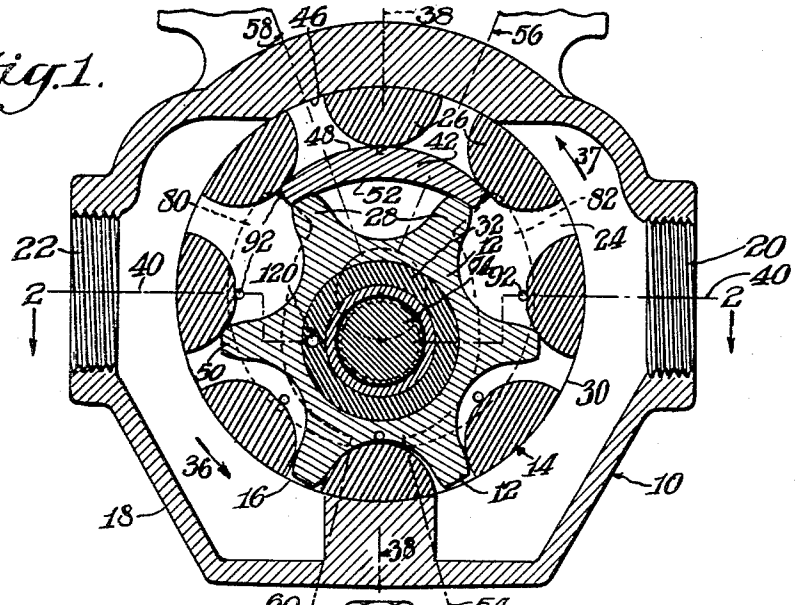
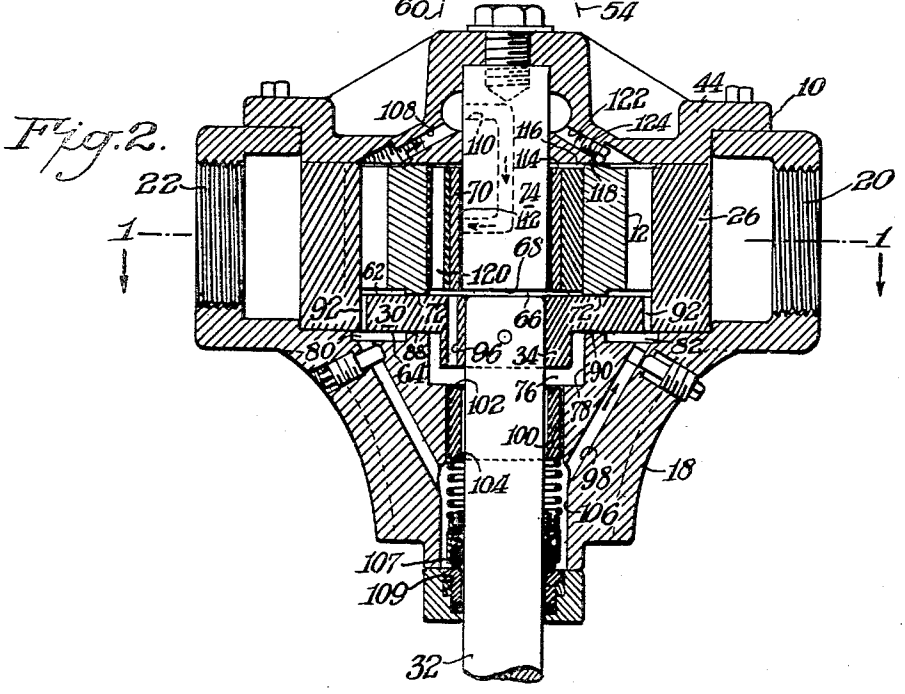


Fig. 2.



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Fig. 3.

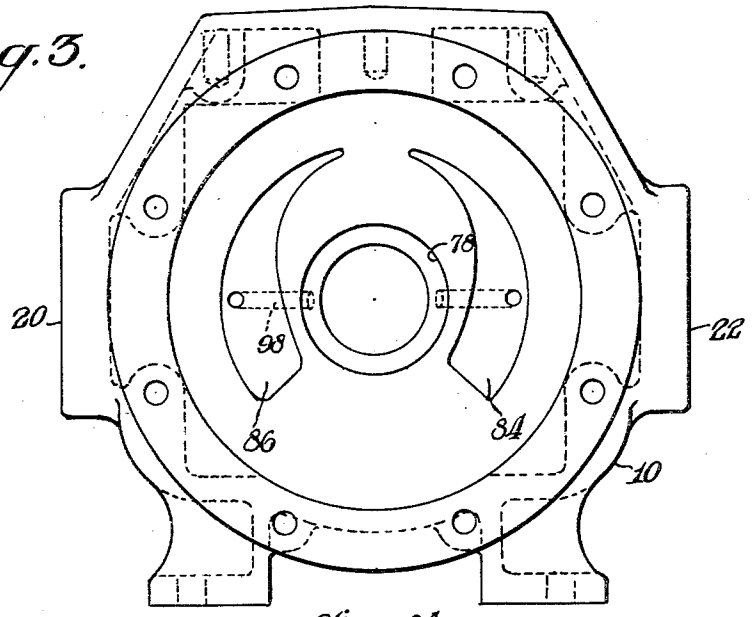


Fig. 4.

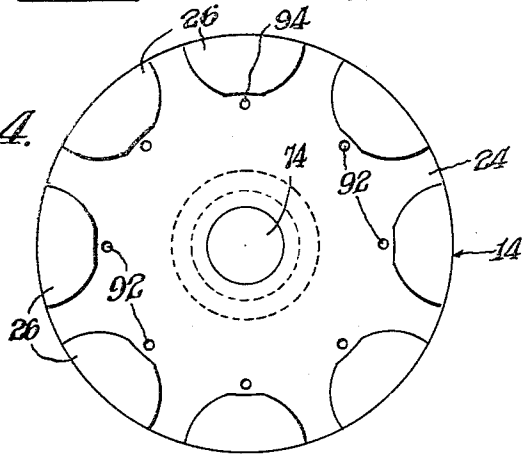
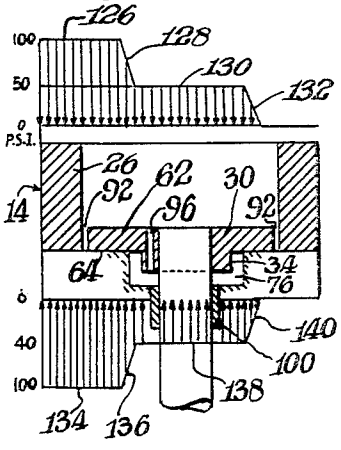


Fig. 5.



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2,940,399

HYDRO-BALANCED PUMP

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11 Claims. (Cl. 103—126)

This invention relates to a rotary gear pump of the type which includes an inner rotor eccentrically meshed within an outer rotor, and more particularly relates to a pump of this type in which means are provided for balancing the pressure forces acting on the rotors.

In rotary gear pumps of the type having an inner rotor eccentrically meshed within an outer rotor, the outer rotor generally incorporates a cylindrical disc having gear teeth extending longitudinally from its outer periphery. During operation, a differential pressure is created across portions of the disc lying between the inlet and outlet ports. This differential pressure reacts unevenly upon the front face of the disc causing bending stresses to be set up in the rotor disc and shaft and urging the disc against the casing in areas exposed to relatively higher discharge pressures.

Other problems encountered with this type of pump are the transmission of excessively high fluid-squeezing forces to the rotor teeth when they are intermeshed and the difficulty of insuring adequate lubrication for the inner rotor or idler gear bearing. Various attempts have been made to solve each of these problems individually, but heretofore, no simple and economical unitary scheme for simultaneously solving or eliminating each or all of the aforementioned problems has been either proposed or put into practice.

An object of this invention is to provide a simple and economical unitary scheme for balancing the pressure forces reacting upon the rotors and for preventing the creation of excessive fluid-squeezing forces between the intermeshing teeth of a rotary gear pump incorporating eccentrically meshed inner and outer rotors.

Another object of this invention is to provide a unitary scheme of the aforementioned type which also lubricates the bearings.

In accordance with this invention, the pressures reacting upon both faces of the outer rotor disc are equalized by providing balanced sets of pockets of fluid under pressure reacting against the front and back faces of the disc. Axially aligned pockets of these sets are connected by equalizing passageways extending through the disc.

One of these pockets lying adjacent the front of the disc is created by recessing the front face of the hub of the inner rotor. This provides a centrally disposed cylindrical pocket surrounded by a pressure-sealing rim which engages in sliding contact with the front face of the disc. Outer pressure pockets or areas, which are constituted by the portions of the disc exposed to suction and discharge pressure, surround this rim on two sides.

One pressure pocket in contact with the back of the disc is provided by recessing a portion of the casing disposed adjacent the back face of the disc in an annular area disposed about the hub of the disc. The outside diameter of this annular recess is substantially equal to that of the cylindrical recess in the hub of the inner rotor.

Outer pressure areas or pockets in contact with the back of the disc are provided by recessing portions of

the casing substantially axially aligned and substantially equal in area with the areas at the front of the disc which are exposed to the suction and discharge pressures. The portions of the casing lying between these recessed pressure areas are constructed and arranged to engage the back of the disc in sliding contact to provide pressure-sealing barriers disposed adjacent the back of the disc which maintains a pressure differential between the fluids in the central and outer recesses. Any slight leakage which occurs between these pressure-sealing barriers and the face of the disc does not prevent this pressure differential from being maintained. The sealing area of these barriers is made substantially equal to the area of the annular rim of the inner rotor which contacts the face of the disc to permit the rim and barriers to maintain similar differential pressures. The rim is, therefore, also referred to as a pressure-sealing barrier.

Equalizing passageways are bored axially through the disc, for example, adjacent the tips of the outer rotor teeth and on their center lines. Another passageway connects the recessed annular area of the casing with a portion of the pump cavity communicating with the suction port. Still another equalizing passageway is provided extending through the inner rotor hub and connecting the pressure pockets adjacent the central portions of both sides of the disc. These passageways in conjunction with the aforementioned recesses and pressure-sealing barriers maintain balanced films of fluid flowing on both sides of the disc from the outer pocket disposed adjacent the discharge port to the inner pockets disposed adjacent the central portions of the disc. This slight flow of fluid is ultimately conducted to the suction side of the pump by connecting the central pocket behind the hub of the disc to the suction side of the pump, for example, by a channel connecting the annular pocket in the casing with the outer pocket in the casing on the suction side of the pump. A slight amount of fluid also flows in a film from the central pockets to the outer areas across the pressure-sealing barriers.

A convenient supply of lubricating fluid for the outer rotor bearing is provided by disposing one of its ends in communication with the central pocket behind the hub of the disc and connecting the other of its ends with the suction side of the pump.

A convenient supply of lubricating fluid for the inner rotor or idler bearing is provided by boring a passageway extending from the high pressure side of the pump through the casing and idler pin. This passageway breaks through the surface of the idler pin approximately at the center of the bearing. The face of the inner rotor hub remote from the disc is recessed in a manner similar to its other face to provide a similar rim and pressure pocket. An equalizing passageway extends axially through the hub of the inner rotor to interconnect the pressure pockets in both of its faces. The fluid flowing through the idler pin, therefore, divides substantially equally and flows in both axial directions through the bearing and into the equalizing passageway in the hub of the disc, either directly or indirectly through the equalizing passageway in the hub of the inner rotor.

Novel features and advantages of the present invention will become apparent to one skilled in the art from a reading of the following description in conjunction with the accompanying drawing wherein similar reference characters refer to similar parts and in which:

Fig. 1 is a cross-sectional view of one embodiment of this invention;

Fig. 2 is a cross-sectional view taken through Fig. 1 along the line 2—2 and looking in the direction of the arrows;

Fig. 3 is a view in elevation of a portion of the embodiment shown in Fig. 1;

Fig. 4 is an end view in elevation of another portion of the embodiment shown in Fig. 1; and

Fig. 5 is a graphical representation of forces acting upon a portion of the embodiment shown in Fig. 1.

In Figs. 1 and 2 is shown a rotary gear pump 10 which includes an inner rotor or idler 12 eccentrically meshed within an outer rotor 14 within the cylindrical cavity 16 formed within casing 18. Casing 18 also includes an inlet or suction port 20 and an outlet or discharge port 22, both in communication with cavity 16. Suction port 20 communicates with the spaces 24 between the teeth 26 on the outer rotor and teeth 28 on the inner rotor.

Teeth 26 on outer rotor 14 extend, for example, longitudinally adjacent the periphery of cylindrical disc 30, and disc 30 is mounted to rotate with a shaft 32 which is inserted through its hub 34 and secured thereto. The number of teeth 28 on inner rotor or idler gear 12 is less than the number of teeth on outer rotor 14, for example, two less in number with inner rotor 12 including, for example, six teeth and outer rotor 14 including, for example, eight teeth. These teeth are, for example, formed in the manner described in U.S. Letters Patent 2,124,377 or, for example, in the manner described in U.S. Letters Patent 2,601,288. Any other form or method of construction for pumps of this type may be utilized.

The casing and rotor teeth are constructed and arranged to engage each other in sliding contact to seal the suction port 20 from the discharge port 22 in two directions about the meshing peripheries of the rotors. This maintains an adequate pressure differential between the ports in conjunction with the intermeshing action of the rotor teeth which disengage to provide larger spaces 24 between them adjacent the suction port and engage to provide smaller spaces 24 adjacent the discharge port for entraining and discharging fluid at a relatively higher pressure from the suction to the discharge ports when the outer rotor rotates in the direction designated by arrow 36.

A seal between ports 22 and 20 in the direction of arrow 36 is provided by the close intermeshing of teeth 26 and 28 approximately, for example, along an imaginary line 38 which is substantially perpendicular to an imaginary center line 40 extending through the centers of ports 20 and 22 which, for example, are longitudinally aligned. A seal between ports 20 and 22 in the direction of arrow 37 is, for example, provided by the sliding contact of teeth 28 and 26 with a crescent-shaped member 42 extending from a wall of casing cover 44. An adequate pressure seal is provided by the sliding contact of outer rotor teeth 26 with the wall 46 of cavity 16 and the convex surface 48 of crescent member 42. The arcuate ends 50 of idler teeth 28 slide in contact with the concave surface 52 of crescent member 42 to complete the pressure seal. The pressure seal provided by the parts which move in sliding contact is not absolutely fluid-tight, and a small film of fluid is continuously allowed to pass through it. However, the quantity of fluid in this film is so slight that it does not interfere with the maintenance of an adequate differential pressure between the suction and discharge ports. Other means for providing an adequate seal between the relatively disengaged portions of the inner and outer rotors have been proposed such as the tooth formation disclosed, for example, in U.S. Letters Patent 2,601,288 which utilizes contact between the teeth of the inner and outer rotors to provide adequate sealing. Another example of a pump of this type not requiring a crescent member is the arrangement disclosed in commonly assigned copending application S.N. 383,996, now Patent No. 2,822,760.

A lower pressure area adjacent the suction port 20 is accordingly formed between imaginary lines 54 and 56 about the periphery of the intermeshed rotors. A high pressure or discharge pressure area adjacent discharge port 22 is correspondingly formed about the peripheries of the intermeshed rotors between imaginary lines 58 and 60. The unbalanced forces resulting from these unequal pressures react upon the face of disc 30 and tend to cause bending stresses to be set up within disc 30 and shaft 32. Disc 30 may also be driven into rubbing contact with the portion of the casing adjacent discharge port 22.

To eliminate these undesirable phenomena, the pressures reacting upon the front face 62 and the back face 64 of disc 30 are balanced by sets of pockets or areas of fluid under pressure reacting against the front and back faces 62 and 64 of disc 30. The pressure areas reacting upon the front face 62 of disc 30 are constituted by the portions of face 62 exposed to the suction and discharge pressure in the area respectively peripherally encompassed between lines 54 and 56 and lines 58 and 60. A centrally disposed cylindrical area or pocket 66 is created by recessing the front face 68 of the hub 70 of inner rotor 12. This provides a centrally disposed cylindrical pocket 66 surrounded by a pressure-sealing rim 72 which engages in sliding contact with the front face 62 of disc 30. Space or pocket 66 may be converted to an annular or semi-annular form by extending pin 74 upon which idler 12 is rotatably mounted longitudinally a short distance towards outer rotor shaft 32.

One pressure pocket 76 in contact with the back face 64 of disc 30 is provided by recessing or enlarging the outer circumference 78 of a portion of casing 18 disposed in an annular configuration about the hub 34 of disc 30. The outer circumference 78 of recess 76 is, for example, made substantially equal in diameter to that of pocket 66 in the face of inner idler rotor 12 to balance the pressure forces imposed by pockets 66 and 76.

Outer pressure pockets 80 and 82 respectively adjacent discharge port 22 and suction port 20 are provided by recessing depressions 84 and 86 (see Fig. 3) in the portion of casing 18 adjacent back face 64 and substantially axially aligned and substantially equal in area with the areas which are exposed to suction and discharge pressures.

The portions of the casing lying between recessed pressure pockets 80 and 82 are constructed and arranged to engage back face 64 of disc 30 in sliding contact to provide pressure-sealing barriers 88 and 90 which maintain a pressure differential between the fluids in outer pockets 80 and 82 and central recess 76. The sealing areas of barriers 88 and 90 are, for example, made substantially equal in area to the area of the annular rim 72 of inner rotor 12 to permit this rim and these barriers to maintain similar balanced differential pressures. Any slight leakage which occurs between pressure-sealing barriers 72, 88 and 90 and respective faces of disc 30 does not prevent maintenance of an adequate pressure differential.

Equalizing passageways 92 are axially bored, for example, through disc 30, for example, adjacent the tips 94 (see Fig. 4) of outer rotor teeth 26 and, for example, disposed along their center lines. Another passageway 96 extends through the hub 34 of disc 30 to connect central pockets 66 and 76 with each other. Still another passageway 98 extends through casing 18 to connect recessed annular or central area 76 with a portion of cavity 16 in communication with suction port 20. Passageway 98, for example, communicates with pocket 82 which is disposed in communication with suction port 20 through successively interposed ports 92. Passageways 92, 96 and 98 in conjunction with recesses 66, 76, 80 and 82 maintain balanced films of fluid flowing along both faces 62 and 64 of disc 30 from outer pocket 80 disposed adjacent discharge port 22 into inner or central pockets 66 and 76. This slight fluid in this film is ultimately conducted to the suction side of cavity 16 through passageway 98. A slight film of fluid also flows from central pockets 66 and 76 across pressure-sealing barriers

72 and 90 to the portion of faces 62 and 64 exposed to suction pressure.

A convenient supply of lubricating fluid for bearing means 100, within which outer rotor shaft 32 is rotatably mounted, is provided by disposing one end 102 of bearing means 100 in communication with pocket 76 behind disc hub 34 and connecting the other end 104 of bearing means 100 with the suction side of the pump by disposing the entrance to passageway 98 at end 104 of bearing means 100. A slight leakage of fluid to lubricate bearing 100, therefore, flows along shaft 32 into a cavity 106 to which passageway 98 connects. The outer end of cavity 106 is sealed, for example, by a conventional set of spring-biased mutually contacting sealing discs 107 and 109.

A convenient supply of lubricating fluid for the rotating bearing surface of inner rotor 12 is provided by boring a passageway 108 extending through casing head 44 from the high or discharge pressure side of cavity 16, and connecting it to a passageway 110 which extends through idler pin 74. Passageway 110 breaks through the bearing surface 112 of idler pin 74 approximately at the longitudinal center of bearing surface 112.

Face 114 of inner rotor hub 70 remote from disc 30 is recessed in a manner similar to face 68 to provide a central pocket 116 and an annnular rim 118 respectively similar to pocket 66 and rim 72. An equalizing passageway 120 extends axially through hub 70 of innner rotor 12 to interconnect pressure pockets 116 and 66. The fluid flowing along the surface 112 of idler pin 74, therefore, divides substantially equally and flows in both axial directions along bearing surface 112 and into equalizing passageway 96 in the hub 34 of disc 30 either directly or indirectly through pocket 116 and equalizing passageway 120.

Passageway 122 extends through casing 18 at a 180° relationship to passageway 108 to permit a single casing structure to be used for pumps operating in either direction of rotation. In the direction of rotation herein indicated, passageway 122 is sealed by a plug 124.

Operation

In Fig. 5 are shown various graphs illustrating the forces reacting upon portions of faces 62 and 64 of disc 30 which are disposed, for example, along line 40 extending through the center of disc 30. Corresponding portions of outer rotor 14 are also shown to correlate the illustrated forces with the parts of the structure upon which they act. These parts are, for example, outer rotor 14 including teeth 26, equalizing passageways 92 extending axially through disc 30, and passageway 96 extending through hub 34 of disc 30, bearing 100, and central annular recess 76 adjacent hub 34.

Continuous lines 126, 128, 130 and 132, disposed above rotor 14, represent the pressure forces reacting along line 40 on the front face 62 of disc 30. The pressure force accordingly drops, for example, from 100 p.s.i. adjacent discharge port 22 and represented by line 126 to 50 p.s.i., for example, across sealing barrier or annular rim 72 incorporated in the face of idler gear 12 as represented by line 128. This pressure remains constant along line 130 across pocket 66 and then drops to 0 p.s.i. or suction pressure along line 132 across the portion of pressure-sealing barrier or annular rim 72 adjacent suction port 20.

Continuous lines 134, 136, 138 and 140 represent the pressure forces reacting on the back face 64 of disc 30 along line 40. Line 134 represents a discharge pressure of, for example, 100 p.s.i. The pressure drops to 50 p.s.i. along line 136 across pressure-sealing barrier 88. The pressure remains constant slightly lower than 50 p.s.i., for example, approximately at 45 p.s.i. through pocket 76 as represented by line 138, by virtue of the connection of pocket 76 through bearing 100 and passageway 98 to the suction sde of the pump at pressure pocket 82. A drop, for example, from 45 p.s.i. to atmospheric or suction pressure occurs along line 140 as the fluid passes across pressure-sealing barrier 90 into suction pressure pocket 82. A comparison of aligned portions of continuous lines 126, 128, 130, and 132 with corresponding continuous lines 134, 136, 138 and 140 indicate that the pressure forces reacting on faces 62 and 64 of disc 30 substantially balance each other.

What is claimed is:

1. A rotary pump comprising a casing including a cylindrical cavity having an inlet and outlet port extending through said casing into said cavity, an outer rotor including a cylindrical disc mounted upon a shaft, a bearing means mounted upon said casing for rotatably supporting said shaft, outer rotor teeth disposed about the periphery of said disc and extending longitudinally therefrom, an inner rotor having teeth, said inner rotor being rotatably mounted within said cavity in eccentric meshing engagement within said outer rotor to provide spaces between said teeth of said rotors of varying size about the periphery of said inner rotor, the number of teeth upon said inner rotor being less than the number of teeth upon said outer rotor, the face of said inner rotor adjacent the front face of said disc being recessed to provide a central pocket and an annular rim of predetermined area which engages said front face of said disc in pressure-sealing contact therewith, a portion of said casing adjacent the back of said disc being recessed in a central annular area disposed around said shaft and in outer areas approximately in axial alignment with and approximately equivalent in effective pressure area with areas at the front of said disc exposed to suction and discharge pressures to provide pressure forces reacting behind said disc which substantially balance the pressure forces reacting upon the front of said disc, portions of said casing lying between said outer areas being constructed and arranged to engage the back of said disc in sliding contact to provide pressure-sealing barriers which maintain a differential between said central and said outer areas, said pressure-sealing barriers being constructed and arranged to provide sealing effects equivalent to said rim, equalizing ports extending axially through said disc from the front to the back of said disc adjacent said rotor teeth to provide in conjunction with the pressure-sealing barriers substantially balanced forces reacting upon the front and back of said disc, and channel means connnecting said central recessed area of said casing with a lower differential pressure portion of said casing to promote a flow of fluid through said equalizing ports.

2. A rotary pump as set forth in claim 1 wherein one end of said bearing means is connected to said annular area of said casing, and conduit means connects the other end of said bearing means to a portion of said casing adjacent said suction port to promote a lubricating flow of fluid from said annular recess through said bearing.

3. A rotary pump as set forth in claim 1 wherein one of said equalizing ports is provided adjacent the tip of each of said outer rotor teeth.

4. A rotary pump as set forth in claim 3 wherein one of said equalizing ports is disposed upon the center line of said outer rotor teeth and contiguous to their tips to relieve excess pressures created when said inner and outer rotor teeth mesh with each other as well as equalizing the pressures between the front and back faces of said disc.

5. A rotary pump as set forth in claim 1 wherein an outer recessed area in said casing is provided adjacent said discharge port and adjacent said suction port, and a channel is provided between said central annular recess in said casing and said outer recessed area in said casing disposed adjacent said suction port to promote flow of fluid from said central annular recess to said suction port.

6. A rotary pump as set forth in claim 1 wherein said pressure-sealing barriers are approximately axially aligned

and approximately equivalent in area with said annular rim of said inner rotor.

7. A rotary pump as set forth in claim 6 wherein the outer peripheries of said outer areas are arcs of a circle of constant radius having a common center with the center of said cylindrical cavity.

8. A rotary pump as set forth in claim 1 wherein a passageway extends axially through the hub of said disc adjacent said shaft to promote a flow of fluid into said recess in the face of said inner rotor and for balancing the forces reacting upon said hub.

9. A rotary pump as set forth in claim 8 wherein the face of said inner rotor remote from said disc is recessed to provide a second annular rim surrounding a central pressure area, and a second passageway extends axially through the hub of said inner rotor to connect said recesses in both of said faces of said inner rotor for balancing the forces reacting upon both faces of said inner rotor.

10. A rotary pump as set forth in claim 9 wherein a pin is mounted upon a side of said casing opposite from said bearing means, said inner rotor is rotatably mounted upon said pin, said casing and said pin being bored to include a passageway extending from a portion of said

cavity exposed to discharge pressure through said pin and breaking through the cylindrical surface of said pin approximately at the longitudinal midpoint of the bearing surface upon which said inner rotor is mounted to promote a flow of fluid under discharge pressure for lubricating said bearing surface.

11. A rotary pump as set forth in claim 10 wherein one end of said bearing means for said outer rotor shaft is disposed in communication with said annular recess in said casing, said casing includes a passageway extending from the other end of said bearing means to a portion of said casing exposed to suction pressure to promote a flow of fluid between said inner rotor and said bearing surface of said pin and then through said bearing means to lubricate said bearing surface and said bearing means as well as balancing the forces reacting upon said rotors.

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2,516,589	Pond et al.	July 25, 1950
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