

June 28, 1932.

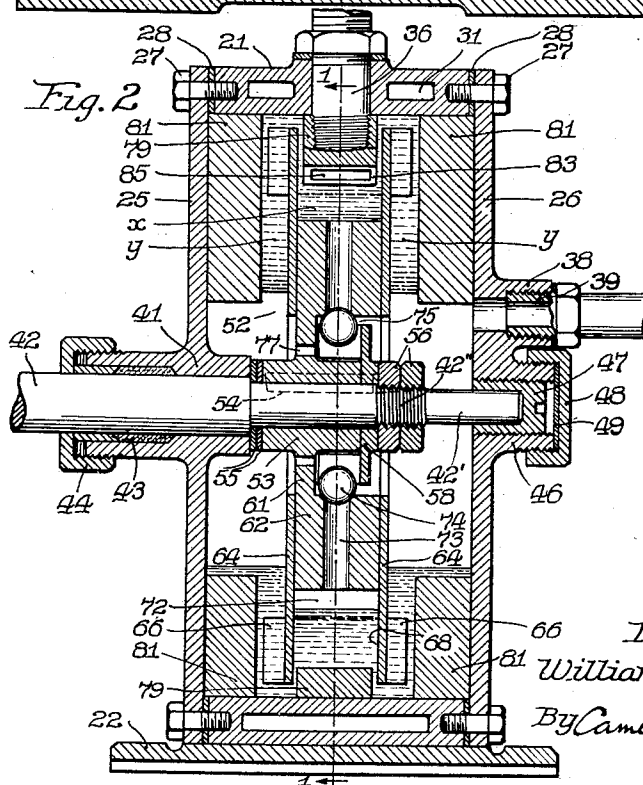
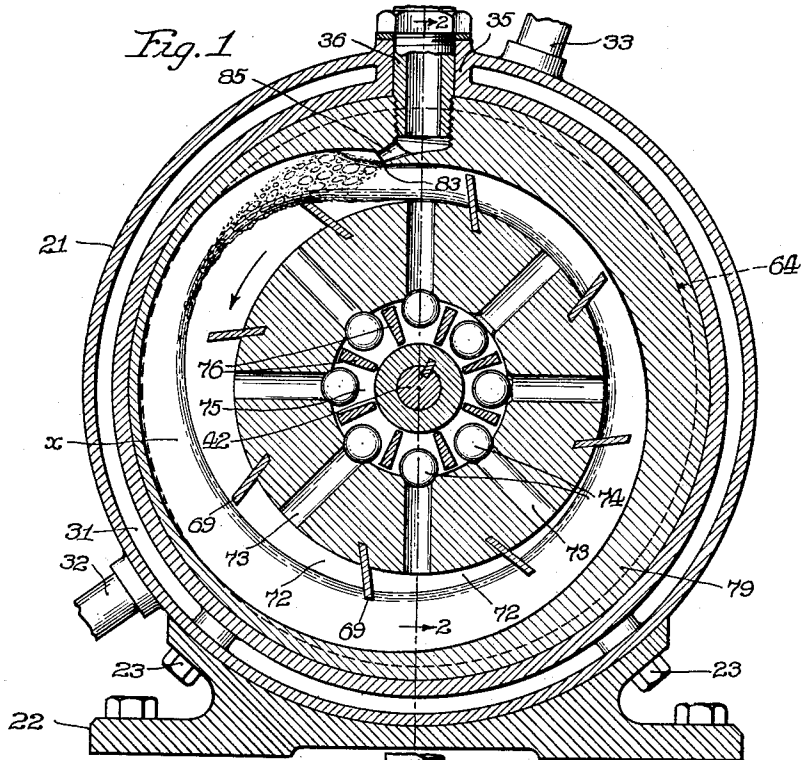
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1,864,640

ROTARY COMPRESSOR AND PUMP

Filed Feb. 17, 1930

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

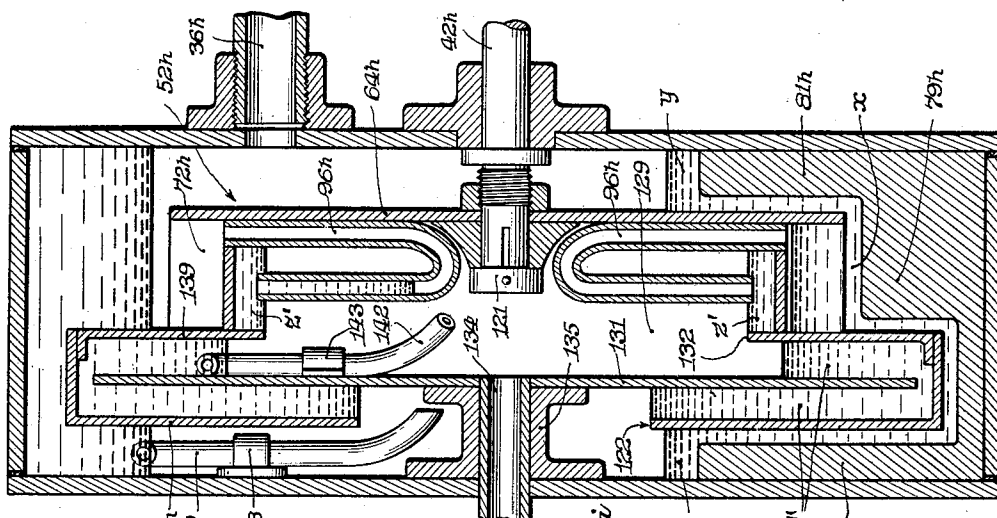


Fig. 4

Fig. 5

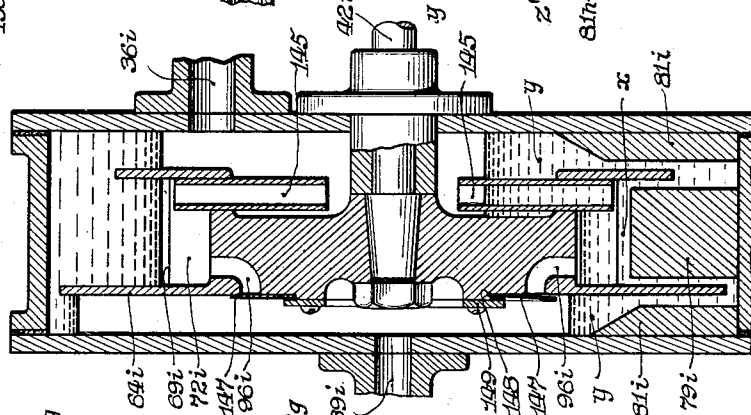
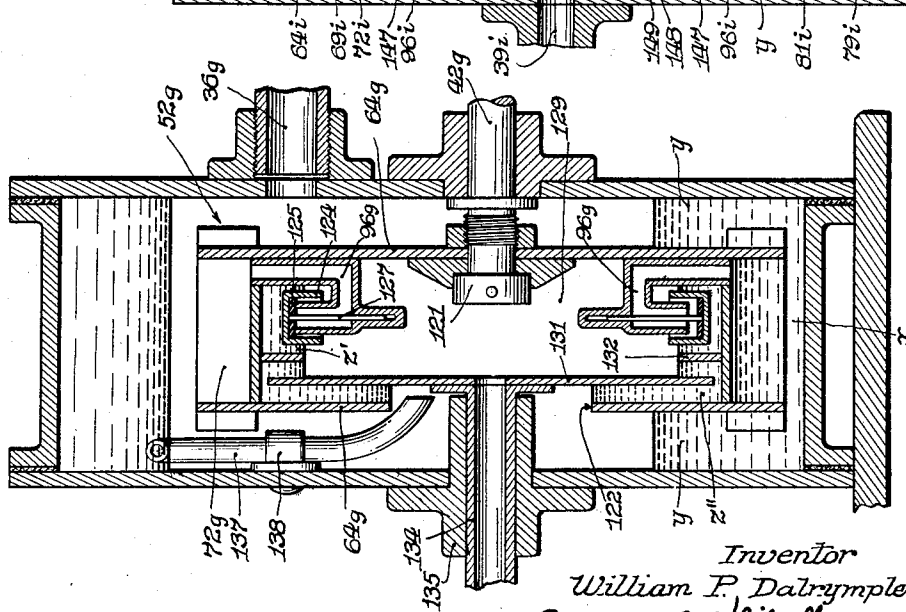


Fig. 3



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ROTARY COMPRESSOR AND PUMP

Application filed February 17, 1930. Serial No. 428,940.

The present invention relates to rotary compressors or pumps for handling either gases or liquids, and serving as a compressor or a pump, depending upon the requirements of the particular use.

One of the principal objects of the invention is to provide an improved construction of rotary pump or the like characterized by an outer casing, a rotor therein having peripheral working chambers, and a rotating liquid ring in said casing serving as the piston for each of the rotor working chambers. This liquid ring revolves at approximately the same speed as the rotor, and in addition to serving as a piston for the rotor chambers also functions as a sealing medium for sealing the space between each side of the rotor and the adjacent side wall of the casing, thereby enabling the rotor to be spaced from the casing, so that there is no metal-to-metal contact between rotating and stationary parts at any point in the construction.

Those lateral portions of the liquid ring revolving between the outer sides of the rotor and the casing, and performing the above sealing function, transmit their centrifugal force as an inwardly acting pressure upon the intermediate portion of the liquid ring which revolves in the plane of the rotor chambers, and one of the features of the invention is the provision of displacement surfaces or members in the casing, whereby the level of these two outer portions can be increased considerably beyond the level of the intermediate portion at the compression stage of the cycle for establishing a relatively large pressure differential between these outer portions of the liquid ring and the intermediate portion thereof. Such enables relatively high pumping or compression pressures to be developed in the device.

Another important object of the invention is to provide improved valve means for the working chambers of the rotor. Such valve means may be of a mechanical type or of a liquid type, both embodiments being shown in the present application. In the mechanical embodiment, one of the features of the invention resides in properly relating centrifugal forces and valve movement whereby effi-

cient and reliable valve operation is obtained. In the liquid embodiment, the intake to the rotor chambers or the exhaust therefrom, or both, is governed by the cyclical immersion of intake and outlet ports in rotating rings of liquid revolving with the rotor.

The liquid type of valve means has the advantage of avoiding the objection of imperfect valve seating, results in a more quiet operation, and is capable of handling fluids which would be difficult to handle with the metallic valves. In this regard, the present device is particularly adaptable to use as a refrigerant compressor for refrigerating apparatus, by virtue of the fact that there are no pistons or other pumping parts requiring lubrication, nor are there any other joints which cannot be effectively sealed against leakage of the refrigerant.

Other objects and advantages of the invention will be apparent from the following detail description of certain preferred embodiments thereof. In the accompanying drawings illustrating such embodiments:

Figure 1 is a vertical transverse sectional view through a relatively simple form of my invention, utilizing mechanical exhaust valves for the rotor chambers, this figure corresponding to a section taken on the plane of the line 1—1 of Figure 2;

Figure 2 is a vertical axial sectional view of the same, taken approximately on the plane of the line 2—2 of Figure 1;

Figures 3, 4 and 5 are vertical axial sectional views of other embodiments.

Referring to Figures 1 and 2, the casing of the device comprises an intermediate ring or cylindrical portion 21, which is secured to a suitable base 22, as by the cap screws 23. The sides of this intermediate ring portion are closed by the side or end walls 25 and 26, which are secured to the cylindrical casing portion 21 by cap screws 27 disposed at angularly spaced points about the casing and threading into the intermediate casing portion 21. Any suitable sealing gaskets 28 may be interposed between the inner faces of the end plates 25, 26 and the edges of the intermediate casing portion. In some instances, it may be desirable to cool

the device by the circulation of a cooling liquid in heat absorbing relation thereto, and to this end the intermediate casing portion 21 may be cored out to form an annular passageway 31 therein, connecting with inlet and outlet pipes 32 and 33, respectively, for circulating the cooling liquid through the chamber or passageway 31.

Formed in the upper portion of the casing ring 21 is a boss 35 into which a nipple 36 or other suitable pipe connection extends for conveying the refrigerant, air or other fluid being handled, into the interior of the casing. For brevity of description, I shall hereinafter refer to this fluid, which is being pumped or compressed in the unit, as the "working fluid". Projecting from one of the end plates 25 or 26 is a boss 38, with which a nipple or other pipe connection 39 communicates for conveying the working fluid from the unit. Formed as a part of the end plate 25 is a bearing boss 41, in which the drive shaft 42 is journaled. This bearing is preferably packed by a suitable gland packing 43 adapted to be taken up by an adjustable packing nut 44 having threaded engagement with the bearing boss 41. The drive shaft 42 extends transversely through the casing and has a reduced portion 42' at its other end extending into a bearing boss 46 projecting from the other end plate 26. A bearing bushing 47 is adjustably mounted in the boss 46 for receiving the reduced shaft end 42'. The end of said bearing boss is sealed by a cap nut 48 screwing over the boss and compressing a gasket ring 49 against the end of the boss.

The rotor is designated 52 in its entirety and comprises a hub 53, which is secured to the drive shaft 42 by a key 54. Interposed between one end of the hub 53 and the bearing boss 41 are washers or bearing rings 55, and engaging with the other end of the hub 53 is any suitable means for holding the rotor against displacement along the shaft, such as the two lock nuts 56 screwing over the threaded portion 42' of the drive shaft. A plate member 58 is interposed between these nuts and the end of the hub 53, such plate member being secured to the drive shaft by the key 54 and comprising part of a ball valve cage, as I shall presently describe.

The rotor comprises a relatively narrow web portion 61 extending outwardly from the hub 53, and a relatively wide body portion 62 extending outwardly from this web portion. Projecting outwardly beyond the periphery of the body portion 62, at each side thereof, are side walls or flanges 64. These annular side walls may be in the form of separate plates rigidly secured to the body portion 62, or they may be in the form of integral extensions of the body portion. A plurality of relatively small vanes or fins 66 project outwardly from these side flanges at spaced

points adjacent to the peripheral edges thereof for imparting rotary motion to the body of liquid, which serves as the liquid pumping ring. The two side flanges 64 define therebetween an annular channel area 68 around the periphery of the rotor, in which channel area the pumping or compressing operation takes place. Referring to Figure 1, transverse baffles or dividing walls 69 project from the periphery of the rotor body portion 62 and extend from side to side across the channel area 68, between the inner sides of the lateral flange portions 64. These baffles or dividing walls may be formed integrally with the rotor body portion or with the side flanges 64, or they may consist of separate plates recessed into the rotor body portion and having tight-fitting engagement against the inner sides of the flange portions 64. The arcuate spaces between such dividing walls 69 constitute working chambers 72, in which the working fluid is compressed. It will be noted that the dividing walls do not extend out to the peripheral edges of the flanges 64, but have their outer edges spaced inwardly considerably from the flange peripheries.

This permits a displacement member to be extended into the channel area 68, in close proximity to the outer edges of the dividing walls 69 and the working chambers 72 for securing an efficient pumping displacement of the liquid ring, as I shall presently describe.

Extending inwardly from each pumping chamber 72 is an exhaust passageway 73, which is normally closed at its inner end by a ball valve 74 seating in the end of said passageway. These ball valves are disposed in an annular pocket 75 defined within the center of the rotor body portion 62. The balls are held against displacement in one direction by the web portion 61 and in the other direction by the plate 58, such plate serving as a valve cage and having ribs 76 extending from the inner side thereof and serving as spacers between the balls for holding them in proper alignment with their respective discharge passageways 73. In the operation of the device, the balls are normally held pressed outwardly against the inner ends of the passageways 73 under the action of centrifugal force and are unseated from these passageways by the pressure of the fluid being compressed in the working chambers 72. The working fluid, after being discharged past these ball valves enters the interior of the casing and then passes out through the discharge connection 39 previously described. In order to maintain uniformity of pressure within the casing on opposite sides of the rotor, small venting passageways 77 may be provided in the web portion 61 of the rotor for equalizing the pressures on opposite sides thereof.

Disposed in the plane of the rotor 52 and extending into the peripheral channel area

68 thereof is a displacement member 79 in the form of a ring or segment secured to the cylindrical casing portion 21. This displacement member acts on the intermediate or inner leg of the liquid ring rotating between the side flanges 64 of the rotor, such displacement member being spaced from the inner sides of the flanges to permit the inward and outward flow of liquid along the sides of said member. Also mounted in the casing on opposite sides of the rotor are displacement members 81, 81 which act on the outer legs of the liquid ring. These lateral displacement members are spaced slightly from the edges of the vanes 66. Referring to Figure 1, it will be seen that the inner surface of the intermediate displacement member 79 is of a maximum radius at the intake point of the rotor cycle and from this point spirals inwardly through a gradually diminishing radius to the discharge zone of the rotor cycle, at which point such inner surface just clears the outer edges of the dividing walls 69. From this zone or point of small radius, the inner surface of the displacement member then extends outwardly at the shoulder or offset portion 83, to the larger radius at the intake zone of the cycle. The working fluid is introduced into the rotor through an inlet port 85 communicating with the fluid inlet connection 36 and opening into the channel area of the rotor through the offset angle portion 83.

In the operation of the device, as the rotor is brought up to speed, the pumping liquid is whirled outwardly under the action of centrifugal force and assumes approximately the condition or form illustrated in Figures 1 and 2. The revolving liquid ring may be regarded as being divided into three main volumes or quantities, at least during the compression stage of the cycle, consisting of the intermediate volume or "leg" x rotating within the channel periphery of the rotor and the two outer volumes or "legs" y, y rotating on the outer sides of the rotor. It will be noted that the intermediate "leg" x has the relation of one leg of a U-tube with respect to each outer leg y . That is to say, by having the outwardly acting centrifugal pressures of the two outer legs y preponderate over the outwardly acting centrifugal pressure of the intermediate leg x , an inwardly acting compression pressure can be created between the inner end of the leg x and the bottoms of the working chambers 72. Such preponderating centrifugal pressure of the two outer legs may be obtained by making each outer leg of greater depth at this point in the cycle so that centrifugal force acting on this greater radius of liquid will tend to force the intermediate leg x to the same balancing radius. These differential radii or levels of the three legs are attained by the displacement members in the casing.

Referring to Figure 1, that portion of the casing at the left-hand side of the rotor may be regarded as the intake stage of the cycle, and that portion on the right-hand side of the rotor may be regarded as the compression or exhaust stage of the cycle.

At the intake stage or zone, the inner surface of the intermediate displacement member 79 recedes away from the rotor so that in this part of the casing, the intermediate liquid leg x is whirled outwardly clear of the dividing walls 69 and working chambers 72. At this intake zone, the two outer displacement members 81, 81 also recede outwardly to lower or diminish the height of the two outer liquid legs y, y , thereby assisting in permitting the intermediate liquid leg x to be whirled out clear of the dividing walls 69. The inlet port 85 opens into the channel area 68 between the side flanges 64 and the working fluid which is drawn in through this port bubbles through the intermediate leg x of the liquid pumping ring, substantially as indicated in Figure 1. The pumping ring of liquid will, in all instances, be of higher specific gravity than the fluid being pumped or compressed by the unit and hence such working fluid will pass inwardly through the rotating ring of liquid and will collect in the descending pockets or working chambers 72 at the left-hand side of the rotor, Figure 1. At this time, the ball valves 74 are seated on the inner ends of the fluid passageways 73, serving as check valves between each pumping chamber and the discharge pressure within the center of the casing. The working fluid fills each chamber 72 and passageway 73 in the downward rotation thereof, and as each pocket approaches the bottom of the rotor, the approaching level of the inner leg x contacts with the outer edge of the dividing wall 69 at the rear of the chamber, thereby sealing the working fluid therein. The diminishing radius of the intermediate displacement member 79 tends to force the intermediate leg of the liquid ring into the working chambers, thereby compressing the trapped fluid therein.

The decreasing radii of the two outer displacement members 81 also coact on the outer legs y to produce the desired differential or unbalance between the intermediate and outer legs for obtaining the compression pressure. The volume of liquid displaced from the channel area 68 by the decreasing radius of the intermediate displacement member 79 augments the quantity of liquid available in the outer legs y for producing a large differential between the legs during the compression stage. Attention is also directed to the fact that the pressure at which the working fluid is discharged from the device is effective on the outer legs y during this compression stage of the cycle. When the pressure in each working chamber reaches the desired exhaust

pressure, the ball valve 74 is forced from its seat and the working fluid is discharged into the central space within the casing, from whence it is conducted to its point of use through the outlet connection 39.

It will be seen that by virtue of having the side flanges 64, 64 project outwardly beyond the outer edges of the dividing walls 69 the admission of the working fluid can be made to occur directly into the peripheral channel 68 of the rotor through a stationary inlet duct 85 projecting into this channel. The peripheral edges of said flanges 64, 64 are indicated in dotted lines in Figure 1 and it will be seen that these flanges prevent the working fluid which is being admitted through the port 85 from bubbling across or around the edges of the rotor at the intake zone, the exhaust pressure effective on the outer legs y also aiding in preventing this.

When the inner leg x passes the offset portion 83 it is thrown outwardly from each chamber by centrifugal and tangential force, thus creating a rarefied condition in that chamber which aids in effecting a quick admission of the working fluid thereto. The admission of the working fluid directly into the peripheral channel of the rotor enables the entire interior of the casing, within the rotating liquid pumping ring, to be used as an exhaust chamber for all the working chambers.

It will be understood that the radius of the rotor and the shape and proportions of the three displacement members 79, 81 and 81 may be changed for obtaining any desired differential between the inner and outer legs of the pumping ring for obtaining high or low pressures. The two portions of the lateral displacement members 81 illustrated in section in Figure 2 are both in approximately the compression stage of the device, and it will be understood that at the intake stage, these lateral displacement members are of lesser depth even than the portions illustrated at the bottom of Figure 2. Different liquids may be employed as the pumping ring and different quantities of this liquid may be used for different pressures.

The use of mercury is typical, permitting the attainment of relatively high pressures in a unit of small radius, such pumping liquid also being substantially inert in most instances to chemical reaction with the working fluid being pumped.

In using mercury, the metallic construction of the device would, of course, be such as not to amalgamate with the mercury. Obviously, water or any of the other liquids of lower or higher specific gravities may be used as the pumping liquid. Liquids of high specific gravities, which might be used, are represented by acetylene tetrabromide, lead chloride, lead bromide and bismuth bromide.

In Figures 3 and 4 I have illustrated other

embodiments wherein one valve function utilizes a liquid ring which is contained entirely within the rotor. This valve function may be either for the inlet or outlet of the working chambers, but is preferably for the outlet discharge from these working chambers, and possesses the advantage of affording a liquid seal whereby the working fluid, discharged from the working chambers, can be conducted from the hollow interior of the rotor to a point outside of the main pump casing without having to pass through a gland packing or other rotating joint such as might be susceptible to leakage.

Referring to the construction shown in Figure 3, and wherein parts similar to parts of Figures 1 and 2 have been given the same reference numerals with the appendix g , the rotor has the previously described arrangement of peripheral pumping chambers 72^s which are preferably arranged to emerge from the pumping ring of liquid x, y to have admission occur across the periphery of the rotor, although it will be understood that admission may be arranged to occur in accordance with the method employed in the embodiment of Figures 1 and 2. Instead of employing displacement members to cause the pumping ring to exert pumping impulses in the rotor chambers, I have, in this embodiment, shown the rotor 52^s as being eccentrically disposed in the housing. Hence, the rotor is caused to dip into the rotating ring of pumping liquid at the near side of the housing, which is preferably the bottom, and in thus dipping into the liquid a certain amount thereof is displaced to establish the preponderating outer legs y, y in the pumping ring. At the upper side of the housing the rotor emerges from the pumping ring for permitting the intake of the working fluid across the periphery of the rotor and into the pumping chambers. That is to say, the quantity of liquid making up the liquid pumping ring is so proportioned with reference to the volumetric displacement of the rotor, the degree of its eccentricity in the housing, etc., that at the intake stage of the cycle the liquid pumping ring separates completely from the peripheral edges of the rotor, so that the working fluid can enter the pumping chambers around such peripheral edges.

It will be seen that the construction shown in Figure 3 has in common with the construction shown in Figures 1 and 2 the admission of the working fluid "peripherally" to the working chambers, i. e., in each of these embodiments the working fluid is introduced into the working chambers at the periphery of the rotor. The "peripheral admission" in Figure 3 differs from that of Figures 1 and 2 in that it occurs from the sides of the rotor across the edges of the channel flanges instead of from an inlet duct extending into the rotor channel. It will also be noted that in the construction shown in Figure 3, the

casing enclosure or area within the liquid pumping ring is at admission pressure, whereas in Figures 1 and 2 this area is at exhaust pressure, being sealed off from the peripheral channel by the side legs of the liquid pumping ring. In Figure 3 the working fluid is admitted to the interior of the housing through the inlet connection 36^s opening into the side thereof.

The driving shaft 42^s is rigidly secured to one of the side plates 64^s of the rotor, such being shown as the right-hand plate.

Any suitable coupling means, generally indicated at 121, may be employed for connecting this shaft to the plate in driving relation, this coupling means sealing the joint between the shaft and plate to prevent leakage from the interior of the rotor outwardly along the shaft. The left-hand side plate 64^s of the rotor has a central opening 122 therein through which liquid is automatically supplied from the main pumping ring *x, y* to the interior of the rotor for replenishing the sealing ring and inner valve ring, which I shall presently describe. Extending inwardly from each working chamber 72^s is a discharge tube 96^s, the discharge end of which is doubled back to face in an outward direction. Revolving with the rotor, inside thereof, is the valve ring of liquid *z'*. Co-operating with the discharge end of each tube 96^s is a valve cup 124 which is partly immersed in the valve ring *z'*. Each of these valve cups preferably has a washer 125 of rubber or like pliable material in the bottom thereof in order more effectively to seal the discharge end of the tube 96^s when the valve cup is pressed in an inward direction against such discharge end. It will be evident that the pressure established in the liquid valve ring *z'* by centrifugal force, will normally tend to force the valve cup in an inward direction against the discharge end of the tube when the rotor is revolving.

The discharge pressure of the working fluid, which may be relatively high, prevails within the interior of the rotor, and this pressure acting on the valve ring *z'* also tends to seat the valve cups against the ends of the discharge tubes. The weight of each cup is preferably heavier than the liquid in the valve ring and this weight is properly proportioned so that the discharge pressure effective on the valve ring just holds the valve closed. The centrifugal force in the valve ring *z'* and in the valve cups go up together and hence variations of speed do not appreciably affect the valve function. The annular flange portion of each cup is spaced from the outer wall of the tube to permit ready egress of the working fluid when the valve is unseated and any suitable guide stem or like guide means 127 may be provided for retaining the valve cups in operative alignment with the discharge ends of said tubes. When the working fluid in each working chamber is

placed under pressure in the bottom part of the rotation of the rotor, this pressure forces the valve cup 124 away from the discharge end of the tube 96^s, in an outward direction in the ring of liquid *z'*, substantially as illustrated of the lower valve cup in Figure 3. The hollow interior of the rotor forms a manifold area 129 into which all of the working chambers discharge in this same manner as they revolve down through the bottom of the rotor cycle.

Such inside manifold area is sealed at the left-hand side of the rotor by a disk 131 which is spaced inwardly slightly from the adjacent side plate 64^s of the rotor. The periphery of this disk is also spaced slightly from the drum portion defining the bottoms of the working chambers. A sealing ring of liquid *z''* rotates in the annular space between the disk 131 and the adjacent side plate 64^s, this ring of liquid sealing the interior manifold area 129 from communication with the interior of the housing, outside of the rotor.

The inner leg of this annular liquid seal is subjected to the discharge pressure prevailing in the manifold area 129 and the outer leg is only subjected to the admission pressure prevailing in the interior of the housing, and hence the latter leg will have to extend inwardly toward the center of the rotor to a greater distance to balance the pressure leg. If desired, a ring 132 may be disposed as a spacer between the inner leg of this sealing ring *z''* and the body of liquid forming the valve controlling ring *z'*.

The disk 131 may be arranged for rotation with the rotor, in which case it would be connected therewith by suitable bridge or spider members, or such disk may be held stationary within the rotor, the latter practice being preferable. Said disk is secured to the flanged end of a tube 134 extending out through the side wall of the housing, the disk having a central opening therein communicating with the bore of the tube.

The working fluid under pressure is discharged from the device through this tube 134. When the disk is to rotate with the rotor, such tube is rotatably mounted in the bearing 135 which is secured to the side wall of the housing, and when such disk is to remain stationary this tube is rigidly secured in said bearing.

When the rotor is started, the sealing and valve controlling rings of liquid *z''* and *z'* are brought to the proper levels and are maintained at these levels through an automatic replenishing and overflow action utilizing a tube 137 which is secured, as by a bracket 138, to the left-hand wall of the housing.

The outer inlet end of this tube extends into the ring of pumping liquid and has its end bent to dispose the opening of the tube counter to the direction of rotation of such

ring, whereby a part of the liquid pumping ring is continuously forced into this tube. The inner outlet end of such tube extends into the central opening 122 in the side plate of the rotor and discharges into the annular outer leg of the liquid sealing ring s' . Hence, liquid is continuously supplied to this sealing ring for maintaining the level thereof even with the edge of the opening 122, the excess spilling back into the liquid pumping ring. The inner leg of the sealing ring, and the valve controlling ring s' , are both maintained substantially at the same level.

If this level should be too low or recede because of insufficient liquid, the preponderating outer leg of the sealing ring will immediately replenish these inner bodies of liquid, being in turn replenished through the tube 137, and if this inner sealing leg and valve controlling ring should have an excessive amount of liquid producing an objectionably high level, the discharge pressure of the working fluid acting thereon will cause such excess liquid to be forced back into the outer leg of the sealing ring for spilling over through the opening 122 back into the pumping ring.

In Figure 4 the pumping ring of liquid x, y is given its pumping impulses through the action of the displacement members 79^a, 81^a, although it will be evident that these pumping impulses may be obtained by disposing the rotor eccentrically in the housing as is shown in Figure 3. The intake occurs transversely across the periphery of the rotor, but, here again, the intake may be arranged to occur in accordance with any of the previously described embodiments. The discharge tubes 96^a extend inwardly towards the center of the rotor to a greater distance than in Figure 3, and have their outlet valve function controlled directly by the valve ring of liquid s' .

The ends of the discharge tubes are immersed only slightly in this valve ring, so that when the working chamber associated with one of the tubes is in its pumping or compression cycle the working fluid can readily blow over or out through the end of the discharge tube and up through the ring of pumping liquid, into the interior of the rotor. When such working chamber is moving through the intake stage of its cycle a portion of the liquid ring is sucked into the end of the discharge tube, substantially as illustrated at the upper part of Figure 4. The centrifugal force of this liquid leg prevents the liquid from being carried over into the working chamber, and the volume of liquid in the ring s' is such that the relatively small quantity of liquid sucked into such discharge tubes does not materially lower the level of the valve ring.

The liquid sealing ring s'' is illustrated as being of greater depth and of greater diameter. That is to say, the adjacent wall of

the working chambers is extended outwardly beyond said working chambers in the form of an annular plate 139, which is secured to the outer, left-hand rotor plate 64^a, as by providing both of these plates with laterally extending flanges, and securing the same together over the disk 131. This disk 131 may rotate or may be held stationary. It is preferably held stationary, and has a liquid replenishing or supply tube 142 secured to the upper portion thereof by a bracket 143.

The valve ring of liquid s' is at a different level than the inner leg of the sealing ring s'' and the tube 142 has its inlet end facing counter to the direction of rotation of the sealing ring so that liquid is continuously supplied through said tube to the valve ring s' , the overflow from such latter ring spilling over the wall 132 back into the sealing ring. This sealing ring is continuously replenished from the liquid pumping ring through the tube 137 substantially as described of Figure 3, the overflow from this sealing ring spilling through the opening 122 back into the pumping ring. The manner in which the working fluid is conducted into the housing through the inlet connection 36^a, is pumped or compressed in the working chambers, and is discharged through the outlet connection 134, will be apparent from the preceding description.

Figure 5 illustrates an inlet valve function and an outlet valve function, either of which may be employed in any one of the previously described embodiments. The pumping impulses of the liquid pumping ring may be obtained either by an eccentric disposal of the rotor in the housing or by the use of displacement members. The inlet conduit 36^a opens into the housing on one side of the rotor, and the outlet connection 39^a opens into the housing on the other side of the rotor.

One of the side plates or flanges 64^a of the rotor is of sufficient diameter to accommodate the necessary difference of levels on opposite sides thereof for sealing the intake side from the outlet side, the pumping ring of liquid also serving as a sealing ring in cooperation with this flange or plate.

The working fluid is admitted to the working chambers through tubes 145, there being one of these tubes for each chamber extending through the inner or top wall of the chamber toward the axis of the rotor. The outer end of each tube terminates at a point at which the actual pumping or compression impulse is to begin in the working chamber. For example, this outer end may be disposed approximately at the same radius as the outer edge of each dividing wall 69^a separating the working chambers, so that when the pumping ring has made contact with the two end walls 69^a of a particular working chamber for sealing the bottom of the chamber the pumping ring has also contacted with the outer

end of the tube 145 so that such tube is sealed against egress of the working fluid. It will be evident that as the pumping ring surges inwardly into the working chamber and builds up its pressure therein such pressure merely causes the liquid of the pumping ring to flow inwardly to a greater extent in the tube 145. The centrifugal force of the leg of liquid in this tube maintains the tube closed and performs the valve function.

If desired, the outer end of each tube 145 may terminate at a shorter radius so that the device can be designed or the pumping ring proportioned whereby such ring will never separate from contact with the outer edges of the transverse dividing walls 69¹ but will always remain in sealing engagement with these walls for maintaining a constant liquid seal between adjacent working chambers. In either construction, when the working chamber revolves into the intake stage of its cycle the pumping ring recedes out of contact with the outer end of the tube 145, thereby opening said tube to the admission of the working fluid through the inner end thereof and into the working chamber.

The discharge occurs through passageways 96¹ extending from the working chambers and opening outwardly through the opposite face or side of the rotor. In this instance, the valve function is shown as being performed by a continuous ring member 147 which is mounted on the side of the rotor to overlie the outlet ends of all of these passageways. This annular valve member has its inner peripheral edge seating on an annular shoulder 148, and is retained in position by an outer ring 149 which overlies the inner edge of the valve ring member 147, such retaining ring 149 being secured to the rotor by screws or in any other suitable manner.

The valve member 147 may have a slight amount of lateral play between the rotor and the retaining ring 149. Such valve ring 147 preferably consists of a very thin metallic ring, of only a few thousandths of an inch thickness. Where the working chambers are moving through the intake stage of their cycle, this ring will be held pressed tight against the ends of the discharge passageways 96¹ by the difference of pressures between such chambers and the discharge chamber area to the left of the rotor. Where the working chambers are moving through the pumping or compression stage of their cycle, this ring will flex away from the outlet ends of said passageways under the pressure of the working fluid being discharged through said passageways. Such flexure will be in the form of a wave motion in the ring. It will be noted that such form of valve means is not influenced by centrifugal force nor variations in the rotor speed. This form of outlet valve means may be employed with different forms of rotors having different intake valve func-

tions. For example, such outlet valve means may be employed in embodiments wherein the intake of the working fluid occurs transversely across the periphery of the rotor at one side thereof, as illustrated in Figure 4. This also applies to the other embodiments previously described, the inlet valve functions or devices being capable of substitution from one embodiment to another, and the same being also true of the outlet valve functions or devices.

It will be seen from the foregoing that the present construction provides a rotary pump, compressor, or the like in which the working chambers are effectively sealed and the valve functions are obtained without having to resort to rubbing metal-to-metal contact between the sides of the rotor and the sides of the casing, or between the periphery of the rotor and the casing, and without having to resort to movable abutments, rotating metallic pistons, etc. Hence, there are no parts to wear or to require lubrication or replacement, and leakage is practically eliminated.

The avoidance of lubrication and leakage particularly adapt this construction to use as a compressor for handling refrigerant in domestic or commercial refrigerating apparatus; but, it will, of course, be understood that the construction is also adaptable to use as an air or gas compressor, and can also be used for pumping liquids. In one use as a liquid pump, the rotating liquid pumping ring x, y, y would be of higher specific gravity than the liquid being pumped. In another use of the device as a liquid pump, the liquid being circulated through the device could function as its own liquid pumping ring x, y, y . In this regard, when used as a refrigerant compressor, some of the refrigerant in the liquid state could be used as the pumping ring, which would be continuously replenished by the entering refrigerant.

Aside from its use as a pump or compressor, there are numerous features of my construction which can be adapted to rotary internal combustion engines, and I have phrased some of the appended claims to cover such possible adaptations.

While the general construction which I have disclosed constitutes one of the preferred embodiments of the invention, nevertheless, it will be understood that such is merely exemplary and that numerous modifications and rearrangements may be made without departing from the essence and broad scope of the invention.

I claim:

1. In a device of the class described, the combination of a casing, a rotor therein having two laterally spaced annular flanges projecting therefrom to form a peripheral channel in the rotor, an inlet and an outlet for the pumped fluid, means defining working chambers in said channel, separate working fluid

passageways in said rotor communicating with each of said chambers, a liquid adapted to be revolved within said casing by said rotor and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, and a displacement member extending into the peripheral channel between said flanges for causing piston surging of the liquid ring in said channel.

2. In a device of the class described, the combination of a casing, a rotor therein having two laterally spaced annular flanges projecting therefrom to form a peripheral channel in the rotor, an inlet and an outlet for the pumped fluid, means defining working chambers in said channel, separate working fluid passageways in said rotor communicating with each of said chambers, a liquid adapted to be revolved within said casing by said rotor and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, said liquid ring in one part of the rotor cycle forming an inner liquid leg within the peripheral channel of said rotor and outer liquid legs on the outer sides of said rotor acting in centrifugal pressure opposition to said inner leg, and displacement means on the outer sides of said rotor for increasing the radial depth of said outer legs relative to the radial depth of the inner leg.

3. In a device of the class described, the combination of a casing having an inlet and an outlet for the pumped fluids, a rotor therein having two laterally spaced annular flanges projecting therefrom to form a peripheral channel in the rotor, means defining working chambers in said channel, separate working fluid passageways in said rotor communicating with each of said chambers, a liquid adapted to be revolved within said casing by said rotor and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, said liquid ring in one part of the rotor cycle forming an inner liquid leg within the peripheral channel of said rotor and outer liquid legs on the outer sides of said rotor acting in centrifugal pressure opposition to said inner leg, a displacement member relatively to which said rotor revolves and extending into the peripheral channel between said flanges for causing piston surging of the inner leg of said liquid ring, and displacement means disposed on the outer sides of said rotor for increasing the radial depths of said outer legs relative to the radial depth of the inner leg to produce a centrifugal pressure differential between said outer and inner legs.

4. In a device of the class described, the combination of a casing, an inlet and an outlet for the working fluid, a rotor therein having two laterally spaced annular flanges pro-

jecting therefrom to form a peripheral channel in the rotor, means defining working chambers in said channel, separate working fluid passageways in said rotor communicating with each of said chambers, a liquid adapted to be revolved within said casing by said rotor and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, and a stationary displacement member in said casing having an inner surface of gradually decreasing radius extending into the peripheral channel between said flanges for causing an inward compression surging of the liquid ring in said channel.

5. In a device of the class described, the combination of a casing, an inlet and an outlet for the working fluid, a rotor therein having two laterally spaced annular flanges projecting therefrom to form a peripheral channel in the rotor, means defining working chambers in said channel, separate working fluid passageways in said rotor communicating with each of said chambers, a liquid adapted to be revolved within said casing by said rotor and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, said liquid ring in one part of the rotor cycle forming an inner liquid leg within the peripheral channel of said rotor, and also forming two outer liquid legs on the outer sides of said rotor acting in centrifugal pressure opposition to said inner leg, and stationary displacement surfaces of gradually decreasing radius disposed on the inner and outer sides of the said peripheral channel for creating a centrifugal pressure differential between said outer and inner legs in the compression stage of the rotor cycle.

6. In a device of the class described, the combination of a casing having an inlet and an outlet for the working fluid, a rotor therein having two laterally spaced annular flanges projecting therefrom to form a peripheral channel in the rotor, means defining working chambers in said channel, separate working fluid passageways in said rotor communicating with each of said chambers, a liquid adapted to be revolved within said casing by said rotor and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, and liquid governed centrifugally acting valve means controlling said working fluid passageways.

7. In a device of the class described, the combination of a casing, having an inlet and an outlet for the working fluid, a rotor therein having two laterally spaced annular flanges projecting therefrom to form a peripheral channel in the rotor, means defining working chambers in said channel, separate working fluid passageways in said rotor communicating with each of said chambers, a liquid

adapted to be revolved within said casing by said rotor and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, and valves normally held closed by the centrifugal force of a liquid ring arranged for controlling said working fluid passageways.

8. In a device of the class described, the combination of a casing, a rotor therein having two laterally spaced annular flanges projecting therefrom to form a peripheral channel in the rotor, means defining working chambers in said channel, separate working fluid passageways in said rotor communicating with each of said chambers, a liquid adapted to be revolved within said casing by said rotor and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, a displacement member extending into the peripheral channel between said flanges for causing piston surging of the liquid ring in said channel, a working fluid inlet port opening into said channel through said displacement member, and an outlet from said casing for the working fluid.

9. In a device of the class described, the combination of a casing having an inlet and an outlet for the working fluid, a rotor therein having two laterally spaced annular flanges projecting therefrom to form a peripheral channel in the rotor, means defining working chambers in said channel, separate working fluid passageways in said rotor communicating with each of said chambers, a liquid adapted to be revolved within said casing by said rotor and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, liquid sealing means in said rotor controlling the flow of working fluid through said passageways, and means automatically governing the height of said liquid sealing means.

10. In a device of the class described, the combination of a casing having an inlet and an outlet for the working fluid, a rotor therein having two laterally spaced annular flanges projecting therefrom to form a peripheral channel in the rotor, means defining working chambers in said channel, separate working fluid passageways in said rotor communicating with each of said chambers, a liquid adapted to be revolved within said casing by said rotor and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, liquid valve means comprising a rotating ring of liquid in said rotor for controlling the flow of working fluid through said passageways, and means automatically governing the depth of said latter liquid ring in rotation.

11. In a device of the class described, the combination of a casing having an inlet and an outlet for the working fluid, a rotor there-

in having two laterally spaced annular flanges projecting therefrom to form a peripheral channel in the rotor, means defining working chambers in said channel, separate working fluid passageways in said rotor communicating at one end with each of said chambers, a liquid adapted to be revolved within said casing by said rotor and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, the other ends of said working fluid passageways rotating in co-operating relation to a rotating liquid ring, and valve means cooperating with said latter liquid ring for sealing the latter ends of said passageways.

12. In a device of the class described, the combination of a casing having an inlet and an outlet for the working fluid, a rotor therein having two laterally spaced annular flanges projecting therefrom to form a peripheral channel in the rotor, means defining working chambers in said channel, separate working fluid passageways in said rotor communicating with each of said chambers, a liquid adapted to be revolved within said casing by said rotor and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, a series of rotating discharge ports connecting with said working fluid passageways and cooperating with another rotating liquid ring, and means for displacing liquid from said first liquid ring to replenish the supply of liquid in said other liquid ring.

13. In a device of the class described, the combination of a casing having an inlet and an outlet for the working fluid, a rotor therein, dividing walls extending transversely of the periphery of the rotor for dividing said periphery into a plurality of working chambers, two laterally spaced annular flanges on said rotor and extending outwardly therefrom beyond said dividing walls to form a peripheral rotor channel in the plane of said working chambers of greater depth than said working chambers, a liquid adapted to be revolved within said casing and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, and means for controlling the discharge of working fluid from said chambers comprising a liquid ring revolving in said rotor.

14. In a device of the class described, the combination of a casing, a rotor therein, means defining a plurality of working chambers in the periphery of said rotor, working fluid passageways in said rotor communicating with said chambers, a liquid valve ring in said rotor controlling one of said working fluid passageways, means for supplying the working fluid to the interior of said casing, an outlet for the working fluid, a liquid adapted to be revolved within said

casing and producing under the action of centrifugal force a liquid ring coacting with said rotor, and means for causing said liquid ring to exert pumping impulses in said working chambers and to recede from said working chambers for permitting the working fluid to enter said chambers peripherally of the rotor from the interior of said casing.

15. In a device of the class described, the combination of a casing, a rotor therein, means defining a plurality of working chambers in the periphery of said rotor, working fluid passageways in said rotor communicating with said chambers, a liquid adapted to be revolved within said casing and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, means for admitting the working fluid into the interior of said casing, means for conducting the exhaust working fluid from the interior of said rotor, and liquid sealing means separating the interior of said casing from the interior of said rotor.

16. In a device of the class described, the combination of a stationary casing, a rotor therein having a plurality of working chambers formed substantially in the periphery of said rotor, an inlet and an outlet for the working fluid, the sides of said rotor being spaced from the sides of said stationary casing, a liquid adapted to be revolved within said casing approximately at the speed of said rotor and producing under the action of centrifugal force a liquid ring having piston coaction with said working chambers, said liquid ring being adapted to extend into the lateral spaces between the sides of said rotor and the sides of said stationary casing for sealing said rotor, and a coacting liquid sealing ring revolving within said rotor.

17. In a device of the class described, the combination of a casing, a rotor therein, an inlet and an outlet for the working fluid, means defining a working chamber in said rotor, a liquid ring revolving within said casing, exteriorly of said rotor, a second liquid ring revolving inside of said rotor, one of said liquid rings exerting pumping impulses in said working chamber, and a valve passageway leading from said working chamber and cooperating with the other liquid ring.

18. In a device of the class described, the combination of a casing, a rotor therein, an inlet and an outlet for the pumped fluid means defining a working chamber in said rotor, a liquid ring revolving within said casing exteriorly of said rotor and creating pumping impulses in said working chamber, a valve passageway communicating between said working chamber and the interior of said rotor, a closure member, and a liquid ring revolving inside of said rotor and cooperating with said closure member for

maintaining a seal between the interior and exterior of said rotor.

19. In a device of the class described, the combination of a casing, a rotor therein, an inlet and an outlet for the working fluid, means defining a working chamber in said rotor, a liquid ring revolving within said casing and creating pumping impulses in said working chamber, and a working fluid passageway in said rotor having a port communicating with said working chamber at a point where said port will be immersed and sealed by said liquid ring substantially in the initiation of the pumping impulse in the working chamber.

20. In a device of the class described, the combination of a casing, a rotor therein, an inlet and an outlet for the working fluid, means defining a plurality of working chambers in said rotor, a liquid ring revolving within said casing and creating pumping impulses in said working chambers, discharge passageways leading from said working chambers and discharging from one side of said rotor, and a relatively thin flexible valve member carried by the rotor and adapted to close the discharge ends of said passageways, said valve member flexing away from the ends of said passageways when the working fluid is discharged there-through and being disposed substantially radially of the rotor so as to remain substantially uninfluenced by variations of centrifugal force.

21. In a device of the class described, the combination of a casing having an inlet and an outlet for the working fluid, a rotor in said casing, means defining a plurality of working chambers in said rotor, a liquid ring revolving within said casing and creating pumping impulses in said working chambers, discharge passageways in said rotor leading from said working chambers, and valve means for said discharge passages carried by said rotor and arranged whereby the functioning of said valve means and the pressure required to open said passages remain uninfluenced and substantially constant during any variations of centrifugal force resulting from different rotor speeds.

In witness whereof, I hereunto subscribe my name this 25th day of January, 1930.

WILLIAM P. DALRYMPLE.