June 11, 1935. B. BOGOSLOWSKY 2,004,563

COMPRESSOR

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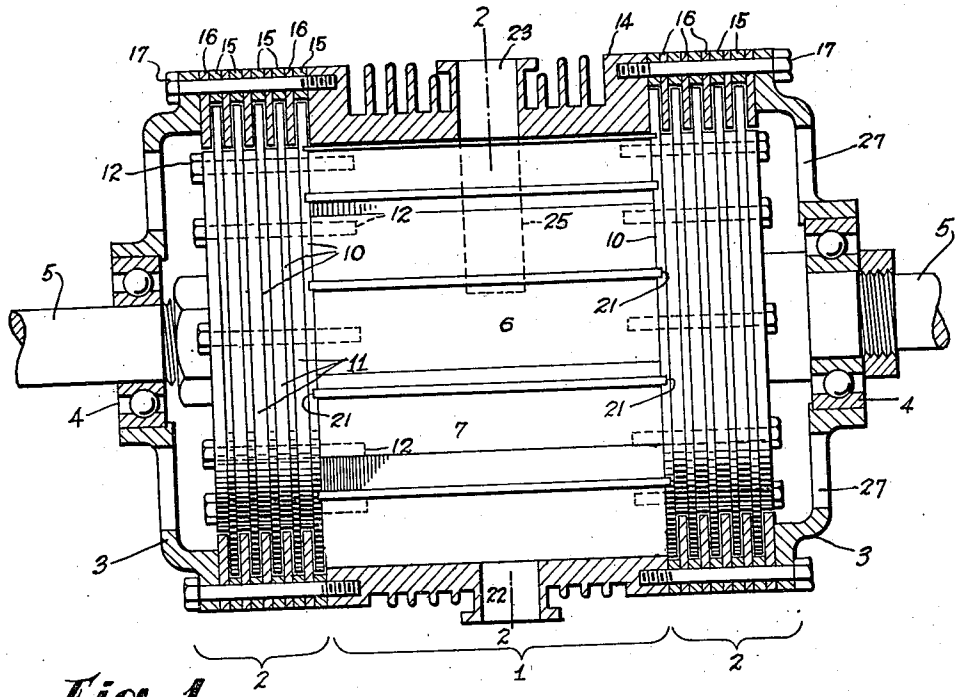


Fig. 1

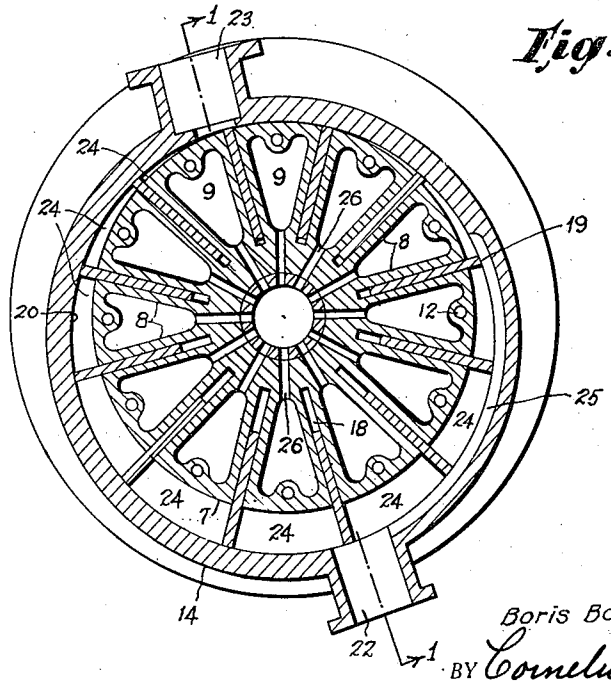


Fig. 2

INVENTOR.
Boris Bogoslowsky
BY Cornelius Zabriskie
ATTORNEY.

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COMPRESSOR

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Fig. 4

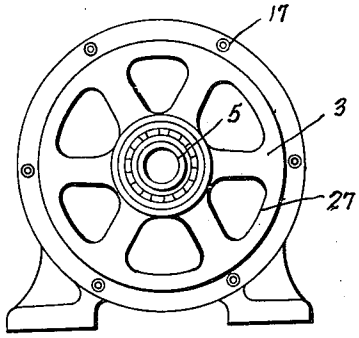


Fig. 3

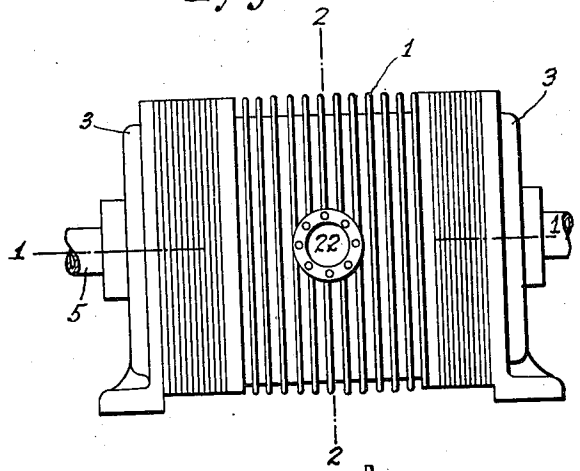


Fig. 5

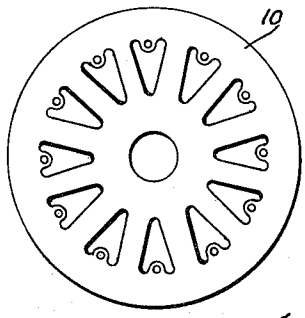


Fig. 6

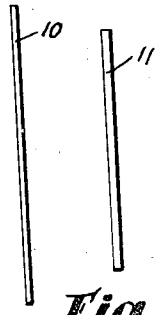


Fig. 7

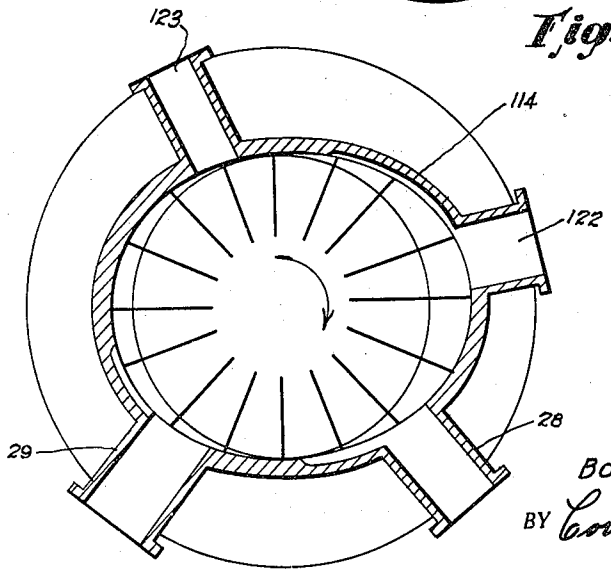


Fig. 8

INVENTOR.
Boris Bogoslosky
BY Cornelius Zabriskie
ATTORNEY.

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Fig. 9

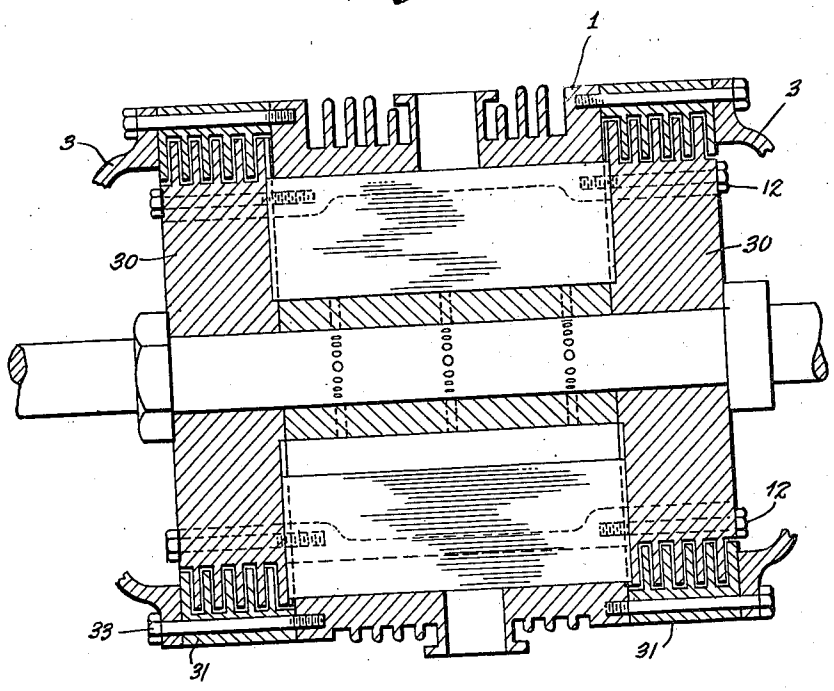
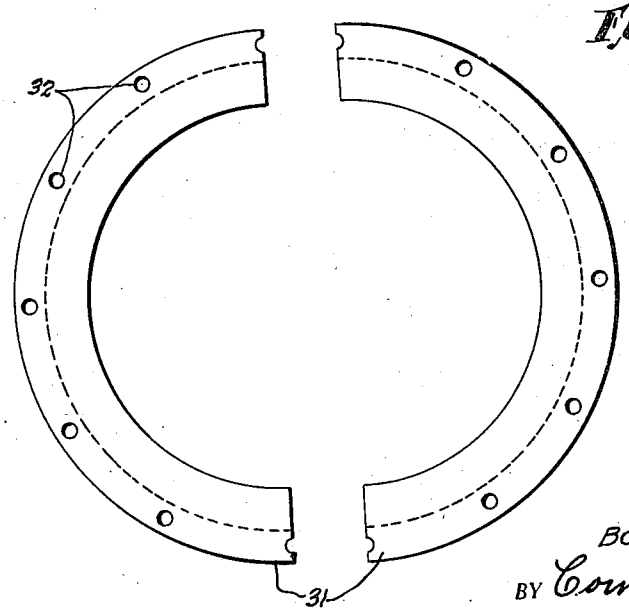


Fig. 10



INVENTOR.
Boris Bogoslowsky
BY Cornelius Zabriskie
ATTORNEY.

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2,004,563

UNITED STATES PATENT OFFICE

2,004,563

COMPRESSOR

Boris Bogoslowsky, Bridgeport, Conn., assignor, by mesne assignments, to Arnold C. Dickinson, Fitchburg, Mass.

Application June 23, 1931, Serial No. 546,274

4 Claims. (Cl. 230—152)

This invention is a compressor and more particularly a compressor of the rotary type. The object of the invention is to provide a compressor of extremely high efficiency and relatively light weight.

A further object of the invention is a compressor which will produce fluid under the desired pressure, but at a relatively low velocity.

An important feature of this invention and one which makes it possible to accomplish the remarkable results which have been attained is the employment of a highly novel and efficient form of packing. The compressor of this invention comprises, generally speaking, a casing provided therein with a cylindrical rotor position in and eccentric to the casing. The rotor is provided at its opposite ends with flanges operating within cylindrical portions of the casing and in order to obtain high efficiency, it is absolutely essential that leakage between these flanges and the casing be minimized. Heretofore various types of packing have been employed between rotors and their casings, but in every case where packing or joints have been utilized for this purpose there has been actual contact between the stationary and rotatable parts. This contact necessarily must and does result in friction and if an attempt is made to operate the compressor at high speeds, the friction becomes so great as to develop excess heat and require too much power to operate the parts. According to this invention, in contradistinction, I have, as a result of thorough experimentation and research, discovered that it is possible to produce what I term a "labyrinth" packing, so constituted as to preclude detrimental leakage without actual physical contact between the stationary and rotary parts. This labyrinth packing consists, generally speaking, in the utilization of interfitting annular flanges formed on the respective parts and having sufficient clearance that they will not contact yet spaced sufficiently close to preclude the unrestricted escape of pressure. With this construction, pressure attempting to escape through the clearance space is arrested and held back due to three factors present, namely, the fact that as this pressure works into the annular channels beyond the circumference of the disks 10, the velocity is diminished with consequent slight loss in pressure. This is accompanied by an expansion, and these two factors coupled with the necessary change of direction in passing through the labyrinth cause the retardation of the pressure to such extent as to practically eliminate the escape of pressure from the pockets between the respective vanes.

Another important feature of this invention resides in the fact that the rotor of my compressor is a hollow or cored rotor and this rotor is provided with a relatively large number of radially operable vanes guided for radial movement in webs formed in the rotor and guided in radial channels in the flanges at the opposite ends of the rotor. These vanes are set as close as they can conveniently be positioned with respect to one another so as to form between consecutive vanes relatively small pockets in which compression takes place. With this construction, the vanes follow one another in such rapid sequence and the pressure between successive pockets is graduated so finely that the pressure will be held in any one pocket by approximately the same pressure in the next succeeding pocket. In other words, the building up of the pressure in the successive pockets is so gradual that the pressure in each pocket will hold substantially the pressure in the preceding pocket. This makes it unnecessary to carefully pack the vanes and further eliminates friction thereby permitting the device to be run at speeds which would otherwise be wholly impractical. To further minimize friction, the vanes are made quite thin and may be fabricated from material which is itself a lubricant.

I have referred to the operation of the vanes in webs in the rotor. The rotor is in the main built up of a series of radial webs providing therebetween chambers, so that the whole rotor is in effect skeletonized. The chambers communicate through passages with the center of the rotor which is hollow and open at its ends and the chambers are also open at their ends to the atmosphere, so that as the rotor is turned at high speed, there will be a constant circulation of cooling fluid through the center of the rotor outwardly through the chambers and from the chambers to the outer atmosphere in the event that an air cooled structure is desired. If a water cooled structure is desired, the end plates of the casing may be connected with a suitable water outlet and water may be fed through the hollow center to produce the circulation of the cooling liquid.

The present invention may, in practice, be incorporated in a single stage compressor or may operate upon multiple stage principles. If a single stage compressor is desired, the casing may have have a single eccentricity with respect to the rotor and may in effect be cylindrical. If a multiple stage compressor is desired, that portion of the casing which coacts with the vanes will have a multiple eccentricity as will be here-

inafter more fully explained, there being an intercooler interposed between the respective eccentricities for reasons which will be fully understood.

The invention embodies further additional important features which will be apparent from the following detailed description when read in conjunction with the appended claims and the accompanying drawings.

The accompanying drawings illustrate different practical embodiments of the invention, but the constructions therein set forth are to be understood as illustrative, only, and not as defining the limits of the invention.

Figure 1 shows a single stage compressor embodying the present invention. The rotor and its shaft are shown in elevation, but the casing is shown in section in the plane of the line 1—1 of Figs. 2 and 3.

Figure 2 is a transverse section in the plane of the lines 2—2 of Figures 1 and 3.

Figure 3 is a side elevation of the apparatus shown in Figs. 1 and 2.

Figure 4 is an end view of the structure of Figure 3.

Figure 5 is a face view of one of the labyrinth packing disks.

Figure 6 is an edge view of the disk shown in Figure 5.

Figure 7 is an edge view of one of the smaller packing disks of the rotor.

Figure 8 is a diagrammatic view illustrating the manner in which the invention may be embodied in a multistage compressor.

Figure 9 is a view similar to Figure 1 but showing a modified form of labyrinth packing.

Figure 10 shows one of the labyrinth packing rings of the casing illustrated in Figure 9.

Referring first to the single stage compressor as shown in Figs. 1 to 7, inclusive, the casing or stationary part of the compressor comprises a central portion 1, which is cylindrical and is eccentric with respect to the two end portions 2 which are also cylindrical. The end portions 2 respectively include end plates 3 which have axial bearings 4 in which is supported the shaft 5 of the rotor 6.

With this arrangement, the rotor 6 is mounted to rotate coaxially with the end portions 2 of the casing and all parts of the rotor are coaxial with one another and with the end portions 2 of the casing, but that portion of the rotor which operates within the central portion 1 of the casing is eccentric with respect to said portion 1 of the casing, as is clearly shown in Fig. 2. This said central portion of the rotor is designated by the reference character 7.

The central portion 7 of the rotor is preferably made in the form of a casting of cylindrical form. This casting is tightly fitted upon the shaft 5 which is hollow and said casting 7 is cored out, so that its cross section resembles the spokes of a wheel, as shown in Figure 2. These so-called spokes constitute in effect webs 8 which support the peripheral cylindrical wall of the casting. Between the respective webs, the casting is hollow and constitutes a plurality of chambers 9 which extend from one end to the other of the casting. On the opposite ends of the casting 7 are mounted flanges and these flanges are each composed of a plurality of packing disks. These packing disks are of two sizes alternately positioned with respect to one another as clearly shown in Figure 1. The larger disks are designated 10 and one of them is shown in Figs. 5 and 6, the smaller disks are designated 11 and one of them is shown in Figure 7. These disks are fastened firmly to the ends of the casting 7, by means of screws or bolts 12 and said disks are provided with openings corresponding in shape and placement to the chambers 9 of the rotor so that these chambers will extend uninterruptedly from one end to the other of the rotor.

The central portion 1 of the casing is in the form of a casting 14 provided on its exterior with radiating fins if the pump is to be air cooled or jacketed if the pump is to be water cooled. This casting is of substantially the same axial length as the casting 7 and interposed between the ends of the casting 14 and the end plates 3 are rings 15 and 16, of which the rings 15 are relatively narrow, while the rings 16 are relatively wide. These several rings 15 and 16 are alternately exposed according to size and screws or bolts 17 extend through the end plates and into the casting 14 to secure the parts of the casing together.

As clearly shown in Fig. 1, the large disks 10 are juxtaposed with the narrow rings 15, while the small disks 11 are juxtaposed with the wide rings 16, so as to produce in effect a castellated cross section. It is important to this invention, however, that none of the disks contact with any of the rings and accordingly the rings 15 and the disks 11 are made of the same thickness, while the disks 10 and the rings 16 are made of the same thickness as one another, but of a lesser thickness, say one or two thousands of an inch less than the thickness of the rings 15 and disks 11. Thus, while all the rings and disks interfit as shown in this figure, they do so without contact in an axial direction and sufficient clearance is also allowed to preclude their contact in a radial direction. The shaft 5 is also mounted so that it will not have axial movement and it therefore follows that the rotor is adapted to turn without any part thereof thus far described coming in contact with any part of the casing except through the bearings 4.

Formed in each of the webs 8 of the rotor is a pocket 18 and in each of these pockets is positioned a vane 19 which, as the rotor is turned, is caused, by centrifugal force, to engage with and follow the inner circumferential wall 20 of the casting 14. It is pertinent here to note that there are preferably as many webs provided as the size of the structure will allow, so as to obtain as many vanes as possible under the circumstances. These vanes are therefore made as thin as the work which they are required to do will permit and are by preference constructed from some self lubricating material or composition embodying as one of its elements some lubricating substance, such as graphite, although the invention is not limited in this regard. Experiments made with graphited bakelite and textolite have given very satisfactory results although other materials may be employed without departing from this invention. The vanes are mainly guided by the pockets 18 of the rotor, but it will be noted from Figure 1 that the innermost disks 10 are also provided with radial channels 21 which register with the ends of the pockets 18 and serve to support and guide the opposite ends of the vanes. This is highly important as it serves as a packing between the vanes and the innermost disks 10 and eliminates side pressure or axial pressure on the vane. Without this structure, it is impossible to satisfactorily hold the pressure. The vanes working in

the channels, however, are highly efficient for the purpose stated.

In the single stage compressor shown in Figs. 1–7, the casing is provided with an inlet 22 and an outlet 23. The inlet is positioned at substantially the point of greatest distance between the rotor and the casing, while the outlet is positioned at approximately the shortest distance between the rotor and the casing. Thus, if the rotor is rotated in a clockwise direction in Fig. 2, air will pass into pockets 24 between the consecutive vanes and as the air is carried along in these pockets, it will be compressed until it reaches its maximum compression adjacent the outlet 23 where it will be discharged. It will be noted, moreover, that a passage or channel 25 extends from the inlet 22 in a retrograde direction along the inner surface 20 of the casing. The purpose of this channel is to permit air to enter the pockets 24 practically as soon as a minus pressure is produced therein. Thus, the pockets 24 are adapted to be fed with air if this is the fluid to be compressed, from the time they overlap the channel 25 until they pass by the inlet 22 and from that point to the outlet compression takes place.

I have referred to the use of as many pockets as convenient under the circumstances and I prefer to have these pockets small so as to permit of a considerable number of them. The purpose of this arrangement is to provide a relatively gradual stepping up of the pressure between the consecutive pockets, so that the pressure in any one pocket will serve as a pressure buffer against the escape of pressure from the next preceding pocket. As a result of this arrangement, it is found unnecessary to have an absolutely leak-proof joint between the outer edges of the vane and the surface of the wall 20. Furthermore, as hereinbefore pointed out, with the labyrinth packing which I have described as formed by the disks 10 and 11 and rings 15 and 16, leakage at the ends of the pockets 24 by escape of pressure through the joints between the flanges of the rotor and the casing is negligible. I have found that this pressure in order to escape must change direction rapidly a great many times. At each change of direction, there is retardation of the flow and this coupled with skin friction has been found by me to produce such efficient retardation that escape of pressure is negligible as to constitute in effect an actual packing through the use of the fluid itself, despite the fact that there is no actual contact between the movable and stationary parts.

It will be noted from Figure 2 that the shaft 5 is hollow and that each of the chambers 9 communicate with the interior of the hollow shaft through passages 26 while from Figure 1 it will be noted that the end plates are cut out or skeletonized as shown at 27. Accordingly, when the rotor is operated at high speed, the air within the hollow shaft will pass through the passages 26 and outwardly through the ends of these passages and through the openings 27, so that there will be a circulation of air within the rotor which will serve as a cooling medium. It will be further noted that by skeletonizing the rotor as shown, all of the walls thereof are relatively thin so that any heat generated can be readily carried off by the flow of cooling fluid through the interior of the rotor as stated. Air cooling is preferred, but, if desired, water or other cooling liquid may be circulated without departing from this invention.

In the invention, as thus far described, the apparatus has been shown as a single stage compressor. In Fig. 8, however, I have diagrammatically illustrated the adaptation of the present invention to a multiple stage compressor. In this figure, the structure is substantially the same as described in the preceding figures with the exception of the cross sectional shape of the casting 114 which corresponds to the casting 14 and with the further difference that there is a variation in the position of the inlet and outlet 122 and 123, which correspond to the inlet 22 and the outlet 23. As shown in Fig. 8, the casting 114 has a double eccentricity, i. e., it is not cylindrical. Furthermore, the casting is provided with an additional outlet 28 adapted to be connected with an appropriate intercooler, and an inlet 29 leading from said intercooler. The first stage of compression takes place while the air or other fluid taken in through the inlet 122 is carried along, compressed and passes it through the outlet 28 to the intercooler. It is returned from the intercooler through the inlet 29 and passed through a further compression stage until it is discharged through the outlet 123. The operation will be clearly apparent from the foregoing description of the invention. The packing operation of the vanes and the formation of the rotor structure is the same as in the preceding figures and the opposite ends of the casing are cylindrical to cooperate with the cylindrical rotor to produce the packing as hereinbefore described.

The apparatus of this invention has been referred to primarily as a compressor for compressing air, gas, or other fluids, but I am of course aware that it may be operated if desired as a vacuum pump.

The apparatus described embodies numerous advantageous features. The hollow rotor with its relatively thin walls permits of proper cooling, and this cooling applies not only to the main casting of the rotor, but also to the cooling of the labyrinth packing disks. These packing disks, as well as the cooperating rings of the casing constitute, in effect, a laminated construction which permit the parts to be readily assembled and also permits me to make the main casting of the casing in one piece without necessitating separable diametric sections. This is highly important from a commercial standpoint and from the standpoint of operation. The rotor of this invention is extremely light as compared with prior practice and its efficiency surpasses by many times any other compressor construction heretofore suggested. With reference to the multistage compressor feature of this invention, it will be apparent that the invention provides in one unit for the use of a single hollow rotor and a single stator in a multiple stage compressor or vacuum pump.

In the foregoing description, the labyrinth packing in both cases is built up in the form of laminations by superimposing disks and rings as described. It is within the purview of this invention, however, to produce labyrinth packing without laminations and in Figs. 9 and 10, such an arrangement is shown. In these figures, the flanges 30 of the rotor instead of being built up by the laminating disks 10 and 11 are made in the form of solid pieces secured to the main casting of the rotor by means of screws 12. The peripheries of these flanges are circumferentially channeled to produce a castellated cross section. The central portion 1 and the end plates 3 of the casing are made the same as in Figure 1, but instead of using packing rings 15 and 16, laminated as shown in Fig. 1, a single thick ring is used between the part 1 and each end plate 3. This

ring is designated 31 and is divided diametrically into two sections as shown in Fig. 10. The inner periphery of each ring is channeled to produce a castellated cross section complementary to and adapted to interfit with the corresponding flange 30 to produce the labyrinth packing. Each ring, moreover, is provided with holes 32 through which bolts 33 may be passed to bolt the rings 30 between the end plates 3 and the main casting 1. By virtue of these bolts, the parts are secured together and the sections of the ring are maintained in assembled relation. The purpose of using a split ring 31 as described is to permit assembly of the parts where the flanges 30 are made solid.

The accompanying drawings disclose the invention in its preferred practical form, but the invention is to be understood as fully commensurate with the appended claims.

Having thus fully described the invention, what I claim as new and desire to secure by Letters Patent is:

1. In an assembly of the character described, a stationary casing having coaxial annular recesses of castellated cross section in the opposite ends thereof, an intermediate portion of the casing constituting an eccentrically positioned chamber having inlet and outlet passages, a rotor positioned within said chamber and mounted to rotate coaxially of said recesses, flanges of castellated cross section on the ends of said rotor interfitting with said recesses, but free from contact with the walls of said recesses, said rotor having radial pockets and the flanges having juxtaposed radial channels in their inner faces, and vanes supported for radial movement in said pockets and channels, said vanes being positioned relatively close to one another to divide the chamber into a large number of relatively small pockets, the opposing surfaces of the interfitted castellated portions of the flanges and recesses being parallel to or coaxial with one another and spaced apart a substantially uniform distance throughout the labyrinth packing thus formed, whereby excessive axial or circumferential leakage or by-passing of pressure from or between the several pockets of the rotor is precluded.

2. In an assembly of the character described, a casing provided with circular end portions and with an intermediate eccentrically disposed cylindrical portion, a rotor positioned within the casing and mounted for rotation coaxially with the circular end portions of the latter, said rotor being provided at its opposite ends with flanges, said flanges having packing ribs of alternately small and large diameter and the corresponding portions of the casing comprising packing ribs of alternate large and small internal diameter complementary to and intermeshing with the packing ribs of the rotor, and spaced therefrom a distance small enough to hold compression, but free from contact therewith to form a labyrinth packing at both rotor flanges, and vanes interposed between the rotor and the intermediate portion of the casing and extending between the flanges of the rotor, the rotor being provided with radial pockets and the flanges having registering radial channels, said vanes being supported for radial sliding movement in said pockets and channels, said packing ribs being spaced axially and radially a substantially uniform distance.

3. In an assembly of the character described, a casing provided with circular end portions, the adjacent end walls of which occupy parallel planes and said casing having an intermediate eccentric cylindrical portion, a rotor positioned within the casing and mounted for rotation coaxially of said circular end portions, said rotor being provided at its opposite ends with flanges positioned in said circular end portions with the adjacent faces of said flanges occupying parallel planes and arranged in close fitting but non-contacting relation with said adjacent walls of the circular end portions, vanes interposed between the rotor and the intermediate portion of the casing and extending between the flanges of the rotor, the rotor being provided with radial pockets and the flanges having registering radial channels with the vanes supported for radial sliding movement in said pockets and channels to divide the interior of the intermediate portion of the casing into a succession of chambers, said circular end portions of the casing being provided with spaced apart inwardly extending ribs and said flanges being provided with spaced apart outwardly extending ribs interfitting with the ribs of the circular portions in close fitting but non-contacting relation with a substantially uniform spacing between the ribs throughout the castellated joint thus formed, whereby excessive axial or circumferential leakage or by-passing of pressure from or between the several chambers of the rotor is precluded.

4. In an assembly of the character described, a casing provided with circular end portions, the adjacent end walls of which occupy parallel planes and said casing having an intermediate eccentric cylindrical portion, a rotor positioned within the casing and mounted for rotation coaxially of said circular end portions, said rotor being provided at its opposite ends with flanges positioned in said circular end portions with the adjacent faces of said flanges occupying parallel planes and arranged in close fitting but non-contacting relation with said adjacent walls of the circular end portions, vanes interposed between the rotor and the intermediate portion of the casing and extending between the flanges of the rotor, to divide the interior of the intermediate portion of the casing into a succession of chambers, said circular end portions of the casing being provided with spaced apart inwardly extending ribs and said flanges being provided with spaced apart outwardly extending ribs interfitting with the ribs of the circular portions in close fitting but non-contacting relation with a substantially uniform spacing between the ribs throughout the castellated joint thus formed, whereby excessive axial or circumferential leakage or by-passing of pressure from or between the several chambers of the rotor is precluded.

BORIS BOGOSLOWSKY.