

June 3, 1941.

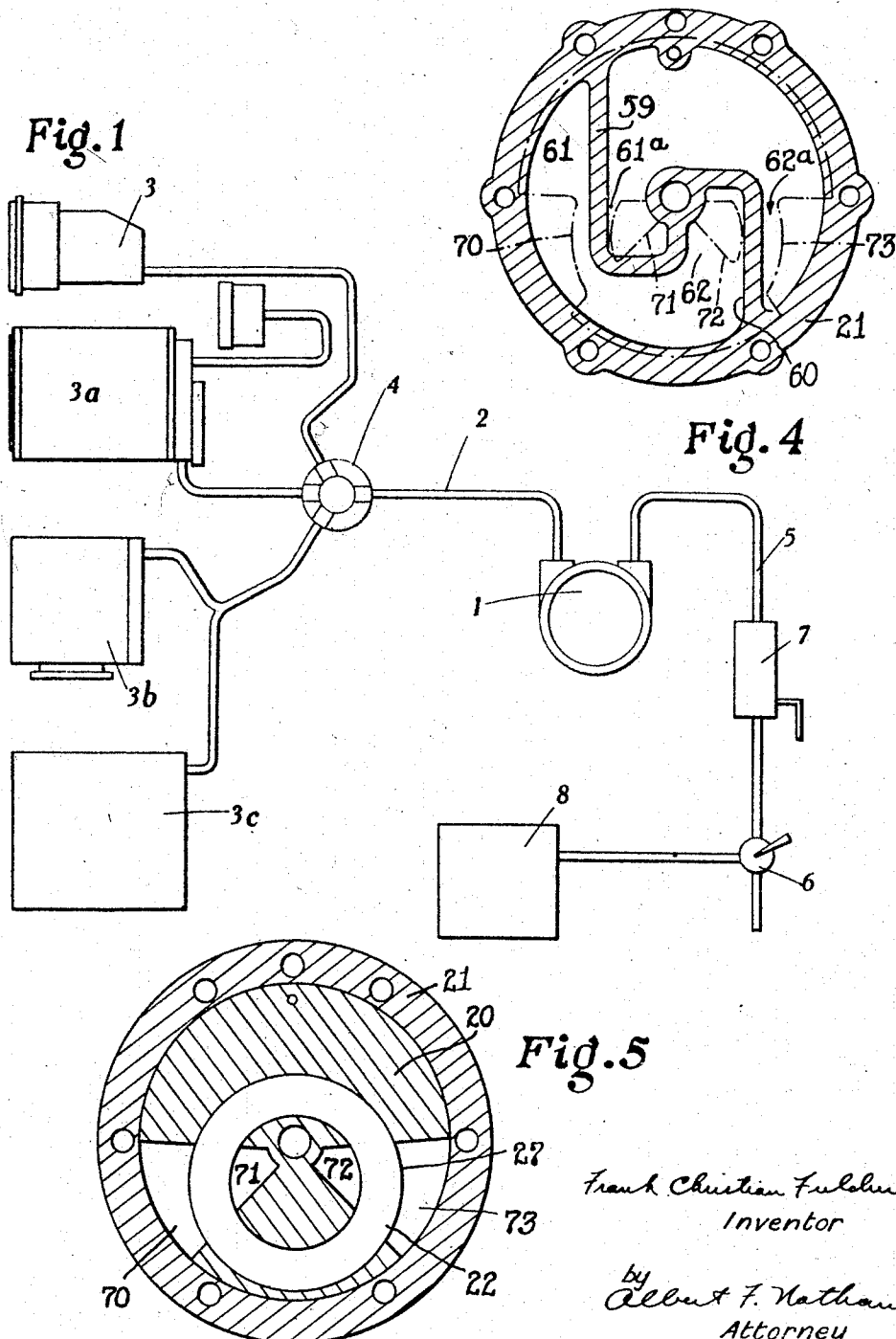
F. C. FULCHER

2,243,901

ROTARY PUMP

Original Filed May 24, 1939

3 Sheets-Sheet 1



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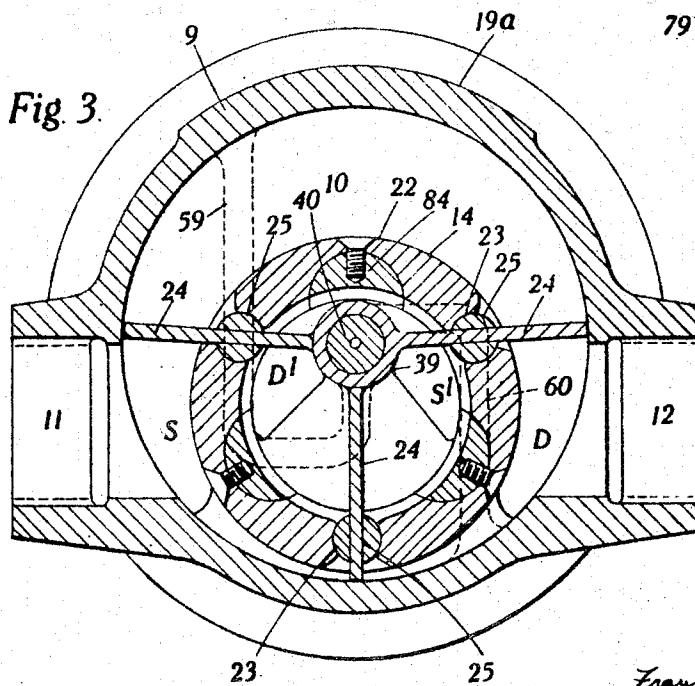
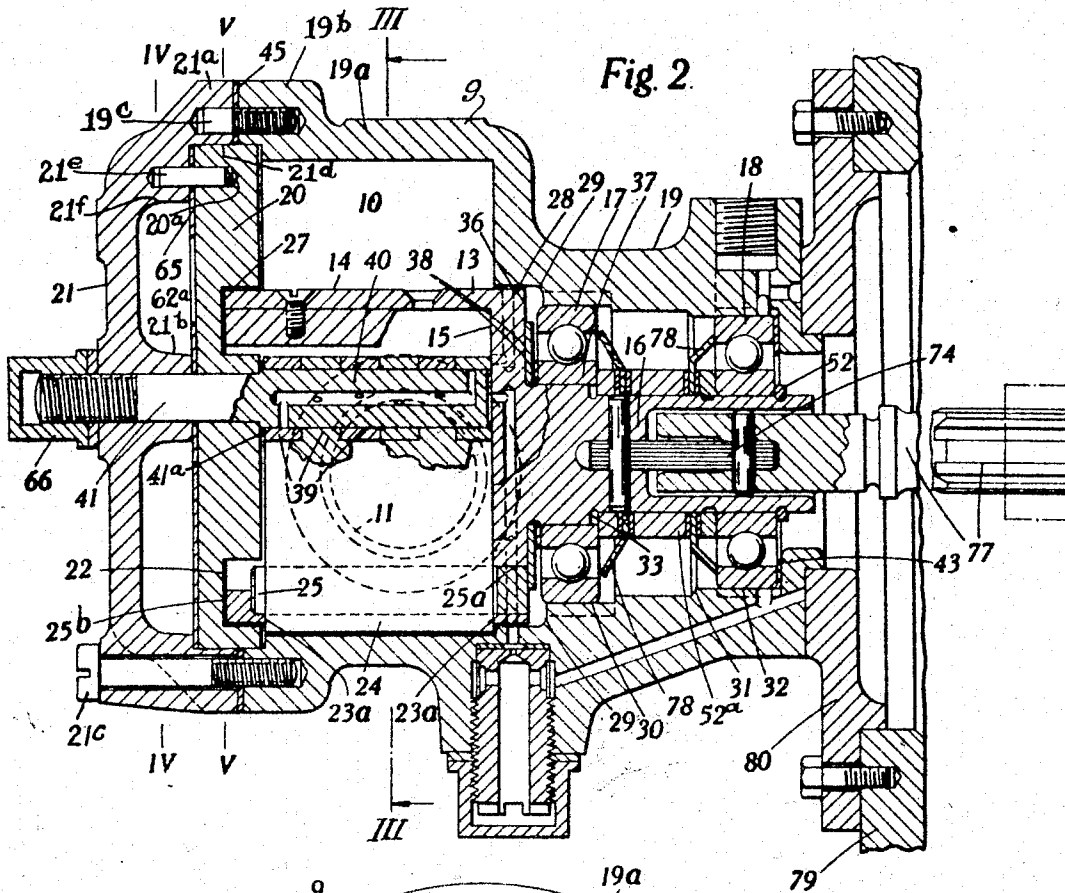
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ROTARY PUMP

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ROTARY PUMP

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3 Sheets-Sheet 3

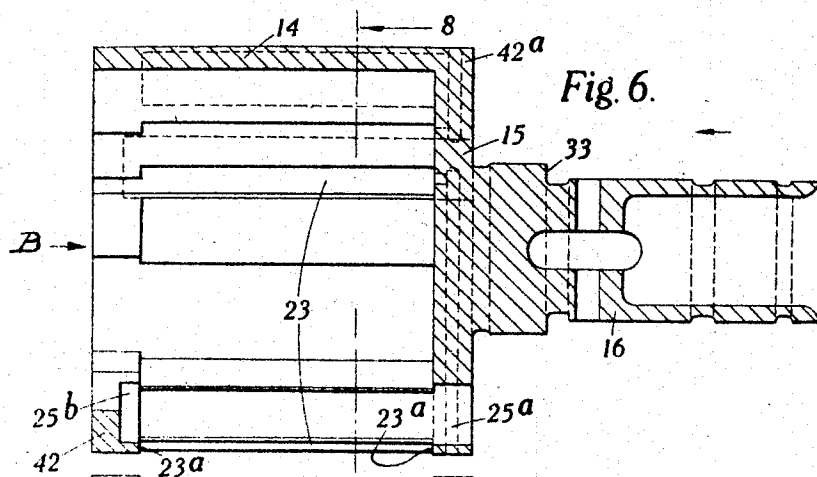


Fig. 6.

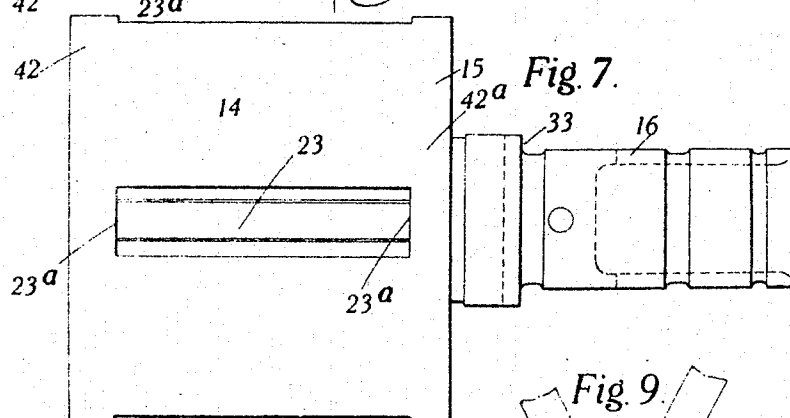


Fig. 7.

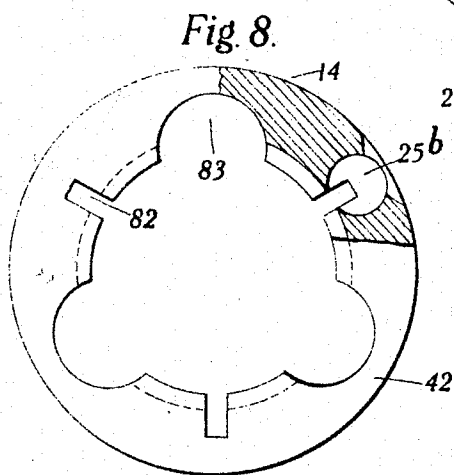


Fig. 8.

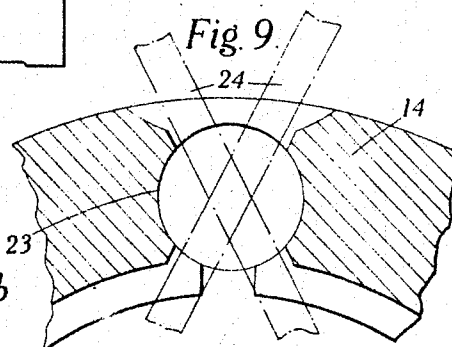


Fig. 9

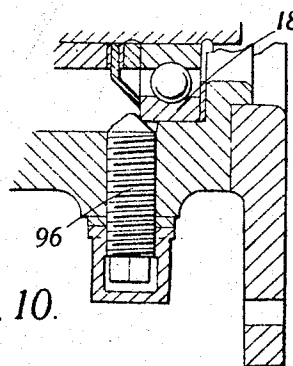


Fig. 10.

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UNITED STATES PATENT OFFICE

2,243,901

ROTARY PUMP

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EnglandOriginal application May 24, 1939, Serial No.
275,454. Divided and this application April 17,
1940, Serial No. 330,224. In Great Britain
October 12, 1938

12 Claims. (Cl. 230—157)

The present invention relates to rotary vacuum pumps for suction-operating instruments of aircraft, and particularly for operating such suction driven flight instruments as the artificial horizon, gyro-compasses and also the gyro-pilot, and preferably the invention relates to systems in which the discharge pressure is utilised for the occasional duty of operating de-icing equipment. The application is a division out of U. S. application Serial No. 275,454, filed May 24, 1939. These small capacity pumps are run at varying speeds from 800 to as high as 4,500 with a normal or cruising speed of the order of 3,000 to 3,500 R. P. M., the vacuum desirable being generally from four to nine inches of mercury inlet suction with a discharge pressure of about four inches of mercury outlet pressure when not operating, and from sixteen to twenty inches of mercury when operating, de-icer equipment. Types of pump favoured at the present time for this duty are (a) one in which vanes pass through a hollow rotor barrel, sliding through guides in the wall thereof, these vanes extending, one through another, diametrically from one side to the other of a working chamber of a ported cylinder whose working internal periphery is the shape of limaçon curve, and (b) a similar pump with a circular chamber but in which short vanes centrifuge into contact with the working chamber. The first type of pump is difficult to reproduce with uniform accuracy and is also relatively expensive. With such a construction it is not possible to avoid that rubbing friction between the vanes and the curved wall of the working chamber as would produce undue heat and cause attenuation of the air in the pump and consequent loss of vacuum and also expansion of the parts which also lowers the vacuum and the second type is objectionable because of the wear and heat which is caused by the centrifuging of the vanes against the periphery of the working chamber.

According to the present invention I operate these instruments by a pump having these essential characteristics, viz., (1) the rotor barrel is eccentrically mounted in a cylindrical working chamber with one end thereof open and intruding into an annular groove in the corresponding end wall of the chamber, there being an end wall at the other end of the barrel from which projects a shaft, (2) the vanes rotate about an axis centrally of such chamber where they are constrained against centrifuging, (3) the vanes pass through slots in cylindrical bearings in the walls of the rotor and (4) the casing is so ported

that upon relative rotation between the rotor and the vanes, working chambers of varying capacity are generated both inside and outside the rotor. Such a pump has hitherto been used for such heavy duties as exhausting gases of gas plants where the pump speed is comparatively low, e. g., 80-150 R. P. M. In reducing such a pump to the size and weight suitable for the purpose of the present invention and correspondingly increasing the speed of the pump, difficulties arise in maintaining the working chamber cool because in the known construction of this pump the ends of the rotor barrel itself are supported at opposite ends of the working chamber and end thrust on the rotor also involves pressure of the barrel against the walls of the chamber.

In such known pumps plain cylindrical bearings of dissimilar materials have to be used in order to prevent undue leakage in the pump at the ends of the rotor barrel and these involve difficulties in lubricating and cooling, the more so if these parts of the barrel were to rotate at high peripheral or linear speeds, and eventually the clearances would increase by wear. Furthermore, the greater the diameter of the borne part and its bearing the greater is the relative expansion of the dissimilar metals due to heat set up in the neighbourhood of the bearing and undue enlargement of the clearances is likely to occur for this reason. The choice of rotor materials is also restricted because certain light-weight metals such as Duralumin which I may use with my pump are unsuitable as a high speed bearing material.

I must maintain fine clearances at these regions because the loss of vacuum involved if these clearances enlarge unduly cannot be tolerated for the purpose of my invention. The cooling of the parts in the working chamber between which pressure cannot be avoided, i. e., mainly between the vanes and their cylindrical bearings is another important desideratum, as also is the avoidance not only of contact between the barrel and the casing, but also between the edges of the vanes and the casing. It is therefore essential for the purposes of this invention that the pump should have all of the four characteristics above enumerated and that the rotor barrel should be wholly supported both radially and against end thrust externally of the working chamber in such a way that the rotor barrel and the edges of the vanes make no contact with the walls of the working chamber. Therefore, according to the present invention the rotor is supported both radially and against end thrust by bearings co-op-

erating with the shaft portion of the rotor so that between the end peripheral portions of the barrel and the surrounding portions of the end walls of the chamber there are fine ring clearances, fine clearances also being provided between the edges of the vanes and the walls of the working chamber, the clearances acting as throttling seals against the loss of vacuum and being maintained not only during the normal running of the pump, but also when the pump is starting from rest and when friction heat and wear could not be avoided if the barrel itself were borne at each end. Fine clearances are in some cases also necessary between the ring face of the open end of the rotor and the bottom of the annular groove in the corresponding end wall of the casing.

The invention makes it convenient to use anti-friction bearings, e. g., ball or roller bearings, for supporting the rotor both radially and also against endthrust, e. g., due to pressure on the closed end wall of the rotor barrel, so that pressure of the ends of the barrel against the wall of the working chamber is not possible. The anti-friction bearings support the shaft of the rotor as near as possible to the closed end wall of the rotor on the one hand and also at such a distance from such end wall on the other as will suitably counteract the cantilever pressure load on the rotor, a suitable distance being one which between the remote ends of the races of the two bearings is at least equal to the length of the vanes. The rollers may run in grooves in the races of sufficient depth to enable the same bearing to take both the radial and the end thrust.

In this way I restrict the pressure areas to where the vanes pass through the rotor wall but effective cooling is possible of the vanes and the cylindrical bearing members firstly by a direct flow through the working chamber of the main body of air displaced by the pump, and secondly by the continuous flow of air through the inside of the rotor barrel so that not only does the use of the inside of the rotor as well as the outside give considerably greater capacity for a given size and weight than pumps of this kind which have hitherto been designed with the working space confined to the outside of the rotor barrel, but the air being displaced within the rotor barrel has valuable cooling properties and serves to distribute the lubricant effectively. In carrying the invention into practical effect, the open end of the rotor may be initially inserted into the annular groove with a push or running fit, the peripheral portion of the other end of the barrel likewise being inserted with a push or running fit into the corresponding cylindrical wall of the casing. I may utilise allowances according to classes P to Z of table III of the Newall Engineering Company. I prefer to start with push fits so that the clearances are established in running in the pump as then the finest clearances I can obtain are made available.

To achieve the fine clearances the invention requires, the pump must be constructed with great precision and the pump hereinafter described is built with this especially in view. It will be found that diametral location of the parts is, wherever possible, achieved by closely fitting co-operating cylindrical surfaces which can be machined with accuracy and that means of adjustment to secure the transverse clearances form important details of the pump. Some of the important constructional features of the invention which contribute to the desired precision and are all embodied in the preferred form of pump

hereinafter described are (a) the rotor is provided with an integral open end as distinguished from the known pump having the aforesaid characteristics in which the rotor has been slotted from that end to receive the cylindrical bearings and the slots subsequently closed by a retaining ring; this removes the difficulty of ensuring that in retaining, e. g., by a retaining ring, the tongue-like parts of the rotor produced by such open-ended slotting against the natural tendency to spring outwards and distort laterally, they will be brought into position to preserve perfect cylindricality especially when the retaining ring has been attached by multiple screws; (b) the shaft of the rotor is an integral projection of the end wall of the barrel of the rotor and is shouldered to provide a length of greater diameter near to the end wall and the extension of the casing which receives the outer races of the bearings is integral with the body of the casing and its inner cylindrical wall is shouldered to provide parts of different diameters, the smaller or smallest being at the end of the extension remote from the working chamber. The advantages of this are, firstly, the shaft and extension of the casing can be machined to true concentricity with the barrel portion of the rotor and lack of concentricity incident to the use of fastening screws or other devices is obviated and secondly, each of the ball races can be secured with the desired driving fit without contacting with the cylindrical surfaces which receive the other races; (c) shimming means which retain the cylindrical bearings in the barrel wall form a fine clearance between the outer surface of the end wall of the barrel and the adjacent end face of the outer race of the inner ball bearing, so providing an additional leakage-reducing zone at this end of the rotor barrel; (d) shims and appropriate clamping means are provided with the aid of which the desired fine diametrical (transverse) clearances between the end walls of the working chamber and the vanes on the one hand and the ends of the rotor barrel on the other can be obtained with especial facility. Finally, (e) the vanes are provided with hinge eyes which embrace the overhung portion of a spindle which projects into the working chamber from one end wall, thereby facilitating the construction of the pump as a precision instrument.

It is to be understood that the objects of my invention cannot be fulfilled with a pump in which divided end portions of the vanes are forced by centrifuging or by spring means into contact with the peripheral wall of the working chamber, and I do not include any such construction in the specification and claims hereof.

I am aware of another proposal of a pump having the four characteristics hereinbefore set forth, but the construction as in the old form of gas exhauster previously referred to is such that the rotor is supported in the working chamber and the rotor is split longitudinally and closed again by a retaining ring and moreover all the air displaced by the pump is compelled to pass through the complex ports of the casing.

Briefly it may be stated that the main object of my invention is to produce a construction of pump which will permit me not only to run the rotor and vanes at high speeds out of contact with the walls of the working chamber, thereby to avoid heat and wear which would soon have a destructive action on the vital parts of the pump, but to employ very fine clearances which will reduce slippage to

a minimum so that a high vacuum can be obtained.

In order to achieve the aforesaid main object, it is a further object of my invention to provide a construction of pump in which although both the vane-supporting spindle and the rotor are overhung, i. e., supported cantilever fashion, deflection of both the vanes and the rotor will be prevented, or reduced to such a minimum that these fine clearances will not be destroyed or interrupted during the running of the pump throughout the predetermined range of speeds.

Another object of the invention is to achieve the aforesaid objects whilst reducing as far as possible the size and weight of the pump by utilizing the space within the pump to the maximum and a further object is to improve the cooling action by the gases being displaced on the interior parts of the pump where heat is especially liable to be generated.

Another object of my invention is to construct the barrel in such a manner that those end peripheral portions which are to make fine ring clearances with the surrounding parts of the casing can be more accurately made to the desired cylindricity and preserved during running of the pump.

Another object of my invention is to facilitate obtaining the desired fine diametrical clearances by means which permit of adjustment during assembly of the pump but prevent these fine clearances where established from being subsequently upset by any external maladjustment.

In order that the present invention may be the more readily understood, I will now describe the same more particularly with the aid of the accompanying drawings, in which:

Fig. 1 is a view of the pump and the line to the instruments, but as no novelty is claimed for the instruments per se or for the connections thereto from the pump, the layout is mainly diagrammatic. Fig. 2 is a side sectional elevation of the pump. Fig. 3 is a cross-sectional elevation on the line III—III of Fig. 2. Figs. 4 and 5 are cross sectional views on the lines IV—IV and V—V of Fig. 2. Fig. 6 is a sectional elevation through the rotor with the vanes and their bearings removed. Fig. 7 is an external side elevation of Fig. 6. Fig. 8 is an end view partly in section looking in the direction of the arrow B, Fig. 6. Fig. 9 is a sectional detail view of one of the slots in the rotor barrel which receives the cylindrical bearings for the vanes. Fig. 10 is a detail view of a means to assist in axially retaining one of the outer bearing races.

Fig. 1 shows a general lay-out in which 1 is the pump, 2 the suction line to the instruments which are indicated diagrammatically and of which the "turn and bank" indicator is marked 3, the artificial horizon 3a and the directional gyro is 3b, whilst the gyropilot is marked 3c, there usually being a suction relief valve 4. A pressure line 5 leads through an oil separator 7 to de-icing equipment control valve indicated diagrammatically at 8, valve 6 permitting of exhaust to the slip stream when the de-icing equipment is not in use.

The pump shown in detail in Figs. 2 to 10 comprises a casing 9 containing a crescent shaped outer pumping chamber 10 having suction and discharge ports 11, 12, the rotor 13 comprising a barrel portion 14 with one end open and the other end closed by a wall 15 from which projects an integral shaft portion 16 which is supported by bearings 17, 18 housed in a reduced

extension 19 of the casing, this extension 19 being integral with the cylindrical part 19a of the casing. The casing is open at the end remote from the bearings, and a cover comprising inner and outer walls 20 and 21, is provided, the inner wall 20 having an annular groove 22. This groove and the bearings 17 and 18 are in axial alignment but are eccentric to the axis of the working cylinder. The barrel wall has slots 23 for the passage of vanes 24 of which three are shown but more could be used if desired. The vanes pass through slots in the cylindrical bearings 25 which can oscillate in the slots 23 in the barrel which are shaped as shown in Fig. 9 for this purpose. The bearings are inserted through holes 25a so that the other end seats into holes 25b in the continuous end ring portion 42 of the rotor. The bearings 25 are preferably of a different metal from the rotor, e. g., of phosphor bronze when the rotor is of steel or Duralumin. The casing is preferably of Duralumin and the vanes of steel.

The outer wall 27 of the annular groove in wall 20 is made of such diameter, as also is the cylindrical wall 28 at the other end of the casing, that the rotor barrel is inserted with a push, or a running, fit therein, and these cylindrical walls do not participate in the support of the rotor, between which and the said cylindrical walls continuous fine ring clearances are permanently maintained (at any rate once the pump has been run in), but the rotor is wholly supported, both radially and against end thrust by the deeply recessed ball bearings 17, 18, the inner one 17 of which is located as near as possible to the end wall 15 of the rotor barrel and the outer bearing 18 being near the remote end of the rotor shaft. The distance between the remote end faces of the two races is made conveniently and advantageously at least substantially equal to the length (axially) of the vanes.

The interior of the casing extension 19 is shouldered down at 29 and the outer dimension of the large bearing chosen so as to allow the latter to pass by the cylindrical wall of the opening 28 which receives the corresponding end of the barrel and to make a driving fit with the cylindrical wall 30 and is also shouldered down at 31 to allow the outer race of a correspondingly chosen smaller ball bearing to pass freely by the walls 28 and 30 and to make a driving fit with the wall 32. The shaft of the rotor is also shouldered down at 33 to allow the inner races to be accurately assembled thereon. A spring ring 52 engages in an annular groove in the shaft 16 and retains the bearings 17 and 18 and associated spacing means 52a in position on the shaft. A conically headed screw 96 may be used if desired (see Fig. 10) for positively locating the outer bearing race axially. By forming the rotor shaft as an integral part of the rotor and the extension 19 as an integral part of the casing, I avoid at this end of the pump jointing which would render accuracy of assemblage more difficult and with the construction of the casing shown, I may very accurately align the rotor barrel with its bearings and the cylindrical walls 27 and 28. Fine transverse or diametrical clearances are preferably obtained with the aid of the shims hereinafter described.

From the foregoing description it follows that when the pump is in normal working condition the rotor is radially supported solely by the ball bearings. Between the outer surface 36 of the end wall of the rotor barrel and the adjacent

end of the inner race 37 of ball bearings 17 shims 38 are provided which retain the cylindrical bearings 25 in the rotor wall against endwise movement and prevent the rotor, particularly due to pressure on the end wall of the barrel, from pressing against the outer race of the ball bearing 17, and finally they may reduce the gap between the outer surface 36 and the adjacent end face of the said outer race to a fine clearance which acts as a further deterrent to the leakage of air from the working chamber to the bearing casing or of oil from the latter to the working chamber. End thrust is in fact taken by the ball bearings, the rotor being kept out of contact with the casing except through the ball bearings.

While the support of the rotor is entirely removed to that portion beyond the end wall of the barrel and clearances should be as fine as possible since they are to act as throttle closures to reduce leakage to the smallest amount possible. I therefore prefer in manufacture to work to push fits in the assemblage of the parts so that the actual clearances are produced in the course of running in the pump. When these clearances are thus established it is ensured that they are of an extremely fine and lasting character and greatly contribute to countering undue loss of vacuum. The provision of ball bearings at opposite ends of the barrel itself would make it practically impossible to produce efficient seals for my purpose where maintenance of an efficient vacuum is vital. On the other hand to use co-operating cylindrical surfaces to support the rotor barrel would involve such friction and heat as would lead to such enlarged clearances in running that the pump would become extremely inefficient for its duties. By removing the support to the rotor shaft I have the choice of bearings and this is for combined radial and end thrust bearings. These bearings externally of the barrel can be readily kept cool, e. g., by packing grease in the sealed space between the two bearings. Moreover, the periphery of the barrel of the rotor has a considerable peripheral (linear) speed which again makes it very undesirable to use the plain cylindrical surfaces surrounding the ends of the barrel as bearings. The vanes must be supported against endwise displacement but as this is effected between the ends of the vanes and the ends 23a of the slots 23 in the rotor the relative travel per revolution at this zone is small in relation to that which occurs between the vanes and the end walls of the chamber so that as compared with the friction which would ensue if contact between such latter parts were permitted friction due to the endwise location of the vanes is small. The vanes are of light weight compared with the rotor and being borne by the small central spindle do not give rise to any problem of heating and wear comparable to that which would be set up by using the cylindrical surfaces surrounding the end peripheral portions of the rotor barrel as supporting bearings. The hinge eyes of the vanes may have initially a Newall push to running fit on the spindle. The hinge eyes are brought close to the inner periphery of the rotor barrel as the smaller the distance between the eyes and such periphery the greater is the volumetric efficiency of the pump.

The vanes are provided with intercalated spaced hinge eyes 39 which encircle the overhanging portion 40 of a spindle 41 which is secured in the end walls 20, 21 of the casing and they are thereby prevented from centrifuging and

pressing against the cylindrical wall of the pump chamber. The slots 23 in the rotor barrel do not extend to the ends of the barrel but are closed at each end at 23a so as to leave integral and uninterrupted end ring portions 42, 42a which greatly conduce to obtaining true cylindricality and the continuous fine ring-clearances between those parts of the barrel and the wall 27 of the annular groove and wall 28 of the casing.

The method of assembling the vanes in the cylindrical bearings will not be described herein, since this forms the subject of my co-pending application Serial No. 275,454 but as shown in Fig. 2 the vanes are positively retained against axial displacement by the ends 23a of the slots 23 in the barrel wall.

The spindle 41 upon which the interleaving eyes or butts 39 of the rotor vanes are rotatably mounted is supported cantilever fashion in the walls 20, 21 so as to extend within the rotor barrel in parallelism with, but eccentric to, the axis of the rotor barrel, and is retained in position by a cap nut 65 which engages the threaded extremity of the spindle.

Various proposals have been made to provide a hollow barrel rotor with the vanes passing through slotted cylindrical bearing pins in the barrel wall, using only the crescent shaped chamber between the barrel and the cylinder wall, but for the purposes of my invention it is essential that the pump should be so constructed that the interior of the rotor is also used as a working chamber because this enables me not only very considerably to reduce the size and weight of the pump but also to obtain a greatly improved cooling action on that part of my pump where heat is most likely to be generated, viz., where the vanes pass through the wall of the barrel.

For this purpose the inner and outer walls 20 and 21 are appropriately passaged and ported to co-operate with the working chambers of varying volume which are formed in the interior of the rotor. For this purpose the annular chamber between such walls is separated by webs 59, 60 which form conduplicated recesses, one having end portions 61, 62 and the other having end portions 61a, 62a.

The inner wall 20 is formed with four ports 70, 71, 72 and 73 which, as shown more clearly in Fig. 5, are disposed across the wall so that ports 71 and 72 lie within an area corresponding to the space inside the rotor 13, and thus communicate therewith, while ports 70 and 73 lie without the groove 22 and peripheral wall of rotor barrel 13 and communicate with the space outside the rotor 13. The ports 70, 73 and 71, 72 may be separated from the groove by concentric arcuate walls so as to leave the cylindrical walls of the annular groove 22 uninterrupted. Although it is still advantageous to have a fine clearance between the end ring face of the rotor and the bottom of the annular groove so as to provide an additional fine throttling seal, this is not then essential.

As shown clearly in Fig. 4, the outer ports 70 and 73 of inner wall 20 register with recesses 61, 62a respectively, while the inner ports 71 and 72 of the said wall register with recesses 61a and 62 respectively.

In Fig. 3 the position of the ports 70, 71, 72 and 73 in the inner wall 20 are also indicated by the letters S, D and S', D', the ports S, S', being placed in communication with the suction port 11 by the cavity 61, 62 and the ports D, D' being

placed in communication with the discharge port 12, by the cavity 61a, 62a.

The relative sliding movement between the vanes and the rotor which is produced during the rotation of the pump generates chambers of increasing and decreasing volume both inside and outside the rotor, each of the outside chambers being defined by any two adjacent blades, the outer periphery of the rotor and the inner periphery of the pump casing and each inside chamber being defined by any two adjacent blades, the inner periphery of the rotor and the outer periphery of the hinge eyes of the vanes.

In a three bladed pump the maximum divergence of the blades is shown in the upper half of the diagram in Fig. 3 in which the chamber therebetween has attained its maximum volume and the leading vane is about to open discharge port D and suction port S' and the trailing vane has just cut off the suction port S and discharge port D'.

As the outside chamber of maximum volume is translated to the position shown in the right quarter of Fig. 3 it generates a chamber of decreasing volume on the outside of the rotor and a chamber of increasing volume on the inside of the rotor, whereby, the air is expelled from the outside chamber through the discharge port 12 and drawn into the inside chamber through the suction port S', cavity 61, 62 and ports S and 11. Simultaneously the chamber on the outside of the rotor in the left quarter of the drawing (Fig. 3) is ultimately translated to the position of maximum volume in the upper half of the diagram (Fig. 3) while at the same time the vanes generate inside the rotor a chamber of decreasing volume in the left hand quarter of the diagram, whereby air is drawn into the outside chamber through the port 11 and expelled from the inside chamber through the port D', cavity 61a and 62a and ports 13 and 12.

When the bearings are mounted on the shaft of the rotor with shims 38 and spacing means 52a in position and the inner race of the outer bearing held by the ring 52, the whole rotor unit with the bearings is entered into the casing, and, since the vanes as before described, are axially located by means of the ends 23a of the slots in the walls thereof, a shim 43 determines the clearance which those end edges of the vanes which are disposed at the shaft end of the rotor have with the corresponding end wall of the pumping cylinder while shims 45, 65, the latter one being appropriately ported to register with the ports in the inner wall, determine the clearance between the other end edges of the vanes and the other end wall of the pumping cylinder and between the end ring wall of the rotor and the bottom of the annular groove 22 in the inner wall and these clearances are pre-formed, i. e., they are not formed during running-in of the pump, although the clearance between the outer longitudinal edge of the vane and the wall of the pumping cylinder is preferably formed during the running-in operation. The construction of the end wall in two parts and the means for clamping and locating the parts together will now be explained. The forming of the inner and outer spaced walls 20 and 21 of the pump in separate components is especially advantageous when the parts or some of them are to be cast owing to the rather complicated ports and passages in the end wall. The kind of pumps, with which the invention deals, run at extremely high speeds and with fine clearances and must be made with pre-

cision, a rigid and accurately assembled casing being a first essential. In accordance with the main feature of the invention, the inner wall is made a close peripheral fit in the body of the casing and preferably also in the outer wall so that the parts are mutually diametrically located. Provision is made for preventing rotation of the parts and for clamping these against relative axial displacement. In this way I obtain a very rigid casing, permitting precision of alignment of the rotor receiving groove in the inner wall and the opposite rotor receiving aperture in the casing body, while the ports and passages in the end of the casing may be more conveniently made in the casting and subsequently formed with smooth walls which facilitates the flow of the gases thereover.

The maintenance of fine clearances between the rotating parts and the walls of the chamber is further facilitated by my method of clamping with the aid of appropriate shims. This adjustability is very desirable when the casing components or some of them have been cast and subsequently machined, so as to compensate for variations in the machining of the parts. Further, by arranging the inner wall to be encircled by the outer wall and the casing body I can dispose the shims in such a manner that the peripheral surfaces of the walls co-operate with a peripheral edge of the shims and serve to confine the shims against radial spread at least in one direction in the course of clamping the parts together. Intrusion of the shims into the working chamber may be particularly objectionable.

Referring more particularly to Figs. 2, 3, 4, and 5, the cover plate 21 is in the form of a disc having a peripheral flange 21a adapted to be fluid tightly secured to the flange 19b of the pump casing with the aid of the jointing shim 45, and has its inner face recessed and webbed to form the conduplicated recesses 61 and 62a about an inwardly projecting boss 21b. The cover plate 21 is adapted to be clamped to the casing by a series of bolts 21c spaced about its periphery.

As shown in the drawings, a radial projection 21' extends inwards from the cylindrical face of the recess 62a and is provided with a hole for the reception of a dowel pin 21e which projects axially to enter a hole 20a formed in the outer face of the insert plate 20, thus to locate the plates 20 and 21 in their correct relative angular positions when assembled. The face of flange 19b is provided with a tapped hole into which the screw-threaded end of a dowel pin 19c is screwed so as to project axially outwards for sliding engagement in an axially aligned hole in the face of flange 21a. The dowel pin 19c thus serves to locate the sealing plate 20 in a predetermined angular position relative to the pump casing 9.

The inner face of the insert plate is provided with an annular groove 22 which is eccentric to the co-axial centres of the sealing plate and insert plate, but concentric with the axis of the rotor barrel and this recess 22 receives with a fine clearance the unsupported end of the rotor barrel, which latter rotates relatively to the insert plate.

The boss 21b on the cover plate is bored axially to receive the reduced extremity of a spindle 41 upon which the interleaving butts 39 of the rotor vanes 24 are rotatably mounted. The spindle 41 extends through the insert plate 20 and is thus supported cantilever fashion in boss 21b so as to extend within the rotor barrel in parallelism with, but eccentric to, the axis of the

rotor barrel, and is retained in position in the boss by a cap nut 66 which engages the threaded extremity of the spindle. The spindle 41 serves by its shoulder 41^a to clamp the insert plate 20 against the cover plate 21 when the cap nut is tightened and to press the plates together to form a fluid tight ring joint between them with the aid of the jointing shim 65 of the desired thickness which further serves to maintain the inner face of the insert plate 20 in the desired spaced relation with the corresponding end edges of the vanes 24 and the bottom of the annular recess 22 in the desired spaced relation with the open end of the rotor 14 when the ring joint between the flanges 21^a and 19^b is formed to that end.

The inner face of flange 21^a is rebated at 21^d for the reception of the outer peripheral edge of an insert plate 20 which acts in a manner more particularly described hereinafter.

The ported insert plate 20, as shown in Fig. 2, is a thick disc which exceeds in diameter the bore of the pumping chamber 10, and intrudes into the rebate 21^d in the sealing plate 21, and into a coaxial internal rebate of equal diameter formed around the open end of the pump casing. The periphery of the insert plate has a close fit in the cylindrical wall of the rebates so that the three parts are mutually diametrically located. When the flanges 19^b and 21^a are clamped together by studs 21^c with the desired thickness of shimming between them and between the cover 21 and the insert plate 20, the latter is positioned in the desired spaced relationship with the vanes and the unsupported end of the rotor.

By fine clearances herein referred to are meant clearances of the order of from one-quarter to one and a half mils or thereabouts (1 mil=.001 inch). The clearances are shown exaggerated in the drawings to facilitate the understanding of the invention.

The rotor with its bearings and the pump casing form a unit in which the shaft portion of the rotor is borne both radially and against end thrust. This is essential because the pump has generally to be fitted to the engine shaft through the medium of a flexible coupling e. g. the laminated flexible coupling 74 attached to the connecting piece 77 which is splined or otherwise formed for keying to the engine shaft. It is necessary to have the rotor properly borne both radially and against end thrust in the pump casing as the pump must be a completely operative unit in itself so as to be readily adaptable to the standard or existing engine equipment. In other words, I do not rely on bearings of the engine to support the rotor either radially or against end thrust. The flexible coupling 74 is not described in detail, since it forms the subject of my co-pending application Serial No. 275,456 in the specification of which a full description is to be found.

The spring washers 78 assist in sealing the interior of the pump from the engine, to the accessory pad 79 of which the pump is secured through the medium of the plate 80.

Grooves 82 and 83 containing filling pieces 84 are for purposes of assembling the vanes and form no part of the present invention.

The method of lubricating will not be fully described herein as it forms the subject of my co-pending application Serial No. 275,453.

I claim:

1. A high speed rotary vane pump comprising a casing providing a working cylinder having

peripheral and end walls cooperating with each other to form a pump chamber, an annular groove in one of said end walls of said cylinder and an opening in the other end wall, said groove and said opening being eccentric to said cylinder, a rotor within said pump chamber comprising a shaft portion and a barrel portion which is open at one end and has a wall at the other, said open end comprising a ring face intruding into said annular groove and the other end of said barrel intruding into said opening in said other end wall, a spindle supported in said grooved end wall so as to project cantilever fashion into the working cylinder centrally thereof, said rotor having its shaft portion extending from one end only of said barrel, a plurality of vanes provided with bearing eyes which are rotatably supported by said spindle and which constrain the vanes from centrifuging, slotted cylindrical bearing members oscillatable in the wall of said barrel, said vanes passing through the slots in said members and said members and said vanes being relatively slidable, said vanes being arranged to generate with the cylinder walls and with the inner and outer walls of the rotor barrel pump working chambers of varying capacity both inside and outside of said rotor barrel and said casing being ported to cooperate with said inside and outside working chambers, there being fine ring clearances not exceeding one and a half mils between the end peripheral portions of said barrel and the surrounding portions of the end walls of the working cylinder, said clearances acting as throttle seals against loss of vacuum and being present when the pump is resting, fine clearance not exceeding one and a half mils also being provided between the edges of the vanes and the walls of the working chambers, shimming means determining the end clearances between the rotor, vanes, and end walls of the working chambers, anti-friction bearings cooperating with the shaft portion of said rotor constructed and proportioned so as to wholly to support said rotor cantilever fashion out of contact with the working cylinder and not only radially but also against the end thrust produced by the pressures within the pump with a rigidity sufficient to preserve circumferential continuity of said ring clearances during the running of the pump to the predetermined maximum speed and said spindle being rigidly fixed to the casing so that during such running, clearance shall be preserved between the edges of the vanes and the walls of the working chamber.

2. A rotary high speed pump comprising a casing providing a working cylinder having peripheral and end walls cooperating with each other to form a pump chamber, an annular groove in one of said end walls of said cylinder and an opening in the other end wall, said groove and said opening being eccentric to said cylinder, a rotor within said pump chamber comprising a shaft portion and a barrel portion which is open at one end and has a wall at the other, said open end intruding into said annular groove and the other end of said barrel intruding into said opening in said other end wall, there being fine ring clearances between the end peripheral portions of said barrel and the surrounding portions of said groove and said opening which act as throttle seals against loss of vacuum and are present when the pump is at rest, a spindle supported in said grooved end wall so as to project cantilever fash-

ion into the working cylinder centrally thereof, said rotor having its shaft portion extending from one end only of said barrel, a plurality of vanes provided with bearing eyes which are rotatably supported by said spindle and which constrain the vanes from centrifuging, slots in said barrel wall, slotted cylindrical bearing members oscillatably mounted in said slots, said barrel slots being closed at each end so that at each end of the barrel there are left continuous integral peripheral portions thereof, which portions cooperate with the said surrounding portions of the casing to form said ring clearances and which by their integral circumferential continuity enable said ring clearances to be of great fineness, said vanes passing through the slots in said members and said members and said vanes being relatively slidable, said vanes being arranged to generate with the cylinder walls and with the inner and outer walls of the rotor barrel, pump working chambers of varying capacity both inside and outside of said rotor and said casing being ported to cooperate with said inside and outside working chambers, fine clearance also being provided between the edges of the vanes and the walls of the working chambers, internal spacing means for adjusting the end clearances between the rotor, vanes and end walls of the working chambers during the assemblage of the pump components, anti-friction bearings cooperating with the shaft portion of said rotor and constructed and proportioned so as wholly to support said rotor cantilever fashion out of contact with the working cylinder and not only radially but also against the end thrust produced by the pressures within the pump with a rigidity sufficient to preserve circumferential continuity of said ring clearances during the running of the pump to the predetermined maximum speed and said spindle being rigidly fixed to the casing so that during such running, clearance shall be preserved between the edges of the vanes and the walls of the working chamber.

3. A rotary vane pump constructed as in claim 1, in which there is a fine clearance between the ring face at the open end of the rotor barrel and the bottom of said annular groove and said shimming means determine said clearance.

4. A rotary vane high speed pump of the kind set forth for displacing air or other gaseous media comprising a casing forming a pumping cylinder and including a removable end cover at one end and having a housing at its opposite end having bearing means therein, a rotor having a barrel portion eccentrically mounted in said cylinder and a journal portion supported by said bearing means, the end of said barrel remote from said journal portion being open, vanes passing through the tubular wall of the barrel and means rotatably supporting said vanes axially of said cylinder and constraining them against pressing on the cylinder wall so that upon rotation of the rotor and the vanes the latter generate with the surface of the cylinder and the inner and outer surfaces of said barrel wall working chambers of increasing and decreasing volume both inside and outside of the barrel, said end cover comprising spaced walls, the inner wall having an annular eccentric groove in one face in which the open end of the barrel is mounted to run with a fine annular clearance with the surrounding wall of the groove and having ports connecting the said chambers and the cavity formed between said walls, said cavity being divided so that said in-

ner and outer chambers are brought into correct communication with one another through the open end of the barrel, said walls being formed by separate components, shim means determining the axial relationship of said inner wall component with respect to said casing body so as to establish fine clearances between said inner wall component and the corresponding end edge of the vanes on the one hand and the open end of the rotor barrel on the other, further shim means determining a fine clearance between the opposite end edge of the vanes and the corresponding wall of the casing, said inner wall component having a close peripheral fit in the body of the casing so that the inner component and said casing body are mutually diametrically located in the axial relationship determined by the shimming means so as thereby to preserve said fine annular clearance in the position of said inner component so determined and means for clamping together said casing body so as to maintain said clearance.

5. A rotary vane high speed pump of the kind set forth for displacing air or other gaseous media comprising a casing forming a pumping cylinder and including a removable end cover at one end and having a housing at its opposite end having bearing means therein, a rotor having a barrel portion eccentrically mounted in said cylinder and a journal portion supported by said bearing means, the end of said barrel remote from said journal portion being open, vanes passing through the tubular wall of the barrel and means rotatably supporting said vanes axially of said cylinder and constraining them against pressing on the cylinder wall so that upon rotation of the rotor and the vanes the latter generate with the surface of the cylinder and the inner and outer surfaces of said barrel wall working chambers of increasing and decreasing volume both inside and outside of the barrel, said end cover comprising spaced walls, the inner wall having an annular eccentric groove in one face in which the open end of the barrel is mounted to run with a fine annular clearance with the surrounding wall of the groove and having ports connecting the said chambers and the cavity formed between said walls, said cavity being divided so that said inner and outer chambers are brought into correct communication with one another through the open end of the barrel, said walls being formed by separate components, shim means determining the axial relationship of said inner wall component with respect to said casing body and said outer wall component so as to establish fine clearances between said inner wall component and the corresponding end edge of the vanes on the one hand and the open end of the rotor barrel on the other, further shim means determining a fine clearance between the opposite end edge of the vanes and the corresponding wall of the casing, said inner wall component having a close peripheral fit in the body of the casing and in said outer wall component so that the inner and outer components and said casing body are mutually diametrically located in the axial relationship determined by the shimming means so as thereby to preserve said fine annular clearance in the position of said inner component so determined and means for clamping together said casing body so as to maintain said clearances.

6. A rotary vane pump of the kind set forth comprising a casing forming a pumping cylinder and including a removable end cover at one end

and having a housing at its opposite end having bearing means therein, a rotor having a barrel portion eccentrically mounted in said cylinder and a journal portion supported by said bearing means, the end of said barrel remote from said journal being open, vanes passing through the tubular wall of said barrel and means rotatably supporting said vanes axially of said cylinder so that upon rotation of the rotor and the vanes the latter generate with the surface of the cylinder and the inner and outer surfaces of said barrel wall working chambers of increasing and decreasing volume both inside and outside of the barrel, said end cover comprising spaced walls, the inner wall having an annular eccentric groove in one face in which the open end of the barrel is mounted and having ports connecting the said chambers and the cavity formed between said walls, said cavity being divided so that said inner and outer chambers are brought into correct communication with one another through the open end of the barrel, said walls being formed by separate components, means for clamping together said outer wall component and the body portion of the casing and separate means for independently clamping together said outer and inner wall components.

7. A rotary vane pump of the kind set forth comprising a casing forming a pumping cylinder and including a removable end cover at one end and having a housing at its opposite end having bearing means therein, a rotor having a barrel portion eccentrically mounted in said cylinder and a journal portion supported by said bearing means, the end of said barrel remote from said journal being open, vanes passing through the tubular wall of said barrel and means rotatably supporting said vanes axially of said cylinder so that upon rotation of the rotor and the vanes the latter generate with the surface of the cylinder and the inner and outer surfaces of said barrel wall working chambers of increasing and decreasing volume both inside and outside of the barrel, said end cover comprising spaced walls, the inner wall having an annular eccentric groove in one face in which the open end of the barrel is mounted and having ports connecting the said chambers and the cavity formed between said walls, said cavity being divided so that said inner and outer chambers are brought into correct communication with one another through the open end of the barrel, said walls being formed by separate components, a ring joint between said outer wall and the body portion of said casing, an inner concentric ring joint between said outer and inner walls, said inner joint being axially displaced with respect to said first ring joint, means for clamping said outer wall against said body portion to effect said first ring joint and separate means for clamping together said outer and inner walls to effect said second ring joint, and said joints being clamped to leave a fine clearance between the said inner wall and the adjacent end edges of said vanes on the one hand and the open end of the rotor on the other.

8. A rotary vane pump of the kind set forth comprising a casing forming a pumping cylinder and including a removable end cover at one end and having a housing at its opposite end having bearing means therein, a rotor having a barrel portion eccentrically mounted in said cylinder and a journal portion supported by said bearing means, the end of the barrel remote from the journal being open, vanes passing through the tubular wall of said barrel and means rotatably

supporting the vanes axially of the cylinder so that upon rotation of the rotor and the vanes the latter generate with the surface of the cylinder and the inner and outer surfaces of said wall of the barrel working chambers of increasing and decreasing volume both inside and outside of the barrel, said end cover comprising spaced walls, the inner wall having an annular eccentric groove in one face in which the open end of the barrel is mounted and having ports connecting the said chambers and the cavity formed between said spaced walls, said cavity being divided so that said inner and outer chambers are brought into correct communication with one another through the open end of the barrel, said walls being formed by separate components, said inner wall component comprising a thick disc, said annular eccentric groove being formed therein, the open end of said barrel being mounted in said groove, said outer wall component and the body of the casing having opposed rebates, said inner wall component having a close peripheral fit in both said rebates so as diametrically to locate said outer wall component and said casing body, means for preventing relative rotation of the outer and inner wall components and the body of the casing and means for clamping together said outer wall component and said casing body against relative axial displacement and means for independently axially clamping together said wall components.

9. A rotary vane pump of the kind set forth comprising a casing forming a pumping cylinder and including a removable end cover at one end and having a housing at its opposite end having bearing means therein, a rotor having a barrel portion eccentrically mounted in said cylinder and a journal portion supported by said bearing means, the end portion of the barrel remote from the journal being open, vanes passing through the tubular wall of said barrel and means rotatably supporting the vanes axially of the cylinder so that upon rotation of the rotor and the vanes the latter generate with the surface of the cylinder and the inner and outer surfaces of said wall of the barrel working chambers of increasing and decreasing volume both inside and outside of the barrel, said end cover comprising spaced walls, the inner wall having an annular eccentric groove in one face in which the open end of the barrel is mounted and having ports connecting the said chambers and the cavity formed between said spaced walls, said cavity being divided so that said inner and outer chambers are brought into correct communication with one another through the open end of the barrel, said walls being formed by separate components, said inner wall component having a close fit in both said outer wall component and the body of the casing so as diametrically to locate said outer wall component and said casing body, a joint between a ring face of said outer wall component and a ring face of the casing, said joint encircling said inner wall component and a joint internally of said outer wall component and said casing body between said outer and inner wall components and means for independently clamping said joints.

10. A rotary vane pump of the kind set forth comprising a casing forming a pumping cylinder and including a removable end cover, a rotor having a barrel portion eccentrically mounted in said cylinder and having a journal portion, said barrel having its end remote from the journal open, bearing means in said casing at the end

thereof opposite to said cover, said journal being supported by said bearing means, a spindle mounted centrally of said cylinder, vanes rotatably mounted on said spindle and passing through the tubular wall of said barrel so as to be rotatable therewith and to generate with the surface of the cylinder and the inner and outer surfaces of said barrel working chambers of increasing and decreasing volume both inside and outside of the barrel, said end cover comprising spaced walls, the inner of said spaced walls having an annular groove for the reception of the open end of the rotor and having ports connecting the said chambers and the cavity formed between said spaced walls, said cavity being divided so that said inner and outer chambers are brought into correct communication with one another through the open end of the barrel, said spaced walls being formed by separate components, means interposed and forming a ring joint between the outer of said walls and the body portion of said casing, means interposed and forming a ring joint between said outer and inner spaced walls, said outer wall and said casing having opposed rebates, said inner wall being arranged with its margin in said rebates and out of contact with the diametral face of the rebate in the body of the casing, said joint means serving to maintain a fine clearance between the inner wall and the end edges of said vanes on the one hand and the open end of said rotor on the other, said spindle having a shoulder adapted to engage the inner face of the inner wall and having a portion passing through said walls and screw-threaded, a nut engaging said screw-threaded portion for clamping said inner wall between the outer wall and said shoulder, and means for clamping together said outer wall and the body of the casing.

11. A rotary vane pump of the kind set forth comprising a casing forming a pumping cylinder and including a removable end cover at one end and having a housing at its opposite end having bearing means therein, a rotor having a barrel portion eccentrically mounted in said cylinder and a journal portion supported by said bearing means, the end of the barrel remote from the journal being open, vanes passing through the tubular wall of said barrel and means rotatably supporting the vanes axially of the cylinder so that upon rotation of the rotor and the vanes the latter generate with the surface of the cylinder and the inner and outer surfaces of said wall of the barrel working chambers of increasing and decreasing volume both inside and outside of the barrel, said end cover comprising spaced walls, the inner wall having an annular eccentric groove in one face in which the open end of the barrel is mounted and having ports

connecting the said chambers and the cavity formed between said spaced walls, said cavity being divided so that said inner and outer chambers are brought into correct communication with one another through the open end of the barrel, said spaced walls being formed by separate components, ring joints comprising jointing shims between the outer wall component and the body of the casing on the one hand and between the outer wall component and the inner wall component on the other, peripheral surfaces of said components co-operating with a corresponding peripheral edge of the corresponding jointing shim to confine said shim in one direction radially, and means for independently clamping said joints.

12. A rotary vane pump of the kind set forth comprising a casing forming a pumping cylinder and including a removable end cover, a rotor having a barrel portion eccentrically mounted in said cylinder and a journal portion, said barrel having its end remote from the journal open, bearing means in said casing at the opposite end to said cover for supporting said journal, vanes passing through the tubular wall of said barrel, means rotatably supporting said vanes axially of the cylinder so that upon rotation of the rotor and the vanes the latter generate with the surface of the cylinder and the inner and outer surfaces of said wall of the barrel working chambers of increasing and decreasing volume both inside and outside of the barrel, said end cover comprising spaced inner and outer walls formed by separate components, said outer wall being a circular plate with an inwardly projecting peripheral flange and a central boss, said flange having an internal rebate, webs between said boss and said flange arranged to form conduplicated cavities of the space between said walls, said inner wall having an annular groove in its inner face for the reception of the open end of the barrel and having ports connecting the said chambers and the cavities formed between said walls, said outer wall having diametrically arranged and axially stepped inner and outer annular jointing faces, means interposed and forming a ring-joint between the outer one of said jointing faces and the body portion of said casing, means interposed and forming a ring joint between the inner one of said jointing faces and the inner wall, said casing having a rebate forming with the rebate in said flange an annular recess in which the margin of said inner wall is situated, said joint means serving to maintain a fine clearance between said inner wall and the end edges of said vanes on the one hand and the open end of said rotor on the other, and means for independently clamping said joints.

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