May 2, 1939. J. P. JOHNSON 2,156,340

VACUUM PUMP

Filed June 1, 1936 2 Sheets-Sheet 1

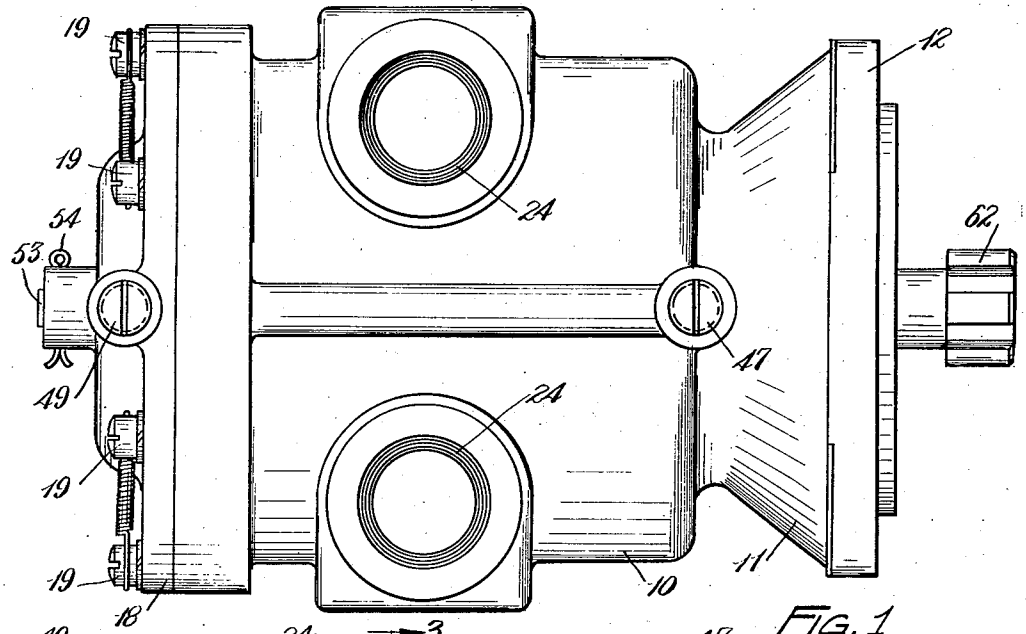

FIG. 1

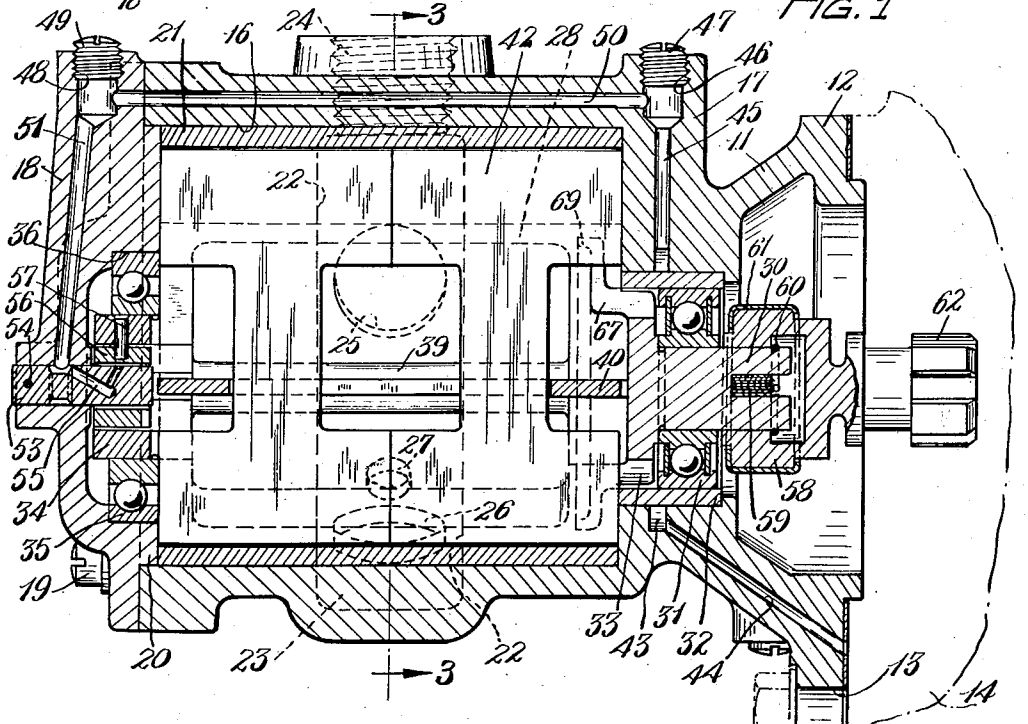

FIG. 2

INVENTOR.

BY JAMES P. JOHNSON

ATTORNEY.

May 2, 1939. J. P. JOHNSON 2,156,340

VACUUM PUMP

Filed June 1, 1936 2 Sheets-Sheet 2

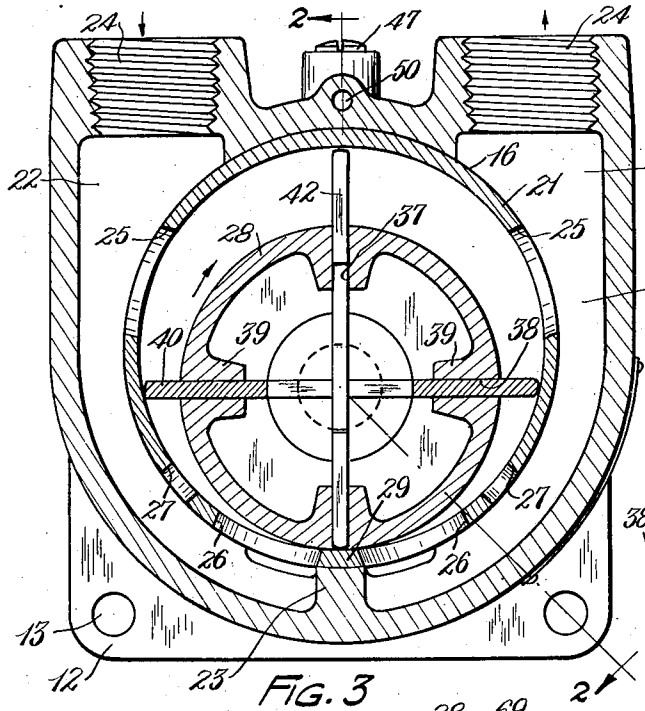

FIG. 3

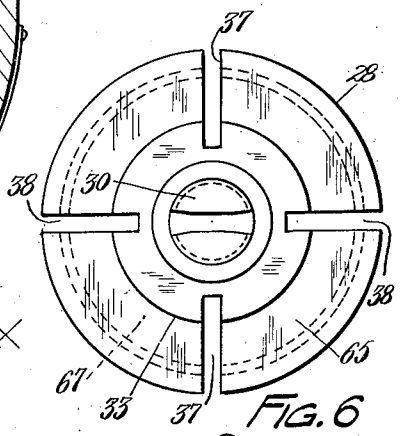

FIG. 6

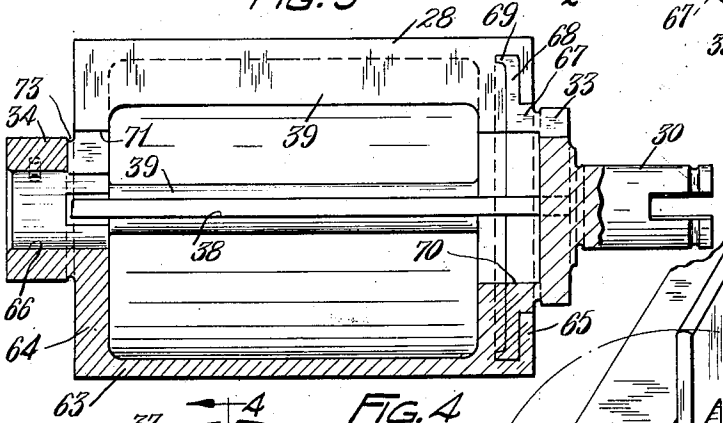

FIG. 4

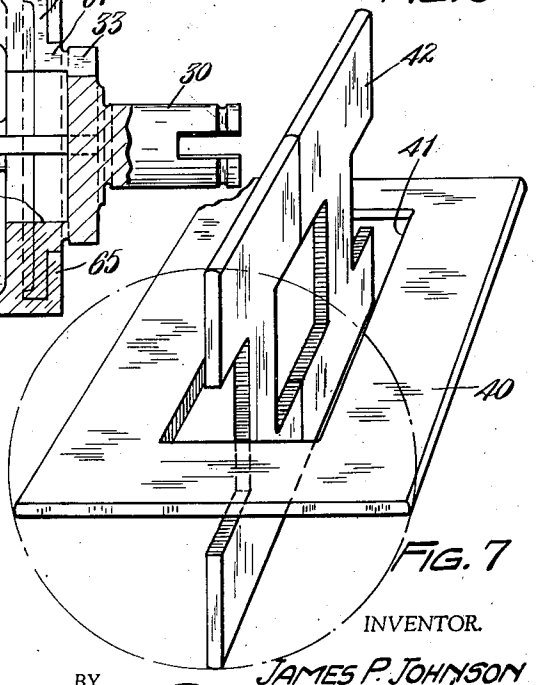

FIG. 7

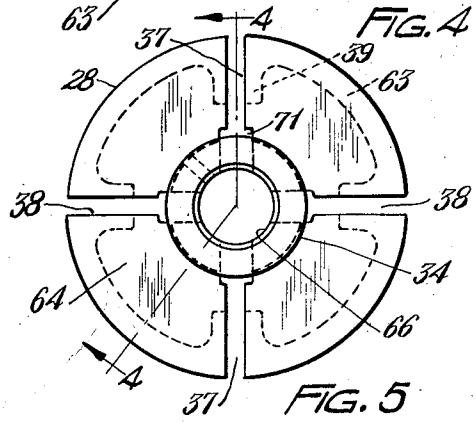

FIG. 5

INVENTOR.

BY JAMES P. JOHNSON

E. Melbourne Green

ATTORNEY.

Patented May 2, 1939 2,156,340

UNITED STATES PATENT OFFICE

2,156,340

VACUUM PUMP

James P. Johnson, Shaker Heights, Ohio

Application June 1, 1936, Serial No. 82,760

10 Claims. (Cl. 230—153)

This invention relates to improvements in rotary pump constructions and more particularly to vacuum pumps and has for its primary object to provide a pump which is light in weight, compact in structure, and efficient in operation.

The above attributes are of essential importance in connection with the design and manufacture of pumps for use on aircraft, as is the primary purpose of the pump embodying the present invention, although it will be obvious that it may be employed for many other purposes thereby not being so restricted.

The purpose of such a vacuum pump is to operate flight instruments accurately at all plane speeds, any time of the day or night, and in all kinds of weather. Furthermore, these pumps have to be made to operate at a minimum temperature and at speeds up to 4500 R. P. M. without sticking or scoring, for periods of 500 continuous hours of flying. All of these requirements are according to specification and pumps which fail to perform in this manner are rejected with the result that such rejection necessarily involves loss of money as it is very seldom that these imperfections can be later corrected in a manner to pass inspection. While the pumps disclosed in my prior Patent No. 2,070,662, granted February 16, 1937, and No. 2,068,803, granted January 26, 1937, operated successfully and came within the heretofore mentioned requirements, certain objectionable structural features were embodied therein and the present invention resides in providing an improved pump structure in which these structural objections have been eliminated and by such elimination the efficiency of the present pump has been greatly increased.

It is therefore a further object of the present invention to provide an entirely new type of blade assembly and operation in which it is possible to obtain a uniform running clearance between the ends of the blades and the inner peripheral surface of the rotor chamber and wherein there is a minimum of blade area exposed to the pressure side.

A further object is to provide through blades supported in such a manner in the rotor that a minimum of friction is obtained between the ends of the blades and the inner peripheral surface of the rotor chamber and relatively thin blades thus producing a small area resulting in a reduction of braking effect and consequent friction.

A still further object of the invention is to provide a new type of rotor and the method by which the rotor is formed.

A still further object of the invention resides in so arranging the blades in the rotor that they are properly balanced thus eliminating wear.

With the objects above indicated and other objects hereinafter explained in view, my invention consists in the construction and combination of elements hereinafter described and claimed.

Referring to the drawings:

Figure 1 is a top plan view of a pump embodying the present invention illustrated in full size.

Figure 2 is a longitudinal sectional view taken substantially on line 2—2 in Figure 3 and showing in detail the features embodying the invention.

Figure 3 is a transverse sectional view taken on line 3—3 in Figure 2.

Figure 4 is a longitudinal sectional view of the rotor taken on line 4—4 in Figure 5.

Figure 5 is an end view of the rotor illustrated in Figure 4 and looking at the left side thereof.

Figure 6 is an end view of the rotor illustrated in Figure 4 and looking at the right side thereof.

Figure 7 is a perspective view of the blades better illustrating their construction and arrangement.

In the drawings I have illustrated a vacuum pump embodying the present invention for use on aircraft but it should be understood that its use is not so restricted although it possesses features particularly essential in pumps of that type.

Referring particularly to Figures 1 to 3, the pump comprises a housing 10 preferably of aluminum or some similar light-weight material cast in the usual manner, and which is open at one end and closed at its opposite end. At the closed end of the housing 10 there is an integral angular circumferential flange 11 which terminates in a laterally extending flange 12 having openings 13 therein by which the housing is adapted to be removably connected to its supporting structure 14. The housing 10 is provided with a circular bore 16 extending inwardly from the open end thereof which is terminated by the end wall 17 of the housing 10. The open end of the housing 10, is closed by a cover plate 18 detachably connected thereto by a plurality of machine screws 19 and the cover plate is provided with a circular extension 20 which fits into the adjacent end of the bore 16 to provide the opposite end wall of the bore.

A tubular sleeve 21, preferably of hard nitralloy, is secured within the circular bore 16 and extends throughout the distance between the end wall 17 and the extension 20 on the cover plate 18, the latter engaging the adjacent end of the sleeve 21

and holding it against longitudinal movement within the bore 16.

The housing 10 is provided with passageways 22 of identical area disposed on diametrically opposite sides thereof, the lower ends terminating in a transversely extending partition 23 and the upper ends communicating respectively with screwthreaded openings 24 which are adapted for connection with the instrument line depending upon the direction of operation of the pump.

The sleeve 21 is provided with transverse openings 25 positioned upon opposite sides thereof adjacent the upper portion which provide means of communication between the respective passageways 22 and the interior of the sleeve 21. These openings 25 function as inlet and outlet openings for the passage of fluid through the pump and, as before stated, their respective function is dependent upon the direction of operation of the pump. The sleeve 21 is further provided with transverse openings 26 and 27 disposed on opposite sides adjacent the partition 23 which also provides means of communication between the respective passageways 22 and the interior of the sleeve 21 for a purpose to be later described.

A rotor 28, the details of which will be later more fully described, is eccentrically positioned within the sleeve 21 and has a running engagement with the inner surface of the sleeve at 29. The rotor 28, of course, is coextensive with the sleeve 21 as more clearly shown in Figure 2. One end of the rotor 28 has an integral axial extension 30 which is rotatably mounted in an anti-friction bearing 31 enclosed in a metal sleeve 32 secured in an opening in the end wall 17 of the housing 10, the free end of the extension 30 projecting beyond the end wall 17. The rotor 28 is also provided with an offset portion 33 between the end of the rotor and the extension 30, of a diameter enabling it to fit freely within the adjacent end of the sleeve 32 so as to prevent displacement of the bearing 31.

The opposite end of the rotor 28 is also provided with an axial extension 34, preferably formed integral therewith, and which is also rotatably mounted in an anti-friction bearing 35 secured in a recessed portion 36 provided upon the inner side of the cover plate 18. This extension 34 has an axial opening therein for a purpose to be later described.

The rotor 28 is provided with pairs of radially disposed slots 37 and 38 on diametrically opposite sides, the slots of each pair being in alignment and extending longitudinally throughout the length of the rotor 28. Ribs 39 are formed on the interior of the rotor 28 and extend longitudinally, for reinforcing the latter and by reason of the fact that the slots extend through the ribs 39 throughout their lengths, additional bearing surface is provided for the blades. Unitary through blades are provided which have many advantages over the type of short blade and roller arrangement disclosed in my referred to copending applications. One blade 40 is rectangular in shape and has a rectangular opening 41 centrally positioned therein as more clearly shown in Figure 7. This blade 40 is relatively thin and preferably made of nitralloy, having its long edges rounded on an arc struck from a small axis while its short edges or sides are flat. This blade is slidably mounted within the slots 38 as shown in Figure 3 and when the rotor is rotated the outer ends of the blade engage or have a running engagement with the inner peripheral surface of the sleeve 21. The other blade 42 comprises two half sections of identical form, preferably of I-shape and made of nitralloy. These sections are arranged with the flanges in abutting relation and with the webs extending in parallelism and when so arranged are substantially the same size as the blade 40. The blade 42 is relatively thin and has its long edges rounded on an arc struck from a small axis while its short edges or sides are flat. This blade 42 is slidably mounted within the slots 37 as shown in Figure 3 and when the rotor is rotated the outer ends of the blade engage or have a running engagement with the inner peripheral surface of the sleeve 21 in the same manner as the blade 40.

The blades 40 and 42 are readily assembled in the rotor by first placing the blade 40 centrally within the slots 38 and then moving the sections of the blade 42 transversely with respect to one another so that the engaging flanges are positioned in alternate relation thus foreshortening the blade. When in this position the blade 42 is inserted in the slots 37 with portions of the blade extending through the opening 41 in the blade 40. The sections can then be joggled around until they assume their normal position shown in Figure 7.

As the rotor rotates in a clockwise direction as viewed in Figure 3 the blades 40 and 42 will assume different angular positions due to the fact that they are rotating about an eccentric axis. The inner peripheral surface of the sleeve 21 being in the nature of a limaçon curve causes the ends of the blades to engage the surface with a minimum area exposed to the pressure side of the blades. Furthermore, by employing through blades it is possible to obtain a uniform running clearance between the ends of the blades and the inner peripheral surface of the sleeve 28. An additional advantage of through blades resides in the fact that they are supported at opposite sides while sliding in the rotor thus avoiding cocking as is found to occur in the blade and roller type heretofore referred to with the result that the frictional resistance is reduced to a minimum.

To provide proper and suitable lubrication for the relatively movable parts of the high speed rotor, it is desirable that the lubricant be supplied substantially continuously under pressure. This is effectively obtained in the present instance by providing a circumferential groove 43 on the inner surface of the opening in the wall 17 as shown in Figure 2. This groove is turned in any suitable manner before the sleeve 32 is secured in position and the latter cooperates therewith to provide an endless circular passageway. A laterally extending passageway 44 is provided in the extension 11 and has its inner end communicating with the groove 43, the outer end being adapted to communicate with the pressure oiling system of the engine through the medium of the engine pad to which the pump is connected by the flange 12. A plurality of such passageways are provided in the extension 11 so that the pump housing may be angularly adjusted about its axis to properly align one of the passageways 44 with the opening in the engine pad, the latter being in engagement with the end surface of the flange when assembled which thereby closes the outer ends of the other passageways not in use.

An opening 45 extends upwardly from the groove 43 through the housing 10 and terminates in connection with a screw-threaded opening 46

normally closed by a removable screw threaded plug 47. A second screw-threaded opening 48 is provided in the upper portion of the cover plate 18 and is normally closed by a removable screw-threaded plug 49. A longitudinally extending opening 50 connects the screw-threaded openings 46 and 48 at a point beneath the plugs so that the opening 50 is in communication with the vertical opening 45. Extending downwardly from the screw-threaded opening 48 in the cover 18 is an opening 51 which communicates with a circumferential groove provided in a hardened steel discharge member 53. This discharge member has its outer end fitting snugly in an axial opening provided in the cover plate 18 and is secured against accidental displacement by means of a removable cotter pin 54. A pair of angularly disposed communicating openings are drilled in the discharge member to provide a passageway 55 communicating with the circumferential groove and the outer surface of the inner end of the discharge member through which a lubricant may pass.

A bronze sleeve 56 is positioned loosely within the axial opening in the extension 34 and is secured to rotate with the rotor by means of a pin 57 having a drop fit in aligned openings in the extension 34 and the sleeve 56. The pin 57 is positioned so as to underlie the inner race of the bearing 35 which prevents accidental disengagement. The sleeve 56 further encircles the inner end of the discharge member 53 and is provided with a predetermined clearance which controls the amount of lubricant discharged from the inner end of the passageway 55. By varying the clearance between the outer surface of the discharge member 53 and the adjacent inner peripheral surface of the sleeve 56 or by varying the size of the passageway 55, or both, the rate at which the lubricant can be discharged is controlled and therefore the amount of lubricant reaching the relatively movable parts.

For further information as to the detailed operation of the oiling system reference should be had to my copending application Serial No. 10,994.

The rotor extension 30 is adapted for connection with a driving means such as the motor of the aircraft and due to the impulses set up during operation it has been found that where this driving connection is directly and rigidly made fatigue and breakage of the parts occur from crystallization. A means of eliminating this condition has been proposed in my copending application which broadly contemplates a resilient or flexible coupling between the rotor and driving means. In the present construction a coupling is used embodying the same principle but of slightly different construction and the details of which constitute an application being filed of even date. The coupling comprises a body portion 58 having an axial opening extending inwardly from one end thereof and a resilient member 59 having its opposite ends mounted in said body portion and its intermediate portion extending across the axial opening. The extension 30 has a transverse slot in its end and when the extension is inserted into the axial opening in the body portion 58 the resilient member 59 is disposed within the slot. As the extension and body portion are mounted so as to have a limited amount of relatively angular movement the impulses are absorbed by the resilient member. A snap ring 60 detachably maintains the extension and body portion in assembled relation and a retainer cap 61 encircles the body portion and prevents the resilient member from becoming disengaged. The body portion has an axial extension terminating in a splined end 62 adapted for connecting with the motor drive.

As previously stated, the rotor 28 is of special construction having features entirely new in this art and reference should be had to Figures 4, 5 and 6 for a clear understanding. The body of the rotor is made of cast iron molded in any well known manner and is of circular cross section having a circumferential wall 63 and end walls 64 and 65 formed integral therewith thus producing a hollow rotor body more clearly shown in Figure 4. The end wall 64 has an axial extension 34 provided with an axial opening 66 which also extends through the end wall 64 into communication with the interior of the rotor body. The opposite end wall 65 has a steel insert 67 integrally united in the wall 65 during the casting of the rotor body, and this extension 30 provides a hardened end for connection with the drive means thus improving the efficiency of the pump. This steel insert 67 has at its inner end a laterally extending circular flange 68 terminating in an axially extending marginal flange 69 which tends to prevent relative movement and separation after the body of the rotor has been cast.

The rotor 28 as previously explained has inwardly projecting ribs 39, four of such ribs being shown positioned on diametrically opposite sides of the rotor and extending longitudinally throughout the length of the wall 63 and terminating as part of the end walls 64 and 65. The rotor 28 as originally cast does not have the slots 37 and 38 provided therein but said slots are cut in a manner later to be described, therefore the position of the ribs on the inside of the rotor body are not ordinarily visible to the eye. The steel insert 67 has an additional important function and that is, it provides a locating means properly positioning and supporting the core. The insert 67 has an axial bore 70 extending inwardly for a short distance from its inner end which, when the insert is properly placed within the mold, receives and supports an axial extension on the end of the core. The opposite end of the core has an axial extension adapted to provide the opening 66 and the outer surface of the core is, of course, provided with grooves which provide the ribs 39.

In order that the position of the ribs may be positively and accurately determined, the core is provided with radial projections of the desired size and the end opposite to the insert 67 so as to provide openings 71 which when the rotor is machined extend through the end wall 64. There are four of such openings illustrated which are positioned directly beneath each rib 39 and the outer ends extend slightly beyond the outer peripheral surface of the extension 34 after the end walls are turned down, as more clearly shown in Figure 5. By thus providing these locating openings the position of the ribs 39 are definitely ascertained and therefore the slots 37 and 38 can be cut in any well known manner with the assurance that each slot will extend substantially centrally of its respective rib.

The pump of course, is designed and built to operate in both directions without the necessity of changing any operating parts thereof, the only change required being the instrument line connection to the proper opening 24 depending upon the direction of rotation of the rotor. In Figure 3 for example if the rotor operates in a

clockwise direction, the vacuum side or instrument line is connected with the opening 24 at the left hand side and the other opening 24 becomes the outlet opening.

In the operation, with the rotor rotating in a clockwise direction, the blades 40 and 42 as they pass the inlet opening 25 create a suction thus drawing the air out of the instrument line and thereby maintaining the proper vacuum therein for operating the flight instruments. As the blades pass the outlet opening 25 the air is forced out and passes through the screwthreaded opening 24 on the right side of the pump as viewed in Figure 3. The openings 25 are so spaced with respect to the blades 40 and 42 that the ends of adjacent blades at all times prevent connection between said openings. In the event any of the discharged air should become trapped ahead of any blade after the latter has passed the discharge opening 25 it is exhausted through the openings 26 and 27 into the associated passageway 22 and out through the screwthreaded opening 24 as before explained thus illuminating any possible breakage of the pump parts by reason of the extreme pressure which would otherwise be present. By using solid through blades in the construction it is possible to plot the contour of the inner peripheral surface of the sleeve 21 so that a uniform running clearance is maintained thus increasing the efficiency of the pump.

While I have described the preferred embodiment of the invention it is to be understood that I am not to be limited thereto inasmuch as changes and modifications may be resorted to without departing from the spirit of the invention as defined in the appended claims.

I claim:

1. A rotary pump comprising a housing having a chamber therein the inner peripheral surface of which conforms to a limaçon curve and fluid inlet and outlet openings communicating with said chamber, a rotor eccentrically positioned in said chamber and rotatably mounted in said housing, said rotor having two pairs of radially extending slots, the slots of each pair being disposed on diametrically opposite sides of said rotor and in longitudinal alignment, the pairs of slots being arranged in different relative angular positions, and a pair of non-extensible blades, each of which is slidably mounted in a different pair of slots and having their opposite ends adapted for uniform running engagement with the peripheral surface of said chamber, one of said blades being of rectangular shape and having an opening extending therethrough, and the other of said blades being of freely cooperating I sections for the purpose of assembly and disassembly and adapted to extend through the opening in said first mentioned blade in angular relation thereto.

2. A rotary pump comprising a housing having a chamber therein the inner peripheral surface of which conforms to a limaçon curve and fluid inlet and outlet openings communicating with said chamber, a rotor eccentrically positioned in said chamber and rotatably mounted in said housing, said rotor having two pairs of radially extending slots, the slots of each pair being disposed on diametrically opposite sides of said rotor and in longitudinal alignment, the pairs of slots being arranged in different relative angular positions, and a pair of non-extensible blades, each of which is slidably mounted in a different pair of slots and having their opposite ends adapted for uniform running engagement with the peripheral surface of said chamber, one of said blades being of rectangular shape and having an opening therethrough, and the other of said blades consisting of two I sections normally arranged side by side with the adjacent edges of the flanges touching and the webs in parallelism and adapted to extend through the opening in said first mentioned blade in angular relation thereto, the sections of said blade being adapted for relative movement longitudinally into a foreshortened position in which the adjacent flanges are in alternate relation thereby enabling assembly and disassembly of said blade.

3. The method of producing a rotor for rotary pumps and the like which comprises casting as a unit a cylindrical body portion with end walls and one or more radially extending ribs upon the inside thereof, the end walls having axial extensions and one or more openings in at least one of said end walls in alignment with said rib or ribs and extending outwardly beyond the peripheral surface of the adjacent extension to definitely predetermine the location of the rib or ribs and subsequently cutting a radial slot or slots in the cylindrical body portion in alignment with the opening or openings whereby said slot or slots will extend substantially centrally through said rib or ribs.

4. A rotary pump comprising a housing having a bore therein and fluid inlet and outlet openings communicating with said bore, a sleeve secured within said bore and having its inner peripheral surface conforming to a limaçon curve, said sleeve being provided with openings extending through the wall thereof and communicating respectively with the fluid inlet and outlet openings in said housing, a rotor eccentrically positioned in said sleeve and rotatably mounted in said housing, said rotor having two pairs of radially extending slots, the slots of each pair being disposed on diametrically opposite sides of said rotor and in longitudinal alignment, the pairs of slots being arranged in different relative angular positions, and a pair of non-extensible blades, each of which is slidably mounted in a different pair of slots and having their opposite ends adapted for uniform running engagement with the peripheral surface of said sleeve, one of said blades being of rectangular shape and having an opening extending therethrough, and the other of said blades being of freely cooperating I sections for the purpose of assembly and disassembly and adapted to extend through the opening in said first mentioned blade in angular relation thereto.

5. A rotary pump comprising a housing having a bore therein and fluid inlet and outlet openings communicating with said bore, a sleeve secured within said bore and having its inner peripheral surface conforming to a limaçon curve, said sleeve being provided with openings extending through the wall thereof and communicating respectively with the fluid inlet and outlet openings in said housing, a rotor eccentrically positioned in said sleeve and rotatably mounted in said housing, said rotor having two pairs of radially extending slots, the slots of each pair being disposed on diametrically opposite sides of said rotor and in longitudinal alignment, the pairs of slots being arranged in different relative angular positions, and a pair of non-extensible blades, each of which is slidably mounted in a different pair of slots and having their opposite ends adapted for uniform running engagement with the peripheral surface of said sleeve, one of said blades being

of rectangular shape and having an opening therethrough, and the other of said blades consisting of two I sections normally arranged side by side with the adjacent edges of the flanges touching and the webs in parallelism and adapted to extend through the opening in said first mentioned blade in angular relation thereto, the sections of said blade being adapted for relative movement longitudinally into a foreshortened position in which the adjacent flanges are in alternate relation thereby enabling assembly and disassembly of said blade.

6. A rotary pump comprising a housing having a chamber therein the inner peripheral surface of which conforms to a limaçon curve and fluid inlet and outlet openings communicating with said chamber, a rotor eccentrically positioned in said chamber and rotatably mounted in said housing, said rotor having two pairs of radially extending slots, the slots of each pair being disposed on diametrically opposite sides of said rotor and in longitudinal alignment, the pairs of slots being arranged in different relative angular positions, and a pair of non-extensible blades, each of which is slidably mounted in a different pair of slots and having their opposite ends adapted for uniform running engagement with the peripheral surface of said chamber, one of said blades being of rectangular shape and having an opening extending therethrough, and the other of said blades being of freely cooperating abutting sections adapted to extend through the opening in said first mentioned blade in angular relation thereto, each of said sections having lateral extensions disposed upon opposite sides of the adjacent portions of said rectangular shaped blade for maintaining the blades normally in assembled relation.

7. A rotor for rotary pumps and the like comprising a cylindrical body portion having integral end walls closing its opposite ends, radially disposed ribs on the inside of said body portion and extending longitudinally thereof, axially disposed outwardly projecting extensions on the respective end walls, one of said extensions having an axial opening extending through it and its respective end wall, the other end wall having an axial bore extending from its inner side toward its outer side and terminating slightly beyond the latter, the diameter of said bore being greater than the diameter of the extension on the opposite end wall, the end wall adjacent the axial opening being provided with transversely extending communicating openings disposed radially of the latter and projecting slightly beyond the peripheral surface of the adjacent extension, said openings being in longitudinal alignment with said ribs whereby the location of the latter are predetermined for the accurate cutting of slots through the end walls, cylindrical body portion and ribs.

8. A rotor for rotary pumps and the like comprising a cylindrical body portion having integral end walls closing its opposite ends, radially disposed ribs on the inside of said body portion and extending longitudinally thereof, said ribs being arranged in diametrically opposite relation, axially disposed outwardly projecting extensions on the respective end walls, one of said extensions having an axial opening extending through it and its respective end wall, the other end wall having an axial bore extending from its inner side toward its outer side and terminating slightly beyond the latter, the diameter of said bore being greater than the diameter of the extension on the opposite end wall, the end wall adjacent the axial opening being provided with transversely extending communicating openings disposed radially of the latter and projecting slightly beyond the peripheral surface of the adjacent extension, said openings being in longitudinal alignment with said ribs whereby the location of the latter are predetermined for the accurate cutting of slots through the end walls, cylindrical body portion and ribs, the end walls, body portion and ribs having longitudinally extending aligned slots provided therein which communicate with the transverse openings and bore in the respective end walls and which slots are adapted to receive non-extensible through blades coextensive with the body portion and end walls.

9. A pair of cooperating non-extensible blades for a rotary pump or the like, one of which is of rectangular shape having an opening extending therethrough, and the other of freely cooperating I sections for the purpose of assembly and disassembly and adapted to extend through the opening in said first mentioned blade in angular relation thereto.

10. A pair of cooperating non-extensible blades for a rotary pump or the like, one of which is of rectangular shape having an opening extending therethrough, and the other of two I sections normally arranged side by side with the adjacent edges of the flanges touching and the webs in parallelism and adapted to extend through the opening in said first mentioned blade in angular relation thereto, the sections of said blade being adapted for relative movement longitudinally in a foreshortened position in which the adjacent flanges are in alternate relation thereby enabling assembly and disassembly of said blades.

JAMES P. JOHNSON.