Sept. 16, 1947. J. P. JOHNSON 2,427,606

ROTARY PUMP WITH RESILIENT END WALL

Filed Oct. 31, 1942 2 Sheets-Sheet 1

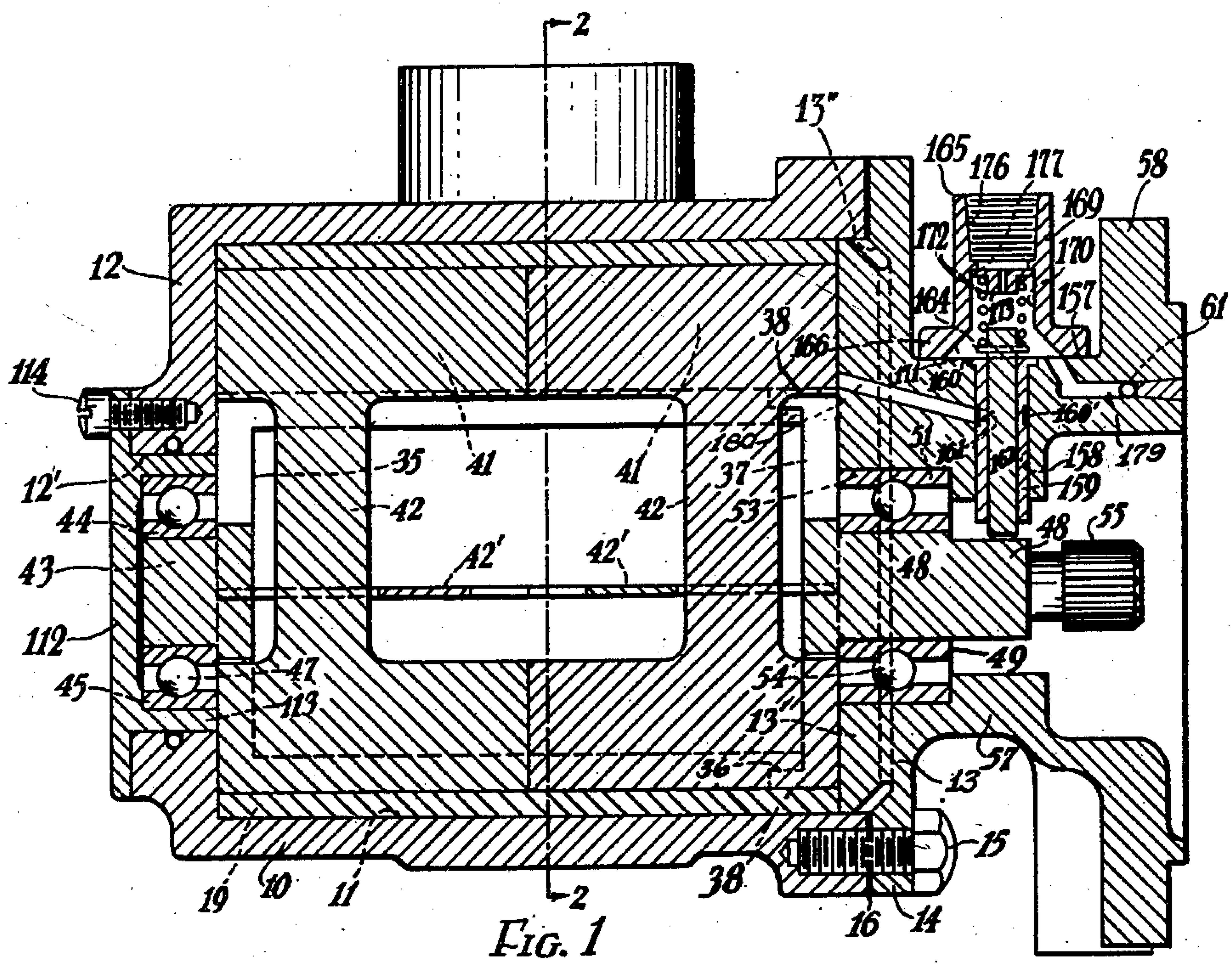

FIG. 1

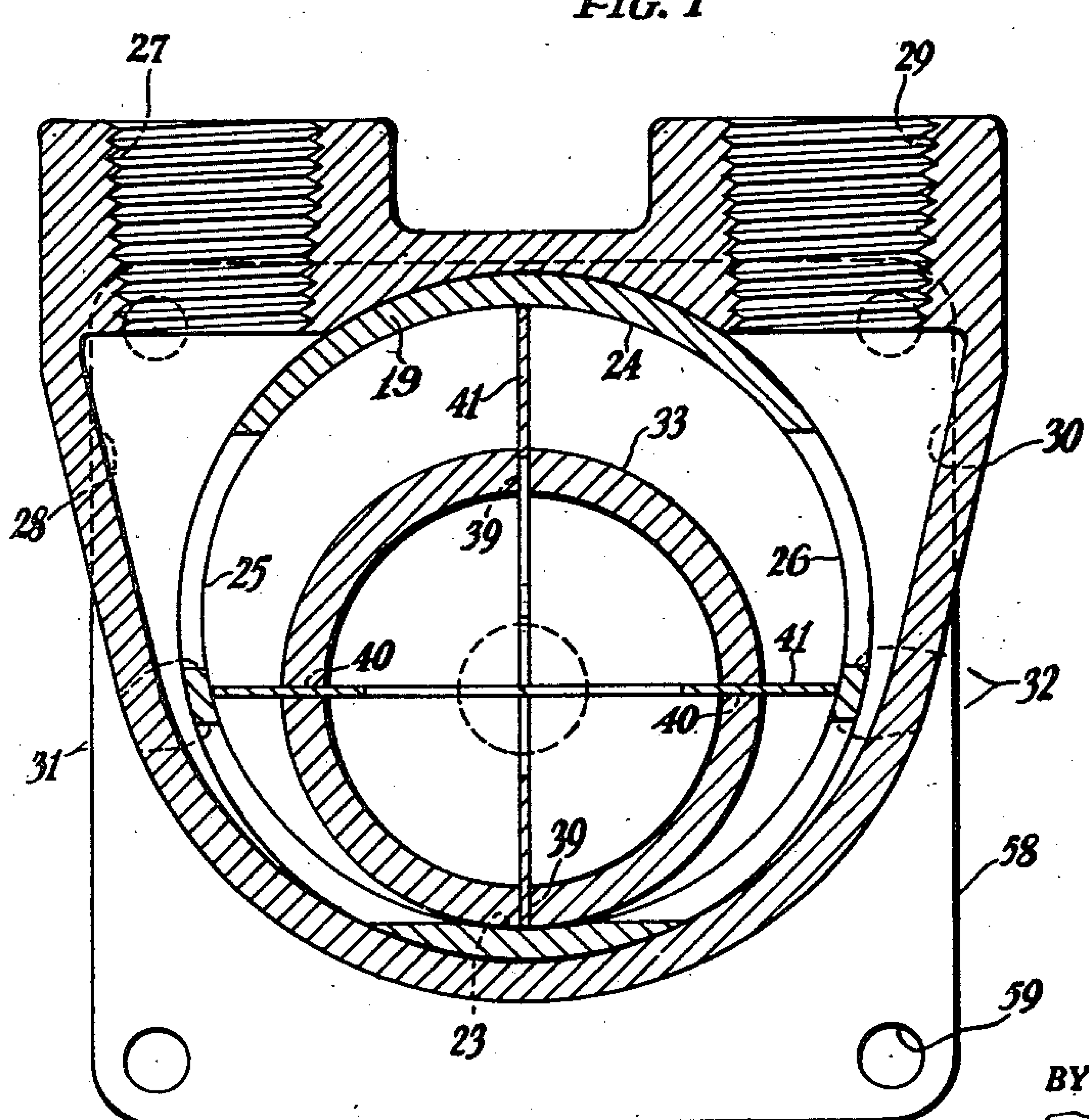

FIG. 2

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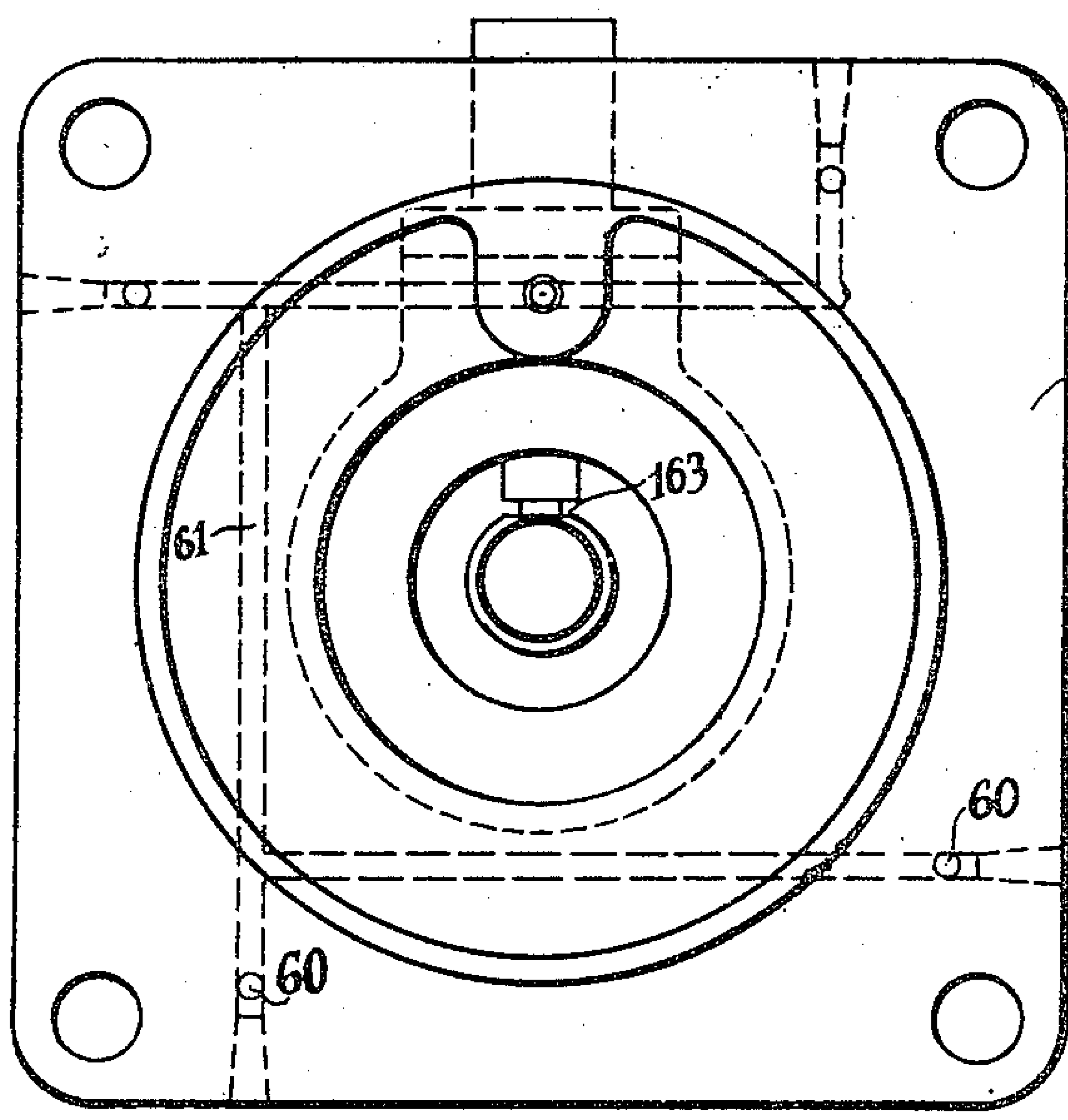

FIG. 3

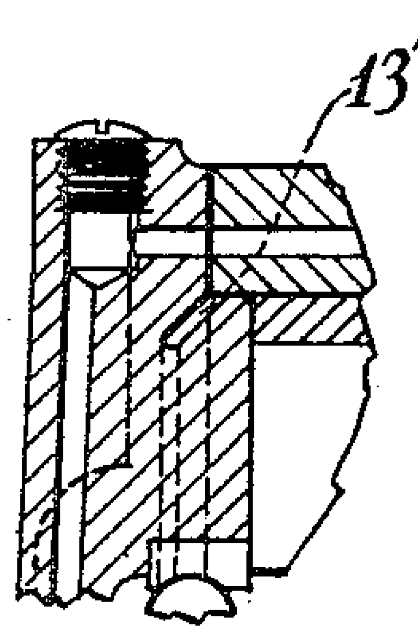

FIG. 4

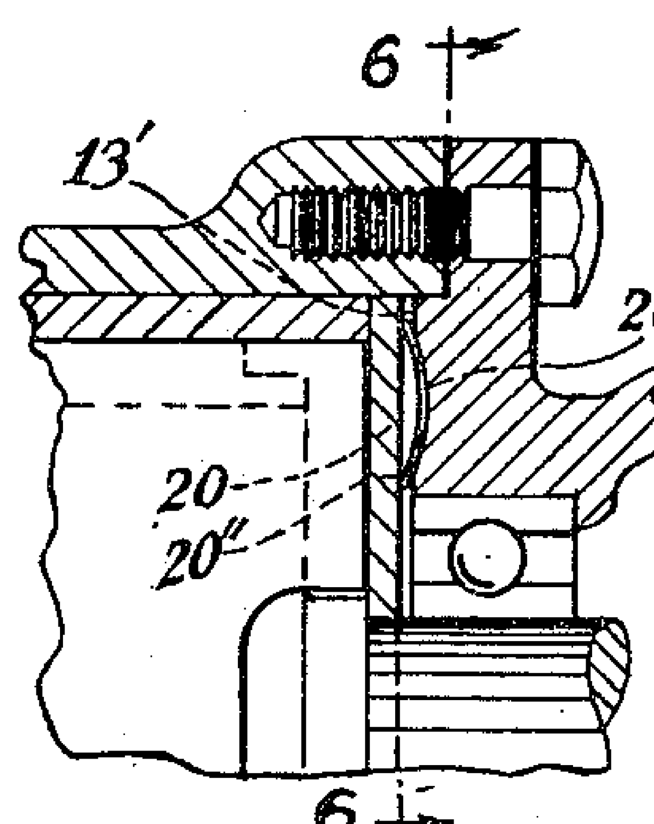

FIG. 5

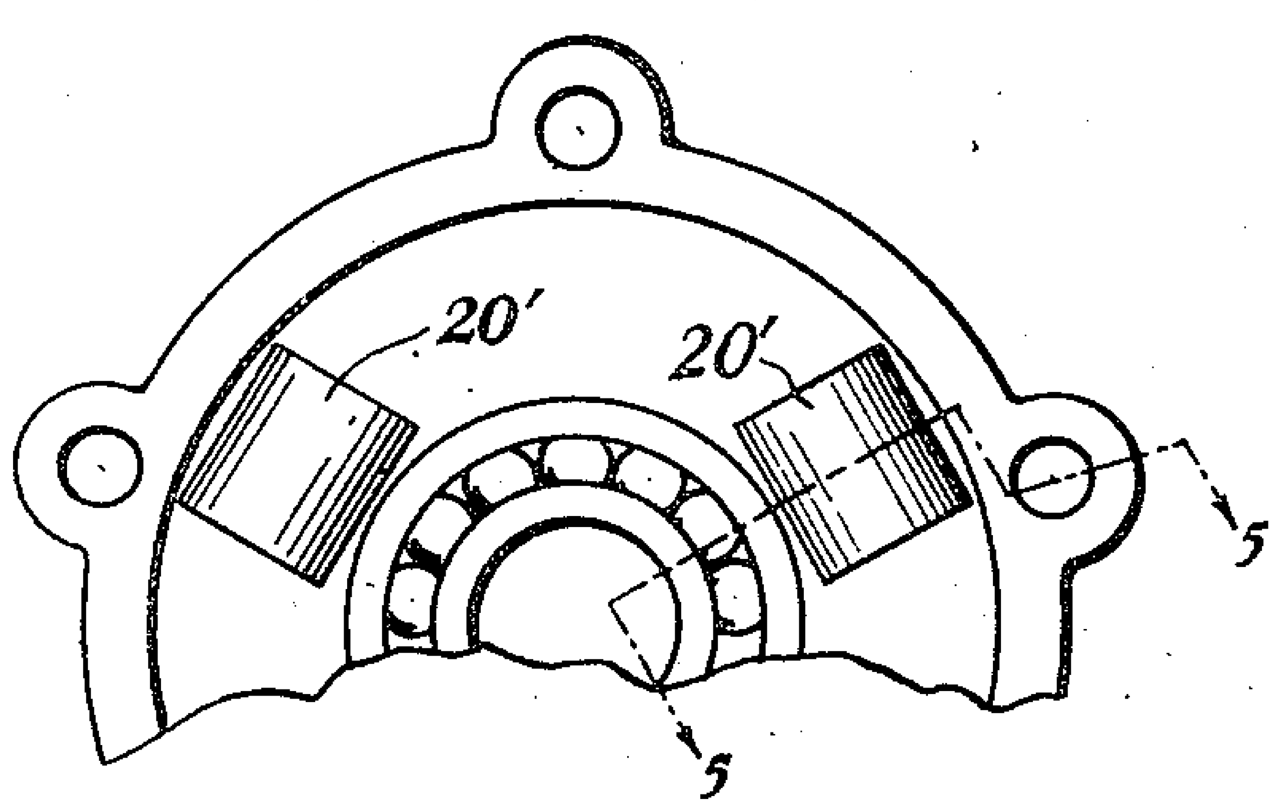

FIG. 6

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ROTARY PUMP WITH RESILIENT END WALL

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Application October 31, 1942, Serial No. 464,101

7 Claims. (Cl. 230—153)

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This invention relates to vacuum pumps of the rotary vane or blade type, especially adapted for use on aircraft although not so restricted and has for its primary object to provide an improved pump of this type which is simple in construction, efficient in operation, and inexpensive to manufacture and assemble.

In the manufacture of pumps of the type referred to certain standard specifications are set up as to weight, size, displacement, etc., and to comply therewith it is necessary that suitable different materials be used in their construction. As a result the efficiency of the pump greatly varies during operation because proper running clearances cannot be maintained due to variations in temperature under actual working conditions. It is therefore, a further object of the present invention to provide suitable spring loading between the removable cover member and the adjacent end of the pump chamber sleeve or liner to maintain these clearances regardless of temperature changes occurring in the pump during operation.

Another object of the present invention is to provide a removable bearing member of suitable material projecting axially inwardly at one end of the pump and engageable with the adjacent end of the rotor to take the end thrust of the latter and prevent engagement between the adjacent faces of the rotor assembly and the housing to prevent scoring.

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 longitudinal vertical sectional view of a vacuum pump embodying the present invention.

Figure 2 is a transverse sectional view taken substantially along line 2—2 in Figure 1 and showing further details of the pump structure.

Figure 3 is an end elevational view of the pump looking at the cover end.

Figure 4 is a fragmentary vertical sectional view showing a modified form of the invention.

Figure 5 is a fragmentary vertical sectional view showing a further modification of the invention.

Figure 6 is a fragmentary transverse sectional view taken substantially along line 6—6 in Figure 5 and showing further details of the structure.

In the drawings I have illustrated the invention embodied in a vacuum pump especially

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adapted for use on aircraft but other adaptations will be obvious to those skilled in the particular art. The present invention is an improvement over the invention described and claimed in my prior Patent No. 2,156,340 to which reference may be had for a clearer understanding. The pump comprises a housing 10, of aluminum or other suitable light weight material, having a bore 11 extending inwardly from one end thereof terminating adjacent an outer integral end wall 12. The open end of the housing 10 is normally closed by a removable cover member 13 of aluminum or other suitable lightweight material having a circular portion 13' projecting into the open end for centrally positioning the cover member, the latter having a laterally extending circumferential flange 14 disposed in abutting relation with the outer adjacent face of the housing. A plurality of cap screws 15 project through openings provided in the flange 14 and are threadably secured in aligned openings provided in the adjacent portion of the housing for removably securing the cover. A gasket 16 is disposed between the adjacent faces of the flange and housing to provide a fluid tight seal. A sleeve 19, of steel or other suitable material, and thus having a different coefficient of expansion than the housing and cover member, is suitably secured within the bore 11 in a manner to prevent relative angular movement and has its inner end in abutting relation with the adjacent face of the end wall 12 while its outer end is in abutment with the adjacent end of the portion 13' for suitably maintaining the sleeve against longitudinal separation.

For greatest efficiency the pump sleeve 19 is preferably provided with an improved bore formed as shown in Fig. 2 by the use of two radii, one effecting the surfaces constituting the working faces 23 and 24 respectively and the other effecting the surfaces constituting the connecting faces 25 and 26 respectively, the centers being located on a transverse plane passing through the axis of the rotor as more clearly shown in Figure 2. This curvature is at diametrically opposite sides of the bore and extends for approximately 67 degrees on both sides of the transverse plane where it intersects the bore.

The connecting surfaces 25 and 26 have identical radii but slightly shorter than those on the working surfaces 23 and 24. Preferably the nearest radius for continuously connecting the working surfaces is desirable and therefore produces a bore which is nearly a perfect circle affording the best operating conditions. The radius for forming the connecting surfaces is struck from a common center positioned on the same transverse plane and midway between the centers of the radii forming the working surfaces. The connecting faces extend over a portion of approximately 46 degrees on diametrically opposite sides and as these do not enter into the working cycle of the rotor their curvature is not so important other than for the purpose already stated.

The housing 10 is further provided with an interiorly tapped opening 27 communicating at its lower end with a passageway 28 on one side of the sleeve 19 and an interiorly tapped opening 29 which communicates at its lower end with a passageway 30 disposed on the other side of the sleeve and opposite with respect to the passageway 28. The sleeve 19 is provided with a pair of openings 31 spaced apart relatively which extend transversely through one side thereof affording communication between the passageway 28 and the sleeve bore. The sleeve is also provided with a pair of openings 32 spaced apart relatively which extend transversely therethrough affording communication between the passageway 30 and the sleeve bore, the openings 31 and 32 being disposed in transverse alignment to afford simple production.

A rotor 33, of a construction to afford proper balancing which materially increases the efficiency of the pump and reduces wear, comprises a cylindrical body portion, of steel or other suitable material, having an inner end wall 35 adapted for relative rotation in definite spaced relation with the inner face of the end wall 12 in a manner to be later described. The outer end of the body portion 33 is provided with a longitudinal extension 36 of reduced diameter and a circular member 37, of steel or similar material, is disposed in abutment with the open end of the body portion functioning as an outer wall for closing the open end. The member 37 is provided with an inwardly extending marginal flange 38 in encircling relation about the reduced portion 36 and their faces are suitably welded, or otherwise secured, to provide a rigid unitary structure, the outer face of the member 37 having a running engagement with the inner face of the circular portion 13' as more clearly shown in Figure 1. The rotor 33 is eccentrically mounted within the sleeve 19 so as to have a close running engagement with the lower working face 23 of its bore between the openings 27 and 29, the axis of the rotor being disposed in the same transverse plane which passes through the radii centers effecting the faces of the bore.

To effect a further balancing of the rotor a pair of through blades, of steel or other suitable material, are employed which embody novel structural and assembly features. The rotor 33 is provided with longitudinally extending slots 39 on diametrically opposite sides which are coextensive with the rotor body and end walls as more clearly shown in Figures 1 and 2. The rotor 33 is further provided with a like pair of longitudinally extending slots 40 on diametrically opposite sides which are coextensive with the rotor body and end walls, the slots 39 and 40 being relatively spaced apart angularly, preferably at right angles as shown in Figure 2. Through blades are slidably disposed in the respective pairs of slots 39 and 40 and each preferably comprises a pair of identical half sections arranged in cooperative relation as more clearly shown in Figure 1. Inasmuch as the half sections of the through blades are of identical construction a detailed description of one section is believed to suffice. It comprises a relatively flat thin substantially I-shaped piece 41, the connecting portion 42 of which is slightly offset from but substantially parallel with a vertical plane passing through the center of the end portions as viewed in Figure 1. By arranging two of such sections 41 with their end portions in longitudinal alignment and their inner sides in abutting relation and the connecting portions 42 nearer to the outer sides of the short flanges, one through blade is provided. The other through blade comprises a pair of sections similarly arranged but with their connecting portions 42' disposed inwardly of the connecting portions 42 on the first through blade, the outer sides of the longer end portions being in transverse alignment with the adjacent sides of the shorter end portions. The pairs of through blades thus assembled are mounted within the respective pairs of slots 39 and 40 in the rotor and have their outer longitudinal edges in running engagement with the peripheral wall of the sleeve bore at diametrically opposite points, while the outer ends of the blades are adapted for running engagement with the adjacent faces of the end wall 12 and the circular portion 13' respectively.

As heretofore stated, predetermined running clearances must be maintained regardless of operating temperatures if the pump is to operate at maximum efficiency. Pumps are now designed with proper running clearances for specified output and when tested at room temperature, as is customary, very good results are obtained. However, these same pumps in actual use where the temperature rises as high as 350 degrees F., develop end clearances alone, between the ends of the sleeve and the adjacent walls of the housing, of some .006 inch which so reduces the efficiency of the pump that it will not meet the test requirements. I therefore sufficiently spring load one end of the sleeve so as to maintain abutting engagement between the ends of the sleeve and the adjacent portion of the housing whereby the initial end clearances are maintained regardless of temperature changes.

Any suitable means may be adopted for effecting this spring loading and a simple, efficient construction is illustrated in Figure 1 which comprises forming an annular recess for groove 13'' in the cover member at the intersection of the circular portion 13' and the flange 14. The groove 13'' is formed substantially like a frustum of a cone and projects inwardly into the cover member in a manner to introduce some resiliency in the circular portion 13' which in turn exerts sufficient resilient end pressure to preload the sleeve to such an extent that abutting engagement between the ends of the sleeve and the adjacent portions of the housing are maintained regardless of temperature changes. In as much as the amount of end clearance can not be exactly calculated because of the diverse variables encountered no definite allowances can be provided for other than the construction for initial test at room temperature and therefore the amount of spring loading necessarily will have to be determined by tests under working conditions.

Other arrangements for spring loading the sleeve are shown in Figures 4–5 and 6 wherein Figure 4 shows the use of the same annular groove 13'' but in this case the pump housing has a cover member mounted at the other end of the housing in a manner similar to that shown in my prior issued patent heretofore referred to.

In Figures 5 and 6 the pump has separate end discs at the opposite ends of the bore which are engageable with the adjacent ends of the interposed sleeve. In this construction one of the discs 20 as shown in Fig. 5 is separate and free for sliding movement in the outer end of the bore and is in abutment with the adjacent end of the sleeve. A space is left between the outer face of the disc 20 and the inner face of the circular portion 13' between which a plurality of thin arcuate shaped springs 20' are disposed relatively in angular spaced relation. It is desirable that at least three such springs be used to assure even distribution of pressure and each has free ends 20'' engageable against the adjacent face of the disc 20 while its intermediate curved portion is partially seated in a complementary shaped recess provided on the inner end of the circular portion 13'. The springs 20' are so disposed that when the cover member 13 is securely in place the springs exert sufficient pressure on the disc 20 that the ends of the sleeve are maintained in abutment with the adjacent discs regardless of temperature changes. And thus in all forms, the end member has recessing which is involved in the accomplishment of the spring loading or pressure functions.

To further insure maximum efficiency in the operation of the pump, the mounting of the rotor 33 is likewise important, and while any suitable means may be adopted the one illustrated in the drawings has proven to possess very desirable features. The rotor 33 at its inner end is formed with an integral extension 43 projecting axially outward therefrom and centrally disposed within an opening 12' extending through the end wall 12. The opening 12' is normally closed by a cover plate 112, of bearing or other suitable material, which is removably mounted on the outside of the end wall 12 and has an integral tubular extension 113 projecting axially inwardly in closely fitted relation in the opening 12'. A plurality of machine screws 114 project through openings provided in the cover plate 112 and are threadably secured in aligned openings provided in the adjacent portion of the housing for removably securing the cover plate in proper position. An inner race 44, of a ball bearing assembly, is securely mounted on the adjacent extension 43 and the outer race 45 is securely mounted in the adjacent end of the tubular extension 113. A plurality of balls 47 are disposed between the inner and outer races and secured in a well known manner. Suitable means for taking the end thrust and preventing scoring of the end walls should be provided and preferably the improved construction illustrated accomplishes both by a single element. The free end of the tubular extension 113 projects slightly beyond the inner face of the end wall 12, actually about .0003 to .0007 inch, and abuts the adjacent end wall 35 of the rotor to simultaneously take the end thrust of the latter and maintain the wall 35 in predetermined spaced relation with respect to the inner adjacent face of the housing end wall 12 whereby scoring will be prevented. The outer end of the rotor 33 is also provided with an integral projection 48 projecting axially outwardly therefrom and the inner race 49 of a ball bearing assembly is securely mounted thereon. The outer race 51 is securely mounted in a bore 53 formed on the inner adjacent side of the cover member 13. A plurality of balls 54 is disposed between the inner and outer races and secured in a well known manner. The outer end of the extension 48 is formed with a toothed pinion 55 adapted for connection with a flexible drive coupling, not shown, as is customarily provided for effecting a flexible connection.

The cover member 13 has a rearwardly extending outwardly flared portion 57 integral with the flange 14 and terminates in a laterally extending mounting flange 58 having openings 59 so spaced as to adapt the flange for suitable mounting upon the engine pad.

While the vacuum pump is primarily employed for creating sufficient vacuum for the operation of flight instruments, the discharged air may be utilized in the operation of a de-icer or other similar instrumentality requiring a supply of air for its operation. The rotor operates at high speeds, usually around 3000 R. P. M., and if the discharged air is connected with a de-icer may probably reach 5000 R. P. M. Inasmuch as the pump handles air with no lubricating qualities it is essential that the relatively movable parts of the pump be suitably lubricated and the quantity of lubricant should be controlled to supply just enough for best operating purposes because too much lubricant is, likewise, detrimental to the most efficient operation. Any suitable means may be employed for lubricating the relatively movable parts of the pump, but one embodying novel feature is shown in the drawings.

The attaching flange 58 is provided with a plurality of openings 60, Fig. 3, at its attaching face and which are disposed angularly in different radial positions to adapt the pump for mounting on the engine pad in such a manner that one of the openings 60 will align with an oil passageway provided in the pad affording communication with the oil reservoir in the engine housing. These openings 60 are connected at their inner ends with an oil passageway 61 formed in the flange 58 through which oil is permitted to flow. Between the flanges 14 and 58 the hollow portion is provided with a flat face 157 on its outer periphery adjacent the top as viewed in Figure 1. A bore 158 extends inwardly in a vertical direction from the flat face 157 passing entirely through the adjacent wall and a tubular bushing 159 is securely fitted in the bore, the inner end of said bushing 159 projecting slightly beyond the inner periphery of the wall while its outer end is formed with a lateral extending marginal flange 160 seated in a complementary shaped recess in the flat face 157. A circumferential groove 160' is formed on the outer peripheral wall of the bushing 159 a suitable distance inwardly and an opening 161 of predetermined size extends transversely through the wall adjacent the groove to afford communication with the inside of the bushing. A plunger 162 is slidably disposed in the bushing 159 and its inner end is adapted for engagement with the adjacent end of the extension 48 on the rotor. The outer end of the extension is provided with a flattened surface adapted to contact the inner end of the plunger during rotation of the rotor to effect reciprocation of the plunger. The outer end of the plunger has a laterally extending peripheral flange 164 secured thereto and inwardly of its end. A spring retainer housing 165 has an attaching flange 166 removably mounted upon the flat face 157 by a plurality of machine screws which project through openings provided in the flange 166 and are threadably secured in the adjacent portion of the hollow extension 57. A gasket is disposed between the adjacent faces to provide a fluid tight seal. The housing 165 has an integral extension 169 projecting centrally outward from the flange 166 and a bore 170 extends inwardly a suitable distance, the bottom of the bore affording a seat. The outer end of the bore 170 is flared outwardly at 171 to provide, with the bore, an oil chamber. A coil spring 172 is disposed within the bore 170 and has its outer end encircling the outer portion of the plunger and engageable with the flange 164. A retainer member 173 with a laterally extending flange is slidably mounted at the inner end of the bore, and has a central projection which fits within the opposite end of the spring, the extreme outer end of the latter abutting the flange, the spring having sufficient resiliency to normally exert pressure on the plunger to assure engagement between the inner end of the plunger and the rotor extension 48. The outer end of the extension 169 is provided with a tapped opening 176 extending inwardly toward the bottom of the bore 170 but in spaced relation thereto, there being provided a communicating passageway 177 therebetween which aligns with a central opening provided in the retainer member 173. This tapped opening 176 is provided to receive oil in the event manual lubrication is required and when not in use it should be closed by a plug, not shown.

A passageway 179 is formed in the flange 58 and the wall of the adjacent hollow portion 57 and has one end communicating with the oil passageway 61 and its other end communicating with the flared outer end 171 of the bore thus insuring flow of oil to the oil chamber. A second passageway 180 is formed in the wall of the hollow portion 57 and has one end communicating with the pump bore while its other end communicates with the circumferential groove 160' thus establishing communication between the oil chamber and the interior of the pump chamber, the amount of oil flowing thereby being controlled by the clearance provided between the upper portion of the plunger and the inner adjacent peripheral surface of the tubular bushing.

In the operation of the pump it should be first pointed out that the construction is such that the pump may be operated in either direction without the necessity of changing any of the parts. With the rotor rotating in the counterclockwise direction as shown in Figure 2, the opening 27 becomes the inlet opening and is suitably connected to the vacuum actuated instruments in a well known manner. In this line, there should be the usual relief valve for maintaining the suction desired irrespective of flying conditions. The outlet opening 29 is suitably connected, as stated before, with a de-icer or is discharged to the slip stream and in this line there should be the usual safety valve and oil separator for separating the oil from the air and the oil is returned through a suitable connection with the engine housing so that the oil is returned to the reservoir. As the rotor rotates suction is created at the inlet opening 27 and the air which is drawn in is forced around the chamber by the blades and discharged under pressure through the outlet opening. The amount of air discharged, of course, is dependent upon the speed of rotation of the rotor. By the use of equal diameters in forming the pump bore a greater displacement is provided than is possible with other types of bores now in common use. Due to the balanced condition of the rotor and blades, by their special construction and cooperative relation, vibrations are reduced to a negligible extent.

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.

What is claimed is:

1. A rotary pump comprising: a housing having a bore extending inwardly from one end thereof and terminating adjacent an end wall; said housing being further provided with an inlet opening and an outlet opening respectively communicating with said bore at opposite sides; a cover member detachably mounted on the open end of said housing for normally closing the same; a sleeve disposed in said bore and having its opposite ends in abutting relation with the adjacent end wall and cover member respectively, said sleeve having openings on opposite sides affording communication respectively with said inlet and outlet openings, said sleeve being made of material having a different coefficient of expansion than said housing and cover member; a rotor eccentrically disposed within said sleeve for running engagement therewith between said sleeve openings and rotatably mounted at diametrically opposite ends in said housing end wall and cover member respectively, said rotor having a transversely extending through-slot; a through blade slidably mounted in said slot and having its outer longitudinal faces engageable at diametrically opposite sides of the inner peripheral wall of said sleeve; and means including recessing in the cover member opposite the end of the sleeve for predeterminately spring loading said cover member for initially exerting sufficient pressure on the end of said sleeve regardless of temperature changes.

2. A rotary pump comprising: a housing having a bore extending inwardly from one end thereof and terminating adjacent an end wall, said housing being further provided with an inlet opening and an outlet opening respectively communicating with said bore at opposite sides; a cover member detachably mounted on the open end of said housing for normally closing the same and having an integral circular portion projecting into said bore; a sleeve disposed in said bore and having its opposite ends in abutting relation with the adjacent end wall and circular portion on the cover member respectively, said sleeve having openings on opposite sides affording communication respectively with said inlet and outlet openings, said sleeve being made of material having a different coefficient of expansion than said housing and cover member; a rotor eccentrically disposed within said sleeve for running engagement therewith between said sleeve openings and rotatably mounted at diametrically opposite ends in said housing end wall and cover member respectively, said rotor having a transversely extending through-slot; a through blade slidably mounted in said slot and having its outer longitudinal faces engageable at diametrically opposite sides of the inner peripheral wall of said sleeve; said cover member being provided with a peripheral groove, substantially in the form of a frustum of a cone, converging outwardly at the outer end of said circular portion for introducing resiliency therein sufficient to initially exert a pressure on the end of said sleeve to substantially maintain abut-

ting engagement between the opposite ends of said sleeve and the adjacent end wall and circular portion respectively regardless of temperature changes.

3. A rotary pump comprising: a housing having a bore extending inwardly from one end thereof and terminating adjacent an end wall, said housing being further provided with an inlet opening and an outlet opening respectively communicating with said bore at opposite sides; a cover member detachably mounted on the open end of said housing for normally closing the same; a sleeve disposed in said bore and having its opposite ends in abutting relation with the adjacent end wall and cover member respectively; a rotor eccentrically disposed within said sleeve for running engagement therewith between said sleeve openings and having outwardly projecting axial extensions rotatably mounted anti-frictionally at diametrically opposite ends in said end wall and cover member respectively, the mounting in the end wall including, an opening through the latter; a cover plate detachably mounted on the outer face of the end wall and having a tubular extension projecting snugly through the opening, the free end of the tubular extension extending slightly beyond the inner face of the end wall and engageable with the adjacent end of said rotor to take the end thrust of the latter, said rotor having a transversely extending through-slot; and a through blade slidably mounted in said slot and having its outer longitudinal faces engageable at diametrically opposite sides of the inner peripheral wall of said sleeve.

4. A rotary pump comprising: a housing having a bore extending inwardly from one end thereof and terminating adjacent an end wall; a cover member detachably mounted on the open end of said housing for normally closing the same; a sleeve disposed in said bore and having its opposite ends in abutting relation with the adjacent end wall and cover member respectively; a rotor disposed within said sleeve for running engagement therewith and having outwardly projecting axial extensions rotatably mounted anti-frictionally at diametrically opposite ends in said end wall and cover member respectively, the mounting in the end wall including, an opening through the latter; a cover plate detachably mounted on the outer face of the end wall and having a tubular extension projecting snugly through the opening, the free end of the tubular extension extending slightly beyond the inner face of the end wall and engageable with the adjacent end of said rotor to take the end thrust of the latter.

5. A rotary pump comprising: a housing having a bore extending inwardly from one end; a cover member detachably mounted on the open end of said housing for normally closing the same and having an extension projecting into said bore; a sleeve disposed within said bore in engagement with the inner faces of the bore and cover member extension respectively, said sleeve having a different coefficient of expansion than said housing and cover member; a rotor rotatably disposed within said sleeve and having a drive shaft, one end of which projects outwardly for connection with a driving means, said cover member being formed with an annular groove at the outer end of the extension to provide resilience in the latter to retain the abutting engagement between the sleeve ends and the inner faces of the bore and cover member extension respectively, regardless of temperature changes.

6. A rotary pump comprising: a housing having a bore extending inwardly from one end; a cover member detachably mounted on the open end of said housing for normally closing the same and having an extension projecting into said bore, a sleeve disposed within said bore in engagement with the inner faces of the bore and cover member extension respectively, said sleeve having a different coefficient of expansion than said housing and cover member; a rotor rotatably disposed within said sleeve and having a drive shaft, one end of which projects outwardly for connection with a driving means; said cover member being formed with a peripheral groove, substantially in the form of a frustum of a cone, converging outwardly at the outer end of the extension to provide resilience in the latter to retain the abutting engagement between the sleeve ends and the inner faces of the bore and cover member extension respectively, regardless of temperature changes.

7. A rotary pump comprising: a housing having a bore extending inwardly from one end; a cover member detachably mounted on the open end of said housing for normally closing the same and having an extension projecting into said bore; a sleeve disposed within said bore in engagement with the inner faces of the bore and cover member extension respectively, said sleeve having a different coefficient of expansion than said housing and cover member; a rotor rotatably disposed within said sleeve and having a drive shaft, one end of which projects outwardly for connection with a driving means; and means including grooved recessing in the cover member, providing resilience in the extension to retain the abutting engagement between the sleeve ends and cover member extension respectively, regardless of temperature changes.

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