

March 31, 1959

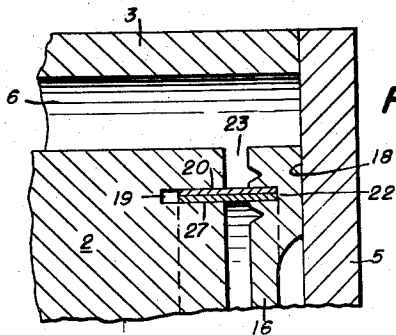
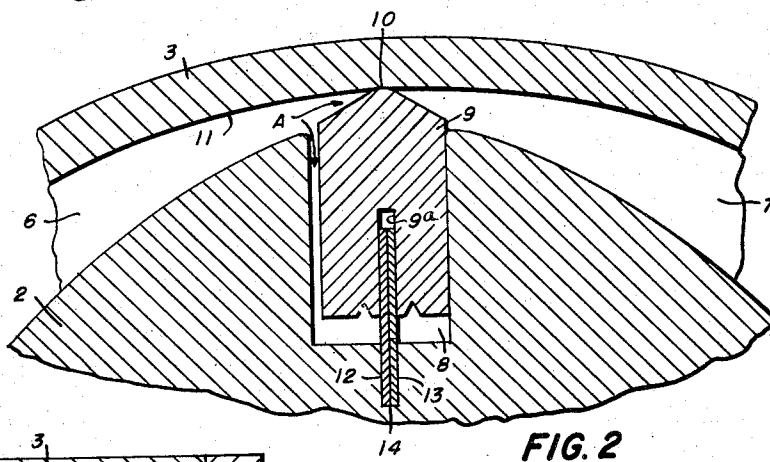
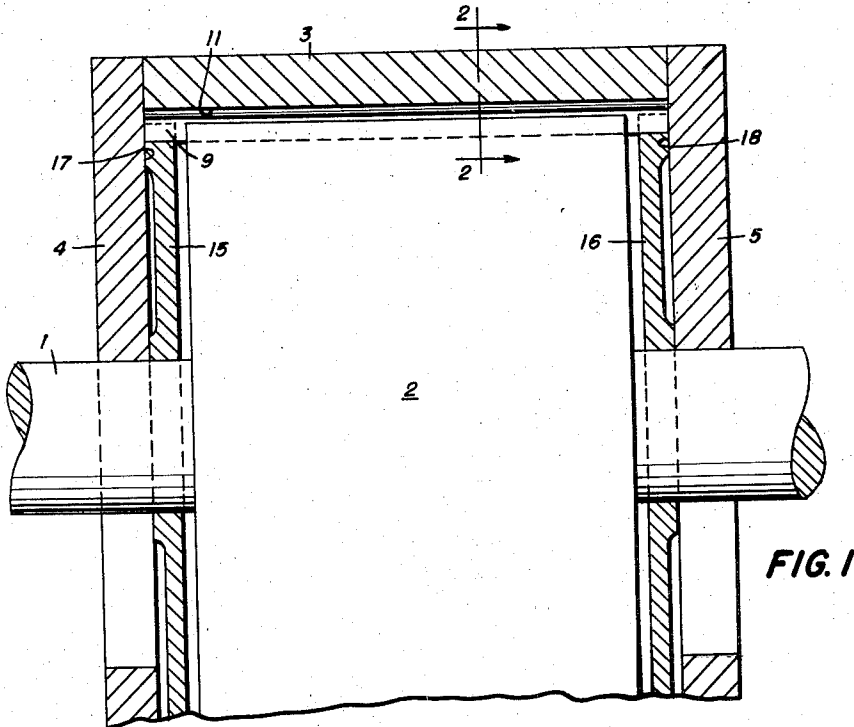
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2,880,045

SEALS FOR WORKING SPACES OF ROTARY PISTON MACHINES

Filed April 24, 1957

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

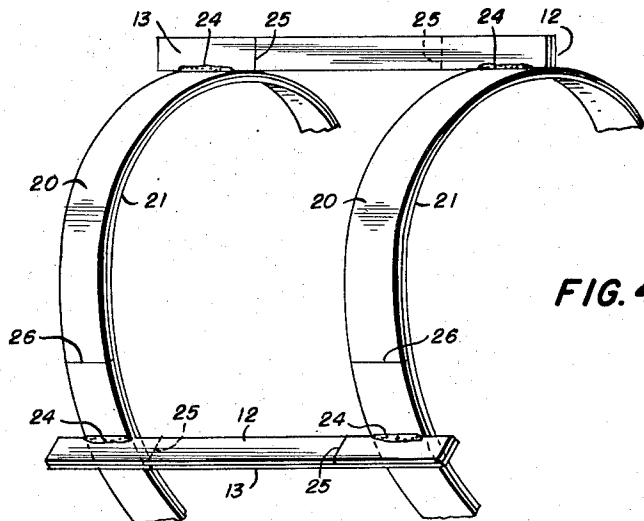


FIG. 4

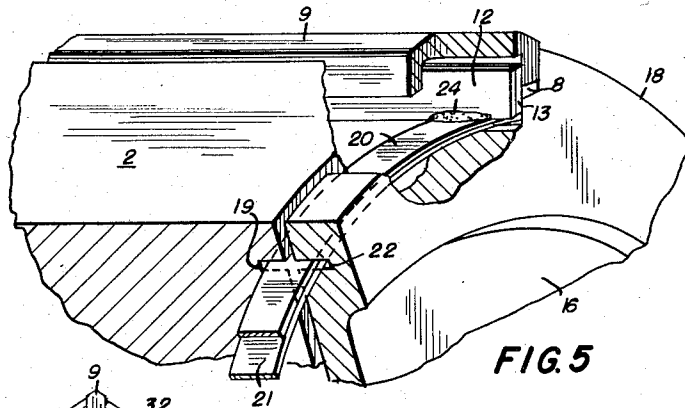


FIG. 5

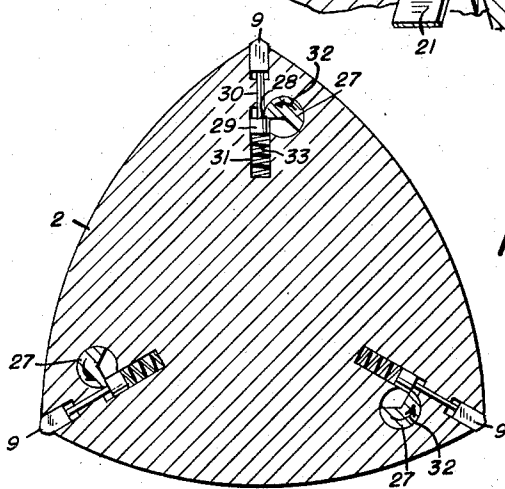


FIG. 6

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3 Sheets-Sheet 3

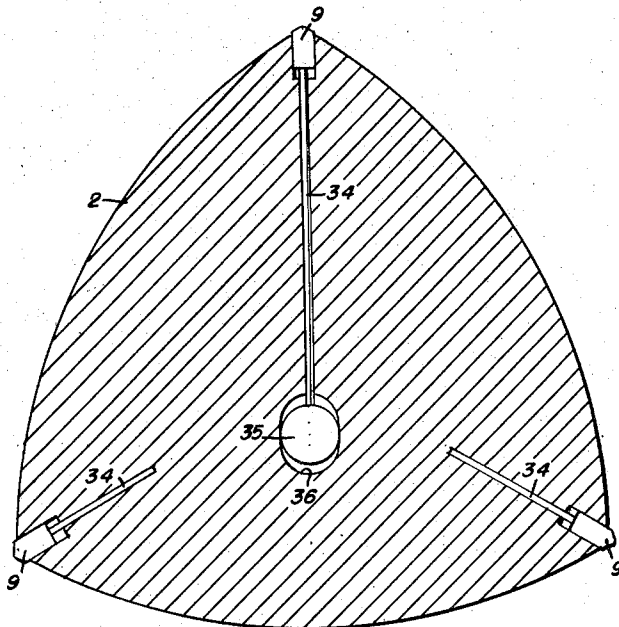


FIG. 7

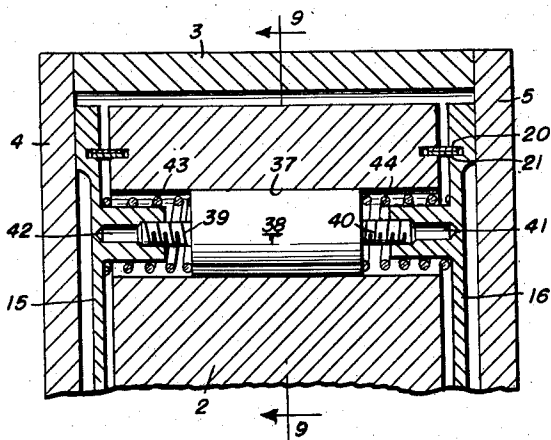


FIG. 8

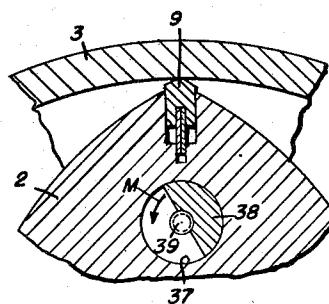


FIG. 9

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SEALS FOR WORKING SPACES OF ROTARY PISTON MACHINES

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Application April 24, 1957, Serial No. 654,840

13 Claims. (Cl. 309—22)

The present invention relates broadly to a sealing arrangement for variable volume working chambers of rotary mechanisms, such as compressors, internal combustion engines, or the like.

More particularly, the invention relates to a sealing arrangement for such machines of the type which include two relatively rotatable elements or rotors mounted on parallel axes and disposed one within the other and having facing parallel surfaces at each end. These parallel surfaces are normal to the axes of rotation. The inner rotor has at least two projecting portions or apices that lie parallel to the axes of rotation of the two rotors. The theoretical apex of these projecting portions on the inner rotor, as the two rotors rotate in the same direction but at different speeds each on its own axis, trace the theoretical curve of the inner surface of the outer rotor. The spaces between the inner and outer rotors between the projecting portions form the variable volume compartments of the machine.

The working spaces of rotary machines of the type in question are usually defined by surfaces belonging to different relatively movable structural parts. The following surfaces, for instance, may be provided:

- (1) The wall of a stationary housing,
- (2) The circumferential surface of a rotor or rotors,
- (3) The end faces of the rotor or rotors,
- (4) The surfaces of locking slides.

One or more of these surfaces contain the control apertures for the operating fluid. The surfaces are partly plane and partly curved in two or three dimensions. It is necessary for the operation of a rotary machine, such as disclosed in application Serial Number 646,752, filed March 18, 1957, in the names of Felix Wankel and Ernst Hoepfner and entitled Rotary Piston Four-Stroke-Cycle Internal Combustion Engine, particularly for the starting process and for lower up to medium speeds, that all joints between facing surfaces be closed as perfectly as possible. Under certain circumstances, a slot seal may be sufficient. In all cases, however, where high temperature differences occur which cause thermic deformations of the material, and where machines have high pressure differentials between the adjacent working spaces, a seal will offer considerable advantages. Each of the variable volume compartments, then, must be sealed from adjacent compartments at the projecting portions of the inner rotor. It is clear that any such seal mounted on the inner rotor will slide over the inner surface of the outer rotor. Also, it is necessary to seal the space between the parallel end faces of the two rotors to prevent radial leakage of gases from one to another of the compartments.

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Therefore, it is one object of the present invention, to provide sealing means for use in a machine of the indicated type.

It is known to seal the variable volume chambers or working spaces of rotary machines by thin-walled plates which are disposed resiliently or elastically. It is, therefore, a feature of the seal according to the invention that the plates are connected to the rotor bodies in gas-tight manner by means of resilient metal strips disposed in slots. This ensures that the deformation caused by the compression is greater than deformations occurring on the sealing surfaces and that fully satisfactory sealing is assured at the joints. This is particularly true in case that, according to a further inventive idea, the metal strips are composed of two or more directly overlying individual strips as these still increase the elasticity.

The sliding movement of the metal strips in the slots may be provided on one side or both sides. In case of but one-sided movement, the metal strip or strips may be secured in the opposite slot by calking. Also, it is possible to make such metal strip of the material of the sealing structure itself.

The construction of such sealing system requires particular care at the corners where e.g. an end face seal of a rotor must be connected to the radial sealing portion. Here too, the metal strips may be used, the deflection from one sealing plane into another plane being effected by deflecting the strips themselves or by soldering, welding or the like at the corner. Also, with such metal strips disposed in several planes, advantageously two or more superposed layers are used the joints of which are arranged offset in known manner.

The centrifugal forces acting on the sealing elements may increase at high speeds to such an extent that the compressing forces surpass the admissible maximum. In such cases, advantageously, a centrifugal force relief is provided which may be obtained by a counterweight. The counterweight may be provided beyond the axis of rotation. In using bellcrank levers or the like, it may be disposed also on the same side as the sealing element.

The centripetally directed relieving force may counterbalance a portion of the centrifugal force, but may be chosen even greater than the centrifugal force. In the latter case, a resilient biasing force must take care of an abutment of the sealing element; this force is balanced with increasing speed by the prevailing centripetal force which causes the sealing elements to be lifted beginning at a selected limit speed. A similar arrangement may also be provided for end face sealing elements, overcoming the originally existing resilient engagement at the sealing point in utilizing centrifugal forces at high speeds and thus reducing losses due to friction.

It is thus an object of this invention to provide sealing means for machines of the type in question which will be efficient under widely varying conditions of use.

Other and further objects and advantages will appear from the following specification taken with the accompanying drawing, in which like characters of reference refer to similar parts in the several views and in which:

Fig. 1 is a fragmentary longitudinal sectional view through a rotary machine of the type mentioned.

Fig. 2 is a sectional view taken along line II—II of Fig. 1,

Fig. 3 is a fragmentary view illustrating a detail at the end face sealing surface in longitudinal section,

Fig. 4 is a diagrammatic view of the metal strips assembled into a jointless sealing system,

Fig. 5 is a fragmentary perspective fragmentary view of a part of the inner rotor partially broken away,

Fig. 6 is a cross section through an inner rotor wherein the axial sealing elements are relieved from centrifugal force by rocking rollers,

Fig. 7 is a cross section through an inner rotor wherein the axial sealing elements are relieved from centrifugal force by counter-weights,

Fig. 8 is a fragmentary longitudinal sectional view through an assembled outer and inner rotor illustrating a means for axially moving the end face sealing plates and

Fig. 9 is a cross sectional view taken along line IX—IX of Fig. 8.

Referring now to Figs. 1 and 2 there is shown a rotary engine in which an inner rotor 2 rotating with a shaft 1 is arranged within a housing which is formed by a mantle 3 and end walls 4 and 5. The housing may rotate or may be stationary. The inner rotor 2 is in constant contact with the inner surface 11 of mantle 3 along a plurality of axially extending crest lines whereby working chambers such as 6 and 7 are formed which are to be sealed from each other. For sealing the inner rotor 2 against said surface 11, sealing strips 9 are provided which are arranged to be radially movable within axial grooves 8 at the corners or crests or apices of rotor 2 and which have their crest lines in constant contact with the inner surface 11 of side wall or mantle 3. Each sealing strip 9 is provided with an incision or narrow slot 9a into which metal strips 12, 13 are inserted. The strips 12, 13 also engage in a slot 14 form in the bottom of groove 8. Each sealing strip 9 is movable with respect to the metal strips 12, 13. Said metal strips are of sufficient elasticity to follow lateral movements of the sealing strip within groove 8. In Fig. 2 the pressure in chamber 6 indicated by arrow A is pressing the sealing strip 9 against the right-hand confining wall of groove 8. If the pressure is in chamber 7 the sealing strip is pressed against the other side wall of groove 8, and the metal strips 12, 13 have to follow this movement. For increasing the flexibility two thin strips are used instead of one thicker one. The use of two thin strips also provides for overlapping of the elements or, as it is expressed "breaking the joints."

In addition to the axially extending contact edges the inner rotor 2 has to contact sealingly against the end walls 4, 5 of the housing. For this purpose sealing plates 15, 16 are provided each having a contour which corresponds essentially to that of the end face of the inner rotor 2 and which are in constant contact with the end walls 4, 5 of the housing over contact faces 17, 18.

The interconnection of the sealing plates 16 with the inner rotor 2 is shown in Fig. 3. A groove 19 is provided in the inner rotor 2 encircling the end wall of the inner rotor inwardly of but near its periphery and into which groove metal strips 20, 21 are inserted. Strips 20, 21 also extend into a corresponding groove 22 in the sealing plate 16 opposite groove 19. The sealing plate 16 is able to move relatively to the metal strips 20, 21 as necessary so that the sealing face 18 is in steady contact with the end wall 5 of the housing. The plate 16 is with its face 18 pressed against the wall 5 by the pressure within chamber 6 which is effective within the slot or gap 23 between inner rotor 2 and end sealing plate 16.

The connecting metal strips 12, 13 for the axially extending sealing strips 9 and the connecting metal strips 20, 21 for the sealing plates 15, 16 are assembled into a jointless sealing system as shown in Fig. 4. The interconnection of the strips 12, 13 and 20, 21 is effected by welding or soldering at 24. The metal strips 12 and 13 and likewise the metal strips 20 and 21 have ends that are staggered with respect to each other in such a way that their joints 25 and 26 are overlapped. With the sealing

system shown in Fig. 4 each working chamber formed between the inner rotor 2 and the housing is sealed in all directions.

Fig. 5 shows a part of the inner rotor 2 in perspective view with the sealing system according to Fig. 4.

In the embodiments shown in Figs. 6 and 7 the axial sealing strips 9 of the inner rotor 2 are relieved from centrifugal force for preventing an excessive pressure of said sealing strips 9 against the mantle 3 of the housing so as to reduce the wear at high rotary speeds. The centrifugal force relief is effected in the embodiment shown in Fig. 6 by a rocking cylinder or cam roller 27 associated with each sealing strip 9. Each rocking cylinder or roller 27 is partially cut out and rotatably supported within an axial bore in the inner rotor 2. The edge 28 of each cylinder 27 engages one end of a plunger 29 which is connected to the sealing strip 9 by a rod 30 and which is radially slidable within a bore 31 of rotor 2. On rotation of rotor 2 the cylinder 27 is turned by the centrifugal force in the direction of arrow 32 thereby tending to shift the plunger 29 radially inwardly under the pressure exerted by edge 28. As the sealing strip 9 is connected to the plunger 29 by the rod 30 the pressure of said strip 9 against the face of mantle 3 caused by the centrifugal force is diminished. A spring 33 acting upon the other end of plunger 29 in a direction opposite to the direction of movement of the plunger by the roller 27 maintains a certain contact pressure of the sealing strip 9 against mantle 3.

Another possibility of centrifugal force relief is shown in Fig. 7. The axial sealing strips 9 are connected to rods 34 arranged radially inside the inner rotor 2. The rods 34 extend beyond the rotational axis of rotor 2 and carry at their ends remote from the sealing strips 9 counter-weights 35, only one of which is shown, arranged within recesses 36. The sealing strips 9, rods 34 and counter-weights 35 are radially movable and, on rotation of the inner rotor 2, the centrifugal force acts upon both sealing strips 9 and counter-weights 35. By suitable selection of weight and position of the counter-weights 35 the centrifugal force acting upon the sealing strips 9 is balanced by the counter-weights 35 insofar as an excessive pressure of the sealing strips 9 against the counter face is prevented.

Figs. 8 and 9 show a device for axially shifting the end face sealing plates 15, 16 of the inner rotor 2 relative to the adjacent end faces or walls 4 and 5 at higher rotational speeds for diminishing friction and wear at such speeds between said plates and walls. For this purpose, a cylinder or roller 38 is rotatably arranged within a bore 37 in the inner rotor 2 adjacent each crest. Each cylinder 38 is partly cut away and is provided at its ends with centrally arranged threaded studs 39 and 40 respectively.

The stud 39 has left-handed thread and the stud 40 has right-handed thread. The sealing plates 15, 16 are provided with correspondingly threaded holes 42 and 41 which respectively engage the said studs 39 and 40. Springs 43, 44 are arranged between the opposite ends of the roller 38 and the respective sealing plates 15, 16. On rotation of the inner rotor 2 the centrifugal force acting upon the roller 38 tends to turn said roller in the direction of the arrow M. This turning moment effects that the stud 40 is screwed into the right-handed thread 41 of the sealing plate 16 and at the same time the stud 39 is screwed into the left-handed thread 42 of the sealing plate 15 both against the action of the springs 43 and 44. By this the sealing plates 15, 16 and their respective contact surfaces recede away from the adjacent side walls 4 and 5 and the friction is reduced.

What I claim as my invention and desire to secure by Letters Patent of the United States is:

1. In a rotary mechanism including an outer hollow body and an inner body supported within the outer body for relative rotation with respect thereto, said outer body having an axially extending inner wall surface and axially

spaced parallel end walls, said inner body having axially spaced parallel end faces and an axially extending outer surface, the respective inner wall surface of the outer body and outer axially extending surface of the inner body being cooperatively shaped to define upon relative rotation a plurality of variable volume working chambers, a sealing arrangement between said surfaces, walls and faces including plate elements disposed between the respective end walls and adjacent end faces, said plate elements being of such thinness as to conform to any deformations existing in or which may occur in operation, the end faces of the inner body having axially extending slots therein, the inner faces of said plate elements having correspondingly positioned axially extending slots therein, and resilient metal strip means disposed within the respective slots and connecting the plate elements to the inner body in a gas-tight manner.

2. In a rotary mechanism including an outer hollow body and an inner body supported within the outer body for relative rotation with respect thereto, said outer body having an axially extending inner wall surface and axially spaced parallel end walls, said inner body having axially spaced parallel end faces and an axially extending outer surface, the axial extent of the inner body being less than the space between said end walls, the inner wall surface of the outer body and the outer axially extending surface of the inner body being shaped to define a plurality of variable volume working chambers upon relative rotation of the bodies, a sealing arrangement for said chambers comprising a sealing plate between the opposite end faces of the inner body and the adjacent end walls of the outer body, said sealing plates having an end wall contacting sealing surface and being of a thinness such as to be capable of conforming to end wall deformations which may exist or occur in operation, the inner face of each sealing plate and the adjacent end surface of the inner body having inwardly of their respective peripheries correspondingly positioned, axially extending, oppositely directed grooves therein, and resilient metallic strip means extending axially of the inner body disposed in the said grooves and connecting the sealing plates to the inner body in a gas-tight manner.

3. In a rotary mechanism including an outer hollow body and an inner body supported within the outer body for relative rotation with respect thereto, said outer body having an axially extending inner wall surface and axially spaced parallel end walls, said inner body having axially spaced parallel end faces and an axially extending outer surface, the axial extent of the inner body being less than the space between said end walls, the inner wall surface of the outer body and the outer axially extending surface of the inner body being shaped to define a plurality of variable volume working chambers upon relative rotation of the bodies, a sealing arrangement for said chambers comprising a sealing plate between the opposite end faces of the inner body and the adjacent end walls of the outer body, said sealing plates having an end wall contacting sealing surface and being of a thinness such as to be capable of conforming to end wall deformations which may exist or occur in operation, the inner face of each sealing plate and the adjacent end surface of the inner body having inwardly of their respective peripheries correspondingly positioned, axially extending, oppositely directed grooves therein, resilient metallic strip means extending axially of the inner body disposed in said grooves and connecting the sealing plates to the inner body, the shape of the outer surface of the inner body defining a plurality of apices, said inner body having a groove extending inwardly of its periphery and axially along each apex, a sealing strip means disposed in each of said last-mentioned grooves, the inner body further having an axially extending slot that extends inwardly from the base of each of said last-mentioned grooves, the inner face of the sealing strip means having an oppositely directed axially extending groove therein, metal strip

means extending axially of the inner body and disposed in the respective slots and said last-mentioned metallic strip means being connected to said first-mentioned metallic strip means.

4. In a rotary mechanism as claimed in claim 3 and all said metallic strip means being of laminar construction, the metal strip of each layer comprising a plurality of jointed strip elements with the joints of one layer being offset with respect to the joints of the adjacent layer.

5. In a rotary mechanism as claimed in claim 3 in which each axially extending sealing strip is thinner than its associated groove and said sealing plates being normally spaced by their interconnecting metal strips from the adjacent end walls of the inner body, whereby during operation gas pressure entering said axially extending grooves in the space between the end faces of the inner body and said sealing plates ensures adequate sealing.

6. In a rotary mechanism as claimed in claim 3 and all said metal strip means being resilient.

7. In a rotary mechanism as claimed in claim 3 and means operably associated with the axially extending sealing strips for relieving excess pressure and reducing wear occasioned by centrifugal force resulting from high rotational speed.

8. In a rotary mechanism is claimed in claim 7 and the means for preventing excess pressure and reducing wear of the axially extending strips comprising separate plunger means housed within the inner body and respectively connected to each axially extending sealing strip, cam roller means having a cutaway portion extending axially of the inner body and housed therein adjacent each plunger means, the cutaway portion providing a cam surface engageable with the plunger means on the side thereof adjacent the axially extending sealing strip, whereby rotation of the inner body imparts turning movement to the cam roller means to apply a force against the associated plunger means to shift the same radially inwards to diminish the pressure of the axially extending sealing strips against the inner surface of the outer body.

9. In a rotary mechanism as claimed in claim 8 and resilient means for applying a biasing force to said plunger means in a radially outward direction.

10. In a rotary mechanism as claimed in claim 3 and means for relieving excess pressure and wear of the axially extending sealing strips responsive to high rotational speeds comprising radially extending rod means connected to each axially extending sealing strip and extending within the inner body a distance to extend beyond the rotational axis thereof, a counterweight means on the inner end of each rod means, and the inner body having counterweight accommodating recesses therein, having opposed radially extending surfaces permitting radial movement of the respective counterweights, whereby upon rotation of the inner rotor centrifugal force is exerted upon both the axially extending sealing strips and the associated counterweights with the centrifugal forces tending to balance one another so as to prevent excessive pressing of the axially extending sealing strips against the inner surface of the outer body.

11. In a rotary mechanism as claimed in claim 2 and centrifugal force responsive means operatively connected between the sealing plates for diminishing friction and wear of such plates occasioned by high rotational speed, by applying an axial movement to said plates in the direction away from the respective end walls of the outer body.

12. In a rotary mechanism as claimed in claim 3 and a cylindrical bore through the inner body radially inwards of each apex, a partially cutaway roller element in each bore, said element having an axial extent less than the bore, oppositely facing stud means projecting axially of the opposite ends of said element and respectively of left and right handed threads, the inner faces of the respective sealing plates having left and right

handed threaded boss means thereon in threaded engagement with said stud, means whereby upon rotation of the inner rotor centrifugal force acting on said rotor elements tends to turn the same in a direction to impart via the threaded engagements axial inward movement to said end plates. 5

13. In a rotary mechanism as claimed in claim 12 and resilient means within the axial bores and biased between said end plates and roller elements.

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