United States Patent

Jones et al.

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[54] MULTI-UNIT ROTARY MECHANISM

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[52] **U.S. Cl.**.....**418/60,** 418/61

[51] **Int. Cl.**.....**F01c 1/02,** F03c 3/00, F04c 1/02

[58] **Field of Search**.....418/60; 123/807; 308/15; 29/447

[56] **References Cited**

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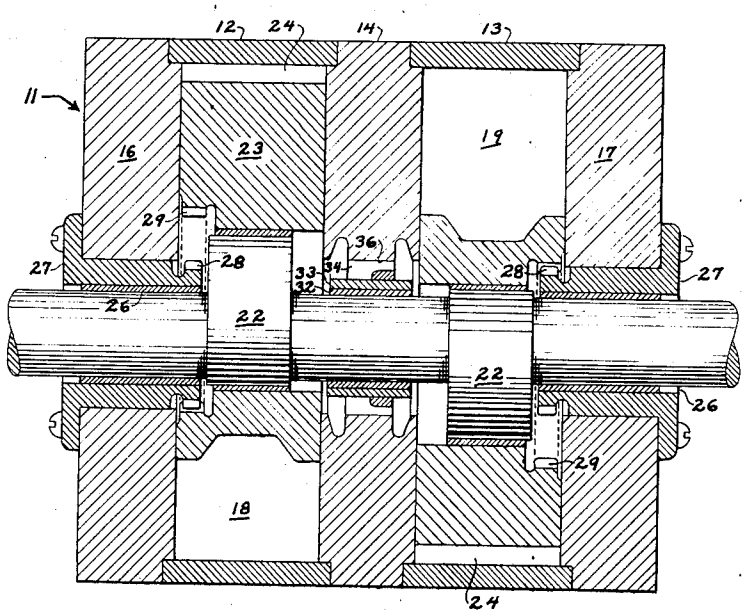
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[57] **ABSTRACT**

A rotary mechanism of the trochoidal type, having a plurality of operating cavities and a one-piece crankshaft bearing a plurality of eccentric portions, one for the rotor in each operating cavity. The intermediate wall between adjacent operating cavities of such a mechanism has an aperture through which an eccentric may be passed for assembly of the mechanism, and a simple and inexpensive split bearing member assembled around the journal of the shaft in the aperture of the intermediate wall, which is then shrunk into fit to hold and support the bearing member.

3 Claims, 6 Drawing Figures



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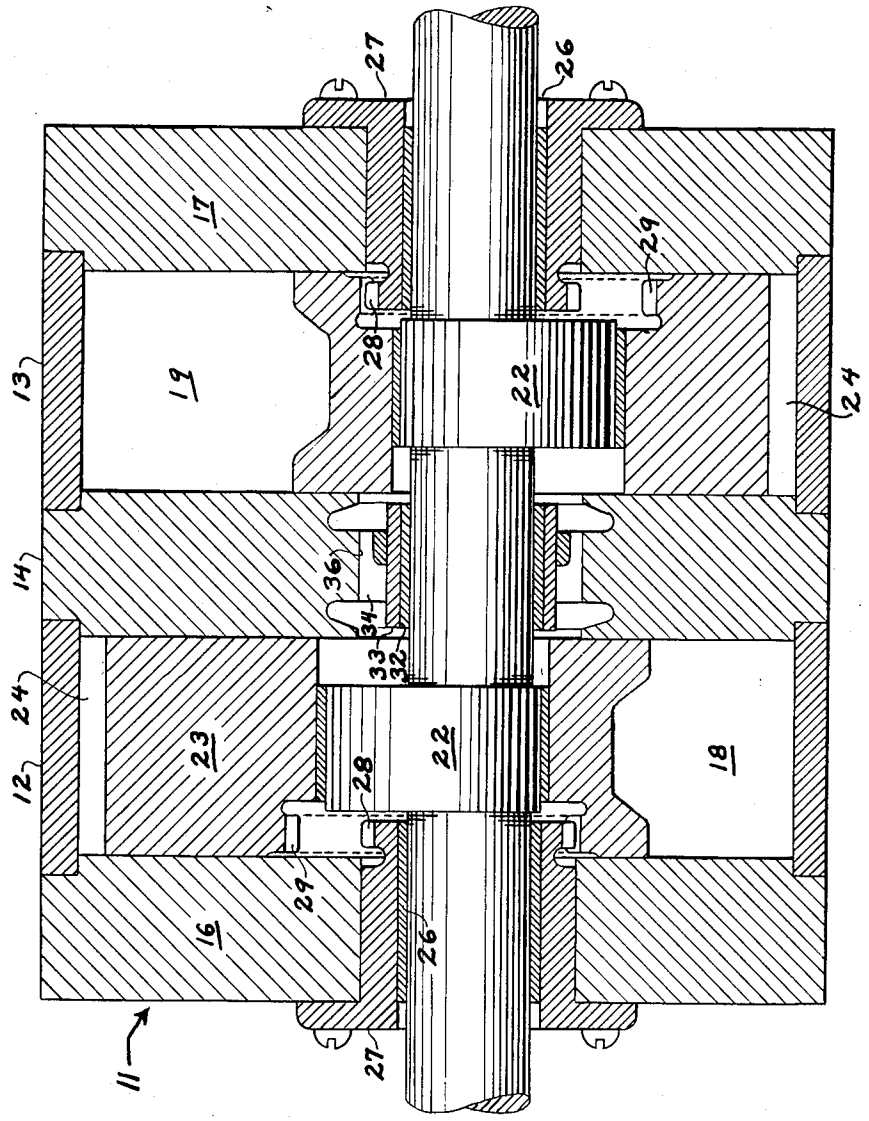


FIG. 1

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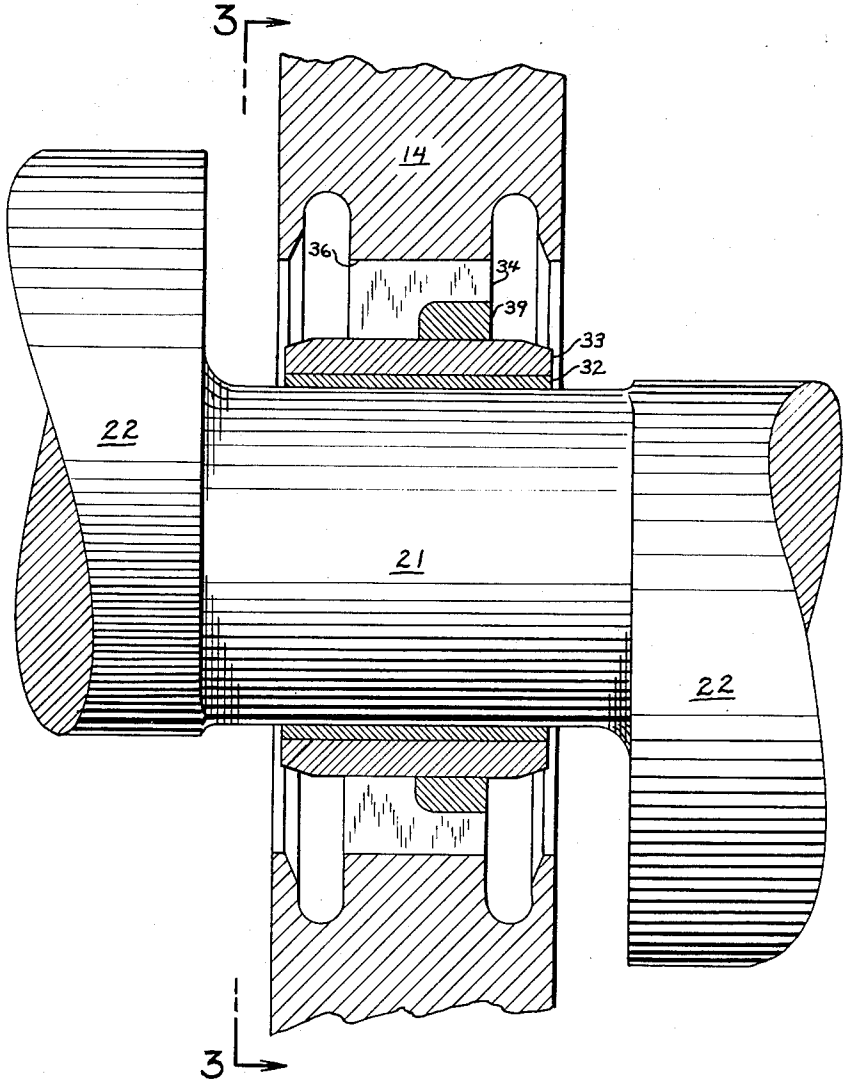


FIG. 2

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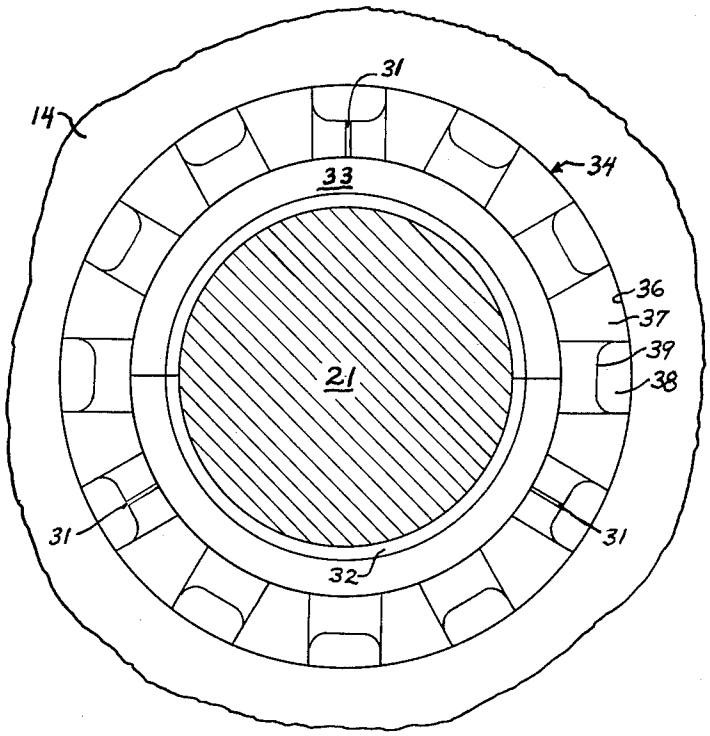


FIG. 3

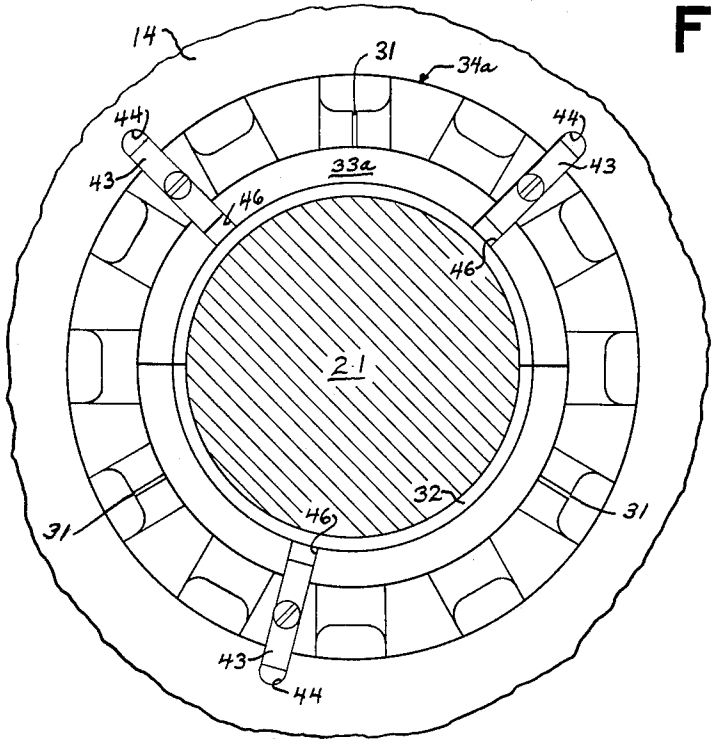


FIG. 6

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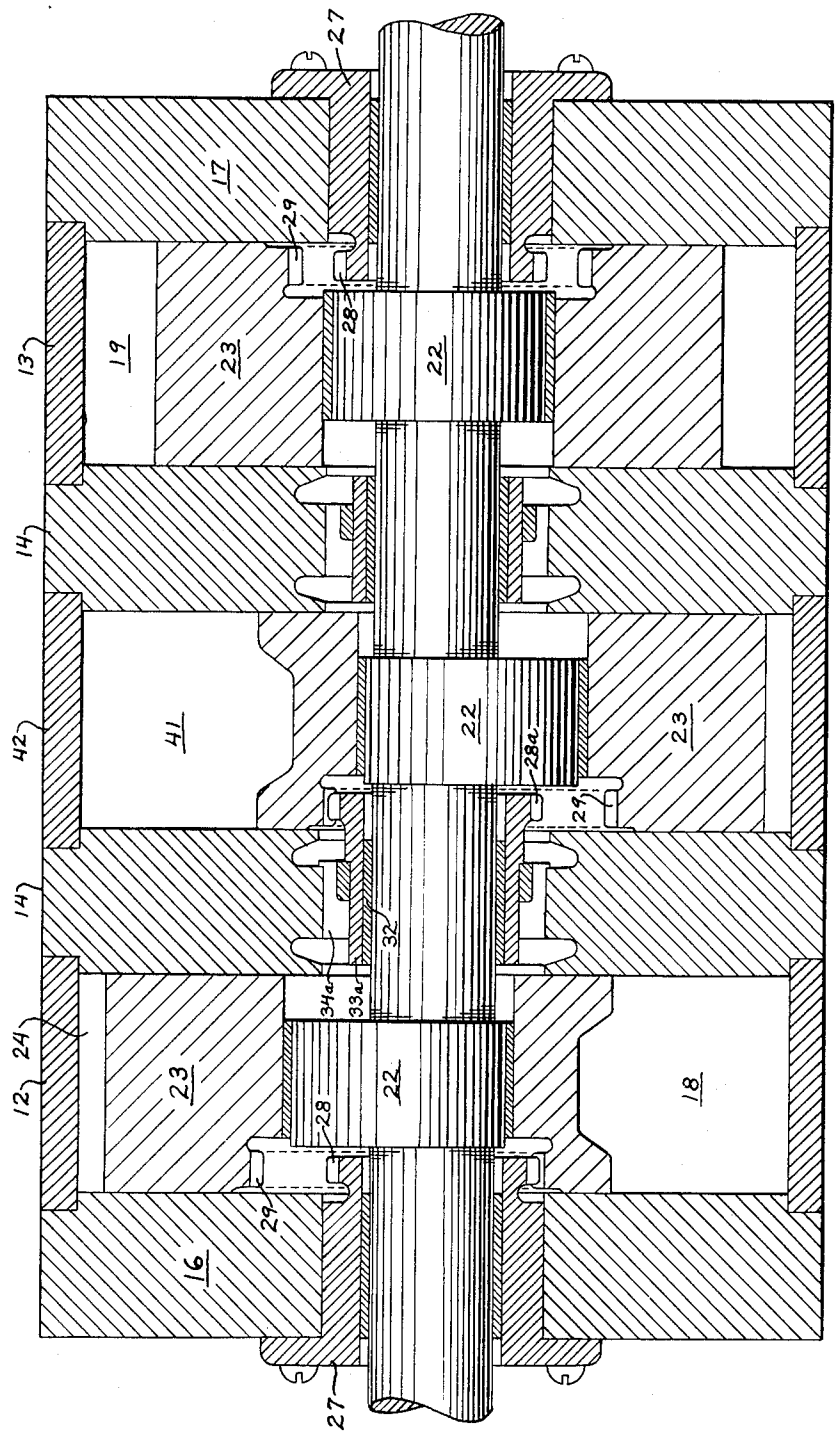


FIG. 4

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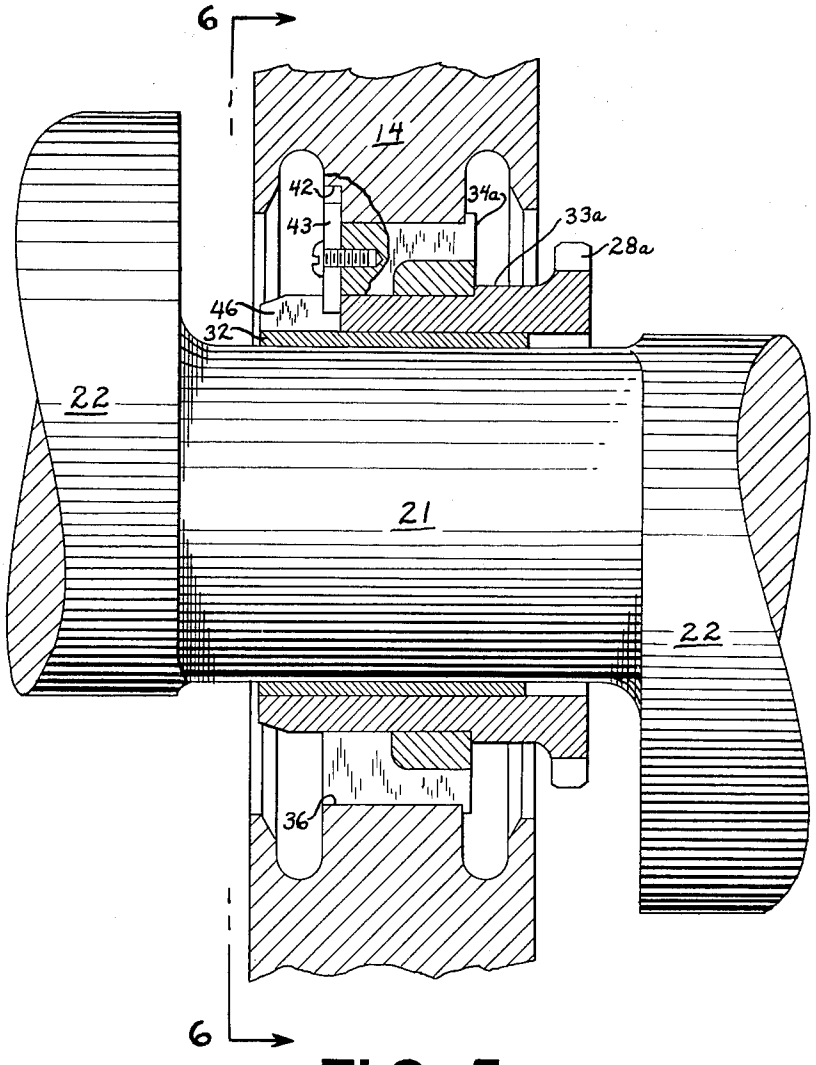


FIG. 5

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MULTI-UNIT ROTARY MECHANISM

BACKGROUND OF THE INVENTION

In rotary mechanisms of the trochoidal type, operating units are multiplied by the addition of rotors and rotor cavities in the axial direction. Rotor cavities must be separated by intermediate walls which may contain a bearing member for the shaft, necessitating either that the intermediate wall be split for assembly, or that a multi-piece shaft be used, or that the bearing be split, as in the present invention.

Split bearings are known in the prior art, as in U.S. Pat. No. 3,193,187. In that patent a split sleeve bearing is assembled around the shaft journal, and positioned around the bearing is a split steel sleeve which bears a flange for axial location. The aperture through the intermediate wall, large enough for passage of the eccentric, is frustoconical, and the space between the steel sleeve and the wall aperture is occupied by a plurality of arcuate wedgelike members having one frustoconical surface fitting the frustoconical aperture; these arcuate wedges are pulled into tight wedging engagement by bolts passing through the wedges and seating in the flange.

Such an arrangement is very expensive to fabricate and difficult to assemble and adjust. The frustoconical surfaces of the wall aperture and the arcuate wedges require a very high degree of precision in both their taper and their concentricity. The bolts required for pulling up the wedges are required to be of very high strength material, and are very costly. The position of the eccentric in close juxtaposition to the intermediate wall makes it difficult to get at the bolts for tightening, requiring special tools, and the wedges require to be tightened precisely in concert, in order not to force the shaft out of line.

SUMMARY OF THE INVENTION

The present invention provides a multi-unit rotary mechanism of the trochoidal type, such as internal combustion engines, fluid motors, or pumps, having a one-piece shaft with at least one center bearing, in which the disadvantages of the prior art are overcome by providing a split bearing sleeve surrounding the shaft journal, a split steel annulus, which may bear a rotor gear, surrounding and supporting the bearing, and a split spacer member of a requisite degree of resilience surrounding the steel annulus and positioned in a bore through the intermediate wall, which is first heated and then shrunk into place around the bearing assembly. This construction and procedure leaves the entire assembly of elements held firmly in place within the bore in the intermediate wall.

It is therefore an object of this invention to provide a journal bearing in an intermediate position for the shaft of a multi-unit rotary mechanism.

It is another object to provide such a bearing which is inexpensive to manufacture and install.

A further object is to provide a bearing assembly in a bore through an intermediate wall of a rotary mechanism, wherein the wall is shrunk into place around the bearing assembly to support and position it.

Other objects and advantages will be apparent on reading the following specification in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an axial cross-section in elevation of a two-unit rotary mechanism with a bearing assembly according to the invention positioned in the intermediate wall;

FIG. 2 is a fragmentary enlarged view of the bearing assembly of FIG. 1;

FIG. 3 is a transverse view taken on line 3—3 of FIG. 2;

FIG. 4 is a view similar to FIG. 1 of a three-unit rotary mechanism;

FIG. 5 is a fragmentary enlarged view similar to FIG. 2, of one of the bearing assemblies of FIG. 4 in which a rotor gear is incorporated; and

FIG. 6 is a transverse view taken on line 6—6 of FIG. 5.

In FIG. 1 there is shown a two-unit rotary mechanism 11 of the trochoidal type; many constructional details not directly concerned with the present invention, such as bolting, cooling system, seals, etc. have been omitted for clarity of presentation. Such a mechanism comprises basically a pair of peripheral rotor housings 12 and 13 having epitrochoidal inner surfaces, separated by an intermediate wall 14, and a pair of end walls 16 and 17, which in combination define a pair of rotor cavities 18 and 19. A shaft 21 transpierces both end walls and the intermediate wall, and bears an eccentric portion 22 within each rotor cavity. Mounted on each eccentric is a multi-apexed rotor 23 having at each apex a seal strip 24 sweeping the trochoidal inner surface of housings 12 and 13, and provided with other appropriate sealing means (not shown).

Since the shaft turns with rotation of the rotors within cavities 18 and 19, suitable shaft bearings must be provided. In the end walls 16 and 17 the shaft is supported on simple sleeve bearings 26, which are surrounded by steel sleeves 27 having at their inner ends a fixed gear 28 projecting into the rotor cavity and engaging a ring gear 29 borne by the rotor. The meshing of spur gear 28 and ring gear 29 serves to keep the rotor in phase during its traversal of the operating cavity, but the gears 28 and 29 do not transmit any torque. This bearing and gear arrangement in the end walls is conventional and known in the art.

A bearing assembly according to the invention (better shown in FIG. 2) is positioned in the aperture through the intermediate wall 14. In order to use a one-piece shaft it is necessary that the bore 36 through the intermediate wall should be large enough to pass one of the eccentrics 22 through it. A bearing must then be assembled in the aperture around the journal portion of the shaft between the eccentrics.

For this purpose there is provided a sleeve bearing 32, split into two semicylindrical halves as shown in FIG. 3, which fits around the journal. Surrounding the bearing sleeve is a bearing support 33, also split into two semicylindrical halves, and formed preferably of steel or other suitable material for bearing support. A spacer member 34, split into three or more arcuate sections, surrounds the bearing support and fits tightly into a bore 36 through the intermediate wall 14. The ends of the arcuate sectors of the spacer are separated by gaps 31, exaggerated in the drawings for clear showing.

The spacer may be formed wholly by machining, but for economical production is preferably formed by one of the metal mold casting techniques, as a ring having the required general configuration, and subsequently machined to finish dimensions and divided into arcuate sectors with a slitting saw. The metal mold casting processes include such techniques as conventional pressure die-casting, low pressure die-casting in which the evacuated mold is fed from a reservoir below, and permanent mold casting wherein the mold is fed by gravity. The material of the spacer may be any metal having a lower modulus of elasticity than that of the bearing support, but of relatively high strength. Preferably the metal should be one of those which are suitable to metal mold casting, such as an aluminum alloy.

The spacer forms in effect a radial spring member, and in order to prevent the introduction of compressive hoop stresses the amount of material removed by splitting it into arcuate sectors with a slitting saw is sufficient to prevent the adjacent ends of the sectors from butting together to simulate a solid ring. Even if two sectors should but together at assembly, the space at their other ends will be correspondingly larger so that all sectors act individually. The sectors may also preferably be provided with additional partial discontinuities in the circumferential direction or changes of section to reduce circumferential strength and lower their effective rigidity. In this way the radial force developed by the interference fit between the outer diameter of the spacer and the inner diameter of the bore in the intermediate wall is transmitted directly radially through the spacer to the bearing support member. Further, the intermediate wall is generally hotter, and when the spacer is circumferentially interrupted there is less thermal transfer from the wall to the bearing assembly.

The spacer member **34** is a ring of circumferentially disposed elements suitable for transmitting radial pressure force, held together at the inner circumference by a flexible ligament having practically no hoop strength. An example of this construction is a spacer such as that shown in FIGS. **1** and **3**, comprising a ring formed with external teeth or spline-like projections **37** separated by interstices **38**, a ligament portion **39** of the ring being left solid to hold the teeth together. Such construction provides a spacer having a certain amount of resilience, the teeth being somewhat deflectable under radial loading, and the integrity of the individual arcuate sectors being maintained by the ligament portion **39** which is left solid. The ligament is slightly flexible, however, and any hoop strength it may have is interrupted by the spaces **31** left between the ends of the arcuate sectors. A suitable spacer may also be constructed by providing a ligament member comprising a flexible circumferential strap having virtually no hoop strength, and having pressure-transmitting members mounted thereon and extending radially outwardly.

At room temperature an assembly of the bearing, support member, and spacer is slightly larger in its composite outer diameter than the diameter of bore **36**, providing a significant interference. To assemble the mechanism, the intermediate wall is first heated to expand the bore, and the eccentric of the shaft passed through it. The elements of the bearing, support member, and spacer member are positioned in place around the shaft within the expanded bore, and the wall allowed to cool, shrinking the bore around the bearing assembly and holding all elements in tight frictional engagement. If desired, the members of the bearing assembly may be chilled to aid in installation. At the operating temperature of the rotary mechanism the degree of compression exerted on the bearing assembly by the intermediate wall may diminish slightly, but not enough to relieve the interference or allow the parts to loosen.

The amount of the interference, the spring rates of the elements of the assembly, and the temperatures selected for the assembly procedure naturally vary with the materials used, the size of the rotary mechanism, and its intended operating temperature, and such parameters are chosen by engineering considerations for the particular device in question.

By way of example, in one such rotary mechanism wherein the steel bearing support member has an outside diameter of the order of about 3 ½ inches and an inside diameter of the order of about 2 ½ inches, the diametral interference of the bearing assembly with the bore through the intermediate wall is 0.0095 inch. Heating the intermediate wall, formed of aluminum alloy, to approximately 400°F causes an increase of 0.0165 inch in the bore diameter, thus making assembly readily possible. In any case wherein the increase in bore diameter might not be sufficiently large to allow such ready assembly, chilling the bearing assembly would provide an additional clearance factor.

In the rotary mechanism described above, having only two rotors, the bearing assembly in the intermediate wall has no function to perform other than that of a journal bearing. In the case of a mechanism having three or more rotors, it is necessary that at least one assembly in an intermediate wall should also bear a spur gear for phasing the rotor. Such an arrangement is shown in the three-unit mechanism of FIG. **4**, and may be repeated as necessary for a greater number of rotors.

The two rotors in the end cavities **18** and **19** in FIG. **4** have their phasing spur gears **28** supported by the end walls **16** and **17**, as previously described. The rotor disposed in the center cavity **41** which is defined by peripheral housing **42** has its ring gear **29** meshing with a spur gear **28*a*** which is an extension of the bearing support member of the assembly positioned in the adjacent intermediate wall. The assembly is shown in enlarged detail in FIGS. **5** and **6**.

A sleeve bearing **32** split into two parts surrounds the journal of the shaft **21**, as in the previous embodiment. Surrounding the bearing is a two-part support **33*a***, having a shoulder for axial location against the spacer member, and bearing at one end a spur gear **28*a*** to mate with the ring gear of the adjacent rotor. A toothed spacer **34*a***, similar to the spacer previously described but provided with a shoulder locating it axially against the intermediate wall **14**, surrounds the bearing support, within the bore **36**. For angular location of the spur gear **28*a*** there is provided in each sector of the spacer a key **43**, seated in a radial keyway slot in the spacer and attached thereto by a screw or other convenient means, and having one end extending into a keyway **44** in the intermediate wall and the other end

extending into a radial keyway slot **46** in the end of the bearing support **33***a*. Such keys not only provide angular location of the gear, but also prevent axial movement in the other direction. Since the gear is only for the purpose of maintaining the phase of the rotor and has no axial loading and no torque except minor effects from friction or change of speed, the shrink fit within the bore in the intermediate wall is sufficient to maintain the bearing and gear assembly in place, the shoulders and keys serving for location during the assembly procedure and as an aid against any incidental transitory forces.

It is apparent that the invention described above provides a simple and inexpensive split bearing assembly for the shaft of a rotary mechanism, fabricated by conventional machining and metal mold casting, and not requiring the complex and difficult adjustment of bearings of the prior art.

What is claimed is:

1. A multi-unit rotary mechanism comprising in combination at least two axially aligned rotary units having a common one-piece rotatable shaft, each rotary unit having a peripheral housing coaxial with the shaft, an intermediate wall between adjacent units and connected with the adjacent peripheral housings, and an end wall at each end of the rotary mechanism connected with the adjacent peripheral housing thereby defining an operating cavity for each unit, the one-piece shaft passing through each of the intermediate walls and the end walls, the shaft having formed thereon a plurality of axially spaced eccentric portions with one such eccentric portion in each operating cavity and a rotor mounted on each eccentric portion, each rotor having an internal gear thereon, a plurality of fixed gears disposed about the shaft with one fixed gear for each internal gear and in meshing engagement therewith, each fixed gear having an inner diameter less than the diameter of the eccentric portions, the intermediate wall having an axial bore therethrough of larger diameter than the eccentric portions, and a bearing assembly disposed within the bore and surrounding the journal of the shaft between eccentric portions, the bearing assembly comprising:

a. a sleeve bearing split into a plurality of partial cylindrical portions surrounding the journal of the shaft between two eccentric portions and having an inner diameter suitable to provide a bearing surface for the shaft journal;

b. a generally cylindrical bearing support member split axially into a plurality of partial cylindrical portions surrounding the sleeve bearing and having its inner diameter in frictional engagement with the outer diameter of the sleeve bearing;

c. a spacer member split axially into a plurality of arcuate portions surrounding the bearing support and having its inner diameter in frictional engagement with the outer diameter of the bearing support and its outer diameter in frictional engagement with the inner diameter of the bore through the intermediate wall;

d. each of the arcuate spacer portions comprising a flexible ligament partially surrounding the bearing support and having its inner diameter in frictional engagement with the outer diameter of the bearing support and having on its outer diameter a plurality of circumferentially disposed radially extending pressure transmitting members in frictional engagement with the inner diameter of the bore through the intermediate wall;

e. the composite outer diameter of the bearing assembly being greater than the diameter of the bore through the intermediate wall and being in interference fit therewith.

2. The combination recited in claim **1**, wherein the outer diameter of the spacer is provided with radially extending spline-like projections integral with the ligament and separated by slots to reduce the rigidity of the spacer.

3. The combination recited in claim **1**, wherein one end of the bearing support member bears a fixed gear in meshing engagement with the internal gear of a rotor, and the bearing assembly is provided with means restraining it from axial and angular movement within the intermediate wall bore, the restraining means comprising:

a. at one end of the bearing assembly the spacer member having a shoulder seated axially against the intermediate wall and the bearing support member having a shoulder seated axially against the spacer,

b. at the opposite end of the bearing assembly the intermediate wall, the spacer member, and the bearing support being each provided with at least one keyway, the keyway of each member being mutually aligned with the keyways of the other members, and

c. a key positioned in and mutually engaging such keyways to angularly position the gear borne by the bearing support member.

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