Aug. 21, 1951 R. A. BAUDRY 2,565,116

SPRINGLESS SELF-EQUALIZING THRUST-BEARING

Filed April 15, 1950 3 Sheets-Sheet 1

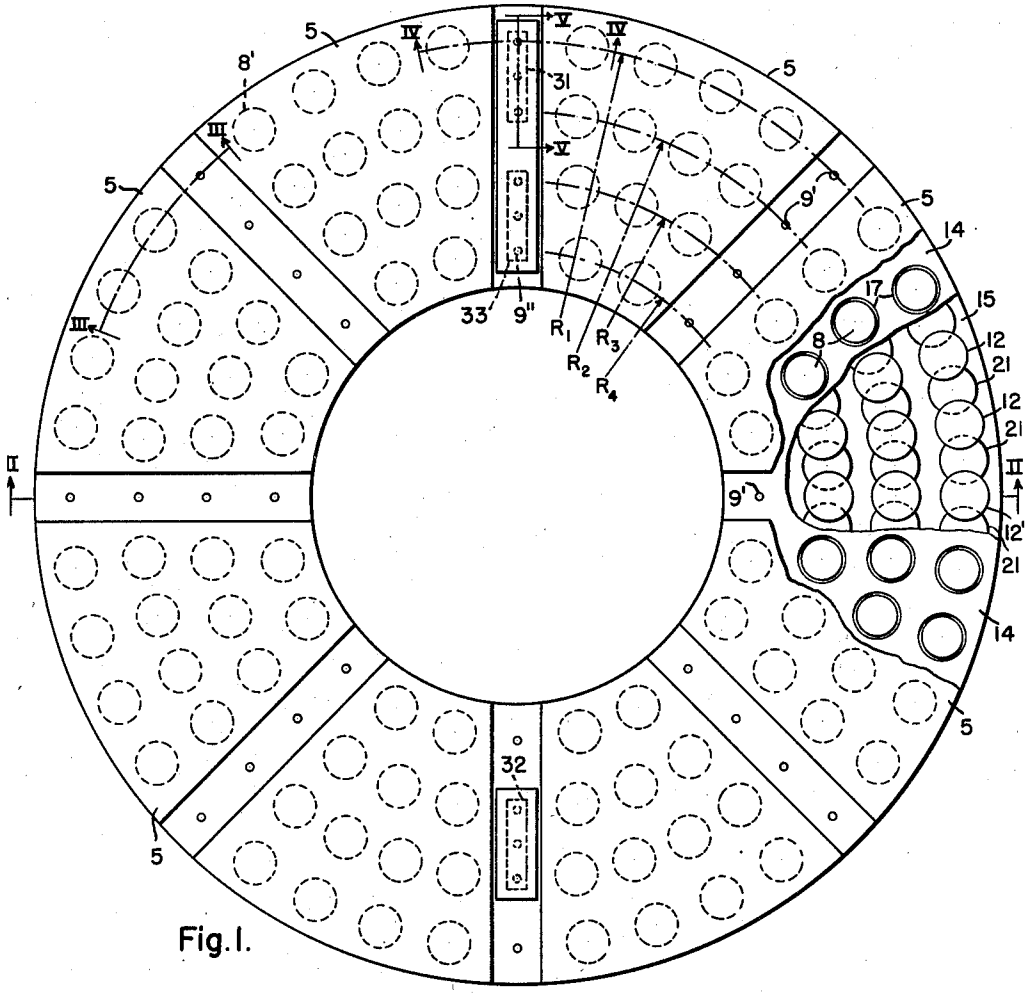


Fig. 1.

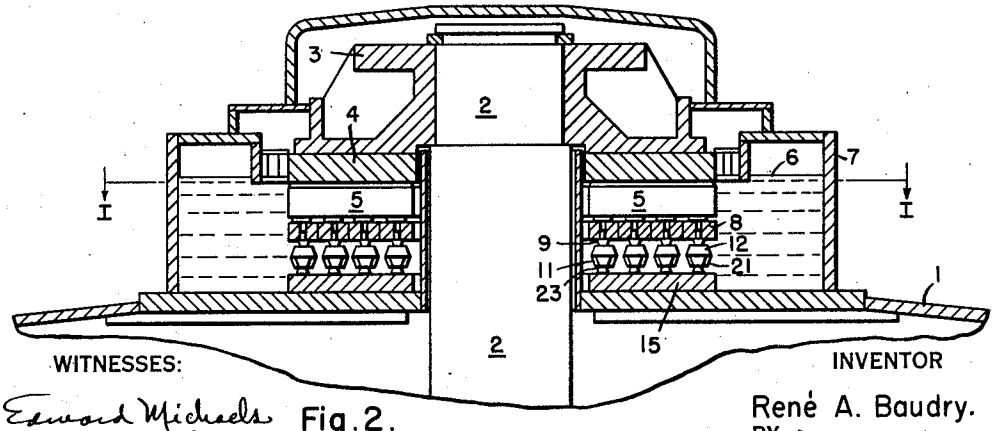


Fig. 2.

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SPRINGLESS SELF-EQUALIZING THRUST-BEARING

Filed April 15, 1950 3 Sheets-Sheet 2

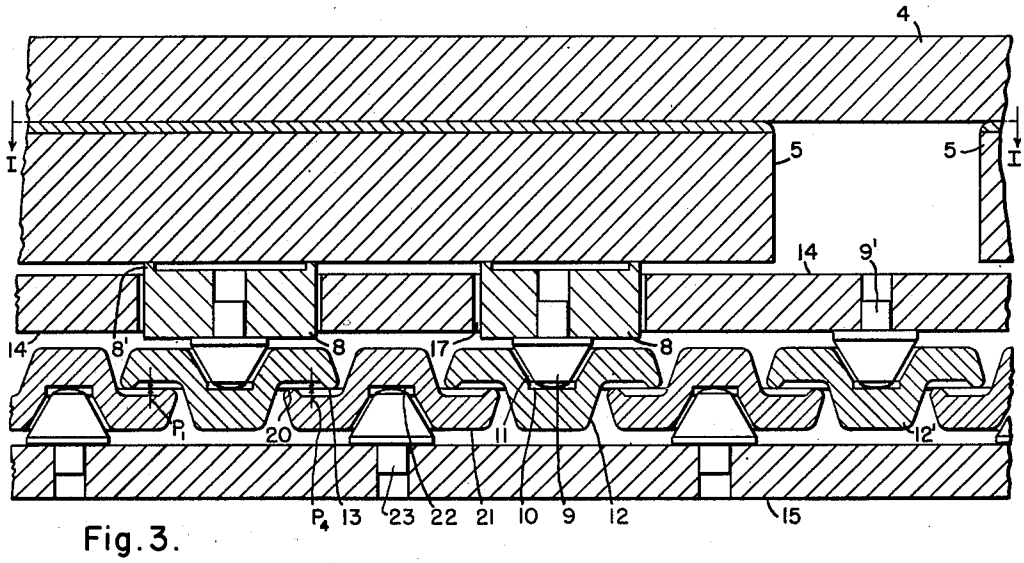


Fig. 3.

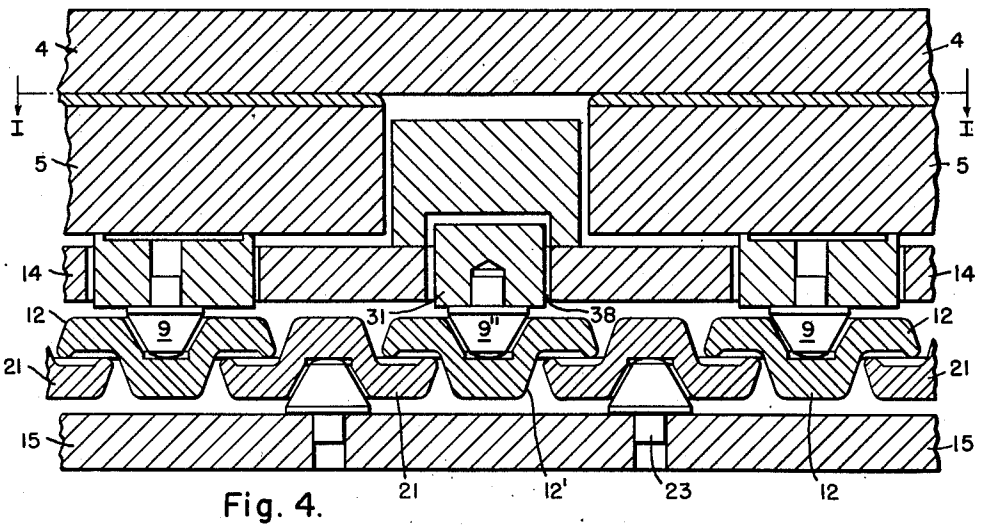


Fig. 4.

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SPRINGLESS SELF-EQUALIZING THRUST-BEARING

Filed April 15, 1950 3 Sheets-Sheet 3

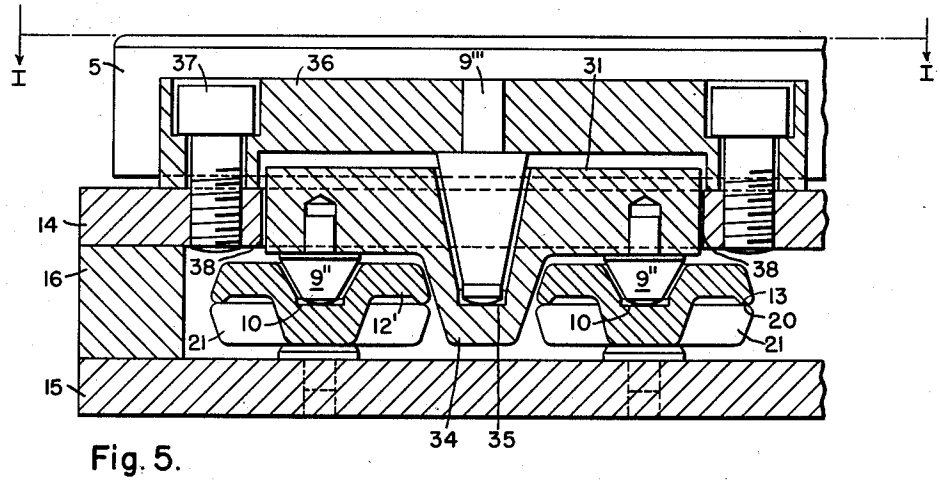


Fig. 5.

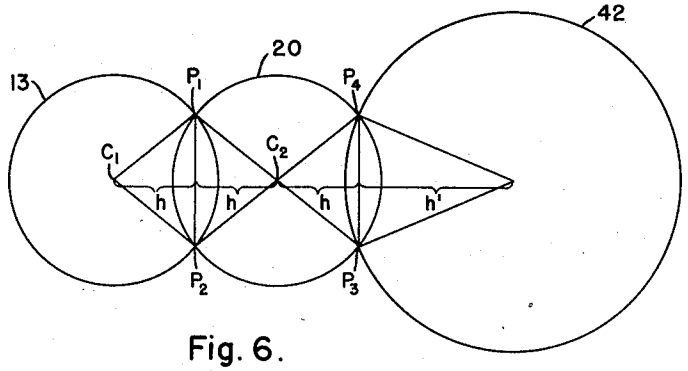


Fig. 6.

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SPRINGLESS SELF-EQUALIZING THRUST BEARING

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Application April 15, 1950, Serial No. 156,074

4 Claims. (Cl. 308—160)

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My invention relates to large thrust-bearings of the type in which a rotating runner of a vertical-shaft machine is supported on a plurality of segment-shaped non-rotating thrust-bearing shoes which are supported so that they are immersed in a body of lubricating-oil. Such shoes have to be mounted so that they are capable of tilting a few mils of their leading edges, so as to accommodate a wedge-shaped film of oil when the machine is in operation. Certain types of these shoes have been built, for many years, so that they will automatically equalize the load between different shoes, both under static and running conditions.

In large self-equalizing thrust-bearings, it is quite difficult to obtain equal distribution of the load all over the bearing-surface of each shoe, and to this end the shoes must frequently be hand-scraped and fitted under thrust-load, in order to make proper allowance for the elastic deformations in the shoe and in the thrust-runner. This fitting under load, however, does not take care of the thermal deformation which is always present in thrust-bearings.

For many years, spring-supported thrust-bearing shoes have been known, for providing a more ideal distribution of the load all over the surface of each shoe. However, this type of spring-supported bearing has a number of disadvantages, among which may be mentioned the excessive vertical displacement of the rotor-member of the machine, when its weight is being carried by the shoe-supporting springs.

The object of my present invention is to provide a springless self-equalized thrust-bearing, which, in addition to equalizing the load between different shoes, also equalizes the load at a number of points distributed over the area of each shoe.

A more specific object of my invention is to accomplish the foregoing object by means of a plurality of small thrust-carrying pads, supported by an interlocking series of equalizer-levers or discs.

My novel load-distribution has many advantages, among which may be named the following:

1. Automatic uniform distribution of the load over the over-all area of each shoe, regardless of "high spots" or slight unevennesses in the bearing-surfaces of the shoe or the runner.

2. Each shoe can be made with a smaller vertical thickness, as a result of the automatic uniform load-distribution, and this smaller thickness reduces the thermal strains resulting from the

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different temperatures which exist at different places in the shoe.

3. The above two features make it possible to manufacture bearing-parts which will fit acceptably without requiring any hand-scraping and fitting, thus resulting in lower manufacturing and assembling costs.

4. My self-equalizing bearing can be made much more rigid than any spring-supporting shoe, thus eliminating the undesirable flexibility of the spring-supported thrust-bearing.

5. Theoretically, my self-aligned shoes provide for an easier formation of the wedged oil-film than is obtained with the spring-supported shoes.

With the foregoing and other objects in view, my invention consists in the structures, assemblies, combinations, parts and methods of design and operation, hereinafter described and claimed, and illustrated in the accompanying drawing, wherein

Figure 1 is a horizontal sectional view, looking down on top of the bearing-shoes, on the section-plane I—I in Figs. 2, 3, 4 and 5, with parts progressively broken away to show the construction.

Fig. 2 is a fragmentary reduced-scale vertical sectional view of the bearing on the section-plane II—II of Fig. 1.

Figs. 3 and 4 are fragmentary developed vertical cylindrical sections on the cylindrical surface indicated by the lines III—III and IV—IV in Fig. 1.

Fig. 5 is a fragmentary radial vertical section, on the section-plane indicated at V—V in Fig. 1, showing one of the radial equalizers which are used for equalizing the disc-loads between different circles or rings of equalizer-discs, and

Fig. 6 is a diagrammatic view illustrative of the operation and calculation of the equalizer-discs.

My invention is shown, in an exemplary form of embodiment, as being applied to the thrust bearing of a large high-speed vertical-shaft generator, of which the stator-member is represented by the top bracket 1 (Fig. 2), and the rotor-member is symbolized by a rotating shaft 2. The top end of the shaft 2 is supported from a runner-bushing 3 which is supported on the top of the runner 4 which rotates with the shaft. The thrust-bearing surface of the rotating runner 4 is supported on the tops of a plurality of non-rotating segmental thrust-bearing shoes 5, which are supported under oil 6 which is contained in a stationary oil-reservoir 7.

In accordance with my invention, each thrust-bearing shoe 5 rests on top of a plurality of relatively small pressure-distributing disc-shaped

pads 8 which are arranged in a plurality of concentric rings or circular rows having radii R_1, R_2, R_3 and R_4, as shown in Fig. 1. Each pressure-pad 8 is centrally supported on a downwardly projecting pin 9 (Fig. 3), which bears on the front or top surface 10 of a central depression 11 in one of a plurality of front or top equalizer-discs 12. These top equalizer-discs 12 have peripheral downwardly presented contact-circles or raised rims 13, which are preferably on the same horizontal level as the central depressed surface 10, for a reason which will be subsequently described.

These top equalizer-discs 12 are arranged in a plurality of circles or circular rows, four circular rows being shown in Figs. 1 and 2, the same number of circular rows as the pads 8. Most of the top equalizer-discs 12, of each circle, are shoe-supporting discs, which support the pressure-pads 8. The pressure-pads 8, in turn, distribute the thrust-loads of the respective shoes 5, which are carried on rings of annular ridges or raised rims 8' which are provided, one on top of each of the respective pads 8. Centered in the radial spaces between the leading edge of one shoe 5 and the trailing edge of the next adjacent trailing shoe 5, are intermediate or between-shoe top equalizer-discs 12', one for each of the circles R_1, R_2, R_3 and R_4, and these intermediate top discs 12' are held down by downwardly projecting pins 9' which are carried by a fixed front or upper plate 14 which is held in fixed spaced relation to the base-plate 15, by suitable means such as spacers 16, shown in Fig. 5. The upper plate 14 is provided with suitable holes 17 for the accommodation of the various shoe-supporting pads 8.

The downwardly facing outer rims 13 of the front or upper equalizer-discs 12 and 12' rest on the up-turned rims 20 of a plurality of circular rows or rings of back or lower equalizer-discs 21, which are similar to the upper discs 12, but reversed or turned upside down. The upwardly projecting central depressions 22 of the lower equalizer-discs 21 rest on forwardly projecting or upstanding pins 23 which are carried by the lower support-plate or base-plate 15.

By means of the construction thus far described, the thrust-loads of each circular series of thrust-pads 8 are equalized in circumferential lines or circles, from one pad to the next, by means of the upper and lower equalizer-discs 12 and 21. The thrust-loads from one bearing-shoe 5 to the next bearing-shoe 5 are also equalized, by means of the intermediate equalizer-discs 12'.

In accordance with my invention, I also equalize the thrust-loads in radial lines, between the outer circle of discs, having the radius R_1, and the next circle of discs, having the radius R_2, and so on from the second circle to the third, and from the third circle to the fourth, etc. This radial thrust-equalization is accomplished by three radial equalizer-levers 31, 32 and 33, as indicated in dotted lines in Fig. 1. The first one of these radial equalizer-levers 31, is shown in transverse section, in Fig. 4, and in longitudinal section in Fig. 5. At the places where these three radial equalizer-levers are located, the intermediate upper equalizer discs 12' are not supported by the upper fixed plate 14, as shown in Fig. 3, but they are supported from depending pins 9'' which are carried by the ends of the respective radial equalizer-levers, such as 31, as shown in Figs. 4 and 5.

As shown in Fig. 5, each radial equalizer-lever, such as 31, is provided with a deep central depression 34, having a top surface 35 which is in line with the contact-surfaces 10, 13 and 20 of the respective equalizer-discs. The upward thrusts of the central depressed surfaces 35 of the radial equalizer-levers, such as 31, are taken by depending pins 9''' which are carried by stationary brackets 36 which are bolted to the upper plates 14, as shown at 37 in Fig. 5. The upper plates 14 are provided with suitable openings 38 for accommodating the respective radial equalizer-levers, such as 31, as shown in Figs. 4 and 5.

As a result of the provision of the radial equalizer-levess 31, 32 and 33, it will be seen that the upward thrusts which are exerted by the central depressions 10 of the associated intermediate equalizer-discs 12' are transmitted or equalized between one ring of discs and the next inner ring of discs, so that the thrust-loads are equalized in all directions.

As a result of my equalizer-construction, the thrust-bearing shoes 5 are automatically self-equalizing in all directions, so that it is impossible for any thrust-transmitting pad 8 to have any more thrust than any other thrust-carrying pad 8, because there is no way for these thrusts to be carried except by balancing one thrust against another and against another, in an endless chain. It will be noted that I use thrust-transmitting pads 8 which are provided, in their upper surfaces, with annular peripheral thrust-carrying surfaces or projections 8', which distribute the thrust of each pad in a circle or annulus, bearing upon the under surface of the shoe 5, so that the entire downward thrust of each of the shoes 5 is carried by a plurality of pad-circles 8', as indicated in Fig. 1. These thrust-pad circles 8' should be distributed so that each pad has, assigned to it, the same proportionate part of the total surface-area of the associated shoe, but this condition needs to be only very approximately satisfied, because the thrusts are carried by circles 8', so that the distribution of the thrust around the respective circles automatically takes care of any reasonable amount of off-centering of any thrust-pad 8 with respect to the portion of the bearing-shoe surface which is assignable to that pad.

In like manner, the upper and lower circular rows or rings of equalizer-discs 12 and 21 are automatically self-leveling, making contacts with each other at four points as shown in Fig. 6 at P_1, P_2, P_3 and P_4. Here again, the equalizer-discs cannot tilt sideways, because of these multiple contacts which keep the discs all substantially horizontal.

The provision of an equalizer-disc construction having peripheral circular rims of contact-points 13 and 20 is also an advantage, in making the discs automatically adaptable to different lengths of separating-distances between successive circle-centers, such as C_1 and C_2 in Fig. 6. Whatever the separation between disc-centers may be, within a wide range of limits, the same size of equalizer-discs may be used, thus making it possible to use a single standard size of disc for all of the discs of my apparatus, notwithstanding the fact that the center-to-center spacings of the discs in the different circles R_1, R_2, R_3 and R_4 are slightly different from each other. In each of these circles of discs, the center-spacings are alike, for that circle. As the diameters of the circles R_1, R_2, R_3 and R_4 become progressively smaller, from the outer circle to the inner circle, it is necessary for the inner-

most circles to use a smaller number of circumferentially spaced discs in those circles, for two reasons, both to maintain an approximately uniform spacing between the centers of the discs in the respective circles of discs, and also so that the thrust-transmitting pads **8** of the innermost circles would have approximately the same proportionate part of the total area-shoe assigned to them, as in the case of the outermost rings of pads.

The design of equalizer-discs with the central depressions is also advantageous, in my bearing, because the whole purpose of the equalizer-discs is so that the discs can tilt through minute arcs or distances, and if the pivot-points, or contacts between the pins **9** and the depression-surfaces **10**, are in the same planes as the contact-rims **13** and **20** of the discs, then a fractional mil, or a few mils, of tilting of the disc, out of its normal horizontal position, will not produce any perceptible rubbing at the respective contact-points which are indicated at P_1, P_2, P_3 and P_4, in Fig. 6, and at P_1 and P_4 in Fig. 3. In like manner, the radial equalizer-levers **31**, **32** and **33** are so constructed that the depressed central surface **35** and the ends of the depending pin **9'''** of each radial equalizer-lever are in approximately the same plane.

In carrying out my invention, it is both necessary and desirable, not only to have comparable, or approximately equal, circumferential spacings between successive equalizer-discs in all four of the circles R_1, R_2, R_3 and R_4, but it is also necessary and desirable to have somewhat comparable, or approximately equal, radial spacings between the intermediate discs **12'** of successive circles, so that there will be adequate radial room for the central depressions **34** of the radial equalizer-levers, such as **31** in Fig. 5, the same as there is adequate circumferential room for the central depressions **11** of the circumferentially displaced equalizer-discs, as shown in Figs. 3 and 4. From the standpoint of having each thrust-transmitting pad **14** correspond to approximately the same proportionate part of the total shoe-surface, it is also desirable for these pads to be spaced about the same amounts radially and circumferentially, although, as I have said, this condition is not extremely critical, because of the circular thrust-transmitting rims **14** of the pads **8**, which properly distribute the pad-thrusts.

While there are advantages in making all of the equalizer-discs the same size, this is not necessary. Thus, if it were desirable to have a somewhat larger or smaller intermediate disc **12'**, as indicated at **42** in Fig. 6, it could be made to maintain the same lever-arm h for the small disc with which it contacts, while having its own different lever-arm h', as shown in Fig. 6.

My invention is of particular advantage during the difficult starting-periods, when the machine is just beginning to turn, after a standstill period. Under these conditions, there is no adequate film on the bearing-surfaces of the shoes and runner, so that it is extremely important that the bearing-load be superbly and meticulously equalized, as is done by my system of equalizer-discs and radial equalizers. After the rotor gets going, an oil-film will be dragged in between the upper shoe-surfaces and the under runner-surface, and this film will pile up in the familiar wedge-shape, being a few mils thicker at the leading edges of the shoes than at their trailing edges. This small tilting motion of the shoes is also permitted by my equalizer-discs, which will automatically tilt whatever small amount may be necessary, to provide for this shoe-tilting, while at the same time performing their normal functions of equalizing all of the vertical thrusts.

While I have described my invention in connection with a single preferred form of embodiment, I wish it to be understood that I am not limited to this one form, and I desire that my appended claims shall be accorded the broadest construction consistent with their language.

I claim as my invention:

1. The combination with a machine having a rotor-member having a rotating runner on which there is a considerable thrust-load, of a self-equalizing thrust-bearing comprising a plurality of oil-immersed non-rotating segmental thrust-bearing shoes bearing against the thrust-bearing surface of said rotating runner, a plurality of relatively small pressure-distributing pads for supporting each shoe, each pad having a peripheral raised rim which bears on the back of its shoe, the pads of the bearing being arranged in a plurality of concentric circular rows, a like number of circular rows of front equalizer-members, each having a forwardly presented central thrust-carrying point, and backwardly presented peripheral points, each pad having a backwardly extending central pin bearing on the central thrust-carrying point of one of said front equalizer-members, some of said front equalizer-members being intermediate members disposed in the radial spaces between the leading edge of one shoe and the trailing edge of the next adjacent trailing shoe, said bearing having a fixed base-plate and a fixed spaced front plate held in fixed spaced relation to the base-plate, said front plate having backwardly extending pins which bear on the central thrust-carrying points of certain of said intermediate equalizer-members, and a plurality of circular rows of back equalizer-members which are similar, in description, to the front equalizer-members except that they are reversed, the front and back equalizer-members engaging each other at their peripheral points, the fixed base-plate having forwardly projecting pins which bear on the central thrust-carrying points of the respective back equalizer members.

2. The invention as defined in claim 1, characterized by said equalizer-members being discs, each having a central depression for its thrust-carrying point, and each having a raised contact-rim for providing the peripheral point of the equalizer-disc, the central thrust-carrying point and the contact-rim of each disc being in approximately the same plane.

3. The combination with a machine having a rotor-member having a rotating runner on which there is a considerable thrust-load, of a self-equalizing thrust-bearing comprising a plurality of oil-immersed non-rotating segmental thrust-bearing shoes bearing against the thrust-bearing surface of said rotating runner, a plurality of relatively small pressure-distributing pads for supporting each shoe, each pad having a peripheral raised rim which bears on the back of its shoe, the pads of the bearing being arranged in a plurality of concentric circular rows, a like number of circular rows of front equalizer-members, each having a forwardly presented central thrust-carrying point, and backwardly presented peripheral points, each pad having a backwardly extending central pin bearing on the central thrust-carrying point of one of said front equalizer-members, some of said

front equalizer-members being intermediate members disposed in the radial spaces between the leading edge of one shoe and the trailing edge of the next adjacent trailing shoe, said bearing having a fixed base-plate and a fixed spaced front plate held in fixed spaced relation to the base-plate, said front plate having backwardly extending pins which bear on the central thrust-carrying points of certain of said intermediate equalizer-members, a plurality of circular rows of back equalizer members which are similar, in description, to the front equalizer-members except that they are reversed, the front and back equalizer-members engaging each other at their peripheral points, the fixed base-plate having forwardly projecting pins which bear on the central thrust-carrying points of the respective back equalizer-members, and radial equalizing means, comprising: a plurality of radial equalizer-levers, each extending from one circular row of front equalizer-members to the next inner circular row, each radial equalizer-lever having, at its respective ends, backwardly extending pins which engage the central thrust-carrying points of intermediate equalizer-members of two adjacent circular rows, each radial equalizer-lever having a central forwardly facing thrust-carrying point, and

a plurality of stationary brackets fixedly carried by the front plate, each of said stationary brackets having a backwardly extending pin engaging the central thrust-carrying point of one of said radial equalizer-levers.

4. The invention as defined in claim 3, characterized by said equalizer-members being discs, each having a central depression for its thrust-carrying point, and each having a raised contact rim for providing the peripheral point of the equalizer-disc, the central thrust-carrying point and the contact-rim of each disc being in approximately the same plane, and further characterized by each radial equalizer-lever having a deep central depression for its thrust-carrying point, said thrust-carrying point and the ends of the backwardly extending pins of each radial equalizer-lever being in approximately the same plane.

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