United States Patent

Cvacho

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[45] May 16, 1972

[54] BEARING ASSEMBLY AND MACHINE USING SAME

[72] Inventor: **Daniel S. Cvacho**, Chesterfield, Va.

[73] Assignee: **Reynolds Metals Company**, Richmond, Va.

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[52] **U.S. Cl.** .....**308/5 R**, 308/122

[51] **Int. Cl.** **F16c 33/10**

[58] **Field of Search**.....308/9, 168, 170, 5, 240; 184/5, 100

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Primary Examiner—Martin P. Schwadron

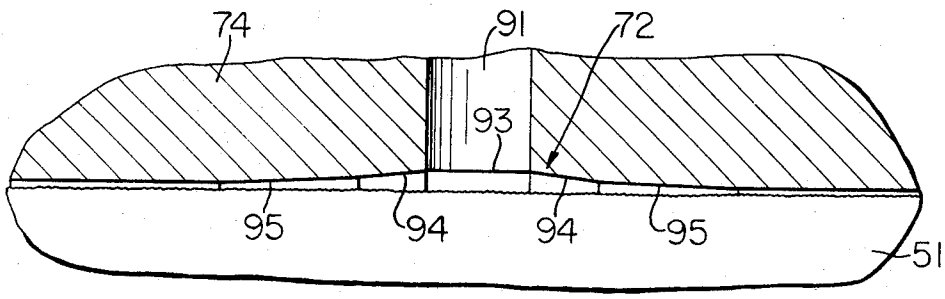
Assistant Examiner—Ronald H. Lazarus

Attorney—Glenn, Palmer, Lyne, Gibbs & Thompson

[57] **ABSTRACT**

A substantially annular volume is provided between a pair of structures which are relatively movable along a longitudinal axis with one of the structures having an annular groove defining an enlargement in the annular volume. Fluid under pressure is supplied directly to the enlargement so that upon relatively axially moving the structures additional fluid from the enlargement is urged toward the annular volume to perform a wedging action which precisely centers one of the structures relative to the longitudinal axis and simultaneously enables the one structure to carry a greater load in a direction transverse such longitudinal axis.

9 Claims, 8 Drawing Figures



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SHEET 1 OF 4

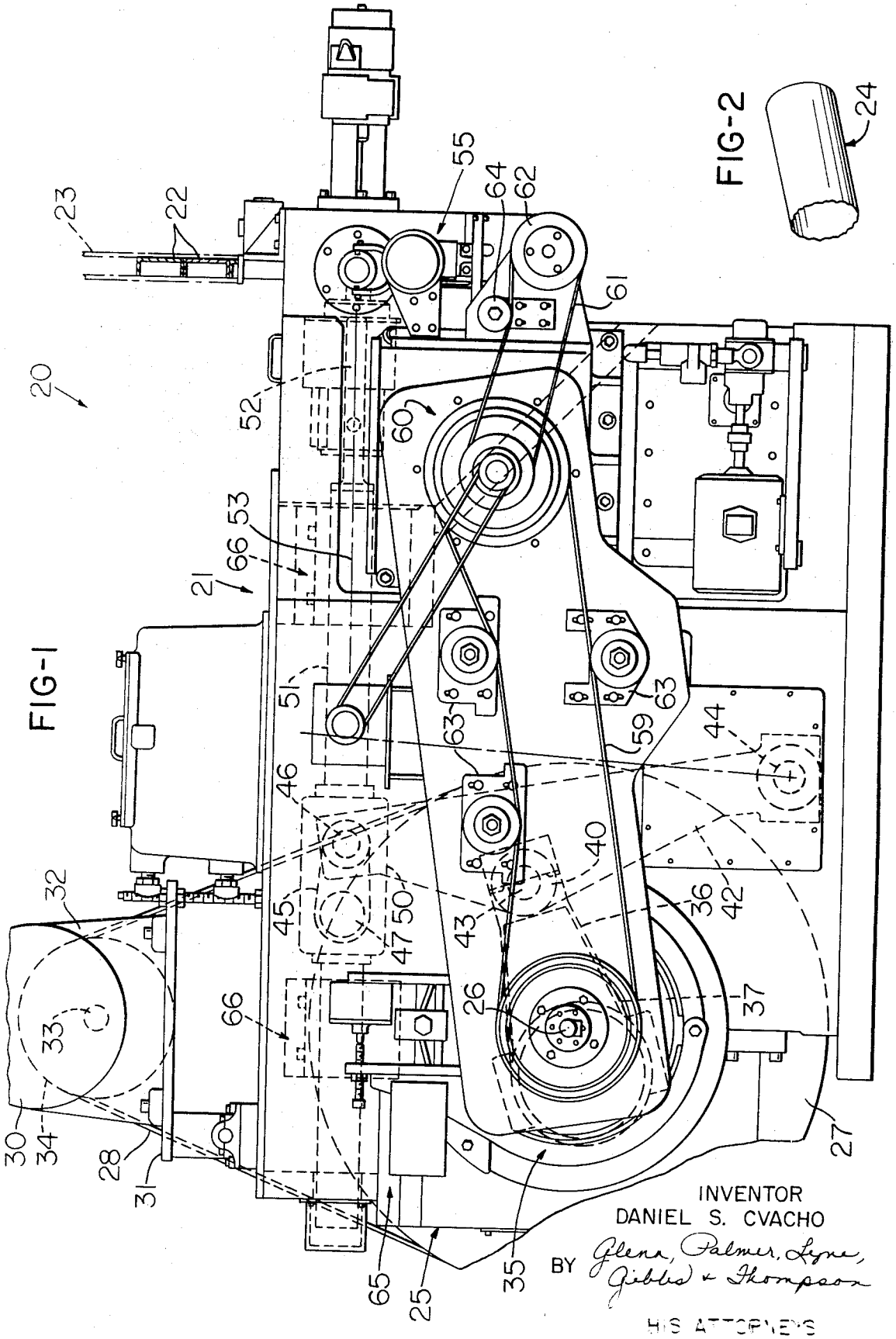


FIG-1

FIG-2

INVENTOR
DANIEL S. CVACHO

BY Glenn, Palmer, Lyne, Gibbs & Thompson

HIS ATTORNEYS

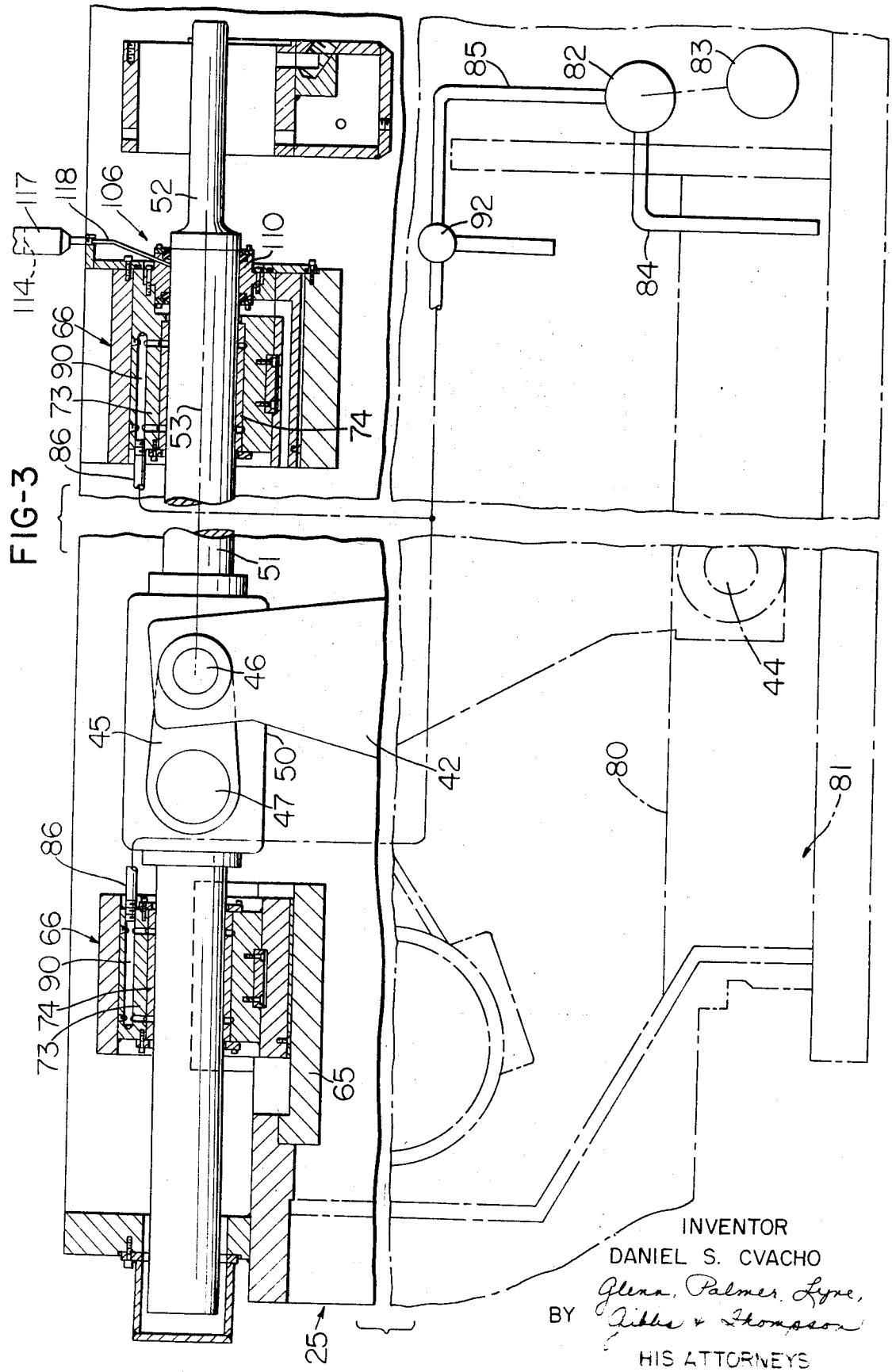


FIG-3

INVENTOR
DANIEL S. CVACHO
BY Glenn, Palmer, Lyne, Gibbs & Thompson
HIS ATTORNEYS

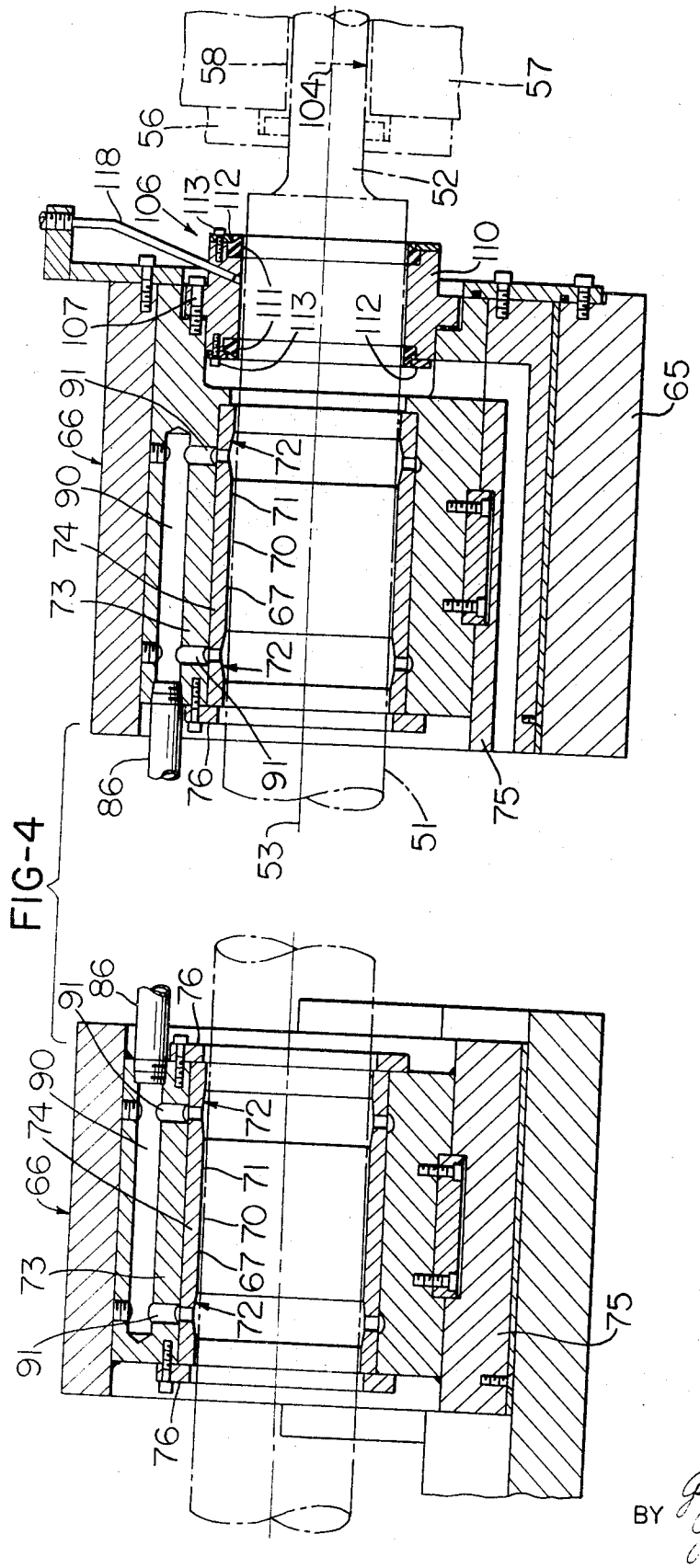


FIG-4

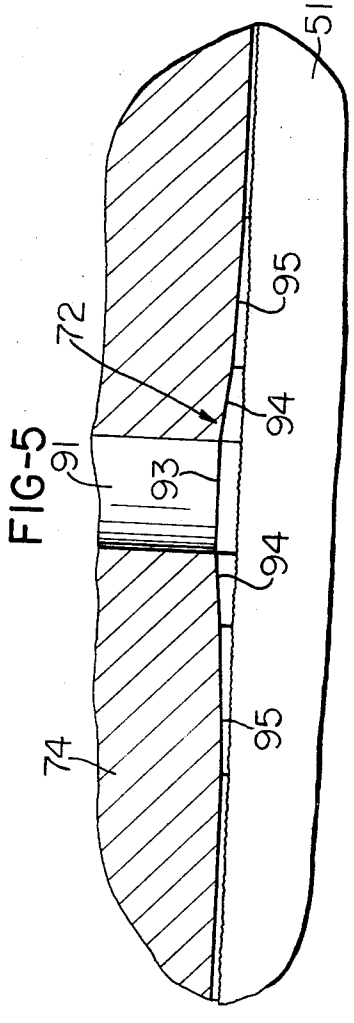


FIG-5

INVENTOR
DANIEL S. CVACHO

BY Gilson, Palmer, Lyne, Gibbs & Thompson

HIS ATTORNEYS

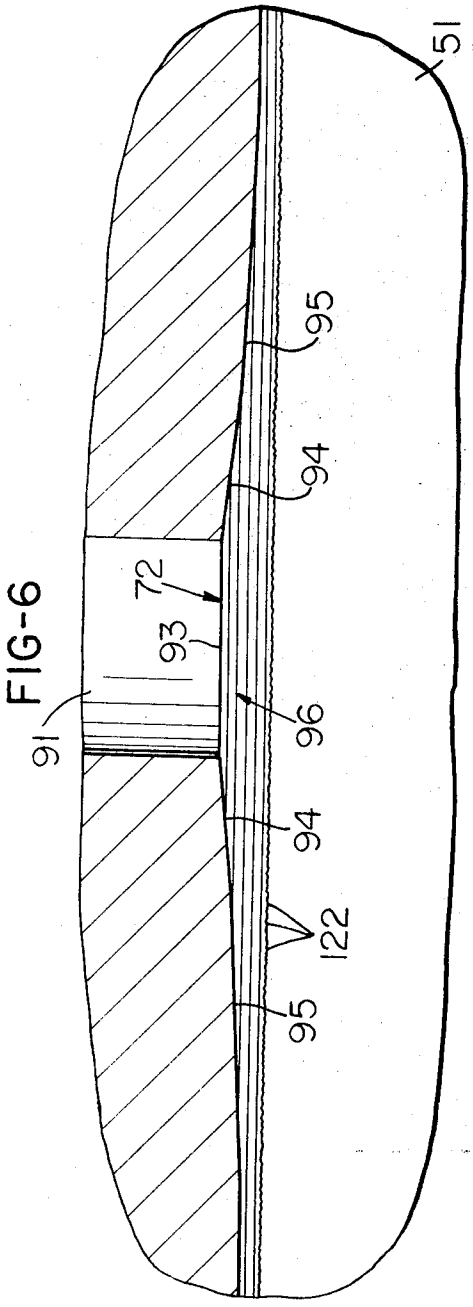


FIG-6

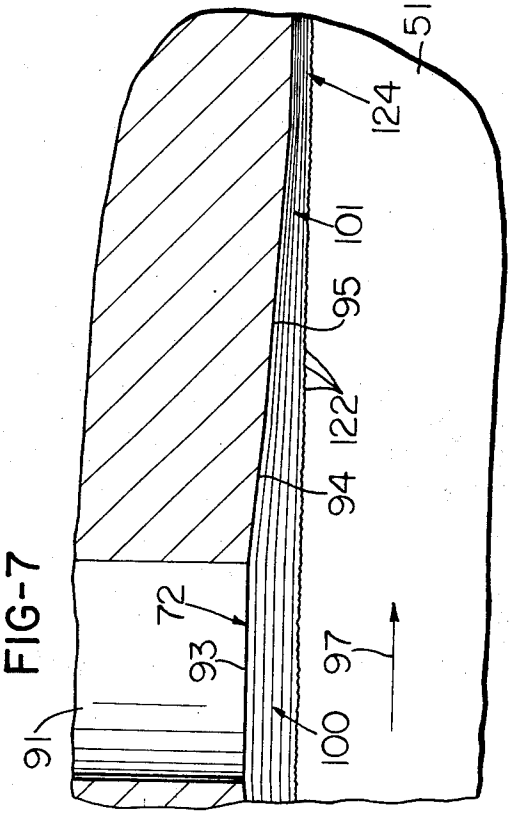


FIG-7

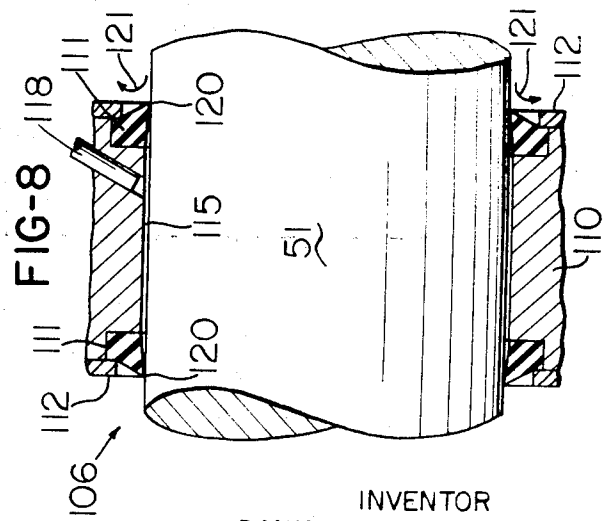


FIG-8

INVENTOR
DANIEL S. CVACHO
Gleina, Palmer, Lyons,
BY Gibbs & Thompson
HIS ATTORNEYS

BEARING ASSEMBLY AND MACHINE USING SAME

BACKGROUND OF THE INVENTION

There are many machines in current use which employ rectilinearly reciprocating members such as shafts, for example, which must be held in precise axial alignment during reciprocating movements and capable of resisting great external loads for extended operating periods. However, most of these present machines have attempted to solve the alignment and load-carrying problem by manufacturing parts to closer tolerances and by using massive structures which have resulted in increasing the costs of each machine without appreciably increasing its performance and operating life.

SUMMARY

This invention provides an improved bearing assembly, and a machine using same, which is of simple and economical construction and provides optimum performance over extended operating periods. The bearing assembly has one structure which is rectilinearly movable relative to another along a common longitudinal axis and employs a fluid to provide self-centering of the one structure with respect to such axis during such rectilinear movement while increasing the capability of the one structure to resist loads imposed thereon in a direction transverse the longitudinal axis.

Other details, uses, and advantages of this invention will become apparent as the following description of the exemplary embodiment thereof presented in the accompanying drawings proceeds.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings show a present exemplary embodiment of this invention, in which

FIG. 1 is a side elevation with parts broken away of an extruding machine used to form metal cans which utilizes the bearing assembly of this invention;

FIG. 2 is a perspective view of a typical metal can made by the machine of FIG. 1;

FIG. 3 is a view with parts in cross section and parts broken away illustrating the overall arrangement of an axially reciprocating shaft comprising the machine of FIG. 1 and the associated fluid supply system used to supply fluid to the bearing assembly;

FIG. 4 is an enlarged view with parts in cross section and parts broken away particularly illustrating the structural details of a pair of axially spaced bearing blocks used to support the axially reciprocating shaft;

FIG. 5 is an enlarged fragmentary cross-sectional view particularly illustrating the details of a typical annular groove provided in each bearing block and utilized to supply fluid under pressure between the shaft and the associated cylindrical sleeve comprising the bearing block;

FIG. 6 is a greatly enlarged view similar to FIG. 5 showing the shaft in a static condition within an associated bearing block and with an associated fluid supply pump operating so that the shaft is substantially centered;

FIG. 7 is a view similar to FIG. 6 illustrating the shaft in a dynamic condition and illustrating by a plurality of lines the manner in which fluid from an annular groove is compressed into an immediately adjacent annular volume to provide self-centering and increase the load-carrying capacity of the shaft; and

FIG. 8 is a greatly enlarged fragmentary cross-sectional view of a seal assembly provided at the forward end of the reciprocating shaft.

DESCRIPTION OF ILLUSTRATED EMBODIMENT

Reference is now made to FIG. 1 of the drawings which illustrates an exemplary machine 20 which utilizes one exemplary embodiment of the bearing assembly of this invention which is designated generally by the reference numeral 21. The machine 20 is a drawing and ironing machine which is

particularly adapted to drawn and iron metal can blanks or cups 22 which are supplied through a supply chute 23 to the forward end of the machine 20 and define can bodies 24, see FIG. 2, each having a bottom wall and an integral side wall of substantially right circular cylindrical configuration and in a manner well known in the art. The outer edge of the can side wall is subsequently trimmed and an end closure suitably fixed in position to define a completed container.

The machine 20 has a supporting frame 25 which supports a rotatable shaft 26 which has a wheel 27 keyed thereto. The wheel 27 and shaft 26 are driven by a drive 28 which may be in the form of a chain drive, a drive belt, or the like. The machine 20 has a drive motor 30 which is supported on an upper portion 31 of the supporting frame 25 and the motor 30 is operatively connected to a gear box assembly 32 which has a driving shaft 33 extending outwardly therefrom and a drive wheel 34 is keyed to shaft 33. The wheel 34 has the drive 28 operatively connected therearound so that upon starting motor 30 to rotate the drive wheel 34 the wheel 27 and shaft 26 are rotated in a simultaneous manner.

The machine 20 has an eccentric crank assembly 35 which is provided with a crank arm or crank 36 which has its inner end 37 operatively connected to the shaft 26 and its outer end 40 pivotally connected to a lever 42 by a pivot pin 43. The lever 42 has its lower end portion supported for pivoting movement by a pivot pin 44 which is carried by a lower portion of the supporting frame 25.

The upper end of the lever 42 has a link 45 which has one end pivotally connected thereto by a pin 46 and the opposite end of link 45 is pivotally connected by a pin 47 to a housing assembly 50 which is suitably fixed to an axially reciprocating structure in the form of a shaft 51 of extended length which has a punch or ram 52 provided at the forward end thereof. The motor 30 and housing assembly 50 together with its intermediate wheels, linkages, and drive connections comprise what may be considered the moving means for the shaft 51.

The shaft 51 is supported horizontally for reciprocating rectilinear movement along a longitudinal axis 53 and as blanks or cups 22 are serially fed from the supply chute 23 into the forward end of the machine 20 a cup positioning mechanism 55 suitably positions each cup 22 within a C-shaped support 56 arranged adjacent an extrusion die 57, see FIG. 4, so that the cup is precisely aligned ahead of the ram 52. The moving means for the shaft 51 moves such shaft and ram 52 forwardly to extrude the associated cup 22 as shown at 58 to define the single piece can body 24.

The machine 20 also has a suitable non-slip belt 59 which is operatively connected to the crank assembly 35 at one end and to a wheel assembly 60 at its opposite end. The assembly 60 has another non-slip belt 61 which operatively connects assembly 60 to a wheel 62 comprising a discharge assembly for the completely extruded can body 24 and the belts 59 and 61 assure that the forward stroke of the ram 52 is synchronized with the positioning movements of mechanism 55 and the operation of the can discharge assembly. The belt 59 is provided with a plurality of tensioning devices 63 to control the tension thereof for reasons which are well known in the art while the belt 61 is provided with a similar tensioning device 64.

The bearing assembly 21 has a fixed outer supporting structure which in this example of the invention is shown as the upper portion 65 of the supporting frame 25 which carries a plurality of two axially spaced bearing block assemblies which for convenience will be referred to as bearing blocks and designated generally by reference numeral 66. Each block 66 has an inside surface portion 67 defining an associated bore therethrough which is arranged coaxially with the longitudinal axis 53 whereby the outer structure in essence has a plurality of axially spaced inside surface portions 67.

The inner structure of the bearing assembly in this example is defined by the shaft 51 which as a plurality of two axially spaced outside surface portions 70. Each outside surface portion 70 cooperates with an associated inside surface portion

67 to define a controlled substantially annular volume 71, see FIG. 4, between associated inside 67 and outside 70 surface portions whereby two of such annular volumes 71 are provided along the shaft 51.

The inside surface portions 67 are substantially identical and the outside surface portions 70 are also substantially identical and sized to cooperate with surface portions 67. However, it will be appreciated that the outside surface portions, for example, at different locations on shaft 51 may be of different sizes provided that the associated inside surface portions are of correspondingly different sizes.

A plurality of annular grooves 72 are provided in one of the structures of the bearing assembly 21 and in this example of the invention a plurality of annular grooves 72 are provided in each bearing block 66 and each groove defines an enlargement also designated by the reference numeral 72 in an associated annular volume 71. Each groove 72 contains an additional pressurized volume of a fluid which is supplied to the inside surface portions of the bearing blocks 66 and for a purpose to be described in detail subsequently.

As best seen in FIG. 4 of the drawings, each bearing block 66 is defined by a substantially annular bearing sleeve support 73 and a bearing sleeve 74 and each annular groove 72 in this example of the invention is defined in the sleeve 74; however, for ease of presentation each groove 72 may also be described as being defined in the bearing block 66. Each sleeve support 73 is supported by a ring 75 which is suitably fixed to the supporting structure 65 and each sleeve 74 has a plate 76 engaging either one or both ends thereof which holds the sleeve 74 against axial movement. Each plate 76 is held in position by a plurality of threaded bolts which extend through associated openings in the plate and are threaded in cooperating threaded openings in the sleeve support 73.

The machine 20 has a supply of fluid which in this example of the invention is in the form of a lubricating oil 80 which is carried in a reservoir 81 defined in the lower portion of the machine 20, see FIG. 3. Means is provided for supplying the fluid or oil 80 under pressure from the reservoir 81 directly to each enlargement or annular groove 72 and in this example of the invention such means comprises a pump 82 and associated conduit means.

The pump 82 is driven by a motor 83 and has a pipe 84 provided with its inlet submerged in the oil 80 and arranged adjacent the bottom of the reservoir 81 and its outlet connected to the inlet of the pump 82. The pump has a conduit 85 suitably connected to its outlet and the conduit 85 serves as a supply manifold which has a plurality of supply conduits 86 connected thereto and each conduit 86 is in fluid flow communication with the annular grooves 72 provided in the sleeve 74 of each bearing block 66.

To provide efficient flow of oil 80 from each conduit 86 into each annular groove 72 an integral passage 90 is provided in each sleeve support 73 which extends substantially parallel to longitudinal axis 53, see FIGS. 3 and 4. Each sleeve support 73 and its associated sleeve 74 is provided with radially inwardly extending passages 91 and each passage 91 communicates with an associated longitudinal passage 90 at one end and an annular groove 72 at its other end whereby oil 80 under pressure is supplied directly to each enlargement 72 and its annular volume 71.

The oil supplying means may also be provided with a pressure control valve 92 operatively connected in the conduit 85 upstream of conduits 86 to precisely control the pressure of the oil supplied to each annular groove 72. Each supply conduit 86 may be of suitable cross-sectional configuration and area or be provided with controlled orifice means to assure that the pressure of the oil supplied to each of the annular grooves 72 in each bearing block 66 is substantially equal irrespective of the position thereof along the longitudinal axis 53 whereby the shaft 51 is precisely supported at all positions along its length.

When the machine 20 is not in operation the pump 82 may be turned off whereupon the shaft 51 will be resting on the bottom portions of the inside surfaces of the spaced sleeves 74. Once the pump 82 is started the shaft 51 will be precisely centered in the bearing blocks 66 with its longitudinal axis arranged coaxially with the longitudinal axis 53 and with the annular volume 71 precisely defined. However, the reference throughout this specification to a substantially annular volume 71 is intended to define such volume under conditions when the pump 82 is operating and with the shaft 51 either stationary or moving as well as when the pump 82 is not operating inasmuch as the volume with the shaft 51 resting on bottom portions of the inside surfaces of sleeves 74 is also a substantially annular volume 71.

As seen particularly in FIGS. 5–7 of the drawings, each annular groove 72 has a base portion 93 which in this example is arranged substantially parallel to the longitudinal axis 53 and a pair of substantially identical sides arranged in a symmetrical manner at opposite ends of the base 93. Each of the sides adjoining the base portion 93 is defined by a substantially abrupt portion 94 adjoining and extending outwardly from the associated end of the base and a gradually feathered end portion 95 extending beyond the terminal end of its associated abrupt portion 94.

Once the machine 20 is started, the pump 82 operates to supply oil 80 around the entire circumference of the shaft 51 causing a centering of such shaft in its bearing blocks 66. The oil pressure in each annular volume 71 and its associated grooves 72 is practically the same and for ease of presentation this condition has been shown by a plurality of parallel lines illustrated at 96, in FIG. 6. As the shaft 51 is moved either forwardly or rearwardly by the moving means of machine 20, oil 80 contained in each enlargement or groove 72 is urged toward its associated controlled annular volume 71 to perform what amounts to a wedging action and serves to precisely center the shaft 51 so that its axis precisely coincides with the longitudinal axis 53. This attempted wedging of more fluid or oil 80 into the annular volume 71 enables the shaft 51 to carry a greater load particularly in a direction transverse the longitudinal axis 53.

The wedging action is illustrated pictorially in FIG. 7 of the drawings for forward axial movement of the shaft 51 in the direction indicated by the arrow 97 by the change from a wide spacing as indicated at 100 between the parallel lines in the groove 72 to a narrower spacing and general convergence of the parallel lines as indicated at 101. Although this wedging action is illustrated during forward movement of shaft 51 in the direction of arrow 97 a substantially identical wedging action occurs during reverse axial movement of such shaft and could be similarly illustrated, if desired, by showing the rear end portion of the groove 72 shown in FIG. 7. Forward and reverse fluid wedging occurs during every extrusion or drawing and ironing cycle and in the machine 20 each cycle may be repeated several hundred times per minute during continuous operation of such machine.

During the drawing and ironing of a cup 22 made of metal containing aluminum, for example, to form a can body 24 the load on the shaft 51 in an axial direction may be generally of the order of 3 to 4 tons while the transverse load on such shaft as represented by a single dotted arrow 104 may be generally of the order of 2,000 to 4,000 pounds. With transverse loads of this magnitude it is important that the shaft 51 be supported in a high-strength manner yet for optimum economy it is preferable that component parts be made to comparatively loose tolerances wherever possible and that precisely ground and honed finishes be avoided. This invention makes it possible to produce a shaft and associated bearing blocks at minimum cost and which operate reliably under high loads over extended periods by using cooperating components which effectively utilize the wedging action provided by the oil.

Further, the shaft 51 is precisely self-centering and has the capability of withstanding large transverse loads not only during forward extruding movement of the ram 52 but also during reverse movement of such ram whereby the drawing may be

achieved with optimum efficiency and the withdrawal of the ram from within the formed can may also be achieved with minimum likelihood of jamming.

It is standard practice to lubricate and cool the forward end of the ram **52** and the associated die with a suitable oil such as a water soluble oil, not shown, to improve the drawing and ironing operation. To assure that this oil does not reach the area of the bearing assembly **21** and in particular to assure that this oil does not enter each annular volume **71**, a seal assembly **106** is provided adjacent the ram **52**, see FIGS. **3**, **4**, and **8**. The seal assembly **106** is suitably fixed in position to the sleeve support **73** of the forward bearing block **66** by a plurality of bolts **107** and the seal assembly **106** includes a substantially annular member **110** which has a pair of annular seals **111** fixed in position at opposite ends thereof by a pair of oppositely arranged rings **112** and associated bolts **113** which extend through openings in each ring **112** and through associated threaded openings in the annular member **110**.

The machine **20** has a supply system for supplying a water immiscible oil **114** into an annular space **115** defined by the inside surface of member **110**, the outside circumference of the shaft **51**, and the seals **111**. The oil **114** is contained in a drip oiler comprised of a reservoir **117** and a tube **118** which extends in sealed relation through member **110** and supplies the oil **114** into the space **115**. The oil **114** occupies the space **115** and prevents the water soluble oil used in the drawing and ironing operation from flowing rearwardly along the shaft **51** during reciprocation thereof.

Each seal **111** has a wedge-shaped outer configuration as illustrated at **120** and during rearward movement of shaft **51** the forward seal **111** serves to scrape the water soluble oil from the outer circumference of the shaft **51** as indicated at **121** in FIG. **8**. This scraping action together with the provision of oil **114** in space **115** assures water soluble oil is not introduced in the bearing assembly **21**.

The oil **114** will readily mix with the lubricating **80**; nevertheless, during forward movement of the shaft **51** the rear seal **111** scrapes the oil **80** off the shaft **51**. Also, the oil **114** in space **115** helps prevent leakage of oil **80** outwardly along the shaft **51**.

In this exemplary embodiment of the invention each annular groove **72** is shown as having a base portion **93** arranged parallel to axis **53** and symmetrically arranged side portions each defined by an abrupt portion **94** and a gradually feathered portion **95**. However, it will be appreciated that the base portion **93** need not necessarily be arranged parallel to the longitudinal axis **53** and each side of groove **72** may be essentially defined as a continuous gradually feathered portion which converges toward the shaft on a very small angle.

As previously suggested, it is not necessary that the shaft **51** have its outside surface provided with a precision finish or superfinish and a finish of 16 microinches rms is about the best that would be used. Thus, the outside surface of the shaft **51**, even with a 16-microinch finish, has a plurality of comparatively evenly spaced projections remaining thereon in the form of tool marks provided by a cutting tool such as a grinding wheel and a few representative ones of such projections are indicated by the reference numeral **122** in FIGS. **6** and **7**. The projections **122** serve as pump elements which assure that the previously described wedging action illustrated by the closely spaced lines **101** is provided with optimum efficiency.

In this example of the invention each bearing block **66** has a plurality of two annular grooves **72** provided therein in spaced apart relation and a pair of spaced bearing blocks **66** are used to support the shaft **51**. However, each bearing block need not necessarily have two annular grooves **72** provided therein; one such groove may suffice in some applications of this invention and more than two may be required in others. Further, it may be desirable in some drawing and ironing machines to provide a plurality of more than two bearing blocks with each bearing block having one or more grooves or enlargements **72** in its associated annular volume. It will also be appreciated that in some applications of this invention a single bearing block or equivalent structure may be used and provided with appropriate annular groove means of the character described earlier.

The outside surface portions of the shaft **51** are preferably right circular cylindrical surface portions and the inside surface portions defining the inside surface of each sleeve **74** comprising each bearing block **66** are cooperating right circular cylindrical portions. However, it is to be understood that the shaft may have a non-circular cross-sectional configuration and the cooperating inside surface of the bearing block may have a corresponding non-circular configuration. Further, each non-circular configuration may be oval or polygonal.

Irrespective of the peripheral configuration of the shaft **51** and the cooperating configuration of each bearing block it will be appreciated that during rectilinear movement of the shaft with respect to each bearing block the unique wedging action previously described is provided by the liquid which is introduced from an associated enlargement provided in the annular volume between the shaft and bearing block. This wedging action provides the unique centering of the shaft **51** in a precision manner and substantially increases the capacity or capability of the shaft to carry large transverse loads such as radial loads.

In this example of the invention, the supporting structure **65** has a pair of bearing blocks **66** fixed in position thereon and in axially spaced relation and each bearing block is comprised of a plurality of component portions as previously described. However, in some applications each inside surface portion **67** may be formed as an integral part of the structure **65** and need not necessarily be provided on a component part comprising the bearing block assembly.

The annular volume **71** defined between the outside circumference of the shaft **51** and the inside surface of each sleeve **74** will vary depending upon the application of the bearing assembly **21**. In the case of a drawing and ironing machine such as the machine **20**, a typical outside diameter of the shaft **51** may range between 4.9950–4.9955 inches while the inside diameter of the sleeve **74** may range between 5.0010–5.0015 inches whereby the thickness of the annular volume may range between 0.0055 and 0.0065 inch and with a height or length corresponding to the length of the associated bearing block.

The pump **82** supplies oil **80** from the reservoir **81** to each enlargement and/or annular groove **72** in a substantially cool condition and at a pressure generally of the order of 100 psig. During reciprocating movement the wedging action provided by the shaft **51** causes the pressure in the annular volume **71** upstream of an associated annular groove **72** in the direction of movement to increase to a value which may be generally of the order of several thousand psig and in some applications with a pressure of 100 psig in the groove **72** the pressure in the annular space at a location indicated at **124** in FIG. **7**, for example, may range between 5,000 and 10,000 psig.

The wedging action and increased pressure causes the oil to heat up; however, the hot oil then returns from within each annular volume **71** to the reservoir by gravity and mixes with the cool oil in the reservoir. The pump **80** then again provides substantially cool oil from the reservoir to each enlargement **72** in a continuous recirculating manner whereby the entire bearing assembly **21** operates in a cooler and more efficient manner.

The depth of a typical groove may vary depending on the particular application and a typical depth for a shaft having a roughly 5-inch outside diameter may be as much as one-fourth inch. Also, as previously suggested the configuration of the annular groove **72** may be varied as desired provided that an adequate supply of oil is made available to each annular groove **72**.

As previously explained each exemplary annular groove **72** has a base portion **93** and opposed side portions each defined by cooperating sections **94** and **95**. A typical groove **72** may have a base portion **93** which is 0.375 inch long and 0.047 inch deep, a portion **94** which is 0.250 inch long and flares

outwardly at 5° to a depth 0.005 inch below its associated inside surface, and a feathered portion 0.500 inch long which flares from the 0.005 inch depth until it coincides with surface 67.

While present exemplary embodiments of this invention, and methods of practicing the same, have been illustrated and described, it will be recognized that this invention may be otherwise variously embodied and practiced by those skilled in the art.

What is claimed is:

1. A precision bearing assembly comprising, an outer structure having an inside surface defining a bore extending therethrough, an inner structure disposed within said bore and having an outside surface which cooperates with said inside surface to define a controlled substantially annular volume between said surfaces, said structures being relatively axially movable along a common longitudinal axis, at least one annular groove in one of said structures defining an enlargement in said annular volume which adjoins both of said structures, said groove having a base and a pair of sides extending away from said base, and means for supplying a fluid under pressure from an associated supply directly to said enlargement so that upon relatively axially moving said structures fluid from the enlargement is urged toward an adjoining associated portion of said annular volume to perform a wedging action which precisely centers one of said structures relative to said axis and simultaneously enables said one structure to carry a greater load in a direction transverse said longitudinal axis, each of said sides having an angled configuration defined by a substantially abrupt portion adjoining and extending outwardly from an associated end of said base and a gradually feathered end portion extending beyond the terminal end of said abrupt portion, said portions assuring provision of said wedging action in an optimum manner.

2. A precision bearing assembly comprising, an outer structure having an inside surface defining a bore extending therethrough, an inner structure disposed within said bore and having an outside surface which cooperates with said inside surface to define a controlled substantially annular volume between said surfaces, said structures being relatively axially movable along a common longitudinal axis, one of said structures being axially movable and the other of said structures being supported at a fixed position, at least one annular groove in said other structure defining an enlargement in said annular volume which adjoins both of said structures, said groove having a base and a pair of sides extending away from said base, and means for supplying a fluid under pressure from an associated supply directly to said enlargement so that upon relatively axially moving said structures fluid from the enlargement is urged toward an adjoining associated portion of said annular volume to perform a wedging action which precisely centers one of said structures relative to said axis and simultaneously enables said one structure to carry a greater load in a direction transverse said longitudinal axis, said movable structure having its surface which defines one wall of said annular volume substantially roughened and said roughened surface being comprised of a plurality of projections which serve as pump elements which provide said wedging action with optimum efficiency.

3. A precision bearing assembly comprising, an outer structure having an inside surface defining a bore extending therethrough, an inner structure disposed within said bore and having an outside surface which cooperates with said inside surface to define a controlled substantially annular volume between said surfaces, said structures being relatively axially movable along a common longitudinal axis, at least one annular groove in one of said structures defining an enlargement in said annular volume which adjoins both of said structures, said groove having a base and a pair of sides extending away from said base and means for supplying a fluid under pressure from an associated supply directly to said enlargement so that upon relatively axially moving said structures fluid from the enlargement is urged toward an adjoining associated portion of said controlled annular volume to perform a wedging action which precisely centers one of said structures relative to said axis and simultaneously enables said one structure to carry a greater load in a direction transverse said longitudinal axis, said outer structure being supported at a fixed position and having said groove formed therein so that it extends inwardly therein from said inside surface, said inner structure being in the form of a shaft arranged within said bore and being axially movable relative to said fixed outer structure, and each of said sides having a gradually feathered outer end portion which assures provision of said wedging action in an optimum manner.

4. A bearing assembly as set forth in claim 3 in which said fluid comprises a liquid, said outer structure has an inside surface in the form of a substantially right circular cylindrical surface, and said shaft has said outside surface in the form of a cooperating right circular cylindrical surface.

5. A bearing assembly as set forth in claim 4 in which said outer structure comprises a bearing block fixed in position as a part thereof and having said right circular cylindrical surface defined therein. 9a length in the order of twenty times its diameter.

6. A machine comprising; a precision bearing assembly; said bearing assembly having an outer structure having a plurality of axially spaced inside surface portions each defining an associated bore, an inner structure disposed within said bores and having a corresponding plurality of axially spaced outside surface portions with each outside surface portion cooperating with an associated inside surface portion to define a controlled substantially annular volume between associated inside and outside surface portions, said structures being relatively axially movable along a common longitudinal axis, a plurality of annular grooves in one of said structures with each of said grooves defining an enlargement in an associated annular volume, each groove having a base and a pair of sides extending away from said base a supply of fluid; means for supplying said fluid under pressure from said supply directly to each enlargement; and means for relatively moving said structures to thereby cause the fluid contained in each enlargement to be urged toward an adjoining associated portion of its associated annular volume to perform a wedging action which precisely centers one of said structures about said axis and simultaneously enables said one structure to carry a greater load in a direction transverse said longitudinal axis, each of said sides of each groove having an angled configuration defined by a substantially abrupt portion adjoining and extending outwardly from an end of an associated base and a gradually feathered end portion extending beyond the terminal end of an associated abrupt portion, said portions assuring provision of said wedging action in an optimum manner.

7. A machine comprising; a precision bearing assembly; said bearing assembly having an outer structure supported at a fixed position and having a plurality of axially spaced inside surface portions each defining an associated bore, an inner structure disposed within said bores and having a corresponding plurality of axially spaced outside surface portions with each outside surface portion cooperating with an associated inside surface portion to define a controlled substantially annular volume between associated inside and outside surface portions, said inner structure being axially movable relative to said fixed outer structure along a common longitudinal axis, a plurality of annular grooves in said fixed structure with each of said grooves defining an enlargement in an associated annular volume, each groove having a base and a pair of sides extending away from said base; a supply of fluid; means for supplying said fluid under pressure from said supply directly to each enlargement; and means for relatively moving said structures to thereby cause the fluid contained in each enlargement to be urged toward an adjoining associated portion of its associated annular volume to perform a wedging action which precisely centers one of said structures about said axis and simultaneously enables said one structure to carry a greater load in a direction transverse said longitudinal axis, said movable structure having each of its surface portions which defines one wall

of an associated annular volume substantially roughened, and each roughened surface portion being comprised of a plurality of projections which serve as pump elements which provide said wedging action with optimum efficiency.

8. A machine as set forth in claim 7 in which said plurality of projections are defined by tool marks which are defined by a cutting tool used to form surface portions on said movable structure.

9. A machine as set forth in claim 7 in which said fluid comprises a lubricating oil, said outer structure has said inside surface portions in the form of substantially right circular cylindrical surface portions, and said movable structure is in the form of a shaft having said ourside surface portions defined as cooperating right circular cylindrical surface portions.

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