

[54] **ECCENTRIC FLEXURAL PIVOT**
[75] Inventor: **Henry Troeger**, Cooperstown, N.Y.
[73] Assignee: **The Bendix Corporation**, Teterboro, N.J.
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[51] Int. Cl. **F16g 1/22**
[58] Field of Search **267/160**

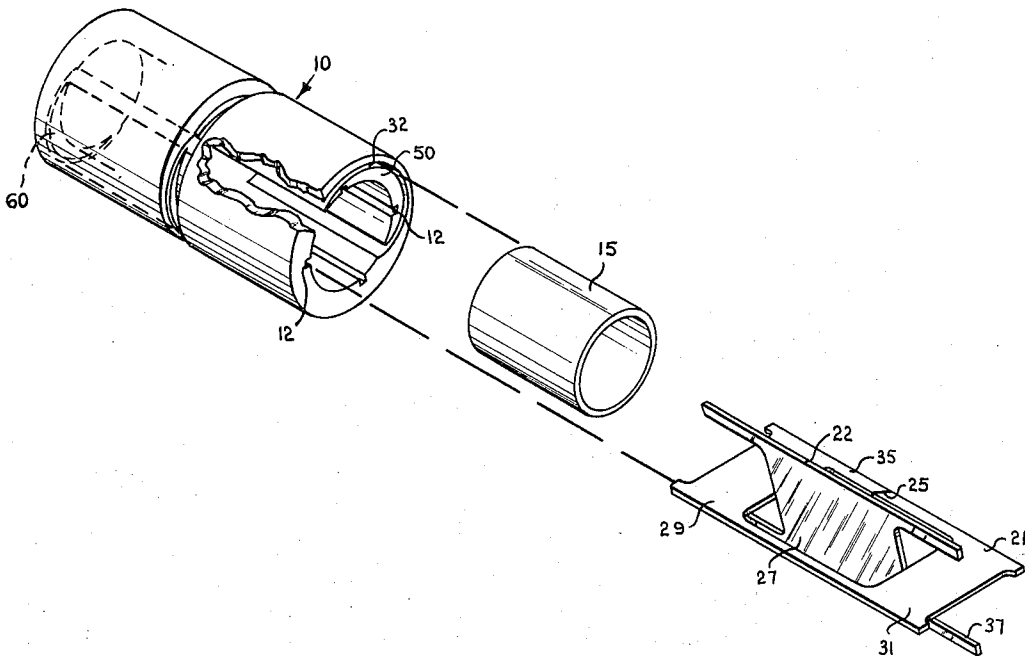
[56] **References Cited**
UNITED STATES PATENTS
3,124,873 3/1964 Troeger 267/160
3,277,555 10/1966 Kutash 267/160

Primary Examiner—James B. Marbert
Attorney, Agent, or Firm—Anthony Cuoco; S. H. Hartz

[57] **ABSTRACT**

A flexural pivot device having first and second housing means arranged on a common axis and being axially spaced from each other, the first housing means having an inwardly projecting arcuate structure disposed eccentric to the common axis, the arcuate structure extending axially into the second housing means and being radially spaced therefrom, a second housing means having inwardly projecting arcuate structure disposed eccentric to the common axis and being diametrically disposed relative to the arcuate structure of the first housing means, the arcuate structure of the second housing means extending axially into said first housing means and being radially spaced therefrom, and cross flat spring means connecting said arcuate structures so that said first and second housing means are rotatable relative to each other on the common axis.

5 Claims, 4 Drawing Figures



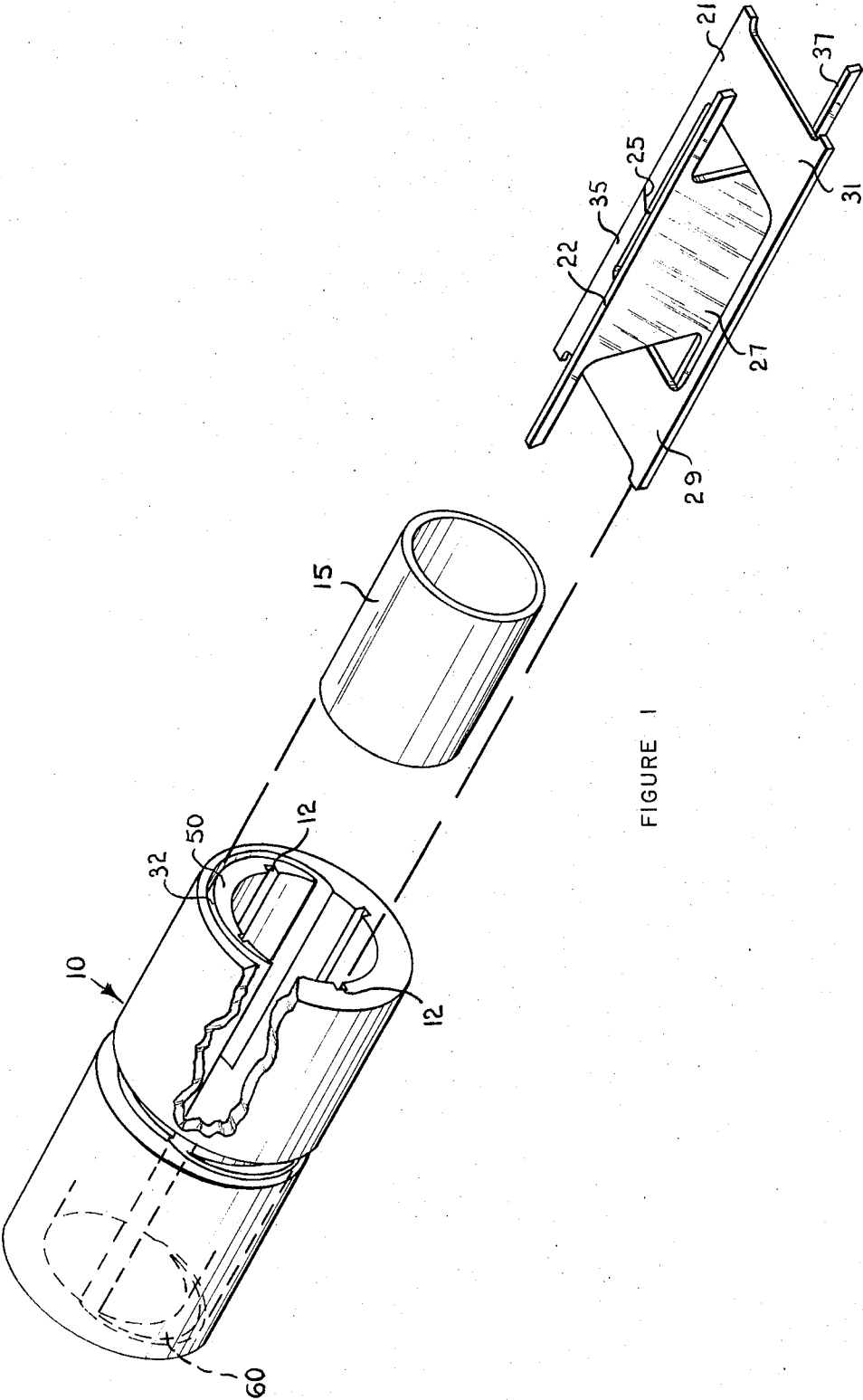


FIGURE 1

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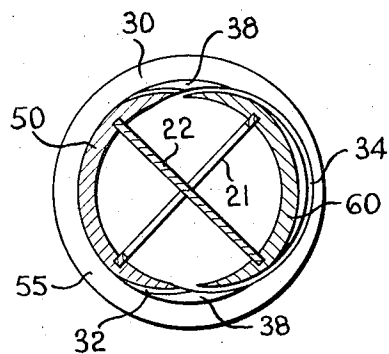


FIGURE 4

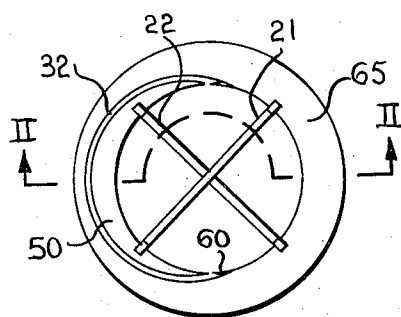


FIGURE 3

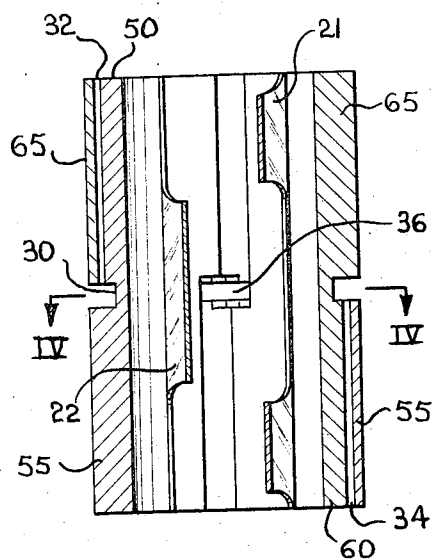


FIGURE 2

ECCENTRIC FLEXURAL PIVOT

FIELD OF THE INVENTION

This invention relates to devices for supporting a mechanism which is to be limitedly rotated about an axis and more particularly concerns improvements in flexural pivot devices which provide limited relative rotation between two parts by flexing flat springs connecting the two parts.

CROSS REFERENCE TO RELATED CASES

This patent application is related to my commonly assigned co-pending patent application U.S. Ser. No. 287,298, filed Sept. 8, 1972.

DESCRIPTION OF THE PRIOR ART

Prior art flexural pivot devices such as those disclosed in my commonly assigned U.S. Pat. No. 3,181,851 disclosed a pivot which was more economical to produce than its predecessor designs. In particular, this patent disclosed a pivot comprised of a pair of flat crossed springs assembled to two pair of arcuate quadrant elements, two of which were slotted and alternately disposed, bonded as a unit and then with the outer sleeve means cut to form a flexural pivot. Although the basic resilient "core" design was unique, it required four quadrant members which had to be stamped and accurately coined, the springs and quadrants had to be assembled and unitized such as by bonding, two diametrically opposed "reliefs" had to be ground on the O.D. of the core, an outer sleeve had to be mounted to the core assembly and then this assembly had to be unitized, a circumferential groove had to be cut therein and the two ends had to be cut and discarded. Thus, this pivot design required essentially five parts and fifteen individual and batch operations.

A subsequent flexural pivot device disclosed in the commonly assigned U.S. Pat. No. 3,319,951 issued in the name of Frederick A. Seelig, eliminated the steps of under-cutting the O.D. of the core and the step of cutting the ends of both core and support structure, however, this device still required the basic core and the problems associated therewith as was mentioned above. Also, the support structure called for in this patent was relatively expensive to form.

My commonly assigned co-pending patent application Ser. No. 286,367 disclosed a method of making a flexural pivot having few parts and greatly reducing the number of operations to be performed in constructing the device. However, the particular electrode design disclosed therein was expensive to fabricate and did not resolve in uniform electrical machining since fresh electrolytic or dielectric fluid could not easily be introduced between the electrode and sleeve because the electrode could not be rotated during the machining operation.

SUMMARY OF THE INVENTION

In the preferred embodiment according to the invention, a flexural pivot is disclosed having first and second housing means arranged co-axially and being axially spaced from each other, the first housing means having an inwardly projecting arcuate structure disposed eccentric to the common axis, the arcuate structure extending axially into said second housing means and being radially spaced therefrom, the second housing

means having inwardly projecting arcuate structure disposed eccentric to the common axis and being diametrically disposed relative to the arcuate structure of the first housing means, the arcuate structure of the second housing means extending axially into the first housing means and being radially spaced therefrom, and a pair of crossed flat springs interconnecting the arcuate structures so that the first and second housing means are rotatable relative to each other on the common axis.

It is, therefore, a primary object of this invention to provide a flexural pivot which requires fewer parts, fewer manufacturing operations, less material and results in stronger pivots than previous devices.

Another object of the present invention is to provide an improved flexural pivot device which is simply constructed and can be made in small sizes and which retains the advantages of no backlash and no friction or wear with resulting limitations due to lubrication at high temperature.

A further object of the present invention is to provide an improved flexural pivot device which has axially aligned housing members connected by a structure including crossed flat springs whereby the device can be simply mounted in support structure and can provide a friction-free sensitive pivotable mounting suitable for high temperature applications.

Further objects of this invention are to simplify the method of manufacture of flexural pivots, to make flexural pivots from only three parts, to reduce the amount of scrap material produced in the manufacture of flexural pivots, to reduce the cost of manufacture of flexural pivots, and to improve the performance characteristics of flexural pivots.

Still a further object of this invention is to provide a flexural pivot having internal axially extending arcuate structure formed eccentric to the axis of rotation, the eccentric disposition of the arcuate structure permitting the pivot to be manufactured with a hollow mill or by use of a cylindrical electrode in an electro-chemical or electrical discharge machining operation. Such an electrode design permits the use of simple tubular electrodes which are more economical to make, can be easily fabricated from a variety of materials suitable for electrodes, e.g., graphite, and can be rotated so that fresh electrolytic or dielectric fluid will be introduced between the electrode and sleeve thus washing out the debris resulting from electrical machining. The last mentioned condition being very important since it permits uniform electrical machining and low electrode wear.

The invention further lies in the particular organization of the various elements and their cooperative association with one another to produce the beneficial results intended. The foregoing objects and advantages of the invention will appear more fully hereafter from the consideration of the description which follows, taken together with the accompanying drawings wherein the preferred embodiment of the invention is illustrated. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description and not to be construed as defining the limits of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded perspective view illustrating from left to right a broken-away view of the pivot hous-

ing after forming the eccentric arcuate structure, a view of a typical electrode that can be utilized in forming the eccentric arcuate structure and the sub-assembly of the flat crossed springs.

FIG. 2 is a longitudinal cross-section of a pivot according to my invention taken along the section 2—2 of FIG. 3.

FIG. 3 is an end view of the pivot shown in FIG. 2.

FIG. 4 is a transverse cross-sectional view of my pivot taken along the section lines 4—4 of FIG. 2.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIG. 1, the main housing 10 of my pivot is shown as a cylindrical member having four diametrically opposed slots 12 therein. Housing 10 can be cast or formed from common bar stock and the slots 12 can be formed by broaching, milling or other conventional means. Two flat springs 21 and 22 are stamped or chemical milled from resilient stock and are assembled as shown. I-shaped spring 22 is slipped through insertion opening 25 in the square-D-shaped spring 21 and the cross element 27 is arranged perpendicular to cross bars 29 and 31 of the square-D-shaped spring 21. Spring 21 has between its cross bars 29 and 31 an axially-extending projection 35. I-shaped spring 22 also has projections 37. It is to be noted that the crossed bars 29 and 31 and cross element 27 merge on a radius to the various projections whereby the cross spring elements are better supported and more durable under flexing when bonded to the housing as will be described. It is apparent that two generally I-shaped springs can be used provided the effective width is about equal, as with the total width of the two bars 29 and 31 relative to the cross element 27. The various projections, of course, have the same thickness as the cross members since the springs are made from metal sheet. Although only one type of flexural arrangement is shown, it should be noted that a myriad of alternate designs could also be used with departing from my invention. For example, a plurality of flat, rectangular flexures or the like as disclosed in my commonly assigned U.S. Pat. No. 3,073,584 could also be successfully employed.

Housing 10 is placed in a machine capable of removing metal by electrochemical or electrical discharge means. Cylindrical electrodes 15, having an O.D. less than the O.D. of housing 10, and an I.D. greater than the I.D. of housing 10 (although this latter condition is not a prerequisite), are advanced into housing 10 on an axis parallel to the axis of housing 10 and displaced from the axis of housing 10 at a distance less than that which would allow the electrode to break through the external surface of housing 10. This process is performed at diametrically opposed ends of housing 10 at an axial depth sufficient to form overlapping arcuate structures 50 and 60 displaced 180° from each other. The arcuate structures thus formed are eccentric to the axis of housing 10 having equally spaced axially extending edges and being radially spaced from housing 10 at each end thereof.

The subassembly comprised of the resilient members 21 and 22 and/or the sleeve or housing 10 are plated with metals capable of forming a brazed attachment of flexures to the housing 10. The subassembly is then inserted into housing 10 with the projections 37 and 35 of the resilient members mating with the slots 12 of the housing. The assembly of the flexures in the housing

can easily be accomplished with automated equipment. The assembly of housing and flexures are then brazed together, preferably by heating in a controlled nonoxidizing atmosphere at a temperature suitable for providing both brazing and proper heat treatment for best flexure properties. Other means of attaching the flexures to the sleeve such as by bonding or welding may also be used, although these means usually require the use of holding fixtures and the like.

Referring to FIG. 2, a circumferential groove 30 is cut into housing 10 as by grinding or other conventional means so that it extends into or below the annular arcuate spaces 32 and 34 formed by the electrodes 15. Two slots 36 (only one shown) are cut, as by broaching or grinding during the same operation immediately above, in housing 10 so as to extend below and therefore sever the inner cusps 38 formed by the inner surface of groove 30 and the outer surfaces of the annular arcuate spaces 32 and 34 shown in FIG. 4. These operations result in separating the sleeve or housing into two cylindrical members 55 and 65 having inwardly projecting arcuate structures 50 and 60, respectively, joined only by the flexures 21 and 22 which maintain axial coincidence of the housing portions 55 and 65 but because of the flexure's ability to bend the housing portions 55 and 65 may be rotated with respect to each other through some angle limited by bending stresses in the flexures. Although the flexures of the preferred embodiment of a pivot made according to my invention are shown substantially perpendicular to each other, one skilled in the art will appreciate that in some cases an unequal angular spacing of the flexures may be desirable.

It should be noted that the objects and advantages of my invention are accomplished and in particular that the cylindrical annular spaces 32 and 34 may be formed with a hollow mill or by the electromechanical or electrical discharge machining as was described. The cylindrical form permits the use of simple tubular electrodes 15 which are economical to make, can be fabricated from a variety of materials suitable for electrodes, for example graphite, and can be rotated so that fresh electrolytic or dielectric fluid will be introduced between the electrode and housing thus washing out the debris resulting from the electrical machining. Obviously, this last condition is very important for uniform electrical machining and low electrode wear.

The operation of the flexural pivot device shown in FIG. 2 as a pivotal mounting is believed to be apparent from the foregoing description. Thus, with reference to FIG. 6 an instrument indicator, one end of a butterfly valve, a turbine engine control vane, one end of a flight vehicle control surface or many other devices which are usually mounted in bearings and have limited rotation or pivoting is mounted to the first housing means 55 and the second housing means 65 is mounted in a hole and support structure and fixed by a set pin or other conventional arrangement. When the instrument indicator, for example, is actuated in a clockwise direction, the first housing means 55 is rotated clockwise from the normal position with the flexing of the springs 21 and 22 as is well known in flexural pivot devices. The radial spacing between the axially extending eccentric arcuate structures 50 and 60, one end illustrated in FIG. 3, provide clearance upon the flexing or bending of the springs 21 and 22. Rotation can be made in either direction as limited by the resistance of the

flexures toward radial or axial forces. It is to be noted that the present easily replaceable flexural pivot is made from only three parts, a cylindrical housing and two flat crossed springs, which are connected by a single bonding step and is more compact for a given capacity than constructions which have springs connected by screws to nontubular mounting means, etc.

It is also to be understood that changes can be made in the disclosed embodiment and methods by persons skilled in the art without departing from the scope of the invention as set forth in the appended claims.

I claim:

1. A flexural pivot device comprising:

first and second housing means arranged on a common axis and axially spaced from each other; said first housing means having an inwardly projecting arcuate structure eccentric to said common axis, said arcuate structure extending axially into said second housing means and being radially spaced therefrom;

said second housing means having inwardly projecting arcuate structure eccentric to said common axis and being diametrically disposed relative to said arcuate structure of said first housing means, said arcuate structure of said second housing means extending axially into said first housing means and being radially spaced therefrom; and crossed flat spring means connecting said arcuate structures so that said first and second housing means are rotatable relative to each other on said common axis.

2. A flexural pivot comprised of:

a pair of flat crossed springs, each of said crossed springs having at least one side projection at each end, each said side projection extending perpendicularly from the side end of the spring and being the same thickness as said spring to provide connecting segments;

first and second arcuate elements disposed eccentric to the axis formed by the crossed springs, said first and second arcuate elements diagonally opposed and fixedly secured to said connecting segments to provide a tubular assembly having two semi-circular-like members interconnected by crossed flat springs and spaced at the lengthwise edges thereof;

first outer sleeve means connected to one of said semi-circular-like members and radially spaced from the other member; and

second outer sleeve means connected to the other of said semi-circular-like members and radially spaced from the first member, whereby said first outer sleeve means can be fixed and said second outer sleeve means can be rotated with flexing of said crossed springs.

3. A flexural pivot device comprised of first and second arcuate elements arranged eccentric to a common

circle with adjacent axial edges equally spaced;

crossed flat springs connecting said arcuate elements and providing an axis of relative rotation for said elements coincident with said common circle;

first means for mounting a rotatable member connected to said first element and being free of any connection to said second element; and

second means for providing a fixed support connected to said second element and being free of any connection to said first element.

4. A cantilever-type flexural pivot device comprised of:

first and second cylindrical means arranged on a common axis and axially spaced from each other;

said first cylindrical means having inwardly thereof arcuate structure, said arcuate structure extending axially into said second cylindrical means and being eccentric to and radially spaced therefrom;

said second cylindrical means having inwardly thereof arcuate structure diametrical of said arcuate structure of said first cylindrical means, said arcuate structure of said second cylindrical means extending axially into said first cylindrical means and being eccentric to and radially spaced therefrom;

crossed flat spring means connecting said arcuate structures so that said first and second cylindrical means are rotatable relative to each other on said common axis, said spring means being so constructed as to limit relative rotation between said cylindrical means;

said first cylindrical means including a first tubular member adapted to provide a fixed end support; and

said second cylindrical means including a second tubular member adapted to provide a rotatable mounting.

5. A flexural pivot device comprised of first and second arcuate inner sleeve elements arranged eccentric to a common circle with axially extending edges being equally spaced and disposed 180° from each other;

first and second outer sleeve means arranged on an axis coincident with said common circle, said first and second outer sleeve means being formed integral with said first and second inner sleeve elements respectively;

said first inner sleeve element being radially spaced from said second outer sleeve means;

said second inner sleeve element being radially spaced from said first outer sleeve means; and

resilient means mounted internally of said inner sleeve elements whereby said first outer sleeve means can be fixed and said second outer sleeve means can be rotated by flexing said resilient means.

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