

(19)



(11)

EP 1 428 986 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
07.03.2007 Bulletin 2007/10

(51) Int Cl.:
F01D 25/16 ^(2006.01) **F01D 17/16** ^(2006.01)
F16C 11/06 ^(2006.01) **F16C 23/04** ^(2006.01)

(21) Application number: **03256367.8**

(22) Date of filing: **09.10.2003**

(54) **Torque tube bearing assembly**

Lageranordnung für ein Torsionsrohr
Ensemble palier d' un tube de torsion

(84) Designated Contracting States:
DE FR GB

(30) Priority: **11.12.2002 US 316778**

(43) Date of publication of application:
16.06.2004 Bulletin 2004/25

(73) Proprietor: **GENERAL ELECTRIC COMPANY**
Schenectady, NY 12345 (US)

(72) Inventors:
• **Bathori, Julius**
Cincinnati, Ohio 45231 (US)

- **Park, Sang Yeng**
West Chester, Ohio 45069 (US)
- **Headley, Mitchell Jay**
Lebanon, Ohio 45036 (US)

(74) Representative: **Goode, Ian Roy et al**
London Patent Operation
General Electric International, Inc.
15 John Adam Street
London WC2N 6LU (GB)

(56) References cited:
EP-A- 1 101 902 **GB-A- 2 038 421**
US-A- 3 529 790 **US-A- 4 755 104**

EP 1 428 986 B1

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

[0001] The present invention relates generally to a gas turbine engine variable stator vane torque tube assembly and, more particularly, to a torque tube assembly having improved bearing life.

[0002] Variable pitch stator vanes are commonly used in compressors of gas turbine engines. The variable pitch stator vanes or, more simply, variable stator vanes are pivotably mounted in axially spaced rows inside a compressor case of the engine. Each of the vanes pivots on a spindle having an axis extending radially with respect to an engine centerline to vary the pitch of the vane. Levers on the outboard ends of the spindles simultaneously pivot each of the vanes in a row. The levers form part of a bell crank mechanism mounted outside the compressor case. Some engines include a torque tube assembly operatively connecting the bell crank mechanism to a variable stator vane actuator mounted outside a fan duct surrounding the compressor case. The torque tube assembly includes an elongate torque tube extending through an access hole in the fan duct from the bell crank mechanism to the actuator.

[0003] During operation, the elongate torque tube rotates in the access hole about a longitudinal axis of the tube extending generally radially relative to the engine centerline from the bell crank mechanism to the actuator. Because the compressor case and the fan duct operate at significantly different temperatures, the relative axial positions of the compressor case and the fan duct change during engine operation. As a result, the outboard end of the torque tube tilts rearward as the engine heats up during engine operation. Thus, the torque tube must be free to tilt and rotate in the access hole. To facilitate this motion, a spherical bearing assembly is positioned between the torque tube and the access hole. The bearing assembly includes a spherical bearing mounted on the torque tube and a housing adapted for receiving the bearing mounted over the access hole on the fan duct.

[0004] GB 2 038 421 describes a turbofan engine in which the angle of a variable blocker door vane in a bypass duct is varied in response to the angle of variable compressor vanes of the engine.

[0005] US 4 755 104 describes a stator vane linkage for manipulating an internal component of a turbofan gas turbine engine.

[0006] Some conventional variable stator vane torque tube assemblies have housings tilted to match the calculated torque tube tilt angle during engine operation. Fig. 1 illustrates a cross section of a bearing assembly used in one such conventional variable stator vane torque tube assembly. This bearing assembly includes a housing tilted at an angle of less than about four degrees. However, in some instances torque tubes tilt rearward by as much as thirteen degrees or more during steady state engine operation. The resulting asymmetric loading developed in the bearing assembly during engine operation when the torque tube is disposed at an angle

with respect to the housing has sometimes resulted in premature bearing assembly failure. Accordingly, there is a need for a torque tube assembly with a bearing that performs more reliably and has improved life under such operating conditions.

[0007] Briefly, the present invention includes a gas turbine engine as described in appended claim 1.

[0008] Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a cross section of a prior art bearing assembly;

Fig. 2 is a section of a portion of a gas turbine engine showing a torque tube bearing assembly of the present invention;

Fig. 3 is a cross section of a bearing assembly of the present invention; and

Fig. 4 is a top plan of the bearing assembly of the present invention.

[0009] Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

[0010] Referring now to the drawings and in particular to Fig. 2, a torque tube assembly for use in a gas turbine engine is designated in its entirety by the reference numeral 20. The assembly 20 extends through an access hole 24 in a fan duct 26 of the gas turbine engine (generally designated by 28) and connects a variable stator vane bell crank (generally designated by 30) positioned inside the fan duct to an actuator (generally designated by 32) positioned outside the fan duct. The torque tube assembly 20 transmits torque from the actuator 32 to the bell crank 30 to vary the pitch of stator vanes 34 connected to the bell crank. The vanes, generally designated by 34, are mounted inside a compressor case 36 of the engine 28. The vanes 34 direct air passing through a flowpath 38 of the engine 28 inside the compressor case 36. Each of the vanes 34 includes a spindle 40 extending through a bushing 42 mounted on the compressor case 36. A lever 44 forming part of the bell crank 30 is mounted on an outboard end 46 of each spindle 40. The levers 44 provide leverage to pivot the vanes 34 about their respective spindles 40 to vary their pitch or angle of attack with respect to the air flowing through the flowpath 38 of the engine 28.

[0011] As further illustrated in Fig. 2, the torque tube assembly 20 comprises a conventional elongate torque tube, generally designated by 50, having an inner end 52 adapted for connection to the variable stator vane bell crank 30, an outer end 54 adapted for connection to the variable stator vane actuator 32, and an imaginary longitudinal axis 56 extending between the inner and outer ends. The features of the torque tube are conventional

and will not be discussed in detail. A bearing, generally designated by 60, is mounted on the torque tube 50. The bearing 60 has a spherical external engagement surface 62 and an internal bore 64 adapted for receiving the torque tube 50. Although the bearing 60 may be mounted on the torque tube 50 in other ways without departing from the scope of the present invention, in one embodiment the internal bore 64 is sized for a close clearance fit with the torque tube so the bearing and torque tube move as a unit. The torque tube assembly 20 also includes a housing, generally designated by 70, having an annular interior surface 72 adapted for rotatably receiving the spherical external engagement surface 62 of the bearing 60. As illustrated in Fig. 3, the annular interior surface 72 has an inner edge 74 and an outer edge 76. Together the bearing 60 and housing 70 form a bearing assembly, generally designated by 80, for mounting the torque tube 50 in the access hole 24 of the fan duct 26. The bearing assembly 80 permits the torque tube 50 to rotate about its longitudinal axis 56 to pivot the vanes 34, as well as tilt within the access hole 24 of the fan duct 26 to compensate for differences in thermal growth between the compressor case 36 and fan duct 26 during engine 28 operation.

[0012] As illustrated in Fig. 3, the housing 70 has a flange 82 adapted for mounting the housing to the fan duct 26 so the annular interior surface 72 of the housing is aligned with the access hole 24 in the fan duct. In one embodiment, the flange 82 is constructed integrally with the housing 70. As illustrated in Fig. 4, the flange 82 includes a plurality of holes 84 for attaching the housing 70 to the fan duct 26 with bolts (not shown) or other fasteners. As shown in Fig. 3, the housing 70 also has an annular rabbet surface 86 for engaging the access hole 24 when the flange 82 is mounted on the fan duct 26 to properly position the bearing assembly 80 on the fan duct. In one embodiment, the annular interior surface 72 of the housing 70 includes a relieved portion 90 for loading the bearing 60 into the housing 70. The relieved portion 90 faces inward when the flange 82 of the housing 70 is mounted on the fan duct 26 so the bearing 60 loads outward against an uninterrupted portion 92 of the interior surface 72 of the housing.

[0013] As will be appreciated by those skilled in the art, the spherical external engagement surface 62 of the bearing 60 and the annular interior surface 72 of the housing 70 make contact along an annular contact area (the outer and inner boundaries of which are designated by dashed lines 100) centered on a contact plane 102 lying between the inner edge 74 and the outer edge 76 of the interior surface 72. The contact plane 102 is tilted with respect to the flange 82 at an angle 104 greater than five degrees. This arrangement results in the torque tube axis 56 extending at an angle 106 (Fig. 2) measured from the flange of less than 85 degrees when the tube 50 is tilted so the tube is centered with respect to the inner and outer edges 74, 76 of the interior surface 72 of the housing 70. In one embodiment, the angle 104 at which the contact

plane 102 tilts is greater than about ten degrees resulting in an angle 106 of less than about eighty degrees. In another embodiment, the angle 104 at which the contact plane 102 tilts is about thirteen degrees resulting in an angle 106 of about 77 degrees. In still another embodiment, the angle 104 is about 13.08 degrees. As will be appreciated by those skilled in the art, the angle 106 is optimally the angle at which the torque tube 50 passes through the access hole 24 during a steady state power setting of the engine. For example, if the engine 28 is an aircraft engine, the angle 106 is the angle at which the torque tube 50 passes through the access hole 24 during steady state cruise operation of the engine. Further, in one embodiment the outer end 54 of the torque tube 50 is positioned behind the inner end 52 of the torque tube during the steady state power setting of the engine 28. In addition, the torque tube axis 56 may be substantially radial when the engine 28 is cold to enhance engine assembly. Those skilled in the art will appreciate the angles 104, 106 result in the torque tube axis 56 extending perpendicular to the outside edge 76 of the interior surface 72 of the housing 70 during at least one steady state power setting of the engine 28 (e.g., during steady state cruise operation of an aircraft engine). This arrangement also results in a rearward side 110 of the housing flange 82 being positioned outboard from the outer edge 76 of the interior surface 72 of the housing 70 when the flange is mounted on the fan duct 26 and a forward side 112 of the housing flange being positioned inboard from at least a portion of the interior surface of the housing when the flange is mounted on the fan duct.

[0014] Each of the previously described components of the torque tube assembly 20 may be constructed from materials conventionally used to construct torque tube assemblies. Although the housing 70 may be made of other materials without departing from the scope of the present invention, in one embodiment the housing is made from stainless steel. A portion of the interior surface 72 of the housing 70 (e.g., the spherical portion 90 of the interior surface) may be coated with a protective coating and/or a friction reducing coating to reduce wear. Although the bearing 60 may be made of other materials without departing from the scope of the present invention, in one embodiment the bearing is made from stainless steel.

[0015] As will be appreciated by those skilled in the art, the torque tube assembly 20 operates conventionally. As the actuator 32 extends and retracts, the torque tube 50 rotates about its longitudinal axis 56 within the access hole 24 of the fan duct 26 to drive the bell crank 30 and thereby vary the pitch of the stator vanes 34 inside the compressor case 36. Further, the bearing assembly 80 permits the torque tube to tilt to compensate for differences in thermal growth between the fan duct 26 and the compressor case 36. The torque tube assembly 20 of the present invention has improved load distribution on the bearing 60 and housing 70 during engine operation. This results in improved life and improved performance

of the bearing assembly 80 consequently improving the life and performance of torque tube assembly 20 and the gas turbine engine.

[0016] When introducing elements of the present invention or the preferred embodiment(s) thereof, the articles "a", "an", "the" and "said" are intended to mean that there are one or more of the elements. The terms "comprising", "including" and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements.

Claims

1. A gas turbine engine (28) including a compressor case (36) and a bearing assembly (80) for use in the gas turbine engine (28) to rotatably mount a torque tube (50) in an access hole (24) extending through a fan duct (26) of the engine (28), said torque tube (50) connecting a variable stator vane bell crank (30) positioned inside the fan duct (26) and mounted outside the compressor case (36) to an actuator (32) positioned outside the fan duct (26), said bearing assembly (80) comprising:

a bearing (60) adapted for mounting on the torque tube (50) having a spherical external engagement surface (62); and

a housing (70) having a flange (82) adapted for mounting on the fan duct (26) adjacent the access hole (24) and an annular interior surface (72) having an inner edge (74) and an outer edge (76), said interior surface (72) being sized and shaped for rotatably receiving the spherical external engagement surface (62) of the bearing (60) so the spherical engagement surface (62) and the annular interior surface (72) make contact along an annular contact area (100) centered on a contact plane (102) lying between said inner edge (74) and said outer edge (76) of the interior surface (72), **characterized by:**

said contact plane (102) being tilted with respect to the flange (82) and the surface of the fan duct (26) to which the flange (82) is mounted at an angle (104) greater than five degrees whereby the bearing assembly (80) permits the torque tube (50) to tilt to compensate for differences in thermal growth between the compressor case (36) and fan duct (26) during engine operation.

2. The gas turbine engine (28) as set forth in claim 1 wherein the angle (104) at which the contact plane (102) tilts is greater than about ten degrees.
3. The gas turbine engine (28) as set forth in claim 1 wherein the annular interior surface (72) of the hous-

ing (70) includes a relieved portion (90) for loading the bearing (60) into the housing (70).

4. The gas turbine engine (28) as set forth in claim 1 wherein the housing (70) includes a rabbet surface (86) for engaging the access hole (24) when the flange (82) is mounted on the fan duct (26).
5. The gas turbine engine (28) as set forth in claim 1 wherein a portion of the housing flange (82) is positioned outside the interior surface (72) of the housing (70) when the flange (82) is mounted on the fan duct (26) and a portion of the housing flange (82) is positioned inside the interior surface (72) of the housing (70) when the flange (82) is mounted on the fan duct (26).
6. The gas turbine engine (28) as set forth in claim 1, wherein the longitudinal axis (56) of the torque tube (50) extends at an angle (106) measured from the flange (82) of less than 85 degrees.
7. The gas turbine engine (28) as set forth in claim 6 wherein the angle (106) at which the torque tube axis (56) extends is less than about eighty degrees.
8. The gas turbine engine (28) as set forth in claim 1 wherein the torque tube axis (56) extends perpendicular to the outside edge of the interior surface (72) of the housing (70) during at least one steady state power setting of the engine (28).
9. The gas turbine engine (28) as set forth in claim 3 wherein the relieved portion (90) faces inward when the flange (82) of the housing (70) is mounted on the fan duct (26).

Patentansprüche

1. Gasturbinentriebwerk (28) mit einem Verdichtergehäuse (36) und einer in dem Gasturbinentriebwerk (28) verwendeten Lagerbaugruppe (80) zum drehbaren Montieren eines Torsionsrohres (50) in einem sich durch einen Bläser-Kanal (26) des Triebwerks (28) erstreckenden Zugangslotz (24), wobei das Torsionsrohr (50) einen im Innern des Bläser-Kanals (26) positionierten und außerhalb des Verdichtergehäuses (36) montierten Winkelhebel (30) einer verstellbaren Leitschaufel mit einem außerhalb des Bläser-Kanals (26) positionierten Stellglied (32) verbindet, wobei die Lagerbaugruppe (80) Folgendes umfasst:
 - ein zum Montieren an das Torsionsrohr (50) angepasstes Lager (60) mit einer gewölbten äußeren Eingriffsfläche (62); und
 - ein Gehäuse (70), das einen Flansch (82) zum

Montieren an dem Bläser-Kanal (26) neben dem Zugangsloch (24) und eine ringförmige Innenoberfläche (72) mit einem inneren Rand (74) und einem äußeren Rand (76) aufweist, wobei die Innenoberfläche (72) für die drehbare Aufnahme der gewölbten äußeren Eingriffsfläche (62) des Lagers (60) dimensioniert und geformt ist, sodass die gewölbte Eingriffsfläche (62) und die ringförmige Innenoberfläche (72) sich entlang einem ringförmigen Kontaktbereich (100) berühren, der mittig auf einer zwischen dem inneren Rand (74) und dem äußeren Rand (76) der Innenoberfläche (72) liegenden Kontaktebene (102) angeordnet ist, **dadurch gekennzeichnet, dass:**

- die Kontaktebene (102) in Bezug zu dem Flansch (82) und der Oberfläche des Bläser-Kanals (26) geneigt ist, an welchem der Flansch (82) in einem Winkel (104) von mehr als fünf Grad montiert ist, wobei die Lagerbaugruppe (80) das Neigen des Torsionsrohres (50) gestattet, um während des Triebwerkbetriebs zwischen dem Verdichtergehäuse (36) und dem Bläser-Kanal (36) bestehende Unterschiede hinsichtlich der Wärmeausdehnung auszugleichen.
2. Gasturbinentriebwerk (28) nach Anspruch 1, wobei der Winkel (104), um den die Kontaktebene (102) geneigt wird, mehr als zehn Grad beträgt.
 3. Gasturbinentriebwerk (28) nach Anspruch 1, wobei die ringförmige Innenoberfläche (72) des Gehäuses (70) einen ausgesparten Bereich (90) zum Aufnehmen des Lagers (60) in das Gehäuse (70) aufweist.
 4. Gasturbinentriebwerk (28) nach Anspruch 1, wobei das Gehäuse (70) eine gefalzte Oberfläche (86) aufweist, um beim Montieren des Flansches (82) an dem Bläser-Kanal (26) in das Zugangsloch (24) einzugreifen.
 5. Gasturbinentriebwerk (28) nach Anspruch 1, wobei ein Bereich des Gehäuseflansches (82) außerhalb der Innenoberfläche (72) des Gehäuses (70) positioniert ist, wenn der Flansch (82) an dem Bläser-Kanal (26) montiert wird, und ein Bereich des Gehäuseflansches (82) innerhalb der Innenoberfläche (72) des Gehäuses (70) positioniert ist, wenn der Flansch (82) an dem Bläser-Kanal montiert wird.
 6. Gasturbinentriebwerk (28) nach Anspruch 1, wobei die Längsachse (56) des Torsionsrohrs (50) in einem ab dem Flansch (82) gemessenen Winkel (106) von weniger als 85 Grad verläuft.
 7. Gasturbinentriebwerk (28) nach Anspruch 6, wobei

der Winkel (106), in dem die Torsionsrohrachse (56) verläuft, weniger als ungefähr achtzig Grad beträgt.

8. Gasturbinentriebwerk (28) nach Anspruch 1, wobei die Torsionsrohrachse (56) während wenigstens einer gleich bleibenden Leistungsstufe des Triebwerks (28) senkrecht zum äußeren Rand der Innenoberfläche (72) des Gehäuses (70) verläuft.
9. Gasturbinentriebwerk (28) nach Anspruch 3, wobei der ausgesparte Bereich (90) nach innen zeigt, wenn der Flansch (82) des Gehäuses (70) an dem Bläser-Kanal (26) montiert wird.

Revendications

1. Turbine à gaz (28) comprenant un contre-carter (36) et un palier équipé (80) destiné à être utilisé dans la turbine à gaz (28) pour monter un tube de torsion rotatif (50) dans un trou d'accès (24) traversant un conduit de soufflante (26) de la turbine (28), ledit tube de torsion (50) reliant un guignol d'aube fixe de stator variable (30) placé dans le conduit de soufflante (26) et monté en dehors du contre-carter (36) sur un vérin (32) placé en dehors du conduit de soufflante (26), ledit palier équipé (80) comprenant :

un palier (60) adapté en vue de son montage sur le tube de torsion (50) ayant une surface d'engagement sphérique extérieure (62), et un carter (70) comprenant une bride (82) adaptée en vue de son montage sur le conduit de soufflante (26) à côté dudit trou d'accès (24) et comprenant une surface annulaire intérieure (72) ayant une arête interne (74) et une arête externe (76), ladite surface intérieure (72) étant dimensionnée et formée de manière à recevoir par rotation la surface d'engagement sphérique extérieure (62) du palier (60) de façon à ce que la surface d'engagement sphérique extérieure (62) et la surface annulaire intérieure (72) soient en contact le long d'une aire de contact annulaire (100) centrée sur un plan de contact (102) disposé entre ladite arête interne (74) et ladite arête externe (76) de la surface intérieure (72), **caractérisé en ce que :**

ledit plan de contact (102) est incliné par rapport à la bride (82) et à la surface du conduit de soufflante (26) sur laquelle la bride (82) est montée selon un angle (104) supérieur à cinq degrés, le palier équipé (80) permettant ainsi au tube de torsion (50) de basculer pour compenser les différences de croissance thermique entre le contre-carter (36) et le conduit de soufflante (26) en cours de fonctionnement de la turbine.

2. Turbine à gaz (28) selon la revendication 1 dans laquelle l'angle (104) d'inclinaison du plan de contact (102) est supérieur à environ dix degrés.
3. Turbine à gaz (28) selon la revendication 1 dans laquelle la surface annulaire intérieure (72) du carter (70) comprend une partie dégagée (90) pour charger le palier (60) dans le carter (70). 5
4. Turbine à gaz (28) selon la revendication 1 dans laquelle la carter (70) comprend une surface à feuillure (86) venant s'engager dans le trou d'accès (24) lorsque la bride (82) est montée sur le conduit de soufflante (26). 10
5. Turbine à gaz (28) selon la revendication 1 dans laquelle une partie de la bride de carter (82) est placée à l'extérieur de la surface intérieure (72) du carter (70) lorsque la bride (82) est montée sur le conduit de soufflante (26) et une partie de la bride de carter (82) est placée à l'intérieur de la surface intérieure (72) du carter (70) lorsque la bride (82) est montée sur le conduit de soufflante (26). 15 20
6. Turbine à gaz (28) selon la revendication 1 dans laquelle l'axe longitudinal (56) du tube de torsion (50) forme un angle (106) de moins de 85 degrés avec la bride (82). 25
7. Turbine à gaz (28) selon la revendication 6 dans laquelle l'angle (106) formé par l'axe du tube de torsion (56) est inférieur à environ quatre-vingts degrés. 30
8. Turbine à gaz (28) selon la revendication 1 dans laquelle l'axe du tube de torsion (56) est perpendiculaire à l'arête externe de la surface intérieure (72) du carter (70) pendant au moins un réglage de poussée à régime permanent de la turbine (28). 35
9. Turbine à gaz (28) selon la revendication 3 dans laquelle la partie dégagée (90) est tournée vers l'intérieur lorsque la bride (82) du carter (70) est montée sur la conduite de soufflante (26). 40

45

50

55

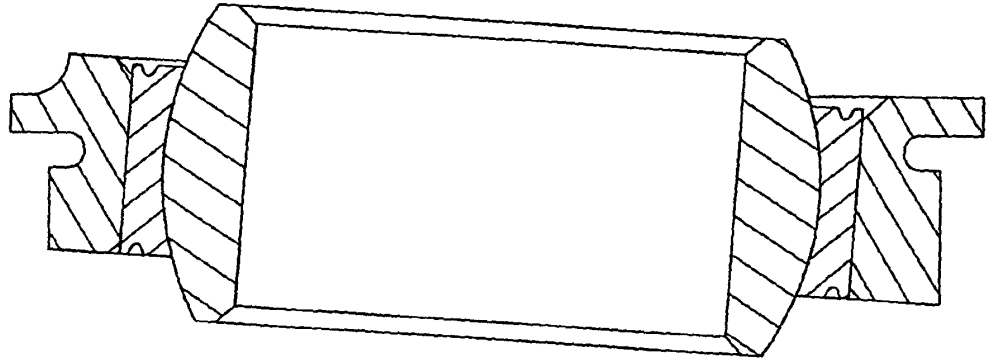


FIG. 1
(PRIOR ART)

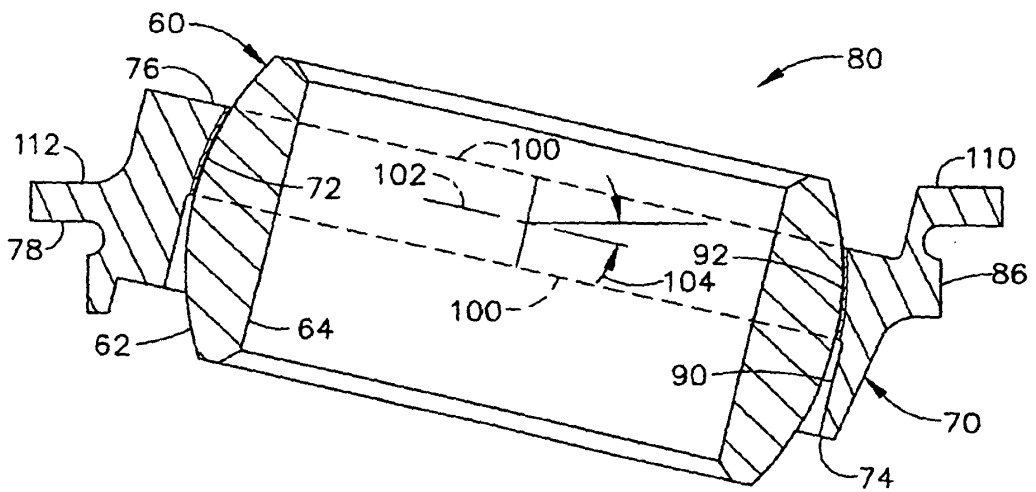


FIG. 3

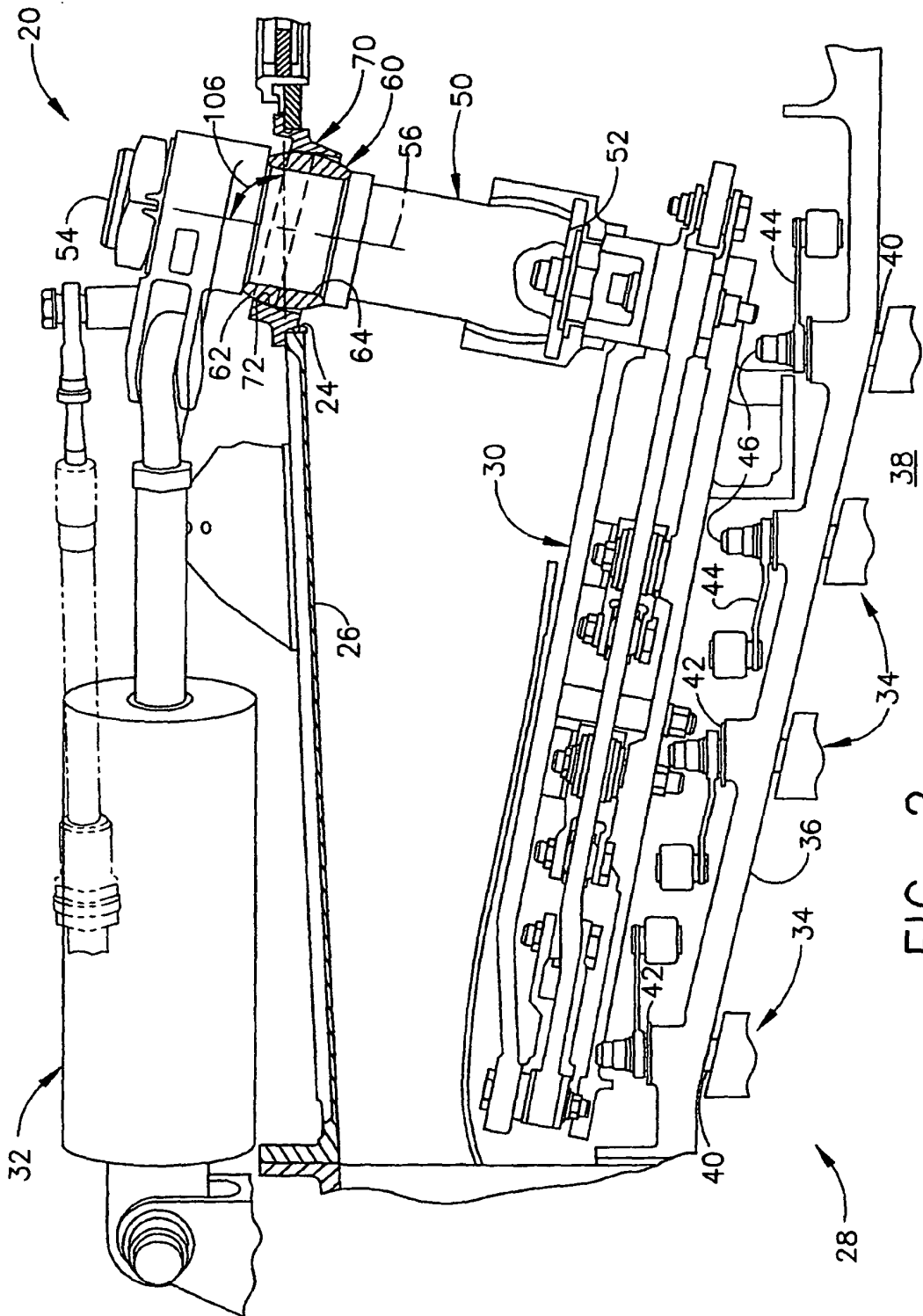


FIG. 2

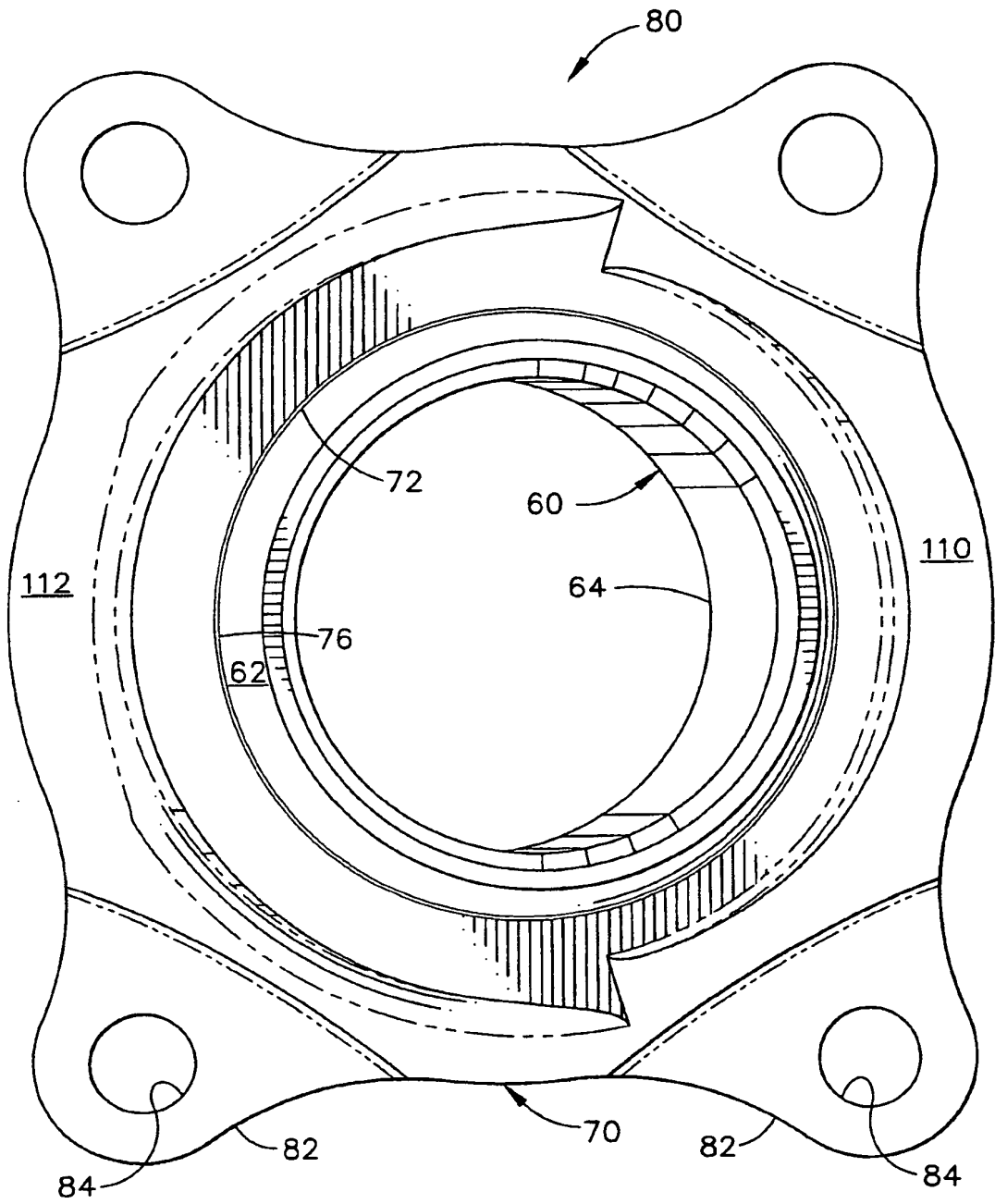


FIG. 4