A gas-lubricated thrust bearing employs relatively rigid inwardly cantilevered spokes carrying a relatively resilient annular member or annulus. This annulus acts as a beam on which are mounted bearing pads. The resilience of the beam mount causes the pads to accept the load and, with proper design, responds to a rotating thrust-transmitting collar by creating a gas film between the pads and the thrust collar. The bearing may be arranged for load equalization thereby avoiding the necessity of gimbal mounts or the like for the bearing. It may also be arranged to respond to rotation in one or both directions.

7 Claims, 10 Drawing Figures
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THrust BEARING

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

Thrust bearings employing pads against which a rotating thrust ring acts are known. Such bearings with rigid geometry members or pads forming a load carrying film with compliant mountings. To date these use elastomeric materials in a compliant mounting. Such materials are severely temperature limited, and do not have adequate stiffness for machines with close tolerance impellers in which axial movement of the rotor must be limited. They are not as sensitive to contaminating particles as the first type. A third type use foil arrangements. These can be started and stopped without external pressurization and are still less sensitive to contaminating particles. Nevertheless, these have limited stiffness. Attempts to increase stiffness have until now led to problems with starting torque and power loss.

OBJECTS OF THE INVENTION

It is an object of the invention to provide an improved gas thrust bearing.

It is another object of the invention to provide a gas thrust bearing of the type using bearing pads which are less sensitive to contaminating particles than prior pad bearing gas thrust bearings.

SUMMARY OF THE INVENTION

A gas-lubricated thrust bearing assembly of the invention employs inwardly cantilevered, relatively rigid beams or spokes carrying a relatively resilient heat resistant annular member. On the resilient member are mounted rigid thrust bearing pads. The pads are located on the annulus circumferentially between the spokes, so that under load the pads yield due to the resilience of the annulus. Hence, the annulus acts as a resilient beam bearing each pad between a pair of spokes. Under selected mounting arrangement, the pads may equalize the load among themselves, avoiding the necessity for gimbals or the like for load equalization. As will appear hereinafter, the bearing may be designed for bidirectional rotation of the bearing rotor. Other objects and advantages of the invention will be apparent from a reading of the specification in connection with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view through a bearing embodying the invention.

FIG. 1a is a partial sectional view useful in describing the operation of the embodiment of FIG. 1.

FIG. 2 is a cross-sectional view along the lines 2—2 of FIG. 1.

FIG. 3 is a partial cross-sectional view along the lines 3—3 of FIG. 2.

FIG. 4 is a partial sectional view of an embodiment of the invention designed for self-equalization of the thrust load against a plurality of pads.
of gimbals or the like in mounting the bearing assembly may be avoided.

FIG. 6 illustrates a configuration for supporting the thrust load in either axial direction. There are two sets of pad resilient beam assemblies 14, each mounted to a set of radial spokes 18. The two sets of spokes 18 are joined to a ring 24 which may be gimbal mounted or, as indicated, rigidly mounted to the machine frame. The collar 12 naturally must be designed to act in either axial direction.

In FIG. 7 is illustrated a configuration for supporting the thrust load to accept a rotor rotation in either direction. FIG. 7a illustrates rotation of the thrust collar 12 in one (arbitrarily termed a primary) direction indicated by an arrow. In FIG. 7b, the reverse direction of rotation is indicated by an oppositely directed arrow. On the annulus 20 are fastened stops 20a and 20b. Each pair of stops 20a and 20b are located adjacent the space between a pair of pads 22 and each stop equally distant from the adjacent pad. Secondary spokes 18c are arranged in opposition to the spokes 18, whereby when the rotor rotates in one direction, the stops 20a reach the secondary spokes 18c to halt the thrust bearing and at the same time locate the pads 22 so that the leading edge of the pad is more remote from its nearest spoke 18 than the lagging edge from its spoke 18. Accordingly, if the stops are spaced correctly, the pads 22 will assume an angular disposition to provide the desired spacing and gas bearing.

The action of the bearing when the rotor is stopped and reversed is such that the initial pad position is not correct and no load capacity can be developed because the ratio b to a corresponding to the ratio described in FIG. 1 is opposite what it should be. The frictional torque applied to the pad by the rotor causes the pad assembly on the bearing 20 to rotate until the stops 20b contact the spokes 18c, the two sets of stops being approximately positioned so that the ratio is optimum for the load in either the primary or reverse directions. The proper functioning of the bidirectional rotation depends on frictional restraint between the resilient beams and the radial spokes being less than that between the rotor and pad when reverse rotation begins. This is necessary so that the rotor can force the pad and beam assembly to slide in its contacts with spokes 18 and 18c until the reverse stops 20b contact the spokes. In FIG. 7 is illustrated simple sliding joints between the resilient annulus 20 and the spokes 18 and 18c. Small diameter rollers could be incorporated into the spokes to bear against the resilient beam or annulus 20 to reduce friction in the circumferential direction. The bidirectional rotation configuration of FIG. 7 may easily be combined with the bidirectional thrust load configuration of FIG. 6 to produce a thrust bearing which may carry the thrust load in both axial directions for rotor rotation in either direction.

The theory relating to the resilient pad gas thrust bearing described herein is more fully developed in a NASA Technical Note identified as NASA TN D-7724 entitled Analysis of an All-Metallic Resilient-Pad Gas-Lubricated Thrust Bearing by William J. Anderson, Lewis Research Center, Cleveland, Ohio 44135.

What is claimed is:
1. A thrust bearing assembly arranged to cooperate with a rotor which rotates in at least one angular direction, comprising,
a mount in annular form,
spokes cantilevered radially inward from said annular form, the cantilevered spokes being arranged at equal angular intervals about the axis of said mount and the coincident axes of said rotor, a heat resistant annulus resilient relative to and supported by said cantilevered spokes against axial thrust, thereby forming flexible beams between adjacent pairs of said cantilevered spokes, and thrust pads supported on said resilient beams to receive the thrust of said bearing, said pads being also spaced at like equal intervals angularly between said spoke, the leading edge of each pad being farther circumferentially from its adjacent spoke than the lagging edge of said pad circumferentially from its adjacent spoke.

2. The bearing assembly as claimed in claim 1 in which said pads are relatively rigid.

3. The bearing assembly as claimed in claim 1, said heat resistant annulus being metallic.

4. The bearing assembly as claimed in claim 3, each of the said spokes supporting said annulus against a flat spoke surface, said spokes being attached to the annulus to constrain the annulus along the lines of attachment to remain in a plane normal to the annulus axis.

5. The bearing assembly as claimed in claim 3, each of the said spokes supporting said annulus against a spoke by an attachment functioning as a fulcrum along the line of attachment of spoke and annulus.

6. The bearing assembly as claimed in claim 3, further comprising a frame, an annulus rotatable about its axis relative to said frame, and cooperating stops, some on said annulus and at least one fixed with respect to the frame, whereby the rotation of said annulus is limited in both directions of rotation.

7. A thrust bearing comprising a bidirectional shaft, a thrust collar having axially bidirectional thrust surfaces carried by said collar, and a pair of bearing assemblies, a different one for each of said thrust surfaces, each bearing assembly comprising a mount in annular form and relatively rigid spokes cantilevered radially inward from said annular form, the cantilevered spokes being arranged at equal angular intervals about the axis of said mount and the coincident axis of said shaft, a metallic annulus resilient relative to said spokes against axial thrust, thereby forming flexible beams between said cantilevered spokes, and rigid thrust pads supported on said beams to receive the thrust of said bearing, said pads being also spaced at like equal intervals angularly between said spokes, the leading edge of each pad being farther circumferentially from its adjacent spoke than the lagging edges of said pad circumferentially from its adjacent spoke, said bearing assemblies being faced oppositely to receive opposite thrusts from said collar.