United States Patent

[11] 3,628,884

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[54] **METHOD AND APPARATUS FOR SUPPORTING AN INNER CASING STRUCTURE**
11 Claims, 5 Drawing Figs.

[52] U.S. Cl. **415/219,** 29/464, 415/108, 415/199
[51] Int. Cl. **F01d 25/28**
[50] Field of Search 74/609, 606; 415/108, 219; 29/464

[56] **References Cited**
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2,888,240 5/1959 Fleischmann et al. 415/108
3,498,727 3/1970 Martin, Jr. et al. .... 415/219 X

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ABSTRACT: A rotary machine such as a turbine, having outer and inner tubular casings encompassing a rotor and divided along a horizontal plane into upper and lower semicylindrical halves. The improvement comprises an arrangement including an annular series of eccentric bushing structures inserted radially through apertures in the outer casing to adjustably fit axially key slots on the periphery of the inner casing to support the inner casing concentrically relative to the axis of rotation of the rotor. Furthermore, external screw means are connected to internal levers to move the inner casing into sealing relation with the outer casing. The invention also involves the method of supporting the inner casing within the outer casing and moving the inner casing relative to the outer casing.

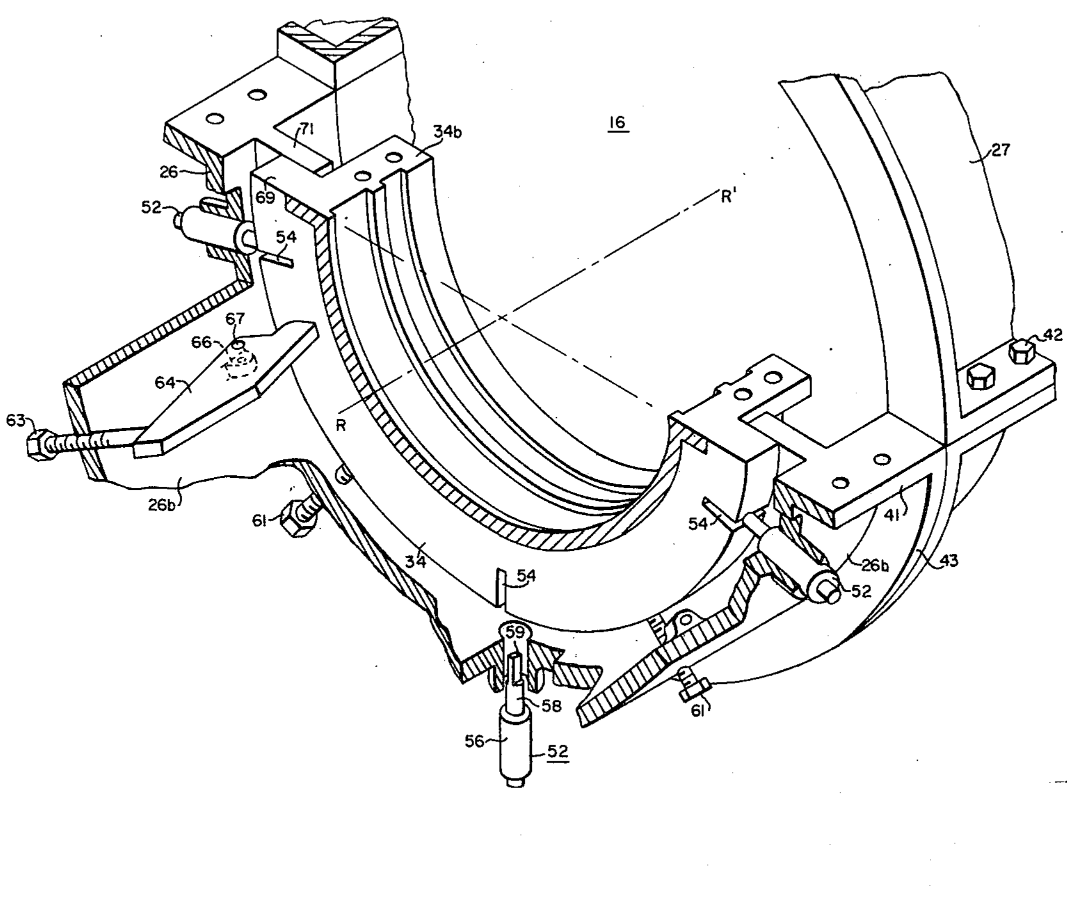
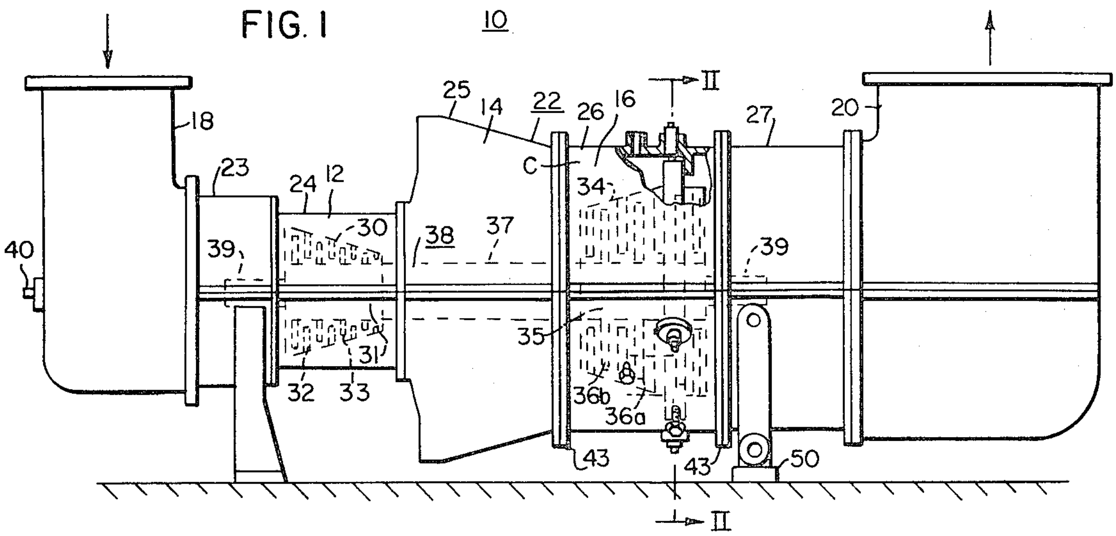


FIG. 1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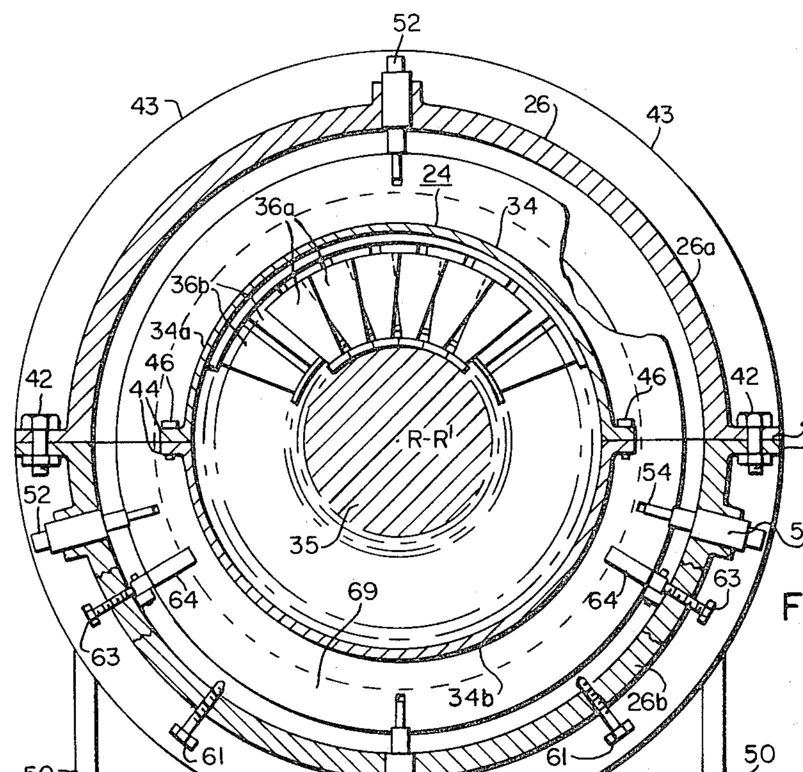
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43
26
43
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36a
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26a
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34a
46
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R-R
52
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52
35
63
69
64
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63
34b
26b
61
61
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52

FIG. 2

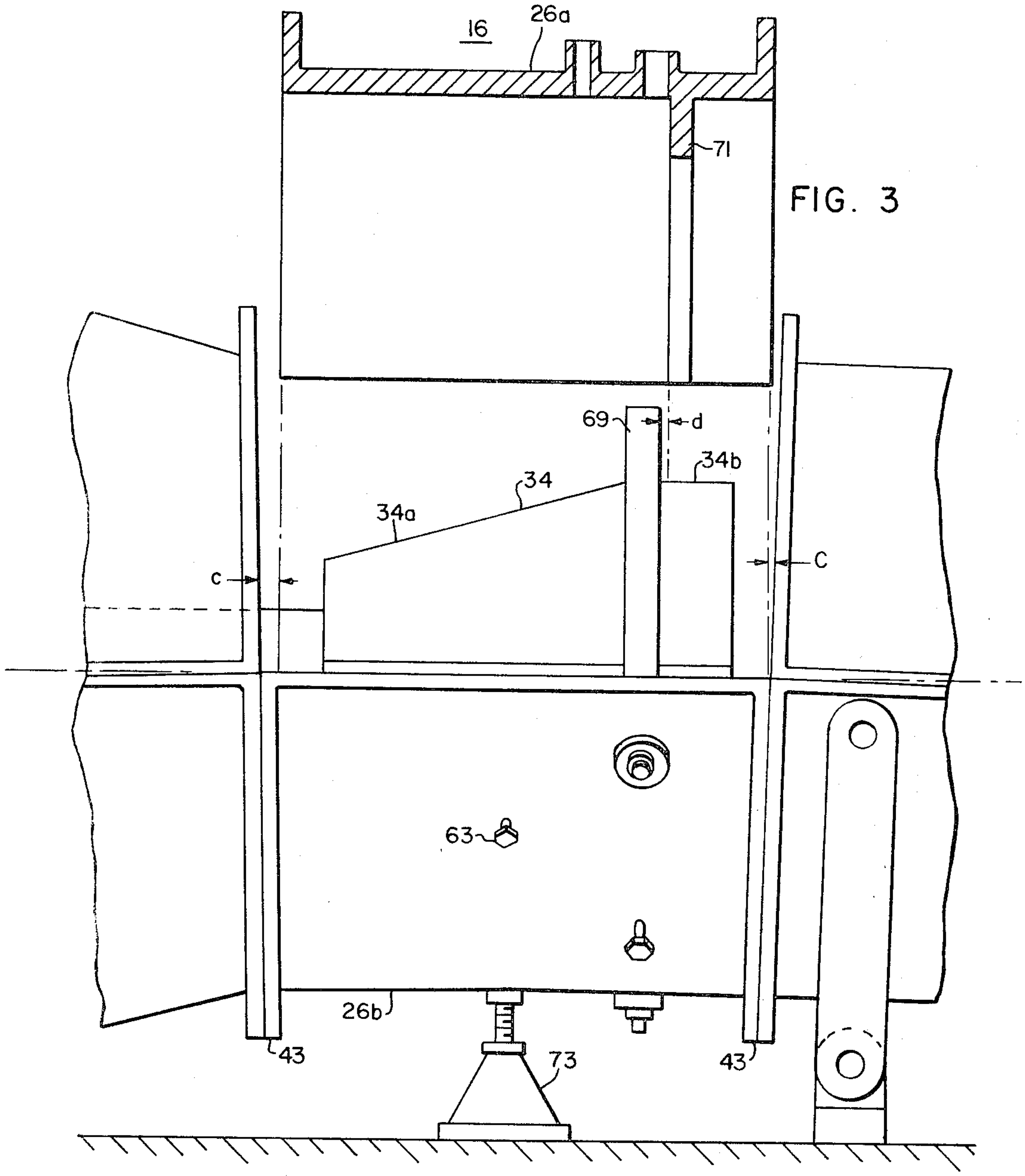

FIG. 3

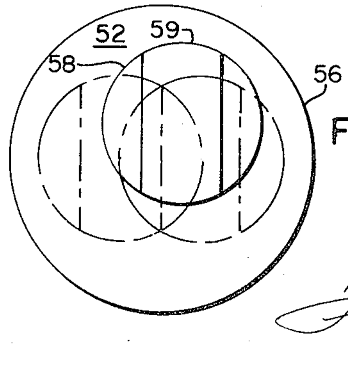

FIG. 5

WITNESSES

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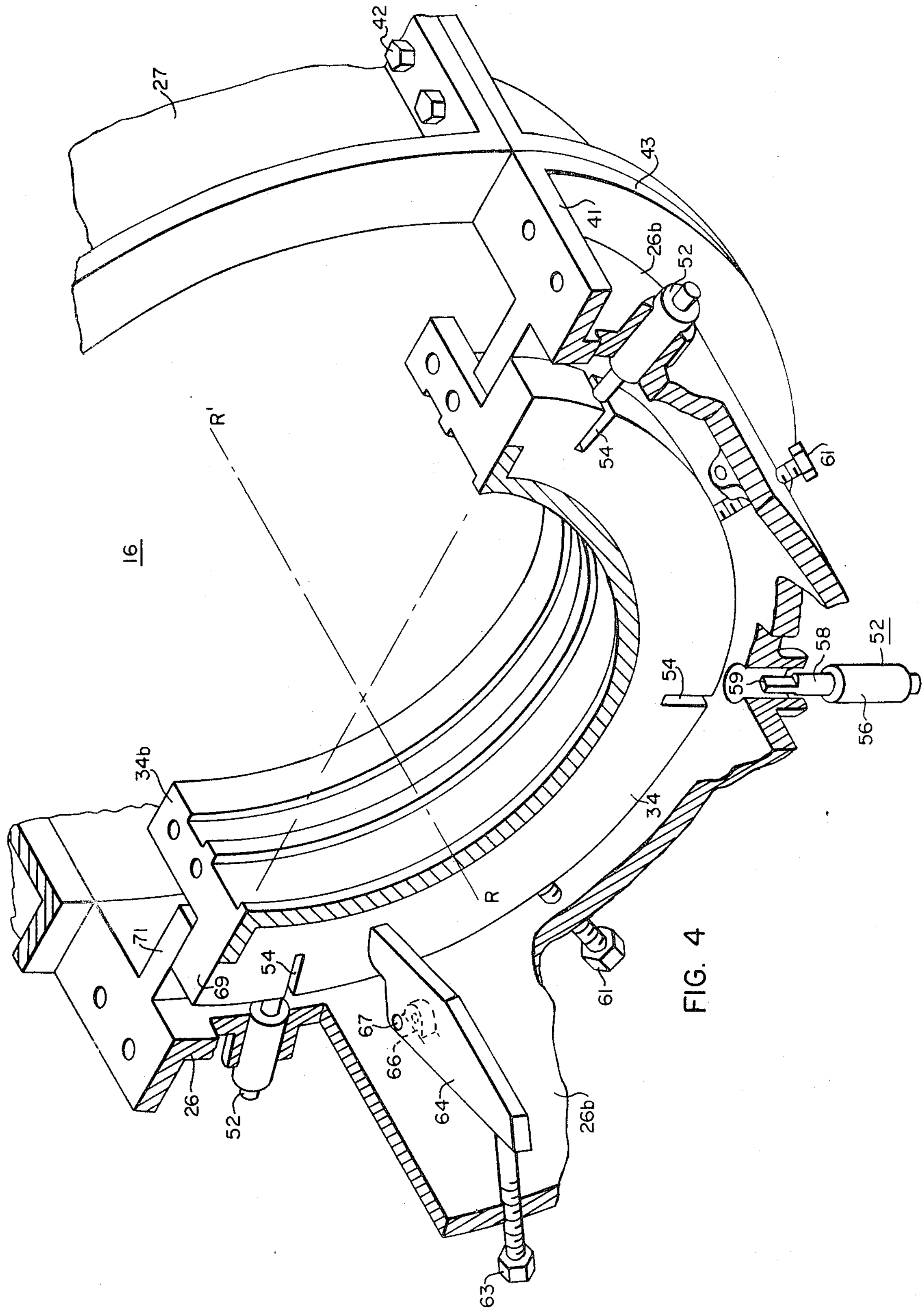
42
27
43
41
26b
52
54
61
16
R'
58
52
54
59
56
34b
34
R
71
69
54
61
67
66
64
26
52
26b
63

FIG. 4

METHOD AND APPARATUS FOR SUPPORTING AN INNER CASING STRUCTURE

BACKGROUND OF THE INVENTION

This invention relates to a rotary machine such as a turbine having outer and inner casings and more particularly to an arrangement and method for supporting the inner casing.

As is well known in the art, it is important that close running clearances be established between the rotor and inner casing.

Various arrangements for positioning the inner casing are shown in R. D. Howard et al., U.S. Pat. No. 3,169,748; R. A. Ladner, U.S. Pat. No. 3,147,952; and A. J. Scalzo, U.S. Pat. No. 3,493,212 all assigned to the present assignee.

The outer and inner casing structures are normally divided into upper and lower halves enclosing a bladed rotor structure and a corresponding stationary blade structure.

During assembly the inner casing halves are fitted with the stationary blades. The lower half of the inner casing is fitted into the lower outer casing half. The rotor is placed in the lower halves of the casings and the upper half of the inner casing is inverted and secured to the lower half. Finally, the upper half of the outer casing is inverted and secured to the lower half.

Presently, during assembly of a turbine, a pair of jackscrews is inserted radially inward from the outer casing to maneuver the inner casing vertically and horizontally in planes normal to the longitudinal axis of the turbine and make it concentric therewith. Once the inner casing is aligned with the longitudinal axis, a complicated and costly arrangement involving a series of key-and-screw arrangements are custom machined and fitted to support the inner casing within the outer casing.

However, an arrangement and method must still be provided to move the inner casing axially into sealing relation with the outer casing to prevent leakage of the high-pressure cooling air. There is an annular shoulder on the inner casing extending radially outward and an annular flange extending radially inward from the outer casing. The inner casing is positioned during assembly in a "backed-off" longitudinal position so that the shoulder and the flange do not come into contact as the upper half of the outer casing is lowered into position. This protects the seal surfaces from possible damage. After the outer casing is in place, the inner casing must then be shifted back, so that the shoulder and the flange are in sealing relation. Presently, this accomplished by a multiplicity of costly hydraulic cylinders which are assembled and removed through a series of handholes in the outer casing wall.

What is required then is an inexpensive arrangement and method to support the inner casing relative to the longitudinal axis of the rotor and, furthermore, a more simplified arrangement and method to move the inner casing into sealing relation with the outer casing.

SUMMARY OF THE INVENTION

The following invention relates to an elastic fluid utilizing machine and more specifically to an arrangement and method for concentrically supporting the inner casing of the machine relative to the axis of rotation of the rotor of the machine.

The machine comprises a tubular outer casing and a tubular inner casing disposed within the outer casing. The inner casing encompasses a rotating rotor structure. Hot motive gases, derived from fuel combustion, are expanded as they flow through the machine to drive the rotor structure as well known in the art.

A plurality of apertures are radially disposed in the outer casing and a plurality of corresponding key slots are disposed on the periphery of the inner casing. After the outer and inner casings are aligned concentrically relative to the axis of rotation of the rotor, a plurality of eccentric bushing structures are radially disposed in the apertures and adjusted to fit the slots to support the inner casing concentrically relative to the axis of rotation of the rotor.

This arrangement, therefore, eliminates the need for machining at the installation site, since the eccentric bushings have the flexibility to adjust to fit the slots. This gives the added advantages of minimizing installation time and therefore, a corresponding reduction in cost.

The outer casing has an annular flange extending radially inward and the inner casing has an annular shoulder extending radially outward. In operating position, the shoulder and flange are in abutment and form a seal between the inner and outer casing. To prevent damage to this sealing surface, the inner casing is disposed in a "backed-off" axial position relative to the outer casing. Therefore, when the upper half of the outer casing is lowered onto the lower half of the outer casing and firmly secured thereto, the inner casing must be moved axially into sealing relation with the outer casing.

A pair of screws which is secured externally to the outer casing and extends radially therethrough, one on each side, abuts corresponding levers mounted on the inner surface of the outer casing and is positioned axially adjacent the inner casing. The screws rotate the levers. The levers axially move the inner casing, so that the shoulder on the inner casing comes into sealing relation with the flanges on the outer casing.

The method of supporting the inner casing within the outer casing and of moving the inner casing into sealing relation with the outer casing comprises the following steps:

1. aligning the inner casing concentrically relative to the axis of rotation of the rotor;
2. positioning the inner casing in a backed-off position relative to the outer casing;
3. inserting a plurality of eccentric bushing structures radially through the apertures in the outer casing;
4. adjustably rotating the bushing structures to fit the axial slots on the inner casing;
5. and urging the inner casing into sealing relation with the outer casing.

This arrangement and method provides an inexpensive way to support the inner casing and to move the casings into sealing relation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of an axial flow gas turbine power plant having the invention incorporated therein;

FIG. 2 is an enlarged sectional view generally taken along line II—II in FIG. 1;

FIG. 3 is an enlarged view of the turbine portion of the power plant shown in FIG. 1, partially exploded and in a jacked-up distorted position;

FIG. 4 is an isometric view of a portion of the lower half of the outer and inner casings of the turbine with the rotor structure, rotary blades, and stationary blades removed; and

FIG. 5 is a plan view of an eccentric bushing structure formed in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The Apparatus

Referring to the drawings in detail, and particularly to FIG. 1, there is shown a gas turbine power plant 10 of the axial flow type having the invention embodied therein. As well known in the art, this machine includes an air compressor section 12, a fuel combustion section 14, a turbine section 16, an air inlet casing 18 and an exhaust hood 20.

The entire machine is enclosed in an outer casing structure 22 comprising an inlet casing 23, a compressor casing 24, a combustion casing 25, a turbine casing 26, and an outlet casing 27. The above casings are joined to each other and to the inlet casing 18 and exhaust hood 20 by suitable bolted peripheral external flanges and are divided into upper and lower casing halves in a horizontal plane coinciding with the central longitudinal axis of the rotor, the upper and lower casing halves being joined to each other by suitable bolted horizontal flanges, for expediency in manufacture, assembly and disassembly for service, as known in the art.

The compressor section 12 includes an inner casing 30, a compressor rotor structure 31, and corresponding alternating annular rows of stationary blades 32 and rotating blades 33 decreasing in height from left to right. The turbine section 16 includes an inner casing 34, a turbine rotor structure 35 and corresponding alternating annular rows of stationary blades 36a and rotating blades 36bincreasing in height from left to right. The stationary blades 36a as shown, are of the hollow type so that they may be air cooled. As more fully explained in A. J. Scalzo, U.S. Pat. No. 3,427,000, assigned to the present assignee, an annular chamber C is defined by the outer casing 26 and inner casing 34 for the pressurized cooling air for the hollow blades 36a.

The compressor rotor structure 31 is drivenly connected to the turbine rotor structure 34 by a connecting shaft 37, the rotor structures 31 and 34 and the shaft 25 being defined as the rotor spindle 38 and being rotatably supported by suitable bearings 38 and 39 at each end. The turbine rotor spindle 38 may be connected to an output shaft 40 for transmitting useful shaft power for driving a load (not shown).

It will be appreciated that in order to service the compressor rotor structure 31 or the turbine rotor structure 35 the corresponding upper halves of the casing structures 24 and 26 must be removed, which involves a considerable expenditure of both time and money.

Referring specifically to the turbine section 16, as best shown in FIGS. 2 and 4, the outer casing 26 is divided into upper and lower halves 26a and 26b along a central horizontal plane and joined to each other along horizontal external flanges 41 by suitable bolts 42. The outer turbine casing 26 is also provided with suitable peripheral flanges 43 for connection to the adjacent casings 25 and 27 (FIG. 1). The turbine inner casing 34 is divided into upper and lower halves 34a and 34b joined together along horizontal flanges 44 by suitable bolts 46.

The inner casing 34 is supported from the outer casing 26 by a plurality of eccentric bushing structures 52, as shown in FIGS. 2 and 4, which are radially disposed in openings in the turbine outer casing 26 and extend into axially extending key slots 54 on the periphery of the inner casing 34. As shown in FIG. 2, four of the eccentric bushing structures 52 are used to support the inner casing 34, two of which are in a vertical plane passing through the center of the rotor 35, one on the top half of the casing 34a and the other on the bottom half 34b. The other two bushing structures 52 are disposed below the horizontal centerline on the bottom half 34b and are equidistant from the vertical centerline.

In FIG. 4, for purposes of clarity, the rotor 35, rotary blades 36a, and stationary blades 36b have been removed. Three eccentric bushing structures 52 are shown, with the bushing on the bottom of the figure being partially exploded. Referring to the exploded bushing structure 52, it can be seen that the structure comprises a tubular outer member or bushing member 56 and a rod member 58 disposed in an eccentric opening in the outer member 56. The outer member 56 and the inner rod member 58 can rotate relative to each other.

On the radially inner end of the rod member 58 and integral therewith is a keyway 59 (FIGS. 4 and 5). The key slot 54 corresponds in size to receive the keyway 59, although the slot is longer in an axial direction than the keyway for reasons which will be subsequently explained.

A pair of jackscrews 61 (FIGS. 2 and 4) is located on the lower half of the turbine outer casing 26b, one on each side of the vertical centerline, disposed radially inward therefrom. The screws 61 are initially used to position the inner casing 34 concentrically relative to the axis of rotation R—R′ of the rotor.

A second pair of jackscrews 63 is disposed radially through the lower half of the outer casing 26b and is located below the horizontal centerline equidistant from the vertical centerline, as shown in FIG. 2 (only one is shown in FIG. 3). Each jackscrew 63 is in abutting relation with a lever 64 (FIG. 4). The lever 64 is mounted on the inner surface of the lower half of the outer casing 26b and is secured to a fulcrum 66 by a pin 67.

In FIG. 3, the turbine section 16 is shown in a jacked-up position with the upper half of the outer casing 26a removed. It can be seen that the inner casing 34 is comprised of a frustoconical portion 34a and a cylindrical portion 34b. Projecting radially outward from the inner casing 34 is an annular shoulder 69 separating the frustoconical and cylindrical portions. Projecting radially inward from the turbine casing 26 is an annular flange 71. The right-hand surface of shoulder 69 and the left-hand surface of flange 71 abut each other in sealing relation as best seen in FIGS. 1 and 4. Although four bushing structures 52 are shown supporting the inner casing 43, more or less can be used.

THE METHOD

In the initial method of fabrication of the turbine section 16, the lower outer casing half 26b is axially aligned with a taut wire or laser beam representing the axis of rotation of the rotor R—R′ (FIGS. 2 and 4).

The inner casing halves 34a and 34b are fitted with stationary blades 36b. The lower half of the inner casing 34b is then lowered into the lower half of the outer casing 26b and is supported on the jackscrews 61.

The upper half of the inner casing 34b is inserted so that it is then in a "backed-off" position meaning that the annular shoulder 69 and the annular flange 71 do not come into contact with each other. By moving screws 61 radially, the inner casing 34 can be moved vertically and horizontally to make it concentric with the axis of rotation R—R′.

Then, the three bottom eccentric bushings 52 are inserted into the key slots 54. Referring to FIG. 5, it can be seen that the tubular outer member 56 of bushing structure 52 can turn, moving the keyway 59 either to the right or the left, as shown by the dash-dot lines. The keyway 59 is kept aligned with the key slot 54 as the outer member 56 rotates around the rod member 58. By moving the keyway 59, the axial position of the keyway is changed, requiring the key slot 54 to be axially longer. This provides the versatility needed to easily line up the inner casing 34, properly position it relative to the axis of rotation R—R′, and to support the inner casing.

After the bushing structures 52 are in the corresponding slots 54, the rod member 58 and tubular outer member 56 are securely fastened together by any suitable means such as by welding (not shown).

The bushing structures 52 are then secured to the outer casing 26 by any suitable means.

As previously mentioned, the upper half of the inner casing 34a (FIG. 3) is lowered onto the lower half 34b in a backed-off position. Jackscrews 63 are turned, causing levers 64 to rotate and come into frictional abutment with shoulder 69 of the inner casing 34 (FIGS. 2 and 4). The levers 64 move the inner casing 34 axially, easing the shoulder 69 into sealing relation with flange 71. In this manner, the sealing surfaces are not damaged. Jackscrews 61 and 63 are then unscrewed.

When it becomes necessary to service the turbine rotor structure 34 (FIG. 3), a jacking device 73 is placed between ground and the lower half of the outer casing 26b, about midway between the flanges 43, although two jacks can be used, one being placed under each of the flanges 43.

Raising the jack 73 causes a slight bowing in the upward direction causing small axial clearances indicated by letter C between peripheral flanges 43 in the upper half of the turbine casing 26a (the bottom half still being bolted). The bowing will also cause a slight clearance space *d* between the flanges 69 and 71. This clearance *d* protects the mating seal surfaces on flanges 69 and 70 from damage when the upper turbine casing 26a is either lifted off of the bottom half of casing 26b or when it is replaced.

After the upper half of the turbine casing 26ais lowered back into position and fastened to the bottom half 26b, jackscrews 61 are turned, rotating levers 64 to move the inner casing 34, so that flanges 69 and 71 are in sealing relation.

What is shown then is an arrangement and method for supporting the inner casing structure **34** within the outer casing **26** comprising a plurality of eccentric bushing structures **52** which adjustably fit key slots on the periphery of the inner casing **34**. An arrangement and method comprising jackscrews **61** and levers **64** are provided to allow the inner casing **34** to be inserted in a backoff position and then to move the inner casing into sealing relation with the outer casing. The apparatus shown is only illustrative and the method is not dependent on the use of the apparatus,

What is claimed is:

1. A rotary machine comprising
   a tubular outer casing structure,
   a tubular inner casing structure disposed within said outer casing structure,
   a plurality of radial apertures annularly disposed in said outer casing structure,
   a plurality of slots on said inner casing structure,
   and a corresponding number of eccentric bushing structures inserted in said apertures and adjustably inserted in said slots to support said inner casing structure relative to said outer casing structure.

2. The structure according to claim **1** and further including an annular shoulder extending radially outward from the inner casing and an annular flange extending radially inward from the outer casing which cooperate to abut each other and form a sealing relation.

3. The structure according to claim **2** and further including means to move the shoulder on the inner casing structure into sealing relation with the flange on the outer casing structure.

4. The structure according to claim **3** wherein the moving means comprise
   at least one screw secured to the outer casing structure and projecting radially therethrough,
   at least one lever secured to the inside surface of the outer casing structure and being in abutment with said screw, and
   said lever being positioned axially adjacent by the inner casing structure so that when said lever is actuated by said screw, said lever will abut the shoulder on the inner casing structure and move the structure axially into sealing relation with the flange on the outer casing structure.

5. The structure according to claim **1** wherein each of the eccentric bushing structures comprise
   a tubular outer member having an eccentric opening therein,
   a rod member disposed within said opening,
   said outer and rod members being rotatable relative to one another enabling said rod member to move into a position to be inserted into the corresponding slot on the inner casing structure.

6. The structure according to claim **5** wherein the rod member has on one end a keyway and the slot on the inner casing has a shape corresponding to the shape of said keyway.

7. The structure according to claim **5** wherein the rod member is disposed in the slot and the outer member and the rod member are secured together by fastening means.

8. The structure according to claim **1** and further including an annular shoulder extending radially outward from the inner casing,
   an annular flange extending radially inward from the outer casing,
   screw means secured to the outer casing structure and projecting radially therethrough,
   lever means secured to the inside surface of the outer casing structure and in abutment with said screw means,
   said lever means being axially adjacent the shoulder of the inner casing and said lever means being adjusted by said screw means so that said shoulder of the inner casing is in sealing relation with said annular flange of the outer casing.

9. The structure according to claim **8** wherein each of the eccentric bushing structures comprises
   a tubular outer member having an eccentric opening therein,
   a rod member rotatably inserted within said openings,
   a keyway on the radially inner end of the rod member,
   a corresponding axial key slot on the periphery of the inner casing,
   said keyway being insertable in said key slot to support the inner casing relative to the outer casing,
   fastening means to secure each of said outer members and said rod members together.

10. A method of supporting an inner casing of a rotary body within an outer casing of a rotary body comprising steps of:
   a. aligning the inner casing concentrically relative to the outer casing and the axis of rotation of the rotary body;
   b. inserting a plurality of eccentric bushing structures each having an outer member and inner rod member, in apertures in the outer casing;
   c. adjustably rotating each outer and inner member to align the inner member with slots on the inner casing; and
   d. securing the bushing structure to the outer casing to support the inner casing.

11. The method recited in claim **10** and further including the step of activating external moving means to rotate internal moving means, and thereby urging the inner casing into sealing relation with the outer casing after the step of securing the bushings to the outer casing.

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