United States Patent

Burge

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[54] **ACTUATION RING FOR VARIABLE GEOMETRY COMPRESSORS OR GAS TURBINE ENGINES**

[72] Inventor: **Joseph C. Burge**, Cincinnati, Ohio

[73] Assignee: **General Electric Company**

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[52] **U.S. Cl.** **415/147,** 415/149, 415/160

[51] **Int. Cl.** **F04d 27/00,** F04d 15/00

[58] **Field of Search**.......415/147, 148, 149, 150, 160

[56] **References Cited**

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Primary Examiner—Henry F. Raduazo
Attorney—Derek P. Lawrence, Frank L. Neuhauser, Oscar B. Waddell, Joseph B. Forman and Edward S. Roman

[57] **ABSTRACT**

An improved actuation ring for controlling the angular position of compressor vanes connected by levers thereto is described. Two arcuate sectors of less than 180° angular extent are joined by bridge members. Each connection between a sector and a bridge member includes a dowel bushing, a bolt extending through the bushing with a loose fit therebetween with a nut threaded onto its inner end and a second bolt extending through the sector and bridge member with a loose fit therebetween and a nut threaded onto its inner end.

4 Claims, 4 Drawing Figures

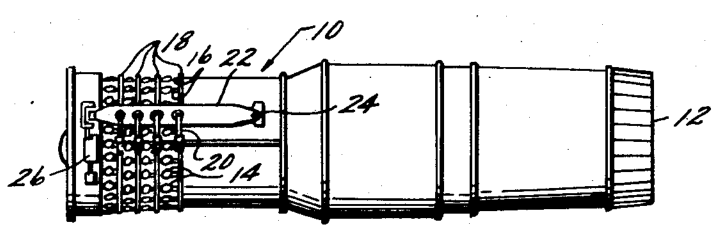


FIG 1

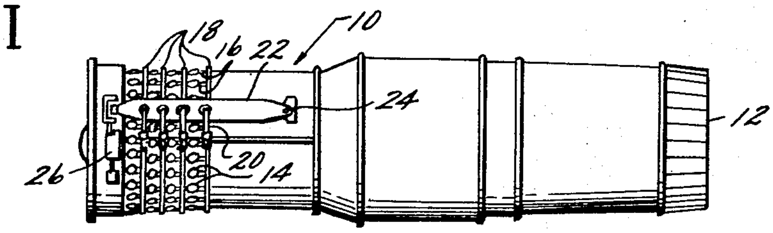


FIG 2

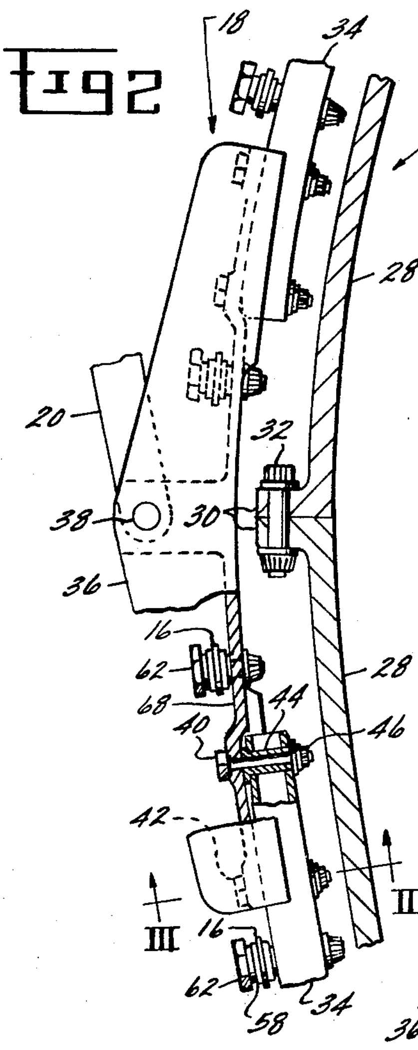


FIG 3

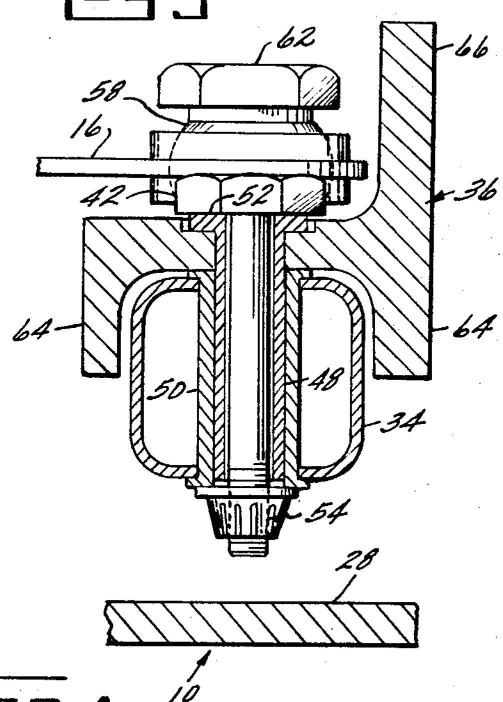
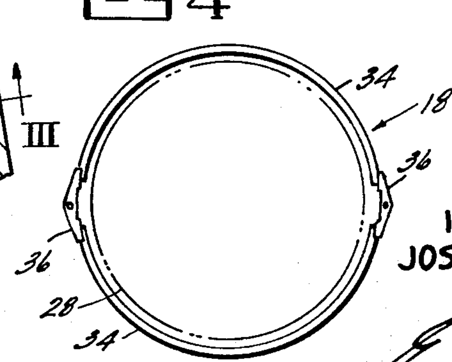


FIG 4



INVENTOR.
JOSEPH C. BURGE

ATTORNEY-

ACTUATION RING FOR VARIABLE GEOMETRY COMPRESSORS OR GAS TURBINE ENGINES

The invention described and claimed in the U.S. patent application herein resulted from work done under U.S. Government contract FA–SS–67–7. The U.S. Government has an irrevocable, non-exclusive license under said application to practice and have practiced the invention claimed herein, including the unlimited right to sublicense others to practice and have practiced the claimed invention for any purpose whatsoever.

The present invention relates to axial flow compressors as used in gas turbine engines and, more particularly, to improvements in actuation rings employed in varying the angular position of the vanes of such compressors.

Axial flow compressors generally comprise alternate circumferential rows of rotor blades and casing-mounted vanes. These blades and vanes are oriented radially of the rotor axis. The aerodynamic shapes of these blades and vanes are idealized for operation at a given set of parameters representing the most important operating condition of the compressor or gas turbine engine in which it is incorporated. At other operating conditions, such as at a lesser rotor speed, the design point aerodynamics are inefficient to the point where the compressor may actually "stall" and no longer pressurize air.

One widely accepted solution to this problem is to vary the aerodynamics of a compressor by pivoting its vanes about axes radial to the rotor axis. Such a compressor is known as a variable geometry compressor. Many mechanisms have been proposed and utilized for this function, many of which involve the provision of levers projecting from shafts connected to the vanes. The levers of a row of vanes are connected to an actuation ring encircling the compressor casing. This actuation ring is then oscillated to simultaneously adjust the vanes of a given row to a desired angular position.

In order to assemble and disassemble the compressor, it is essentially, if not absolutely, necessary that such actuation rings be compositely formed.

While there have been many acceptable actuation rings, problems recur in obtaining proper angular positioning of their individual components and at the same time providing ease of assembly and disassembly. The latter problem is further complicated by the usual requirement that the actuation ring be closely spaced from the compressor casing to minimize weight and engine envelope. This, plus the large number of vane levers, makes it particularly difficult to fasten and remove the bolts and nuts employed in connecting the actuation ring assembly components.

Accordingly, the object of the invention is to provide an improved actuation ring assembly which has accurate angular positioning of its component parts and which permits easy assembly and disassembly while maintaining other requirements, such as minimum weight and small envelope size.

These ends are attained by an actuation ring assembly, comprising at least two sectors, to which vane levers are to be attached. These sectors have an angular extent of less than 180° and are joined by bridge members to form a complete ring. The bridge members overlie and are fastened to adjacent end portions of the sectors. The connection between each bridge member and sector end portion comprises two bolts and a dowel bushing. The dowel bushing extends through accurately aligned, radial holes in the bridge member and sector with a tight fit to obtain precise angular positioning. One bolt extends through the dowel bushing with a loose fit permitting it to be readily threaded into or out of a nut on the inner surface of the sector. The other nut extends through aligned, radial holes in the bridge member and sector with a loose fit so that it may also be threaded into a nut on the inner surface of the sector. With the loose fits of the bolts, the nuts may be simply held against rotation as the bolts are turned to clamp or unclamp the assembly.

The above and other related objects and features of the invention will be apparent from a reading of the following description of the disclosure found in the accompanying drawing and the novelty thereof pointed out in the appended claims.

In the drawing:

FIG. 1 is a schematic representation of a gas turbine engine in which the present invention is embodied;

FIG. 2 is a cross-sectional view, on an enlarged scale, of a portion of the compressor casing and actuator ring seen in FIG. 1;

FIG. 3 is a section, on a further enlarged scale, taken on line III—III in FIG. 2; and

FIG. 4 is a smaller scale view of an actuation ring assembly.

FIG. 1 is a simplified external view of a gas turbine engine. Within a compositely formed, outer casing **10** there are, in series flow arrangement, a compressor, a combustor and a turbine which generate a high energy motive fluid stream. A portion of the energy of this motive fluid stream drives the turbine which, in turn, powers the rotor of the compressor, all in known fashion. The remainder of the energy in the motive fluid stream may be converted to a propulsive force by being discharged from a nozzle **12**. on the opposite side of the casing **10** to balance the forces transmitted into the actuation rings.

The compressor of this engine is of the axial flow, multistage type comprising alternate, circumferential rows of rotor blades and stationary stator vanes. Some or all of the rows of the stator vanes are pivotally adjustable about axes radial of the rotor axis. Such adjustment to provide improved compressor performance during off-design point operation is well known. In an adjustable vane row, the individual vanes are journaled on the casing **10** with stub shafts **14** projecting therethrough. Levers **16** extend from the stub shafts of each adjustable vane row to an actuation ring **18** for that vane row. To simultaneously pivot all of the adjustable vanes, the actuation rings are respectively connected by links **20** to an arm **22** which is pivotally mounted on the casing **10** at **24**. The opposite end of the arm **22** is connected to an actuator **26** which is controlled by known means to pivot the arm **22** and thus vary the angular positions of the adjustable vanes. A similar arm and actuator may be provided ON THE OPPOSITE SIDE OF THE CASING -) TO BALANCE THE FORCES TRANSMITTED INTO THE ACTUATION RINGS. The referenced actuation system is described in greater detail in U.S. Pat. No. 3,314,595. Also, it is to be noted that other mechanisms are available for rotating such actuation rings.

Within the described environment, FIGS. 2, 3 and 4 illustrate the present invention. The compressor portion of the casing 10 comprises two semicylindrical shells 28 which have longitudinal flanges 30, joined by bolts 32. Each actuation ring comprises two sectors 34 of hollow, square cross section and an angular extent of somewhat less than 180°. Each pair of sectors is joined by bridges 36 to which the links 20 are pivotally attached at 38. Each end of each sector 34 is respectively connected to each of the bridges 36 by bolts 40 and 42. Each bolt 40 extends through a hole in the bridge 36, through a tube 44 which is swaged at its opposite ends to the walls of the tubular sector 34 and then is threaded into a nut 46 to clamp the bridge firmly to the sector 34. There is sufficient clearance between the body of bolt 40 and the bridge and tube 44 for the bolt to be turned freely while the nut 46 is held against rotation as the bolt is torqued for firm clamping action. Each bolt 42 extends through a dowel bushing 48. The dowel bushing (FIG. 3) extends through a hole in the bridge 36 and through a tube 50, also swaged, at its opposite ends to the sector 34. The dowel bushing has a flanged head 52 at its outer end and terminates short of the inner end of the tube 50. A nut 54 is threaded onto the bolt 42 and also firmly clamps the bridge to the sector 34. A loose fit is provided between the body of the bolt 42 and the dowel bushing 48 so that this bolt may also be turned freely while the nut 54 is held against rotation by a wrench as the bolt is torqued for firm clamping action.

With the described actuation ring assembly, accurate arcuate positioning of the sectors is obtained by the dowel bushings 48. The holes therefor may be accurately premachined to provide an extremely close or tight fit with the outer diameter of the bushing or even an interference fit. Alternately, a matched assembly may be prepared by positioning the sectors and bridges on a fixture and line-reaming the holes for the dowel bushings. In the assembly operation, the dowel bushing 48 and bolts 42 would preferably be first assembled and the nuts 54 tightened by rotation of the bolts 42. The bolts 40 would then be inserted and threaded into the nuts 46. All of the bolts 40 and 42 turn freely so that assembly is greatly facilitated by simply holding the nuts 46 and 54 against rotation in the crowded work area of the exterior of the compressor casing.

THe crowded nature of this work area is further illustrated in FIGS. 2 and 3 which show vane levers 16 secured to the actuation ring. The levers 16 may be attached, as taught in U.S. Pat. No. 3,502,260 of common assignment with the present application. This connection comprises a spherical journal 58 secured to the sectors 34 by bolts 60. The vanes of the compressor are so closely spaced that they must also connect with the bridges 36. Thus, spherical journals 58 are secured thereto by shorter bolts 62 for other levers 16 to connect therewith.

The bridge 36 preferably has inner legs 64 embracing the end portions of the sectors 34 and an outwardly projecting flange 66 on the side opposite that to which the levers extend. Further, the base portion 68, which engages the outer surfaces of the sectors 34, has an intermediate portion with an outer surface formed on the same radius as the outer surfaces of the sectors 34. This permits the use of identical levers and journals for all vanes of the stator row.

Having thus described the invention, what is claimed as novel and desired to be secured by Letters Patent of the United States is:

1. In an axial flow compressor having
an outer casing
a circumferential row of vane shafts projecting from the casing and
levers projecting from these shafts
an actuation ring to which the outer ends of the levers are connected,
said actuation ring comprising
at least two sectors of less than 180° angular extent
bridge members interconnecting said sectors to form a 360° structure encircling the casing,
said bridge members spanning and overlying, respectively, adjacent end portions of said sectors,
each overlying bridge portion being secured to and positioned relative to the respective end portion of the sector by
a dowel bushing projecting radially through said bridge member and sector with a tight fit therebetween to accurately position said bridge member and sector in an angular sense,
a first bolt extending through said bushing with a loose fit
a first nut threaded onto the inner end of said first bolt
a second bolt, angularly offset from the first bolt and extending through aligned radial holes in said bridge member and sector with a loose fit and
a second nut threaded onto the inner end of said second bolt.

2. A combination as in claim 1 wherein there are
two sectors of somewhat less then 180° and
the dowel bushings are at the outer ends of the bridge members and
the second bolts are inwardly, from the first bolts.

3. A combination as in claim 2 wherein
the dowel bushings have flanged heads at their outer ends bearing against the bridge members.

4. A combination as in claim 3 wherein
portions of the bridge members, intermediate the sectors, have outer surfaces formed on the same radius as the outer surfaces of the sectors and
vane levers are connected to these intermediate bridge portions.

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