April 19, 1960 G. NEUMANN 2,933,234

COMPRESSOR STATOR ASSEMBLY

Filed Dec. 28, 1954 2 Sheets-Sheet 1

Fig 1

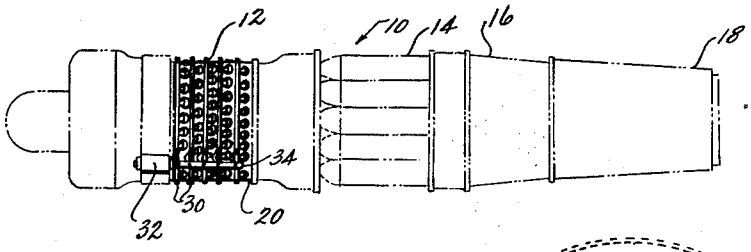
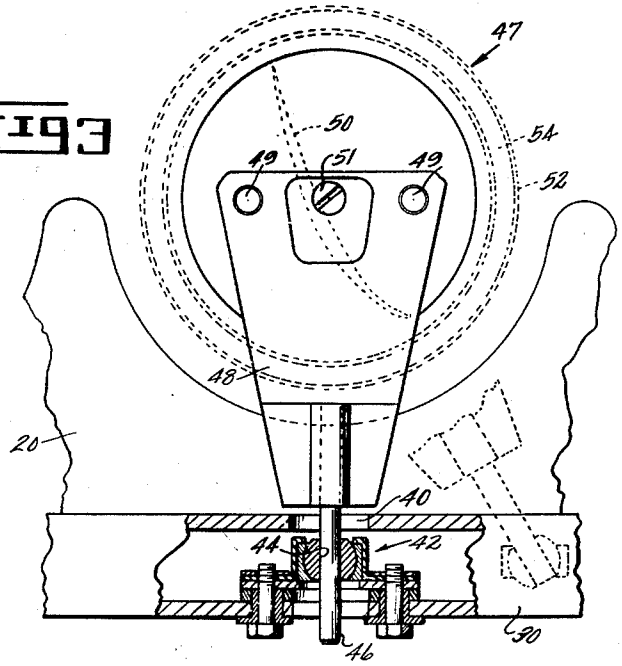


Fig 3



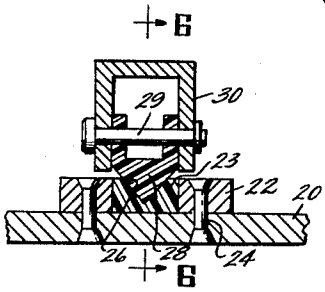


Fig 5

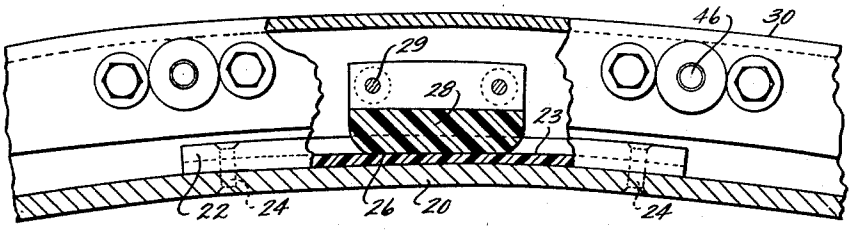


Fig 6

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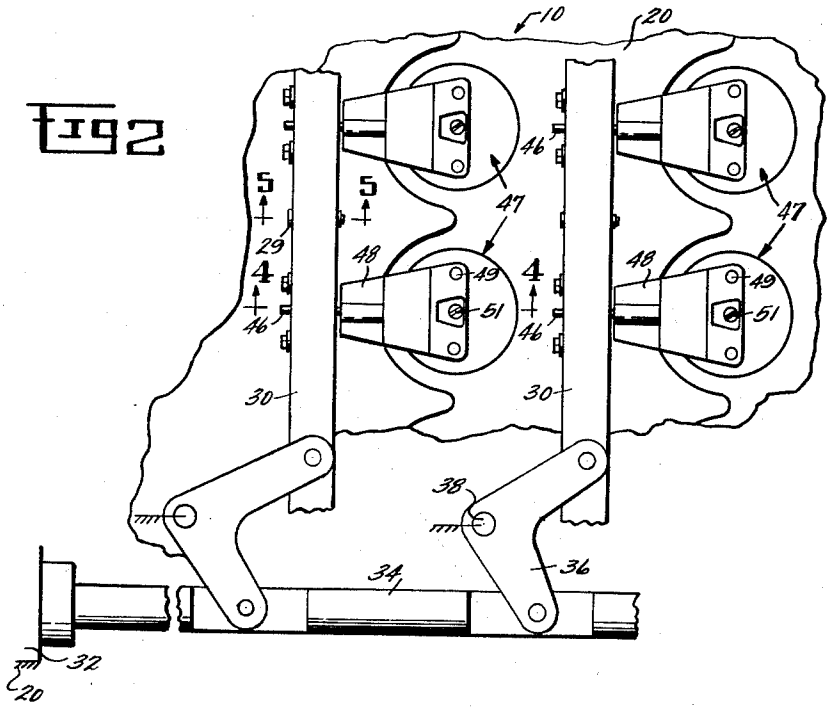
April 19, 1960 G. NEUMANN 2,933,234

COMPRESSOR STATOR ASSEMBLY

Filed Dec. 28, 1954 2 Sheets-Sheet 2

Fig 2



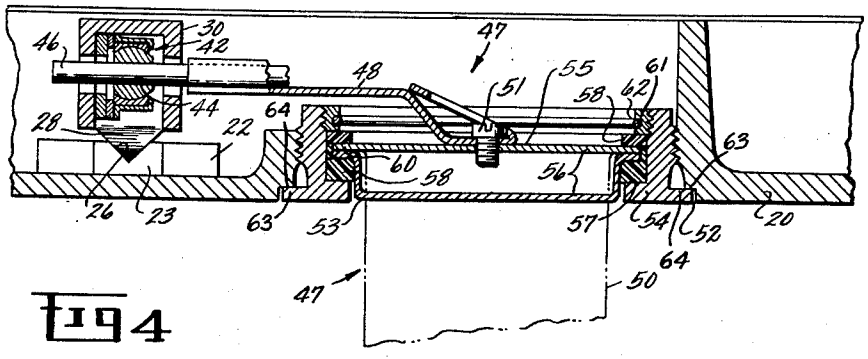


Fig 4

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2,933,234

COMPRESSOR STATOR ASSEMBLY

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Application December 28, 1954, Serial No. 478,100

6 Claims. (Cl. 230—114)

This invention relates to stator vanes in a compressor for a gas turbine engine or the like, and, in particular, to a means for varying the position of the stator vanes in the compressor.

Wherever high pressure ratio compressors of the axial flow type are used, aerodynamic stall conditions exist at some period when going from zero speed to maximum speed. It has been found that the higher the pressure ratio, the more pronounced the stall conditions become. This stall condition exists as a result of the flow failing to match the aerodynamic design of the blading itself. In other words, the angle of attack is too high. Therefore, in order to correct for these stall conditions, the positions of the stator vanes are varied by changing the angle of attack to meet the flow conditions over a wide range of operating conditions.

It is well known that stator vanes are attached to the compressor casing at one end thereof, and, therefore act as cantilever beams. These stator vanes are subjected to extremely heavy loads and vibratory forces. It is, therefore, an object of this invention to provide a wide base support that is capable of maintaining a stator vane in a firm condition and still be easily rotatable. For this invention, a wide base support or shoulder is intended to cover a base which is relatively large in diameter with respect to the chord of the vane.

The compressor casing is often made of a relatively thin construction to hold its outside diameter to a minimum. In order to provide a support for the vanes the casing must be built up, thereby increasing the weight of the engine and reducing the advantages of the variable stator vane engine. Accordingly, it is a further object of this invention to make a light weight, shallow support that is capable of maintaining the blade in a firm condition without affecting its rotatability.

In order to make the stator blades of a compressor variable, the bases of the blades are actuated by levers which in turn are actuated by a circumferential band extending about the circumference of the compressor. Since the levers pivot in a plane tangential to the circumference of the actuator band, a problem arises as to how to connect the actuator band to the levers. It is therefore a specific object of this invention to provide a connection between the actuator band and levers which will permit them to turn in different planes, with the actuator band being constrained in an axial direction.

One of the most sought for features in a jet engine is lightness of parts. It is therefore another specific object of this invention to provide fabricated lightweight levers and bases for the stator vanes with a runner mounted on the actuator bands and a sector on the compressor casing provided with anti-friction material to support the runner and for supporting the levers so as to maintain the vibratory forces at a minimum.

It is a more specific object of this invention to provide the compressor of a jet engine with a variable stator mechanism by having the base of the stator vanes rotatable in a flat bearing in the compressor casing, the base of the blades being fabricated for lightness. Fabricated lever arms are connected to the bases of the blades so as to be rotatable therewith, the levers being pivotally connected to actuator bands through a ball and socket joint, the levers having rod ends slidably positioned in the ball. The actuator bands are supported on the casing and constrained axially and actuated by hydaulically actuated bellcranks having their fulcrums on the casing.

It is a still more specific object of this invention to provide a lightweight variable stator blade assembly and lightweight lever for actuating the blade, the blade being fabricated so as to have a flat base and the lever being fabricated in a manner so as to be fixed to the fabricated base and carried by an actuator band, the blade assembly having a portion fixed to the casing and the blade having a portion rotatable with respect to the casing.

These and other objects will become more apparent when read in the light of the accompanying drawings and specification wherein like parts have the same numbers and wherein the terms used for the individual parts are intended to be as generic in their application as the prior art will permit, and wherein:

Figure 1 shows generally a gas turbine engine in which a variable stator vane construction is employed;

Figure 2 is a fragmentary plan view showing actuating means for moving the actuating ring and brackets for rotating the vanes;

Figure 3 is a plan view, partly in section, showing the ball and socket joint;

Figure 4 is a cross-sectional view taken on lines 4—4 of Figure 2;

Figure 5 is a cross-sectional view taken on lines 5—5 of Figure 2 showing the ring supporting means;

Figure 6 is a cross-sectional view taken on lines 6—6 of Figure 5.

Referring to the drawings, and in particular to Figures 1–4, the numeral 10 generally designates a gas turbine engine provided with a compressor section 12, combustor section 14, turbine section 16, and an exhaust nozzle section 18. A compressor casing 20 is provided with a plurality of stator vanes rotatably mounted in the casing as will hereinafter be described. Attached to the compressor casing 20 by rivets or the like 24 are a plurality of sectors 22. The sectors 22 are spaced circumferentially about the compressor casing 20. Fixedly mounted in each sector 22 is a grooved member 23 made of a bearing material, such as Teflon which is well known in the art and well adapted for this purpose since it has good heat resistant and lubrication properties. A V-shaped runner 28 made of similar bearing material is adapted to slide in the corresponding groove 26 in the member 23. This runner 28 is mounted in an actuator band 30 by means of pins 29.

The actuator band 30, of which there is one for each stage of stator vanes, is adapted to be moved in either direction by a hydraulic piston and cylinder arrangement 32 fixed to the compressor casing 20. Fixed to the piston of this cylinder is a longitudinally extending bellcrank rod 34 which carries a plurality of bellcranks 36 pivotally mounted on the bellcrank rod 34. The bellcranks are fixed at their fulcrum to the compressor casing as shown at 38 equi-distant from the bellcrank rod 34. The bellcranks 36 are pivotally connected to the actuator bands 30 but the arms of the bellcranks are at varying distances for each stage, as is readily apparent by referring to Figure 2, according to a predetermined schedule. The actuator bands 30 are provided with openings 40 which extend through the sides thereof for the purpose which will be hereinafter explained. The actuator band 30, being of inverted U-shape is provided with a ball and socket arrangement

as shown at 42. The ball contains an opening 44 therethrough for receiving a rod 46 which is fixedly attached to a lever arm or bracket 48. The bracket 48 is attached to the compresser blade assembly 47 and blade 50 by dowel pins 49 and screw 51 so as to rotate the blade.

The compressor casing 20 is provided with a plurality of openings 52 for receiving the compressor blade assembly 47. Fixed to the openings in the compressor casing 20 is a sleeve 54 that may be either threaded or press fitted into the opening 52. The compressor blade 50 is welded or brazed to the base or support 56. The base 56 is fabricated for lightness as shown in Figure 4. The base is formed by a cup-shaped member 53 with a cover 55 also welded or brazed thereto. The cup-shaped member 53 and cover 55 form a flat shoulder 60. The sleeve 54 has a flat bearing seat 57. The base or support 56 is mounted in a flat bearing 58 of anti-friction material, such as Teflon. This material completely surrounds the base 56 above and below the shoulder 60. The bearing is held in place by a lock ring 62 fixed in the sleeve 54. Therefore the flat shoulder or seat 60 is embedded between two flat sheets of bearing material 58 and one cylindrical along the side of the flat shoulder, which bearing material is held between the abutments formed by the lock ring 62 and the seat 57. It is noted that the three portions of bearing material can be made integral in the form of a U-shaped ring.

The leakage of any of the motive fluid from the compressor will decrease the efficiency and result in poor performance of the engine. Therefore, a close fit is maintained between the blade assembly and compressor casing by providing a flat bearing seat 63 surrounding the opening 52 and a mating flat bearing seat 64 on the fixed sleeve 54. It is noted that this arrangement provides for ease of assembly of the blade assembly in the compressor cassing. Also, the Teflon surrounding the shoulder 60 on the wide base 56 also acts as a seal to prevent leakage from the compressor.

In order to operate the stator vanes the piston and cylinder arrangement 32 is operated so as to move the bellcrank rod 34 which in turn operates the bellcranks 36. Since the throw of the bell cranks for each stage is different, the actuator bands 30 are moved by a different pre-determined amount. Movement of the actuator band 30 results in the movement of the lever arms 48. It is noted that the rod 46 is slidably mounted in the ball and socket arrangement 42 to permit the turning of the bracket 48 without twisting even though the actuator band 30 and levers 48 turn in different planes. Since the bracket 48 is fixed to the root of the blade 50 through the dowel pins 49 and screw 51, the blade 50 will turn a pre-determined amount. Further, since the lever arms 48 are of lightweight material, they are too flexible to operate without a support on their outer ends. Therefore, the actuator bands 30 support the lever arms at the rod portions 46 by having the actuator bands slide on sectors 22 fixed to the casing 20. In this manner the operating parts are well supported so as to eliminate the destruction of the parts by the large vibratory forces generally found in jet engines.

Therefore, a variable stator mechanism is provided which can be constructed of lightweight material, in which the base of the blades are fabricated so as to have a flat base. The compressor casing is provided with a flat bearing surface in which flat bearing material is used for carrying the base. This provides a bearing having good sealing and lubricating properties as well as temperature qualities. Further, the connection between the lever arms and actuator band is such that they can move in different planes. Also, sections of runners are provided on the casing for carrying the actuator bands which support the lever arms.

It is apparent that the above description has been given by way of explanation and not by way of limitation and that many modifications, improvements and changes may be made to the above structures without departing from the spirit and intent of this invention. All of such modifications and improvements are intended to be included within the scope of this invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a compressor for a turbomachine comprising a casing, at least one stage of stator vanes rotatably mounted in the casing, lever arms fixed to the base of said stator vanes so as to turn therewith, an actuator band slidably mounted on said casing adjacent each stage of rotatable stator vanes, ball and socket arrange- means in said actuator bands openings in the ball portions, said lever arms having rod ends extending axially of the arms through the openings in said ball portions, the actuator bands having a runner and the casing having a sector thereon for supporting the runner and actuator bands, anti-friction material on the runner and sector constraining the actuator band in an axial direction while permitting the band to be actuated in a circumferential direction, and means for actuating the bands.

2. In a compressor for a turbomachine comprising a casing, at least one stage of stator vanes rotatably mounted in the casing, the bases of said stator vanes each having a rotatable portion with a flat bearing surface, sleeves mounted in said casing for receiving said bases, each sleeve having a flat bearing seat surface, a layer of anti-friction material positioned between the seat surface and the flat bearing surface of the associated blade, lever arms fastened to the rotatable portion of the bases to as to turn therewith, actuator bands extending about the casing, balls rotatably mounted in the actuator bands, the lever arms having rod ends thereon extending through the balls, said bands being actuated so as to turn said stator vanes.

3. In a turbomachine, a casing, openings in the casing, a blade assembly fixed in each opening, the blade assembly including a sleeve having a fixed seat and a removable seat, a blade provided with a base having a flat shoulder which is located between the seats, and flat bearing material positioned between each seat and the flat shoulder to permit the blade to rotate with respect to the sleeve, and means for simultaneously rotating the blades.

4. In a turbomachine, a casing, openings in the casing, a blade assembly fixed in each opening, said blade assembly including a sleeve having a fixed seat and a removable seat, a blade provided with a base having a flat shoulder which is located between the seats, and flat bearing material positioned between each seat and the flat shoulder to permit the blade to rotate with respect to the sleeve, a lever arm fixed to each blade base so as to rotate therewith, actuator bands slidably mounted on the casing, ball and socket joints in the actuator bands, said actuator bands being connected to the lever arms through the ball and socket joint to permit the band to rotate in an arc of a circle and the lever arm to rotate in a plane tangent to the arc of the circle.

5. In a compressor for a gas turbine engine, comprising a casing, openings in the casing, bearing seats in said casing each surrounding an opening therein, a plurality of stator vanes mounted on said seats and extending through said openings, the openings containing a removable seat spaced from the seat in the casing, the base of each of the vanes forming a substantially wide shoulder, flat bearing material positioned between the spaced seats and wide shoulder on the base of each of the vanes, lever arms fixed to the stator vanes so as to rotate therewith, the lever arms being sufficiently light so as to be flexible, band actuators slidably mounted on the casing, said band actuators carrying the lever arms, means on the band actuators to permit movement of the lever arms without twisting, and means for actuating the bands.

6. In a compressor for a gas turbine engine comprising a casing, a plurality of openings in the casing, spaced bearing seats in each opening, a plurality of stator vanes each having a substantially wide shoulder, the wide shoulder being positioned between the bearing seats, flat bearing material interposed between and bearing against the seats and the wide shoulder, lever arms fixed to the vanes, actuator bands slidably mounted on the casing, ball and socket joints mounted in the actuator bands, the actuator bands being connected to the lever arms through the ball and socket joints to permit the actuator bands and lever arms to move in different planes.

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CERTIFICATE OF CORRECTION

Patent No. 2,933,234 April 19, 1960

Gerhard Neumann

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, lines 13 and 14, for "arrangemeans" read -- arrangements --.

Signed and sealed this 29th day of November 1960.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents