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Gardiner

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[54] **BLADED ROTORS**

[75] Inventor: **Terence Edward Gouvenot Gardiner,** Bristol, England

[73] Assignee: **Secretary of State for Defense in Her Britannic Majesty's Government of the United Kingdom of Great Britain and Northern Ireland, London, England**

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[52] **U.S. Cl.** **416/220,** 416/193

[51] **Int. Cl.** **F01d 5/30**

[58] **Field of Search** 416/193, 219, 221, 416/174

[56] **References Cited**

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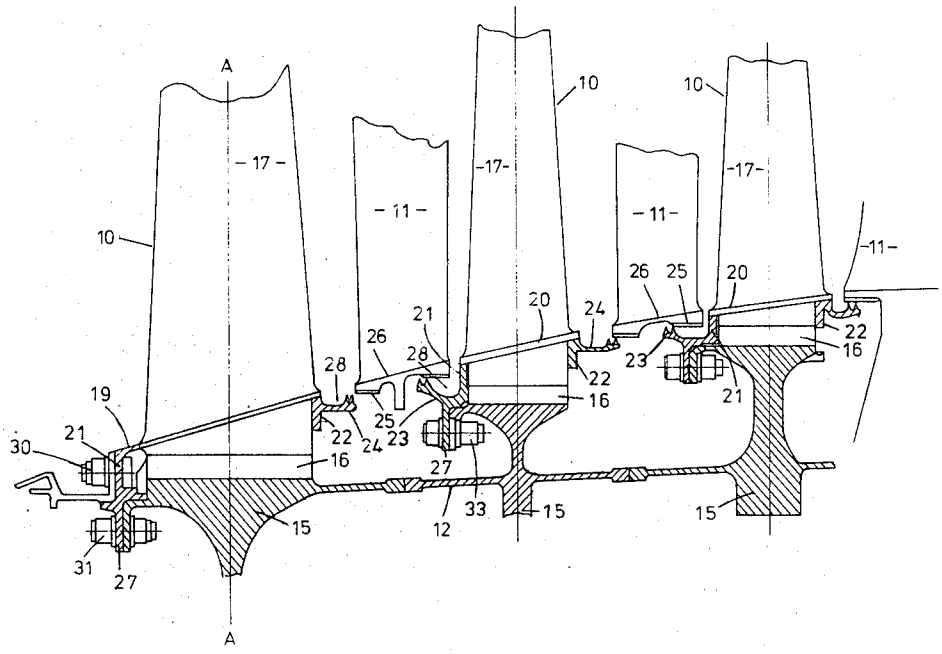
Primary Examiner—Everette A. Powell, Jr.

Attorney—Richard K. Stevens et al.

[57] **ABSTRACT**

A bladed rotor for a gas turbine engine comprises a ring of blades mounted on a disc. The platforms for the blades are provided on a separate platform ring which has axially extending sealing rings at the axial ends to form seals with adjacent stator rings. Additional features are that additional radial flanges can be provided at the axial ends of the platform ring to act as sealing plates and locking tabs.

8 Claims, 5 Drawing Figures



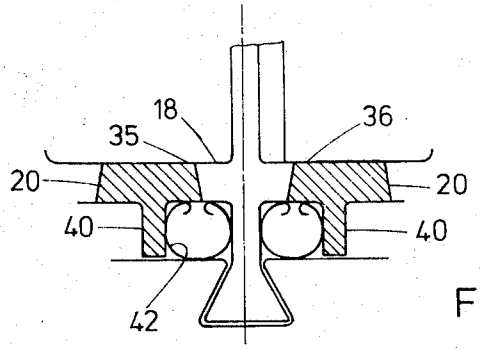


FIG. 4

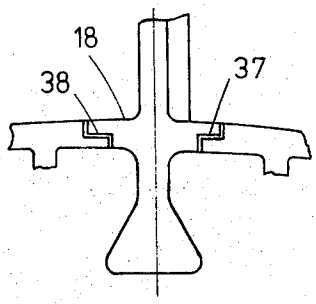


FIG. 5

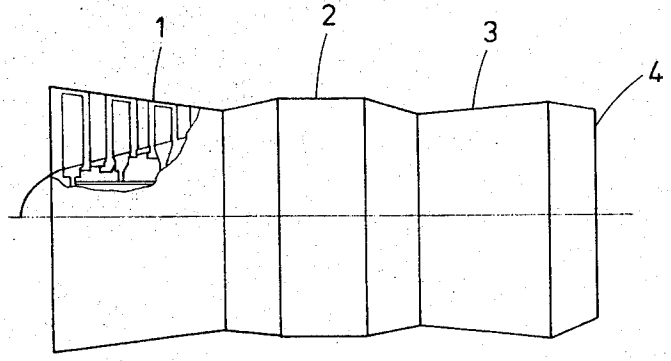


FIG. 1

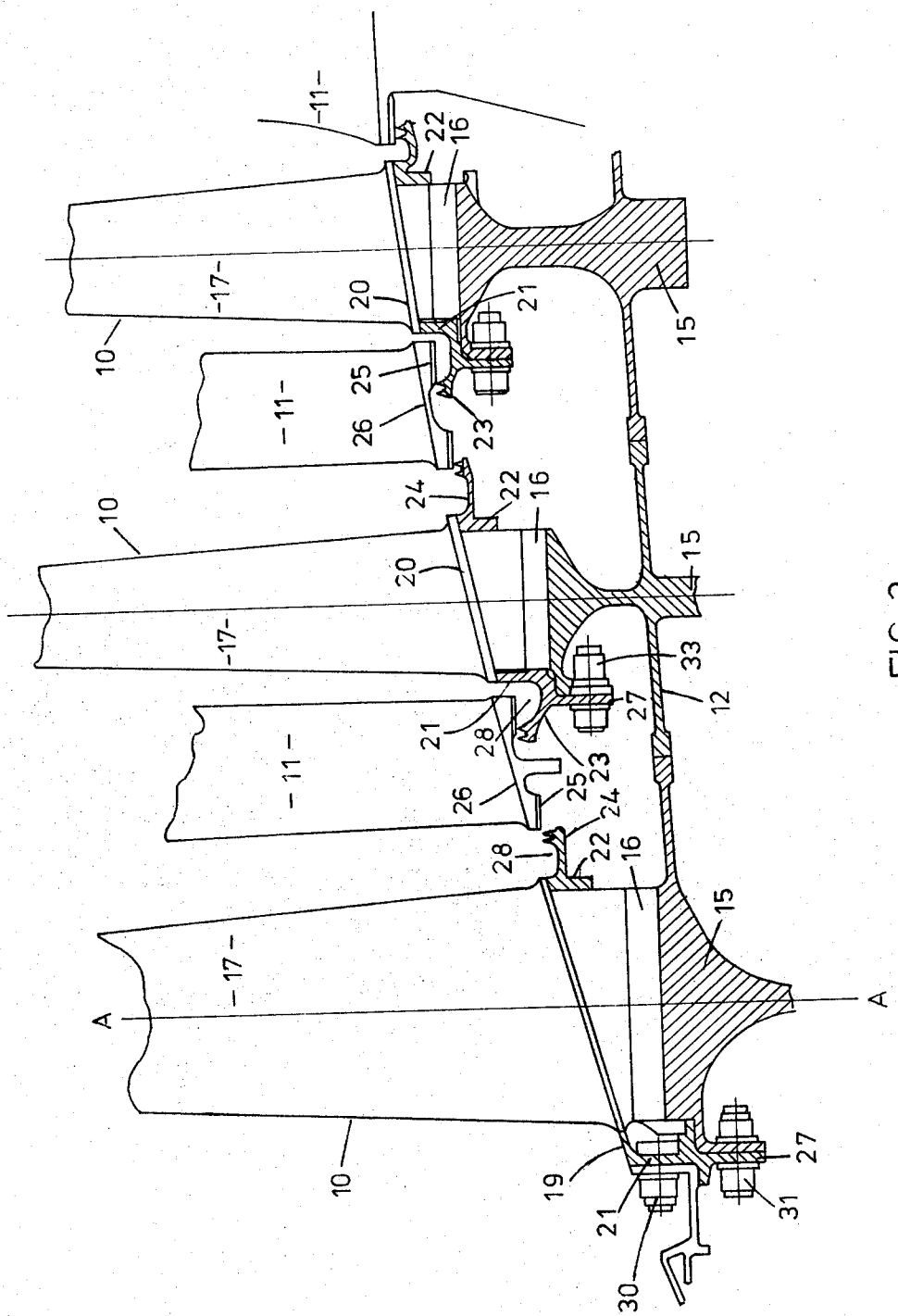


FIG. 2

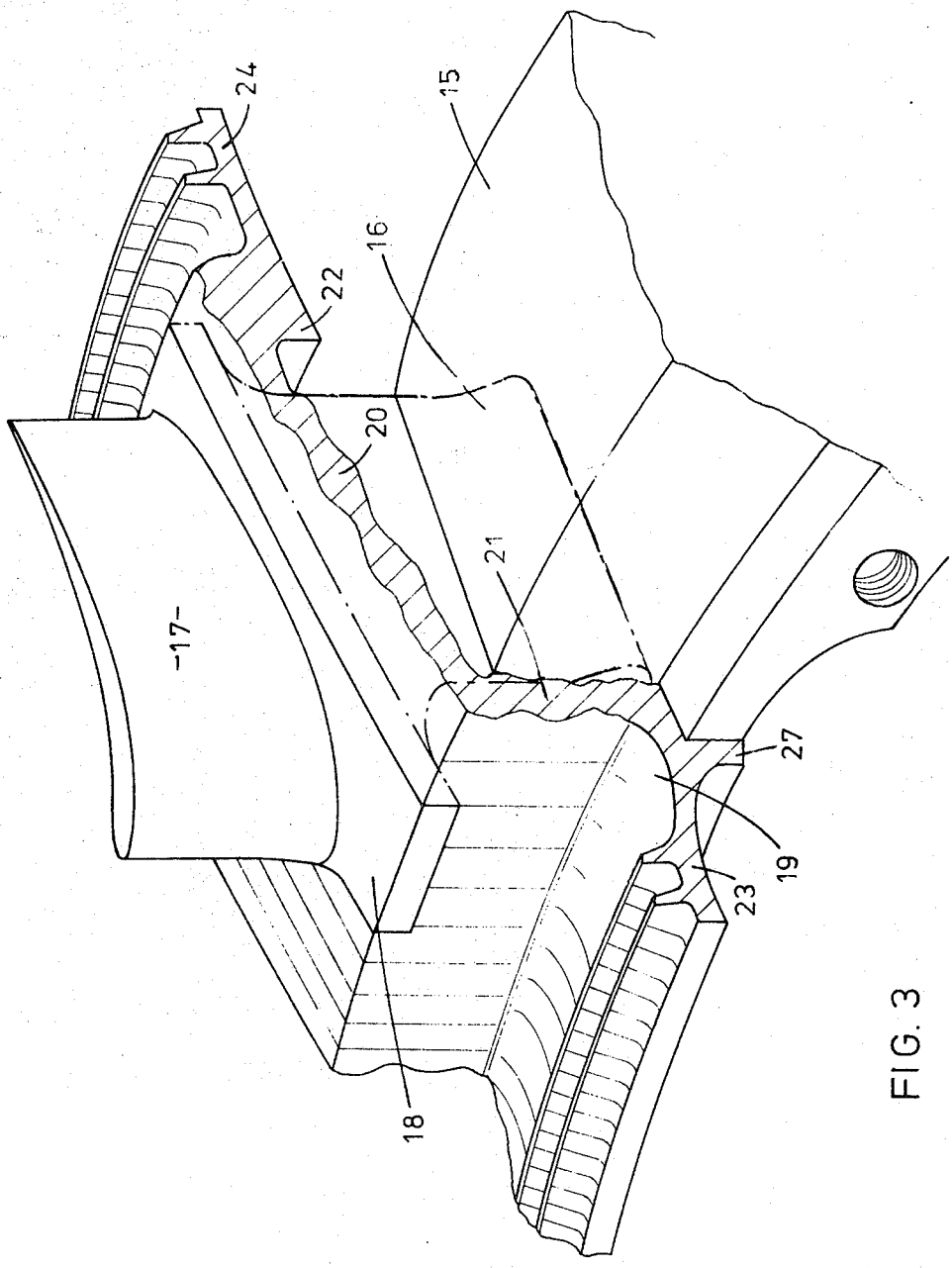


FIG. 3

BLADED ROTORS

The present invention relates to bladed rotors for gas turbine engines and has particular reference to a construction of platforms for the rotor blades of the rotor.

In a multi-stage compressor or turbine of a gas turbine engine, each stage comprises an individual bladed rotor disposed between stator blades. It is necessary to provide a seal between the bladed rotors and their adjacent stator blades.

In the past these seals have been carried by the blades themselves or by the disc, and in either case they have been a dead weight which has had to be supported by the disc, and the size and weight of the disc has been increased. Where the seals have been carried by the disc it has been the practice in some cases to form the seal on the disc at the minimum possible radius to reduce the centrifugal loads on the seal and thus to minimise the additional weight of the disc. This has resulted in the stator blades being extended radially inwardly to provide a corresponding sealing surface, and apart from increasing the weight of the stator blades, this produces a zone of stagnant air beneath the inner surface of the air flow passage which can affect the surge margin of the compressor.

Further, the blades must be provided with platforms which make up the inner surface of the gas flow passage and the weight of these has been supported by the disc, adding to the disc weight.

The object of the present invention is to provide a bladed rotor in which said seals and platforms are provided in a manner which enables the weight of the rotor to be reduced.

According to the present invention a bladed rotor for a gas turbine engine comprises an annular rotor disc having a plurality of slots in its outer periphery, a plurality of aero-foil shaped blades having root portions engaged in the slots, a platform ring surrounding the periphery of the disc, said ring having slots therein into which the blades are fitted, and having at least at one axial end, a continuous circumferential sealing member, means being provided for removably attaching the platform ring to the disc.

The blades may have a vestigial platform portion on each aerofoil surface adjacent the root of the blade, and the platform ring may be in the form of a cage having a plurality of axially extending bars defining the slots therebetween, the slots being dimensioned to receive said platform portions.

The vestigial blade platforms may be shaped to provide friction surfaces for damping vibration of the blades and for giving additional support to the portions of the platform ring which extend between the blades.

Also in a preferred form of the invention the radially outer part of the platform ring extends axially of the disc and has radially inwardly extending flanges at each end which extend at least partly over the radially outer portions of the axial end faces of the disc, the sealing members extending axially from the flanges. By this means the platform ring retains the blades against axial movement in the slots in the disc.

At least one of the flanges may extend radially to a point radially inwardly of the bottoms of the slots so that the flange also acts as a sealing plate, to prevent fluid from the high pressure side of the rotor from leaking back to the low pressure side.

The sealing ring is preferably attached to the disc by means of bolts.

The invention will now be more particularly described, merely by way of example, with reference to the accompanying drawings in which:

FIG. 1 is a diagrammatic representation of a gas turbine engine incorporating a bladed rotor of the present invention,

FIG. 2 is a sectional view of the compressor of the engine of FIG. 1 which is constructed according to the present invention,

FIG. 3 is a pictorial view of a portion of the compressor of FIG. 2,

FIG. 4 is a section of the first row of blades of FIG. 2 on the line A—A, and

FIG. 5 is an alternative blade construction to that shown in FIG. 4.

Referring now to the drawings there is shown in FIG. 1, a gas turbine jet propulsion engine, which may be of any desired form having compressor means 1, combustion equipment 2, turbine means 3 and a propulsion nozzle 4 all in flow series. The engine may be a single or multi-shaft engine since the invention is concerned only with a bladed rotor of the engine. In the particular embodiment to which the invention is applied the engine is a three shaft engine having a three stage front fan in which all the fan rotors are constructed according to the invention. The front engine casing is shown broken away in FIG. 1 to illustrate the front fan, and FIG. 2 shows the fan in greater detail.

Referring now to FIGS. 2 and 3, the fan comprises three bladed rotors 10 each having a row of stator vanes 11 downstream thereof. The rotors are drivingly interconnected by means of a shaft 12 to a turbine of the engine.

Each rotor comprises a disc 15 which is slotted at its outer periphery to receive the roots 16 of a plurality of rotor blades 17.

The roots of the rotor blades are of substantially dove-tail cross-section having an included angle of 90°, but clearly any other suitable shapes may be used, for example a conventional fir tree root.

Each rotor blade has vestigial platform portions 18, and a platform ring 19 is provided in the form of a cage which surrounds the outer periphery of the rotor to provide a platform surface between the adjacent platform portions 18 of the blade, which surface forms the inner boundary of the fluid flow passage through the duct. The radially outer portion of the cage comprises a plurality of bars 20, which extend axially of the rotor between the axial end faces of the disc, and between which are defined a plurality of slots for receiving the vestigial platform portions 18 of the blade.

The assembly is such that the blades can be inserted into the platform ring from the outside, and thus the slots in the platform ring and the vestigial blade platforms, must be slightly wider than the blade roots to enable the blade roots to pass through said slots. Once all the blades are in position in the platform ring the assembly is offered up to the rotor disc and the blade roots are inserted into the slots in the disc.

One of the main advantages of the construction described so far is that each blade and its vestigial platform can be made more easily as a precision forging from the raw material, and there is much less machining to be done on the blade and hence much less waste of material. Because of this, much more of the material

of the blade which has been worked during the forging process, i.e., the parts near the surfaces of the material, is retained in the finished article and the blades are therefore stronger. In addition the weight of the blade and its vestigial platform is less than if the full platform were formed on the blade, and the weight of disc required to support this reduced weight is therefore reduced.

At each axial end of the platform ring **19** there are radially inwardly extending flanges **21** and **22** which carry axially extending continuous sealing rings **23** and **24.** The sealing rings **23** and **24** are disposed at such a radius from the centre of the engine, as to be capable of co-operating with corresponding sealing surfaces **25** on the radially inner surfaces of shrouds **26** of the adjacent stator vanes. The upstream rotor blade row has only one sealing ring, which extends downstream therefrom.

Below the flange **21** on the upstream side of each platform ring there is a further radially extending flange **27** which is locally enlarged at several places around the rotor to provide bosses for bolting the platform ring to the disc **15.**

The advantage of making the platform in this way is that the cylindrical sealing rings **23** and **24** are self-supporting, as long as they lie within the free hoop radius of the rotor, and can, with the aid of the radial flanges **21** and **22,** support the bars **20** of the cage. Thus there is no dead weight of platform, other than the platform portions **18,** which has to be carried by the disc, and a further weight reduction in the disc can be achieved.

Further advantages of the platform ring constructed in the manner above described are that the radially extending flanges **21** and **22** act as locking means for preventing axial movement of the blade roots in the slots in the disc, and the flanges **21,** being continuous, further act as sealing plates for preventing recirculation of high pressure fluid from downstream of the blade row back to the low pressure upstream side through the slots in the disc. Separate sealing plates and locking tabs can therefore be dispensed with, thus saving time in the assembly of the rotor.

A still further advantage of this construction, however, is provided by having the platform rings carry the upstream and downstream sealing rings **23** and **24.** This provides a single, easily removable component, which not only aids assembly of the rotor but allows the seals to be replaced, should they become worn or damaged, without having to disturb the disc. Such replacement can be done easily in the field, which is not the case where the seals are integral with or shrunk onto the disc rim.

Additionally the seal is carried at the greatest possible radius, and the volume **28** between the rotor blade row and the stator vanes between the radii of the platform surface and the seal, is minimized. By this means the circumferential flow of air between different pressure levels around the rotor is cut down, thus increasing the engine surge margin.

The assembly and dis-assembly of the rotor as a whole can be seen from FIG. **2.** Starting with the compressor assembled, the dis-assembly can proceed as follows:

Nuts **30** are removed thus releasing the nose bullet from the first row of rotor blades. The ring of bolts **31** are then removed thus allowing the platform ring and the blades to slide out forwardly, disengaging the blade roots from the disc slots. The blades can then be removed from the platform ring. The ring of stators are then removable axially forwardly by removing bolts (not shown) which connect the stators to the engine casing. Then by undoing the ring of bolts **33** retaining the platform ring of the second stage rotor to its disc, the second stage blades and platform ring can be removed. The second stage stators and third stage blades are removed in exactly similar manner.

It can be seen that the platform rings as described above combine into a single removable piece, the sealing rings, locking means and sealing plates, most of which on present engines are connected separately to the rotor.

In addition FIGS. **4** and **5** illustrate how vibration damping features can also be added simply to the rotor. The vestigial platforms can be shaped to provide a friction damping surface where they abut the platform ring.

For example in FIG. **4** the axial surfaces of the blade platforms are provided with oppositely radially outwardly inclined surfaces **35** and **36** adapted to engage with corresponding surfaces on the platform ring, and in FIG. **5** the axial surfaces have circumferentially extending lips **37** and **38** which are arranged to fit over a corresponding lip on the platform ring.

It can be seen that in operation of the rotor, centrifugal action will urge the co-operating surfaces of the platform ring into engagement with those on the blade, and the effects of this are that the portions of the platform ring which lie between the blade platforms receive additional support against bending outwardly, and the contact surfaces between the blade platforms and the platform ring will frictionally damp any relative movement which occurs therebetween.

In addition the contacting surfaces may aid in the assembly of the rotor by preventing the vestigial blade platforms from passing completely through slots in the platform ring in place of the axially extending lips at the bottom of the slots on which the ends of the blade platforms seat.

Alternatively or in addition, as shown in FIG. **4,** the bars **20** of the cage may be provided with radially extending ribs **40** to cut down outward deflection of the bars under centrifugal loads. This enables damping means, which may be in the form of U-shaped spring members **42** to be fitted into the spaces between the ribs **40** and the roots **16** of the blades.

In another alternative form of the invention, the blades may be made without any platform at all on their aerofoil surfaces, and the slots in the platform ring may be reduced to aerofoil shaped slots only. To assemble the blades and platform ring in such a construction the blades may be inserted into the slots from inside the platform ring, or may have separate roots brazed or welded on after the aerofoil part has been inserted.

I claim:

1. A bladed rotor for a gas turbine engine comprising an annular rotor disc having means defining a plurality of slots in its outer periphery, and a plurality of aerofoil shaped blades having root portions engaged in the slots, a platform ring surrounding the periphery of the disc, said ring having means defining slots therein into which the blades are fitted, and having at least at one axial end a continuous circumferential sealing member,

means being provided for removably attaching the platform ring to the disc.

2. A bladed rotor according to claim 1 and wherein each blade has a vestigial platform portion on each aerofoil surface adjacent the root of the blade, and the platform ring is in the form of a cage having a plurality of axially extending bars defining the slots therebetween, the slots being dimensioned to receive said platform portions.

3. A bladed rotor according to claim 2 and wherein the vestigial blade platforms are shaped to provide support for those parts of the platform ring which contact the vestigial blade platforms against radial growth under centrifugal forces, and to act as damping means for the blades.

4. A bladed rotor according to claim 1 and wherein the platform ring has at each axial end thereof a radially extending flange which acts as a locking means to retain said blade roots against axial movement in the slots.

5. A bladed rotor according to claim 4 and wherein one of said flanges extends radially to a point inward of the bottoms of said slots and acts as a sealing plate to prevent leakage of air from one side of the blade to the other beneath the platform.

6. A bladed rotor according to claim 1 and wherein the diameter of the sealing rings at each axial end of the platform ring are substantially equal to the inner diameter of the air flow passage at said ends.

7. A bladed rotor according to claim 2 and wherein the bars have axial supporting ribs extending radially inwardly therefrom.

8. A bladed rotor according to claim 7 and wherein the ribs form one side wall of a cavity between the radially outer periphery of the rotor disc and the underside of the platform ring, and damping means are disposed in said cavity.

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