April 9, 1968 K. R. GUY 3,377,050

SHROUDED ROTOR BLADES

Filed May 10, 1967 3 Sheets-Sheet 1

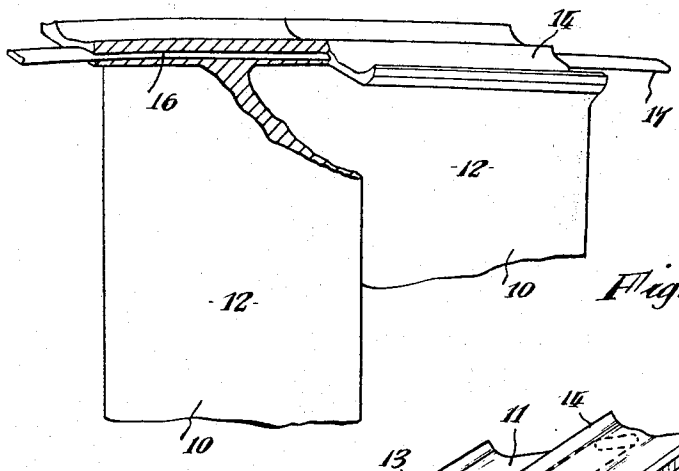


Fig. 1.

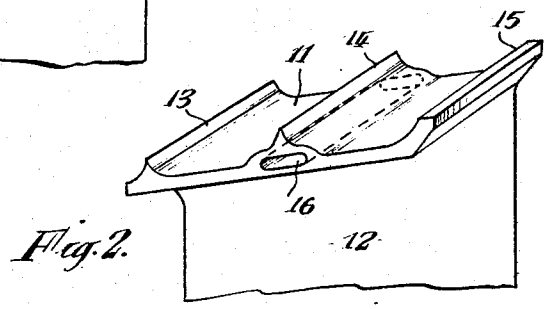


Fig. 2.

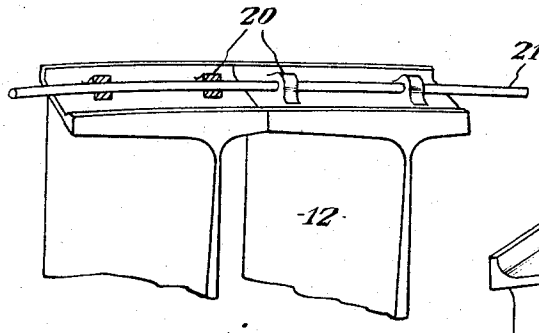


Fig. 3.

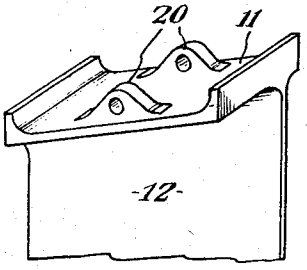


Fig. 4.

April 9, 1968 K. R. GUY 3,377,050

SHROUDED ROTOR BLADES

Filed May 10, 1967 3 Sheets-Sheet 2

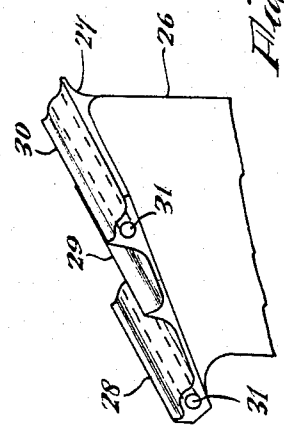


Fig. 5.

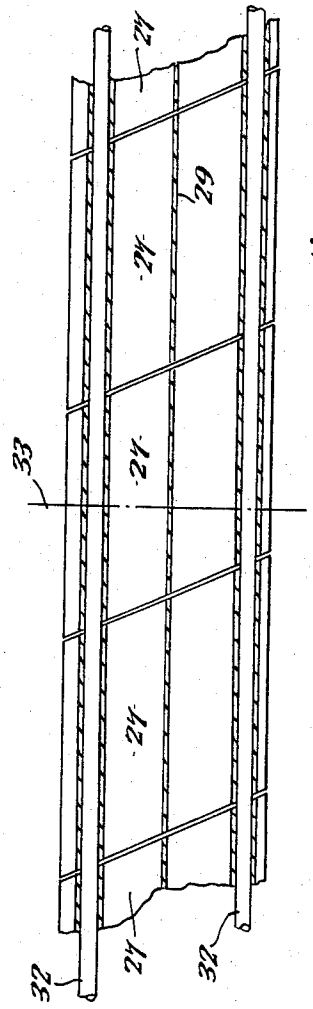


Fig. 4.

April 9, 1968 K. R. GUY 3,377,050

SHROUDED ROTOR BLADES

Filed May 10, 1967 3 Sheets-Sheet 3

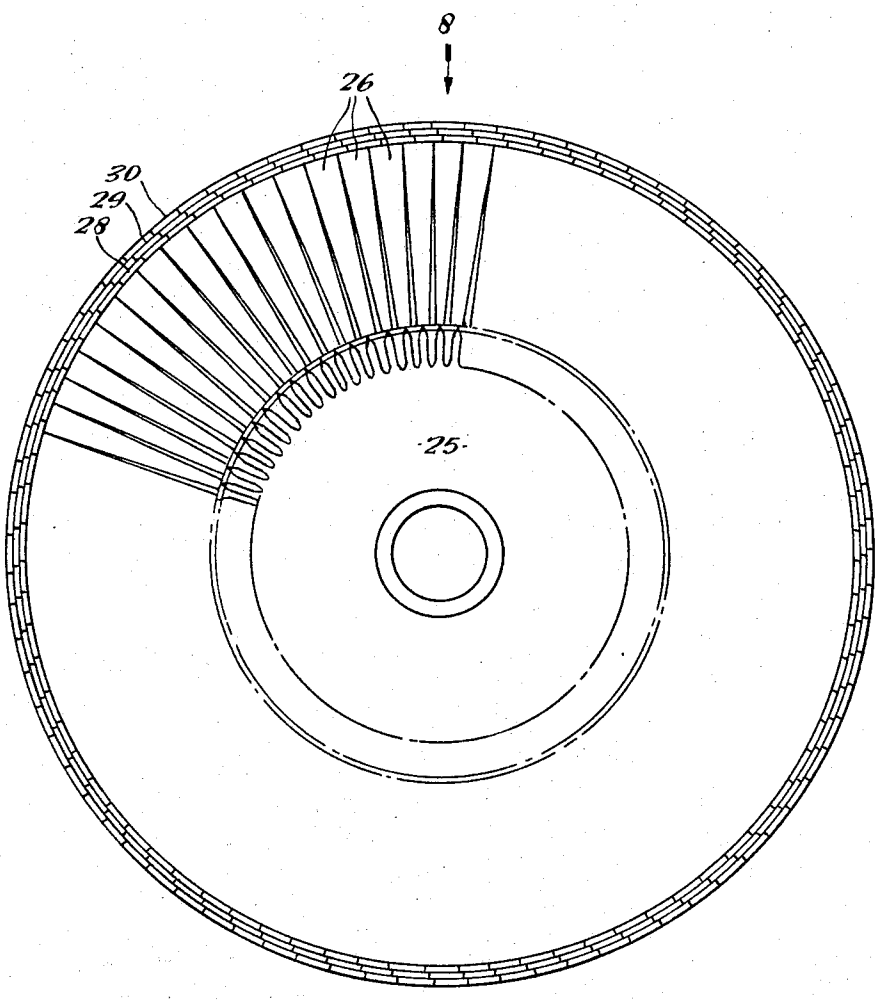


Fig. 6.

United States Patent Office 3,377,050
Patented Apr. 9, 1968

3,377,050

SHROUDED ROTOR BLADES

Kenneth Ronald Guy, London, England, assignor to Bristol Siddeley Engines Limited, London, England, a British company

Filed May 10, 1967, Ser. No. 637,586
Claims priority, application Great Britain, June 21, 1966 27,564/66
1 Claim. (Cl. 253—77)

ABSTRACT OF THE DISCLOSURE

A turbine rotor having a disc supporting at its rim a ring of blades each provided at its tip with a shroud being apertured to provide a ring of circumferential connecting passages and at least one length of a flexible elongate member extending through the connecting passages to constitute a frictional connection between successive blades when being urged against the walls of the apertures by centrifugal force during operation of the rotor.

The disclosure of this invention relates to a turbine rotor blade which is provided with a tip shroud the radially outer side of which is apertured to receive a circumferential wire for resisting blade vibration.

The term "wire" is used herein in a broad sense to mean a flexible elongate member.

According to one aspect of the invention, a rotor blade is provided at its tip with a shroud which is apertured to receive a circumferentially-extending wire.

According to another aspect of the invention, a turbine rotor comprises a disc supporting at its rim a ring of blades, each blade being provided at its tip with a shroud supporting at least one fin-shaped member which projects from the radially outer side of the shroud, the fin-shaped members of the shrouds being apertured to provide a ring of circumferential connecting passages, and at least one length of flexible elongate member which extends through the connecting passages.

One object of this invention is to provide wire lacing for gas turbine blades which lies outside the main stream of gas through the turbine and is located to take full advantage of the effect of centrifugal force.

By way of example the invention will now be described with reference to the accompanying drawings of which:

FIGURE 1 is a perspective view, partly in section, of the shrouded blade tips of two adjacent gas turbine blades and shows one form of apertured member for a vibration-resisting wire, FIGURE 2 is, on a larger scale, a perspective view taken from another angle of one of the tip shrouds,

FIGURE 3 is a perspective view, partly in section, of the shrouded blade tips of another two adjacent gas turbine blades and shows an alternative form of apertured member for a vibration-resisting wire,

FIGURE 4 is a perspective view taken from another angle of one of the tip shrouds of FIGURE 3.

FIGURE 5 is a perspective view of the shrouded blade tip of a gas turbine blade with a further form of shroud for receiving vibration-resisting wires,

FIGURE 6 is, on a smaller scale, a view of the upstream face of a bladed turbine disc provided with shrouded rotor blades according to FIGURE 5, and

FIGURE 7 is, on a different scale, a developed view in section of part of FIGURE 6 taken in the direction of the arrow **8**.

Referring to FIGURES 1 and 2, a circular row of axial flow gas turbine rotor blades carried at the periphery of a rotor disc has each blade **10** provided at its tip with a shroud **11** which extends at right angles to the aerofoil portion **12** of the blade. When the blades are assembled together their respective shrouds forms a shroud ring.

Each shroud has on its side remote from the aerofoil portion **12** a number of circumferentially-extending sealing fins **13, 14, 15** which cooperate with opposing turbine stator structure (not shown) to provide gas seals in known manner. The central fin **14** is widened at its base where an elongate circumferential passage **16** is formed to receive one or more wires **17** for reducing blade vibration. When the blades are assembled together, the passages **16** join up to form a ring of circumferential connecting passages for the wire.

In FIGURES 3 and 4 the arrangement is structurally similar except that the single apertured member represented in part by the central fin **14** is replaced by a plurality of circumferentially-spaced apertured lugs **20** through which a wire **21** is threaded as shown.

In the embodiment of FIGURE 1, the substantially continuous ring of central fins **14** will prevent outward bulging of the wire **17** under centrifugal loading and damping of the blades will be caused by friction between the wire and that portion of each rib **14** against which the wire is urged by centrifugal force. Such friction damping is promoted by the location of the wire beyond the aerofoil portion of the blade, at which location the loading on the wire due to centrifugal force is at its maximum for any given operational conditions, as also may be the amplitude of blade vibration, depending on the mode of vibration.

However in the embodiment of FIGURE 3, the wire which is non-continuous would normally be of a material which is sufficiently flexible to bulge outwards under centrifugal force between the circumferentially-spaced lugs **20**. Such bulging would oppose relative circumferential movement between wire and blades and so reduce friction damping between those members.

The vibration of free cantilever blades, which for example may follow a sinusoidal variation in gas pressure around the annular flow passage through the turbine, results in each blade having the same phase of vibration as the excitation force and the blades would be free to vary in phase with one another.

On the other hand, the vibration of blades wired together as in FIGURE 3 would have a greatly reduced amplitude, compared with vibrating blades not wired together, because the blades on any one length of outwardly bulged wire would be forced by the wire to have the same phase of vibration as one another.

In the FIGURE 3 embodiment the wire must be non-continuous to permit bulging. The spacing between the lugs **20** can be chosen to vary the unsupported span of the wire and thus lessen the uneven application along the wire of the centrifugal stress, so matching a wire of given strength and stiffness to the blade damping requirements. Another reason for making the wire non-continuous is to allow it to accommodate radial thermal expansion of the blades, a consideration which also applies to the embodiment of FIGURE 1.

The non-continuous wire may consist of more than one length, e.g. four lengths which between them form substantially a ring. In the friction damping embodiment of FIGURE 1 the wire may consist of a plurality of lengths alongside one another to permit friction rubbing between wire lengths.

Referring to FIGURES 5, 6 and 7 a turbine rotor disc **25** supports at its outer rim a ring of blades **26** provided with tip shrouds **27**. Each shroud is formed on its radially outer side with three sealing fins **28, 29, 30** which extend circumferentially and are spaced apart in the chordwise direction. The fins **28, 30** which are located adjacent the

leading and trailing edges respectively of each shroud are thickened and formed with circumferential passages **31** which connect up to provide co-axial annular passages. Wires **32** of circular cross-section are passed through the passages **31** to form flexible vibration-resisting rings. Each ring of wire may be made continuous or its ends left unconnected. The rotational axis **33** of the turbine is indicated in FIGURE 7.

The chordwise-spaced wires restrict the blades against flexural vibration, i.e. vibration normal to the chordwise direction, against edgewise vibration, i.e. vibration substantially in the chordwse direction, and against torsional vibration.

In all the embodiments of the invention the wire lies outside the main flow passage through the turbine and thus is not only shielded from the main gas flow but also does not obstruct it. In addition the blade aerofoil portions **12** are not weakened by holes for the wires. A further important advantage is that should a blade failure occur, e.g. at the aerofoil portion adjacent the blade platform, the outwardly escaping portion of the blade must overcome the wire before it can penetrate the turbine casing. In this manner the invention may assist the containment of escaping rotor blade parts.

The invention is also applicable to axial flow compressor blades of gas turbine engines and to steam turbine blades.

What I claim is:

1. A rotor for a bladed fluid flow machine comprising an annular row of blades, each blade including at the tip thereof a shroud so dimensioned that there is a clearance between the shrouds of adjacent blades, the shrouds each including a circumferential aperture registering with the apertures of the adjacent shrouds, at least one elongate member placed into the apertures of successive blades so as to constitute a frictional connection between successive blades when being urged against the walls of the apertures by centrifugal force during operation.

References Cited

UNITED STATES PATENTS

1,165,005	12/1915	Herr	253—77
1,544,318	6/1925	Hodgkinson	253—77
3,025,037	3/1962	Beckstrom	253—77
3,095,138	6/1963	Warnken	253—77
3,326,523	6/1967	Bobo	253—77

EVERETTE A. POWELL, JR., *Primary Examiner.*