

June 25, 1968

R. N. PENNY
AXIAL FLOW ROTOR

3,389,889

Filed June 5, 1967

4 Sheets-Sheet 1

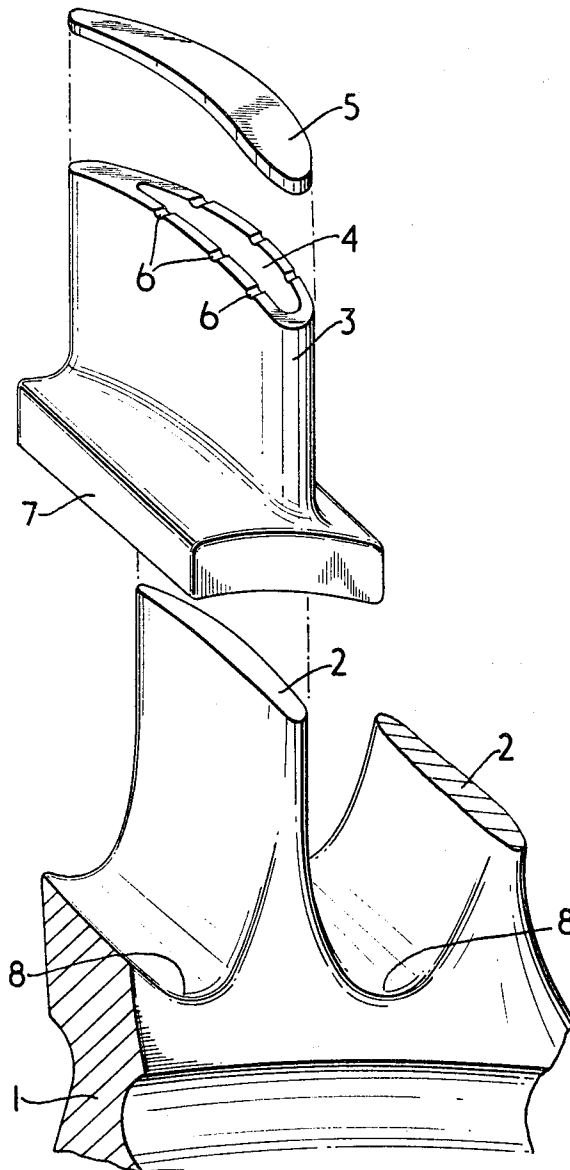


FIG. 1.

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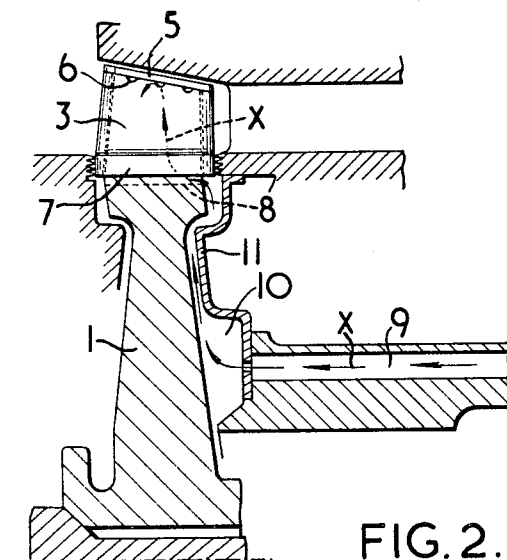
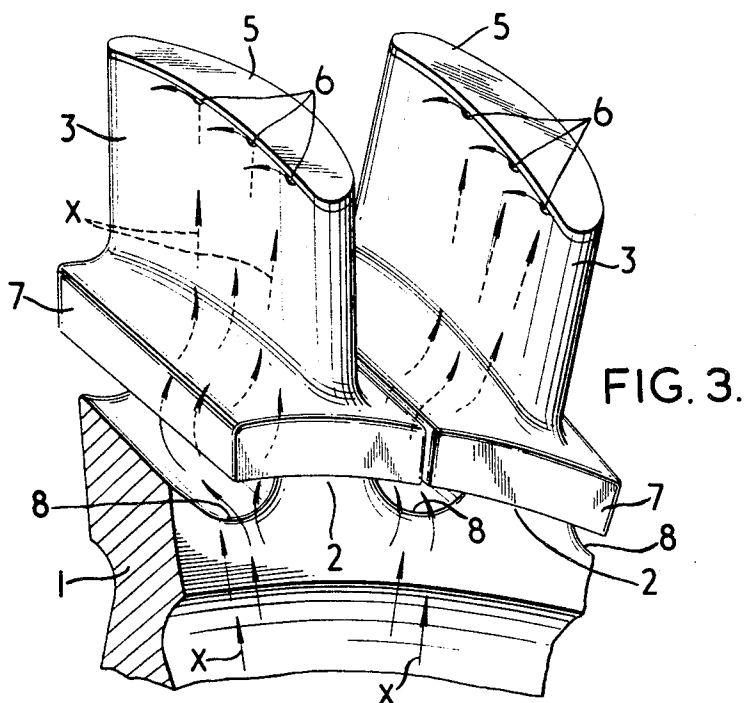
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4 Sheets-Sheet 2



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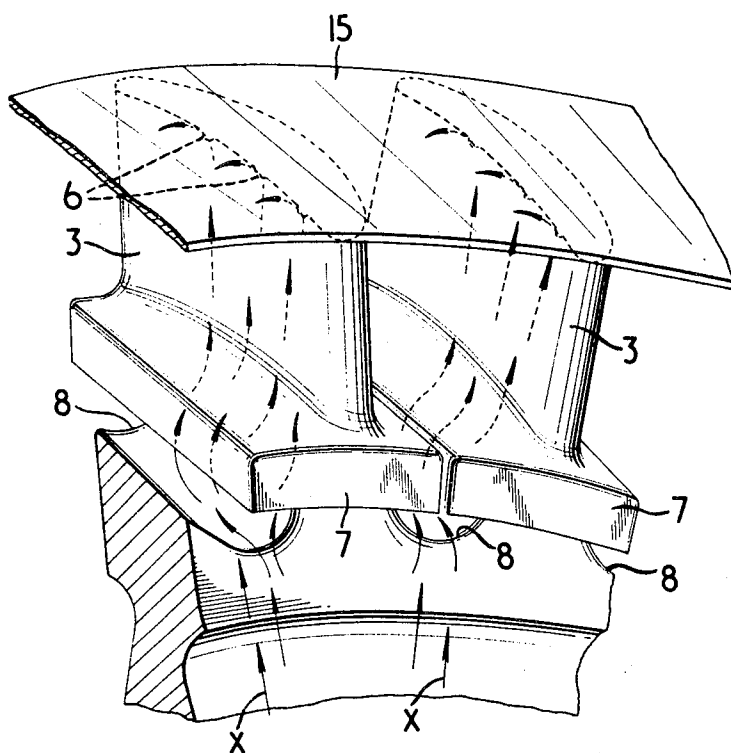


FIG. 4.

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AXIAL FLOW ROTOR

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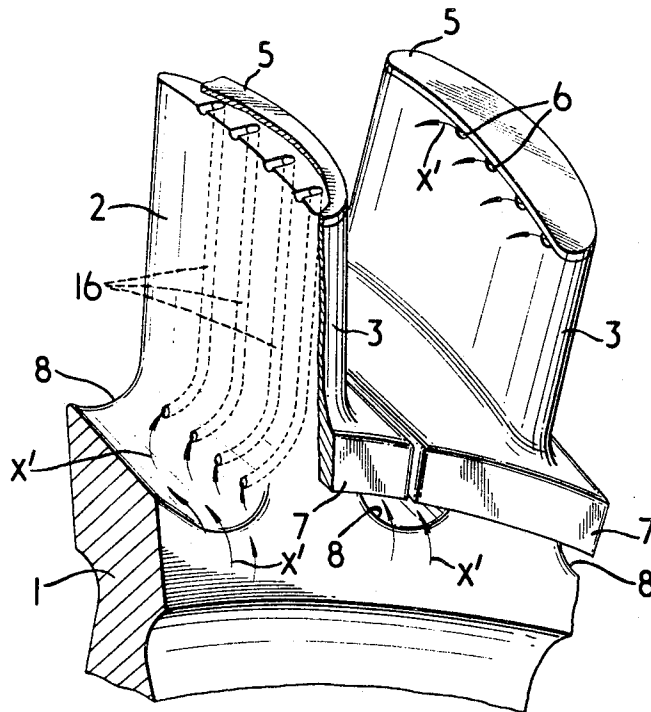


FIG. 5.

ROBERT NOEL PENNY

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3,389,889

AXIAL FLOW ROTOR

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6 Claims. (Cl. 253—39.15)

ABSTRACT OF THE DISCLOSURE

An axial flow rotor in which each blade is an open-ended tubular sleeve carried on a stub extending radially from the rotor body, each stub protruding radially beyond the radially-outer end of the sleeve carried thereby and having a retaining cap secured to its radially-outer end, the retaining cap extending outwardly from the peripheral surface of the stub to form a stop to restrain the sleeve from centrifugal movement on its stub, and in which a blade platform extends circumferentially outwardly from the radially-inner end of each sleeve, the platforms of adjacent sleeves co-operating to shroud the periphery of the body portion between each stub from the working fluid.

The invention relates to a bladed rotor of the axial flow type and is particularly concerned with a rotor having blades capable of withstanding a high operating temperature, e.g., of the order of 1100° C.

It is known to make blades of a ceramic or other non-metallic material; but such blades have the disadvantage that they have a lower tensile strength than do metallic blades. An object of the invention is to provide a rotor having high tensile strength and also having blades of a ceramic or non-metallic material capable of withstanding a high operating temperature.

According to the invention, a bladed rotor of the axial flow type comprises a body portion having a plurality of radially-outwardly extending, blade-supporting stubs spaced apart around its periphery, a plurality of blades each in the form of an open-ended tubular sleeve carried on one of said stubs, each stub protruding radially beyond the radially-outer end of the sleeve carried thereby and having a retaining cap secured to its radially-outer end, the retaining cap extending outwardly from the peripheral surface of the stub to form a stop to be engaged by the radially-outer end of the sleeve, thereby to retain the latter on the stub against centrifugal movement during rotation of the rotor, and a blade platform extending circumferentially outwardly from the radially-inner end of each sleeve, the platforms of adjacent sleeves co-operating to define the radially-inner wall of the working fluid flow path between the blades and also to shroud the periphery of the body portion between each stub from the working fluid.

Each sleeve is conveniently a loose fit on the supporting stub, whereby clearance is provided between adjacent surfaces of the stub and the sleeve, the clearance communicating adjacent the radially-inner end of the sleeve with a source of compressed air for cooling the sleeve and the stub and communicating adjacent the radially-outer end of the sleeve with the working fluid flow path between the blades. The radially-outer end face of the sleeve or the radially-inner end face of the associated retaining cap, or each said end face, may have grooves therein forming outlet passages permitting the cooling air to flow from the clearance into the working fluid flow path during operation of the rotor, when the sleeve is held by centrifugal force in abutment with the retaining cap. Alternatively, the radially-outer of each sleeve may be formed with outlet holes to permit the flow of cooling air

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from the clearance between the sleeve and its supporting stub. The cooling air is conveniently admitted into the clearances from spaces between the platforms and the periphery of the body portion intermediate the stubs. Alternatively the stubs may be hollow and have internal cooling air passages communicating with the clearances through holes in the stubs adjacent the radially-inner ends thereof.

The retaining caps carried by the stubs may be separate from each other or the retaining caps of two or more circumferentially adjacent stubs may be common to said stubs and be of annular or part-annular form.

Each sleeve may have an integral shroud extending circumferentially from the outer end thereof, the shrouds of circumferentially adjacent sleeves co-operating to form an annular shroud defining the radially-outer wall of the working fluid flow path.

Conveniently, the sleeves are made of a ceramic or other non-metallic material capable of withstanding a high operating temperature e.g. of the order of 1100° C., the body portion, the stubs and the retaining caps being made of metal.

The securing of the retaining caps to the stubs, after the sleeves have been fitted thereon, may conveniently be performed by welding or brazing. Where the caps are to be welded to the stubs electron-beam welding may be employed.

The body portion, including integral stubs, is conveniently a precision casting; but it may be fabricated in any other suitable manner. For example, the stubs may be cast integrally with a ring which is then secured around a circular hub, e.g. by electron-beam welding.

By way of example, three alternative constructions of an axial flow rotor in accordance with the invention will now be described with reference to the accompanying drawings, in which:

FIGURE 1 is an exploded, perspective view of a portion of the rotor according to the first construction;

FIGURE 2 is a half axial cross-section through the rotor, illustrated in FIGURE 1, when assembled;

FIGURE 3 is a perspective view showing the portion of the rotor, illustrated in FIGURE 1, when assembled;

FIG. 4 is a perspective view similar to FIGURE 3 showing a portion of the rotor according to the second construction; and

FIGURE 5 is a perspective view similar to FIGURE 3, except that a portion of a blade has been broken away, showing a portion of the rotor according to the third construction.

As will be seen from FIGURES 1 to 3, the rotor comprises a body portion 1 having integral blade-supporting stubs 2, spaced apart around its periphery. The body portion 1 and the stubs 2 are a precision casting. Each stub carries a blade 3 in the form of an open-ended sleeve of ceramic or other non-metallic material. The sleeve 3 is of blade shape in cross-section and has a central throughway 4 through which the stub 2 protrudes. The sleeve 3 is a loose fit on the stub and so clearance is provided between adjacent surfaces of the stub and the sleeve. After each sleeve has been placed on a stub, the protruding radially-outer end of the stub 2 has an end cap 5 welded or similarly secured thereto, e.g., by electron-beam welding. The profile of the retaining cap 5 is of substantially the same shape and size as the outer peripheral surface of the sleeve 3 and therefore it extends outwardly all around the profile of the stub 2 and forms a stop against which the sleeve will abut when the rotor is rotating, thus preventing the sleeve 3 from moving off the stub 2 under centrifugal force. The radially-outer end face of the sleeve 3 is formed with grooves 6 which provide communication between the clearance between the sleeve 3 and the stub 2 and the working fluid flow path,

when the rotor is turning and each sleeve 3 has moved, under centrifugal force, into abutment with the respective retaining cap 5.

The radially-inner end of each sleeve 3 has an integral platform 7 which abuts the platforms of adjacent sleeves in the assembled rotor and thereby forms an annular wall defining the radially-inner boundary of the working fluid flow path and also acting to shroud the periphery 8 of the body portion 1 intermediate the stubs 2 from the working fluid.

During operation, as shown in FIGURES 2 and 3, cooling air is admitted into spaces between the periphery 8 of the body portion 1 and the platforms 7. This air flows outwardly in the direction of arrows X through the clearances between each sleeve 3 and its supporting stub 2 and emerges in the working fluid flow path at the radially-outer ends of the sleeve through the grooves 6. In this way, the periphery 8, the stubs 2 and the sleeves 3 are cooled. Also the stubs 2 and the periphery 8 are shrouded from the hot working fluid by the non-metallic sleeve 3 and its platform 7. The retaining cap 5 is coated with a protective material capable of withstanding the high working temperature.

With this construction, the tensile loading is carried by the stubs and not by the non-metallic sleeves 3. Therefore the construction is capable of operating at a high working temperature and has a tensile strength comparable with that of a rotor having metallic blades.

The cooling air may be derived from any convenient source. For example, it may be bled from a compressor of an engine including the rotor shown in FIGURES 1 to 3, the cooling air being led (as shown in FIGURE 2) through an annular passage 9 surrounding the rotor shaft, to an annular passage 10, bounded on one side by an end face of the body portion 1 and on the other side by a casing 11, and then to the spaces between the periphery 8 of the body portion 1 and the platforms 7.

The second construction of rotor illustrated by FIGURE 4 is similar to that of FIGURES 1 to 3 with the exception that, instead of the separate retaining caps 5, two or more circumferentially-adjacent stubs 2 are interconnected, after placing the sleeves 3 on the stubs, by an annular plate 15 or part-annular plates which serve, like the retaining caps 5, to hold the sleeves 3 on the respective stubs 2. The plate or plates 15 also form a shroud defining the radially-outer boundary of the working fluid passages between the blades. The plate or plates 15 may be attached to the radially-outer ends of the stubs 2 by welding; e.g., electron-beam welding. With the exception of reference numeral 15 all other reference numerals also appear in FIGURES 1 to 3 and denote like parts in both FIGURES 1 to 3 and FIGURE 4.

The third construction of rotor illustrated by FIGURE 5 is similar to that of FIGURES 1 to 3 with the exception that, the sleeves 3 are a tighter fit on the stubs 2 so that no clearance is provided therebetween. Instead, the stubs 2 are hollow or have axially-extending passages 16 therein. The passages 16 communicate at their radially-inner ends with the spaces between the platforms 7 and the periphery 8 of the body portion 1 and at their radially-outer ends with the grooves 6, the cooling air flowing in the direction of arrows X'. Like parts in FIGURES 1 to 3 and FIGURE 5 are shown by the same reference numerals. Instead of separate retaining caps 5, an annular plate 15

or part-annular retaining plates may be provided, as in FIGURE 4.

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

1. A bladed rotor of the axial flow type comprising a body portion, a plurality of radially-outwardly extending, blade-supporting stubs spaced apart around the periphery of the body portion, a plurality of open-ended tubular sleeves of a ceramic material capable of withstanding a high operating temperature and carried one on each of said stubs and each defining a blade, and a blade platform extending circumferentially outwardly from the radially-inner end of each sleeve, the platforms of adjacent sleeves co-operating to define the radially-inner wall of the working fluid flow path between the blades and also to shroud the periphery of the body portion between each stub from the working fluid, wherein the improvement comprises each sleeve is a loose fit on the supporting stub, whereby clearance is provided between adjacent surfaces of the stub and the sleeve, the clearance communicating adjacent the radially-inner end of the sleeve with a source of compressed air for cooling the sleeve and the stub and communicating adjacent the radially-outer end of the sleeve with the working fluid flow path between the blades, each stub protrudes radially beyond the radially-outer end of the sleeve carried thereby, a retaining cap is secured to the radially-outer end of each stub and each retaining cap extends outwardly from the peripheral surface of the stub to form a stop to restrain the sleeve from centrifugal movement on the stub.

2. A rotor as claimed in claim 1 in which at least one of the adjacent end faces of each sleeve and its retaining cap has grooves therein forming outlet passages for the cooling air to flow from the clearance between said sleeve and said stub.

3. A rotor as claimed in claim 1 in which the radially-outer end of each sleeve is formed with outlet holes for cooling air to flow from the clearance between said sleeve and said stub.

4. A rotor as claimed in claim 1 in which each said stub has an internal cooling air passage therein communicating with the clearance between the sleeve carried thereon and said stub through holes in the stub adjacent the radially-inner end thereof.

5. A rotor as claimed in claim 1 in which a retaining cap carried by at least two circumferentially adjacent stubs is common to said stubs and is in the form of at least part of an annulus.

6. A rotor as claimed in claim 1 in which each said sleeve has an integral shroud extending circumferentially from the outer end thereof, the shrouds of circumferentially adjacent sleeves co-operating to form an annular shroud defining the radially-outer wall of the working fluid flow path.

References Cited

UNITED STATES PATENTS

2,479,057	8/1949	Bodger	253—77
2,786,646	3/1957	Grantham	253—39.15
2,931,623	4/1960	Hyde	253—77

FOREIGN PATENTS

57,426	11/1952	France.
(Addition to No. 999,820)		

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