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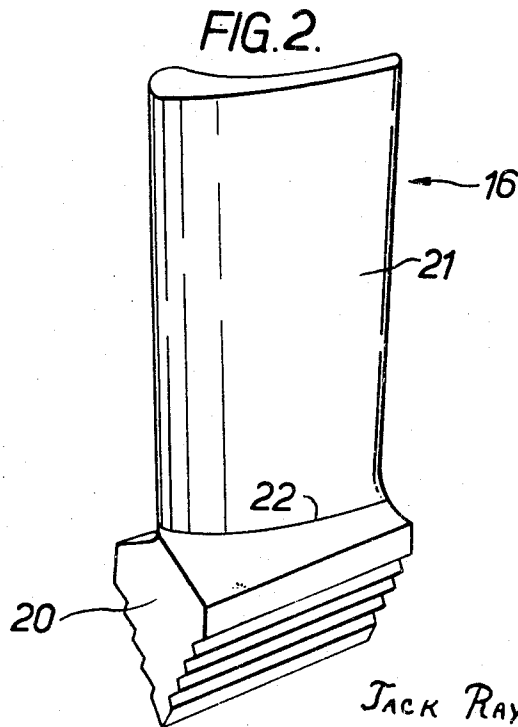
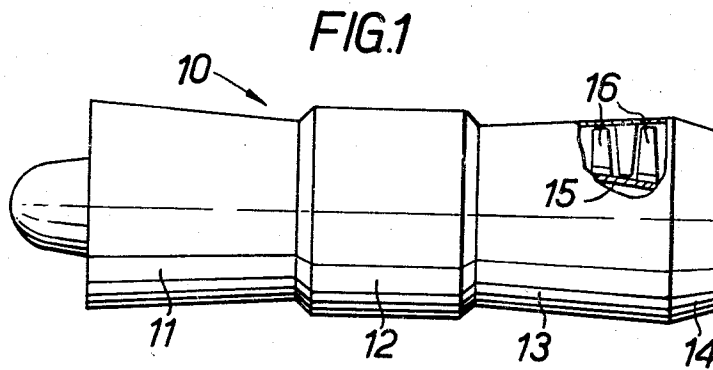
J. R. BIRD ET AL

3,549,273

BLADE FOR USE IN A FLUID FLOW MACHINE

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2 Sheets-Sheet 1



INVENTORS

JACK RAYMOND BIRD

RODNEY TRENCHARD BRYANT

By

Cushman, Darby & Cushman

ATTORNEYS

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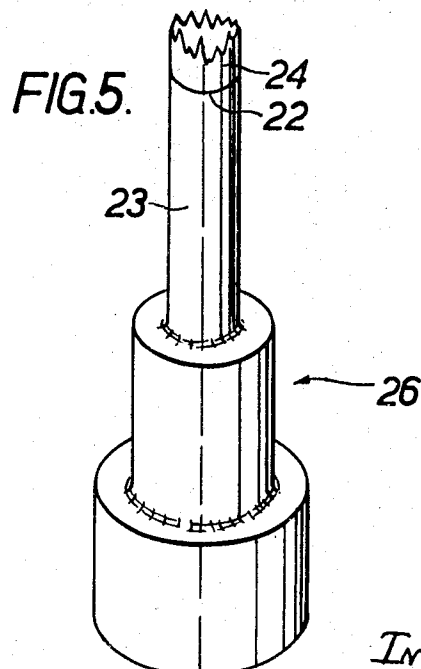
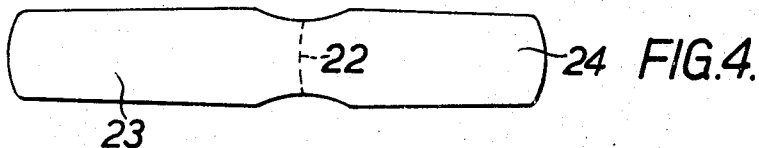
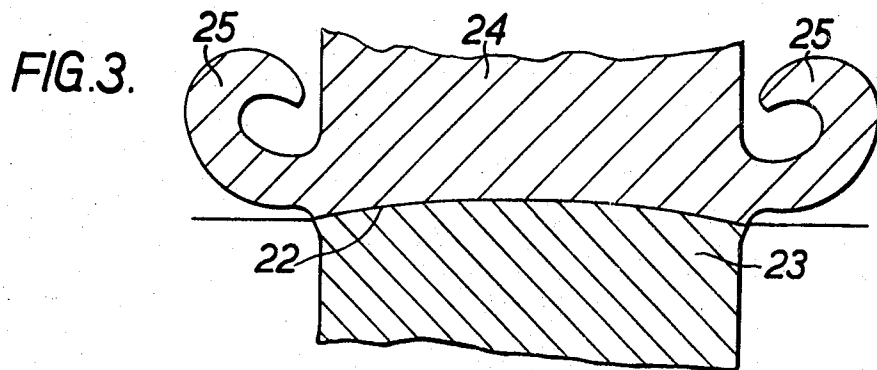
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BLADE FOR USE IN A FLUID FLOW MACHINE

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INVENTORS
JACK RAYMOND BIRD
RODNEY TRENCHARD BRYANT
By Cushman, Darby & Cushman/
ATTORNEYS

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BLADE FOR USE IN A FLUID FLOW MACHINE
Jack Raymond Bird, Chellaston, and Rodney Trenchard
Bryant, Balsham, Cambridge, England, assignors to
Imperial Metal Industries (Kynoch) Limited, Birmingham,
England, and Rolls-Royce Limited, Derby, Eng-
land, both British companies

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2 Claims

ABSTRACT OF THE DISCLOSURE

A gas turbine engine blade has its root and blade portions respectively made of different alloys having the same base metal such as niobium or titanium.

This invention concerns a blade for use in a fluid flow machine such, for example, as a gas turbine engine. Thus, although the invention is not so restricted, the blade may be a turbine rotor blade although the invention is also applicable to compressor blades. The term "blade" is, moreover, used in a wide sense as including nozzle guide vanes.

A turbine rotor blade is usually composed of two principal parts, namely a blade portion, against which the impelling gases impinge, and a root portion which anchors the blade to a support and transmits forces from the blade to the support.

Blades for gas turbine engines are usually produced by forging and machining suitable alloy material. The choice of alloy for the blade has been a compromise to meet the operating conditions expected for both the root and blade portions, this compromise having regard, for example, to the nature of the impinging gases and to the operating temperatures and stresses.

For example, the blade portion must be strong and must be subject to only a limited amount of creep deformation under high centrifugal stresses at elevated temperatures, and the blade portion, even when suitably coated, must be resistant to oxidation by the gases employed.

The root portion, on the other hand, requires relatively high strength to withstand the high centrifugal bending and vibrational stresses imposed during operation, but is not subject to such high temperatures. The root portion, moreover, should also be oxidation-resistant so as to withstand the lower temperatures without it being necessary to provide it with an oxidation-resistant coating.

According, therefore, to the present invention, there is provided a blade for use in a fluid flow machine in which at least part of the root and blade portions of the blade are respectively made of different alloys.

The root portion and/or the blade portion may be made up of a number of parts which are respectively made of different alloys.

Preferably the immediately adjacent parts of the root and blade portions are respectively made of different alloys.

Each of the alloys may be based upon a common metal. Thus each of the alloys may, for example, be a niobium based or a titanium based alloy.

The different parts of the blade are friction welded to each other.

The invention also comprises a method of making the said blade comprising welding together the root and blade portions of the blade, at least the adjacent parts of the root and blade portions being respectively made

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of different alloys having coefficients of expansion such as to prevent the blade from fracturing at the weld.

The invention additionally comprises a method of making the said blade comprising forming a weld between a root blank and a blade blank, and forging the blade with the said weld disposed substantially at the junction between the root and blade portions of the blade, at least the adjacent parts of the root and blade blanks being respectively made of different alloys having coefficients of expansion such as to prevent the blade from fracturing at the weld.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:

FIG. 1 is a diagrammatic view, partly in section, of a gas turbine engine provided with blades in accordance with the present invention,

FIG. 2 is a perspective view of one of the blades of the engine of FIG. 1,

FIG. 3 is a broken-away sectional view of two united blanks which may be used in the formation of a blade,

FIG. 4 is a diagrammatic view of the united blanks after they have been forged to produce a flattened cross section, and

FIG. 5 illustrates the position of a fracture in a tensile test piece formed from the united blank of FIG. 4.

In FIG. 1 there is shown a gas turbine engine 10 having in flow series a compressor 11, combustion equipment 12, and a turbine 13, the turbine exhaust gases being directed to atmosphere through an exhaust duct 14.

The turbine 13 is provided with a rotor 15 which carries rotor blades 16.

As shown in FIG. 2, each of the rotor blades 16 comprises a "fir tree" root portion 20 and a separate blade portion 21 which has been welded to the root portion 20 at a weld 22. The root portion 20 and blade portion 21 are respectively made of different alloys which have coefficients of expansion such as to prevent the blade 16 from fracturing at the weld 22.

Each of the said alloys is preferably based upon a common metal, such as niobium. Thus the blade portion 20 may be made from a niobium based alloy containing 17% tungsten, 3.5% hafnium and 0.08% carbon (all these percentages being by weight), while the root portion 21 may be made of niobium based alloy containing 10% molybdenum and 10% titanium (all these percentages also being by weight).

If desired, only the immediately adjacent parts of the root and blade portions may be respectively made of the said different alloys, although preferably the whole of the root and blade portions are respectively made of the said different alloys.

Alternatively, both the root portion 20 and the blade portion 21 may, if desired, be made up of a number of parts which have been respectively made of different alloys.

As illustrated diagrammatically in FIG. 3, each of the blades 16 may be made by forming a weld 22, e.g., a friction weld, between a root blank 23 and a blade blank 24 and forging the blade so that the finished blade has the weld 22 disposed substantially at the junction between the root portion 20 and blade portion 21 of the blade.

In order to effect the said friction weld, the blanks 23, 24 are placed coaxially in end-to-end relationship and one of them is held stationary while the other is rotated at high speed while forcing adjacent ends of the blanks together. When a sufficiently high temperature has been generated, rotation of the rotating blank is stopped and the adjacent ends are forced together (e.g., under a load of 1.5 tons for blanks 23, 24 having a diameter of 3/8") to produce the weld 22. This also causes the formation of flash 25 from the softer alloy of the blank 24, and

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there may also be some flash (not shown) from the harder alloy. This flash is then removed and the united blank so produced is then forged to produce the final blade.

FIGS. 4 and 5 illustrate test pieces formed from the united blank. Thus in FIG. 4 the united blank, after having been heated and maintained at 1300° C. in vacuum for one hour, was subsequently forged at 800° C. in air to produce the flattened cross section shown in FIG. 4. Examination of this united blank showed that the weld 22 was sound.

Moreover, as shown in FIG. 5, a standard tensile test bar 26 was machined from the united blank. A tensile test at 450° C. produced failure at a stress of 29.3 tons per square inch at a point away from the weld 22, indicating that the weld 22 was stronger than the weaker of the parent alloys.

A turbine blade forged and machined from the united blank referred to above should not require special heat treatment nor the provision of a coating for its root portion. This is because of the strength and oxidation resistance which the root portion possesses below 600° C., while the blade portion has good stress rupture strength at blade operating temperatures.

We claim:

1. A blade for use in a gas turbine engine, the blade being subjected to elevated temperatures and capable of withstanding high stresses when in use and comprising: a root portion and a blade portion united by a friction weld therebetween, said root portion and said blade por-

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tion being made of different alloys, each of which is a niobium based alloy or a titanium based alloy, and the alloy of said base portion having a coefficient of expansion compatible with the alloy of said blade portion whereby fracture of the friction weld is prevented.

2. A method of making a blade for use in a gas turbine engine at elevated temperatures and capable of withstanding high stresses, the blade having a root portion united to a blade portion by a weld which resists fracture, the steps comprising: forming a root blank of a niobium or titanium based alloy having a predetermined coefficient of expansion, forming a blade blank of a different niobium or titanium based alloy, but having a compatible coefficient of expansion, friction welding the root blank to the blade blank to form the weld therebetween, and then forging the blade portion from the blade blank and forming a root portion from the root blank so as to dispose the friction weld therebetween.

References Cited

UNITED STATES PATENTS

1,948,793	2/1934	Lewis	253—77(M)UX
2,019,329	10/1935	Warren	29—156.8
2,807,435	9/1957	Howlett et al.	253—77(M)

FOREIGN PATENTS

535,229	4/1941	Great Britain	170—159(M)
696,715	9/1953	Great Britain	416—223

EVERETTE A. POWELL, JR., Primary Examiner