United States Patent [19]

Guy et al.

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[54] **FLUID FLOW MACHINES**

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[52] **U.S. Cl.** **416/193**; 416/196; 416/241; 416/500

[51] **Int. Cl.** **F01d 5/22**

[58] **Field of Search** ..... 416/193, 213, 224, 230, 416/241 A, 196

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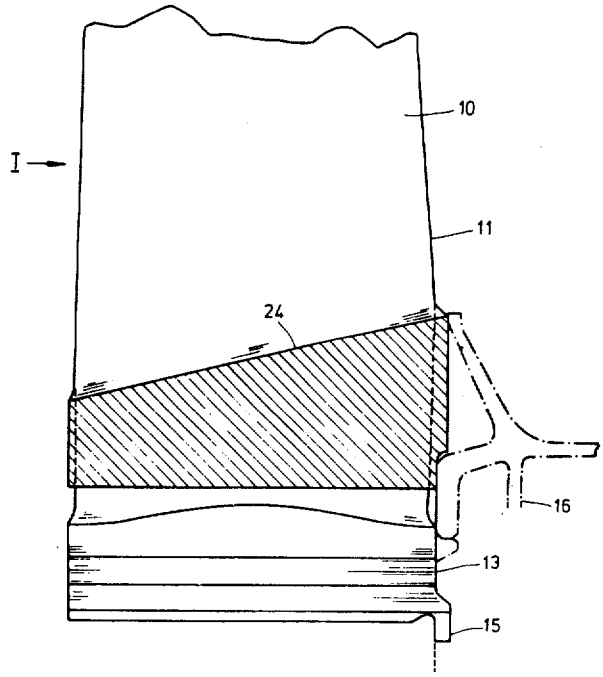
[57] **ABSTRACT**

A fluid flow machine has a plurality of compressor blades, each blade has aerofoil and root portions together with a platform portion which is made of a material of a different nature to that of the blade, and which is joined to it. In one embodiment the blade is titanium and the platform portion is a foamed polyurethane resin.

3 Claims, 7 Drawing Figures



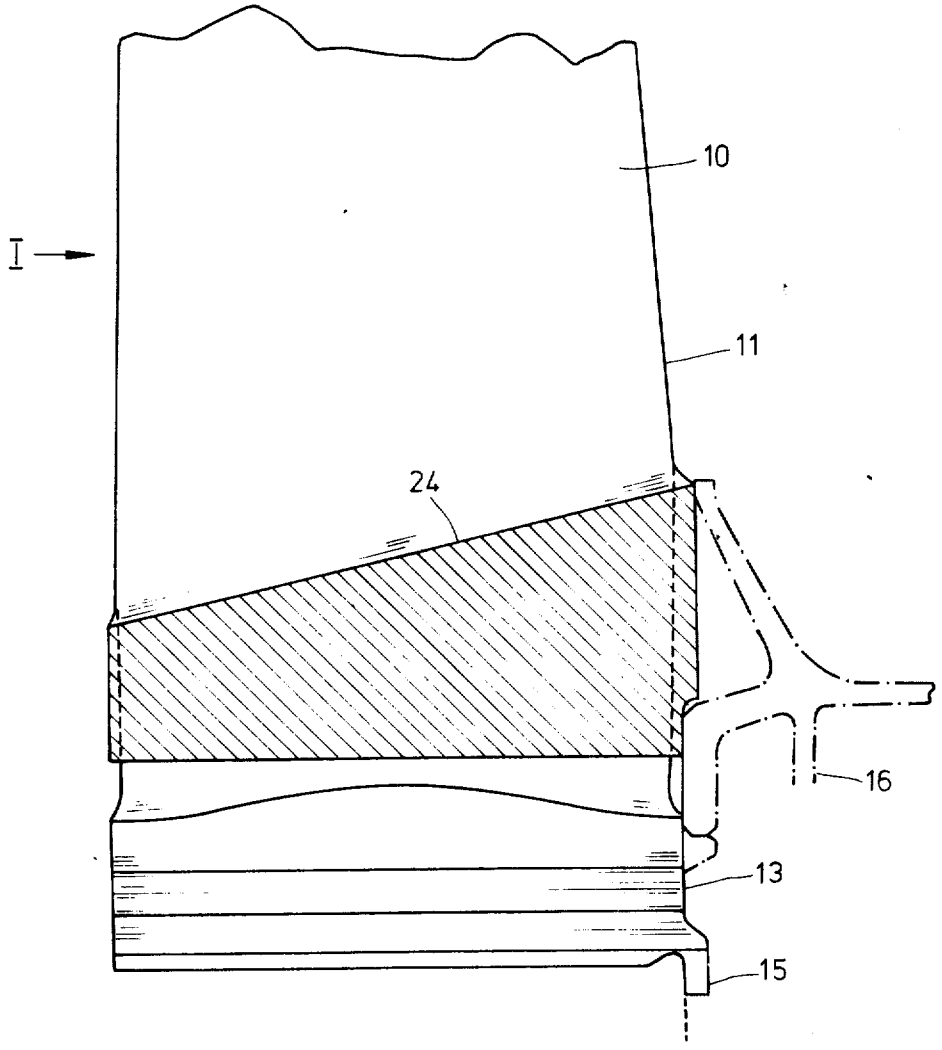


FIG. 1

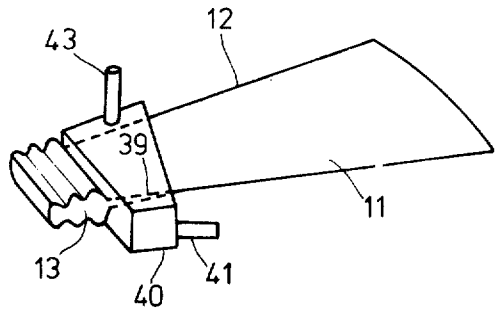


FIG. 5

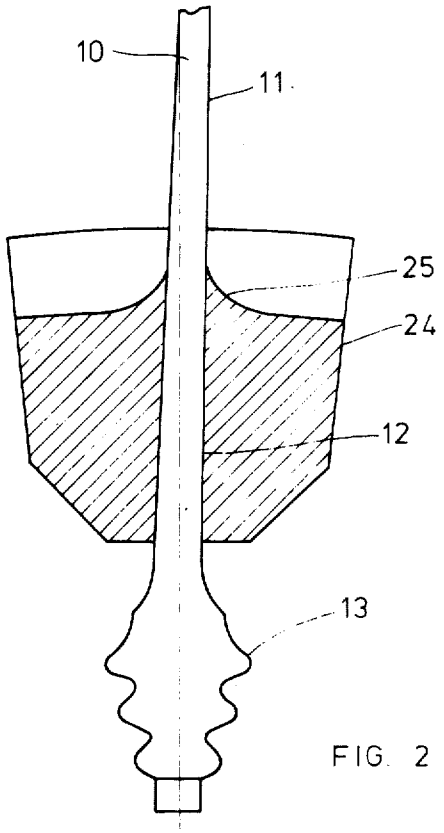


FIG. 2

FIG. 3

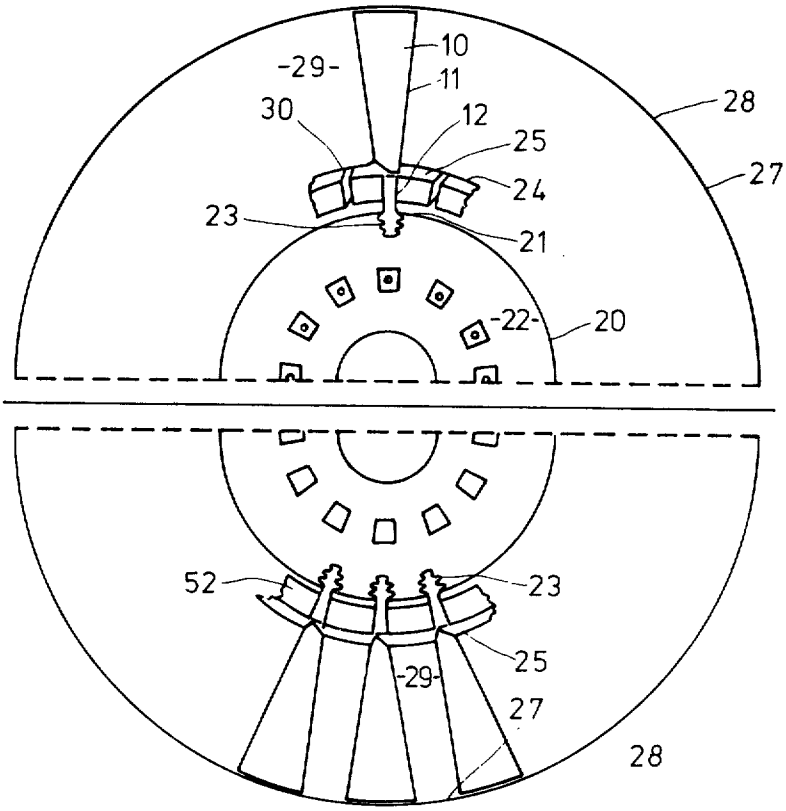


FIG. 4

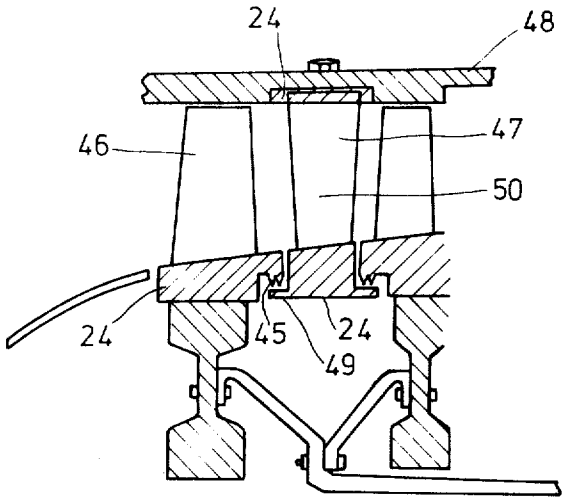


FIG. 6

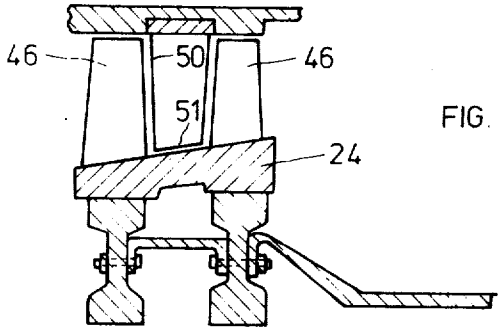


FIG. 7

FLUID FLOW MACHINES

This invention relates to compressor blades for use in fluid flow machines.

Such blades generally comprise aerofoil, platform, and root portions and would typically be formed by forging operations to produce the general shape, followed by machining operations to produce the finished blade. The platform assists the fluid flow through the machine and may, by contacting the platforms of adjacent blades in the fluid flow machine, provide a frictional damping mechanism for blade vibrations.

The provision of a platform for a blade creates many manufacturing problems; in particular, for a forged blade the shape of the forging discs becomes more complicated and costly and the finished machining of the blade requires several operations to profile the platform.

It is an object of the present invention to provide an improved construction of compressor blades.

The term compressor blades will be understood to include constructions such as ducted fan blades.

According to this invention there is provided a compressor blade for use in a fluid flow machine, the blade having aerofoil and root portions together with a platform portion which is made of a material of a different nature to that of the blade and joined to the blade.

Also according to this invention a method of manufacturing a compressor blade for use in a fluid flow machine comprises the steps of making a component having aerofoil and root portions and subsequently joining a platform portion to the blade, the platform portion being made of a material of a different nature to the blade.

In one embodiment a plurality of said compressor blades is arranged in an annular array and adjacent surfaces of adjacent platform portions are provided with anti-fretting coatings.

In another embodiment in which a plurality of said compressor blades is arranged in an annular array adjacent platform portions are joined together.

In a further embodiment in which a plurality of said compressor blades is arranged in an annular array the annular array comprises a number of segments and the platform portions of each blade within the segment is joined to the adjacent platform portions of adjacent blades within the segment.

An annular array of blades may be secured to a disc to form a bladed rotor or may be secured to a casing to form a stator row.

The platform portions of compressor blades comprising successive rotor or stator rows may be joined together.

Leakage of the working fluid of a fluid flow machine between successive rotor and stator rows may be reduced by forming the platform portions to include sealing means.

One particular method of manufacturing a said compressor blade comprises the steps of making a component having aerofoil and root portions, placing the component into a moulding box, and casting the platform portion onto the component.

A preferred material for the platform portion is a foamed polyurethane resin. Preferably the moulding box is an exact female replica of the platform portion thus obviating the need for machining the as cast platform portion.

It will be understood that the said method of machining a single platform portion by casting the platform portion about the component in a moulding box may be extended to an annular array, or a segment comprising said compressor blades.

An embodiment of the invention will now be described by way of example only with reference to the accompanying drawings wherein.

FIG. 1 shows a plan view of a blade according to the invention.

FIG. 2 is a view in the direction I of FIG. 1.

FIG. 3 is a segment of a bladed rotor provided with the blade of FIG. 1.

FIG. 4 is another segment of a bladed rotor showing an alternative embodiment.

FIG. 5 illustrates a blade in a moulding box for the purpose of casting the platform portion onto the blade.

FIG. 6 is a longitudinal section through part of a compressor showing a seal between compressor rotor row and a stator row.

FIG. 7 is a longitudinal section through part of a compressor showing the platform portions of two rotor rows joined together.

Referring to FIGS. 1, 2, 3 and 4 a compressor blade **10** has integral aerofoil, and root portions **11** and **13** respectively. A bladed rotor **20** comprises a plurality of such blades **10** regularly spaced about, and extending in a radial direction from, the periphery **21** of the rotor disc **22** in an annular array **26** (only part of which is shown). The blades **10** are secured to the disc by serrations **23** in its periphery which accommodate the root portions **13** of the blades. A lug **15** and a locking device **16** prevent the blade moving axially relative to the disc **22.** The aerofoil portion **11** of the blade is blended directly into the root portion **13** without an integral platform. Thus in operation the stresses in the blade may be led directly into the root avoiding the stress concentrations and other disadvantages that can be associated with forming a blade platform integrally with the blade, particularly the folds and cracks that can occur as a result of the severe deformation necessary to provide an integral platform on a forged blade are avoided, and the manufacturing process is simplified.

Each blade **10** is however fitted with a platform portion **24** the platform portion **24** being made in a material of different nature to the material of the blade. By nature is meant that the material is either a different material to that of the blade or is the same material but the material is of a different structure. For example the invention contemplates that the blade may be of forged titanium and the platform portion may be of a titanium honeycomb or sintered from titanium powder the honeycomb or sintered structure being subsequently brazed to the aerofoil portion **11** of the blade **10.**

The present embodiment involves the joining of a platform portion **24** in foamed polyurethane resin to a blade of forged titanium.

Reference to FIG. 5 will show a component **12,** having aerofoil and root portions, partially enclosed in a moulding box **40.** The portion **39** of the component inside the moulding box has prior to inserting therein been cleaned and vapour blasted, and the inside of the moulding box coated with a releasing agent. A valve **41** in the moulding box allows the admission of a known quantity of a polyurethane resin and a foaming agent. The polyurethane resin and the foaming agent react to produce a foamed polyurethane resin which expands to

fill the moulding box. Air entrapped in the moulding box is allowed to escape through a venting valve **43**. The quantity of polyurethane resin and foaming agent added is in excess of the amount necessary to fill the moulding box **40** this results in a precompressed foamed resin which has improved mechanical properties.

The foamed polyurethane resin will quickly cure and this may be accelerated by warming the moulding box or by the addition of additives to the polyurethane-resin.

The moulding box is illustrated for use with a single component **12** but it will be readily appreciated that the technique can be extended to form platform portions **24** for a complete annular array of blades, adjacent platform portions **24** of adjacent blades being joined together to form an annular ring, or for a plurality of blades joined together in a segment as illustrated by the three blades of FIG. **4**. The annular ring may be formed about the blades when they are inserted in the disc or alternatively the blades may be located in a jig not shown during the moulding process and the whole assembly subsequently fitted to the rotor disc.

On removal from the moulding box any surplus foam may be trimmed off and the blade is preferably given a coat of sealing compound, for example polyurethane paint. The sealing compound should preferably have good resistance to abrasion. The moulding box **40** is an exact female replica of the shape of the platform portion **24** it is desired to produce thus obviating the need for any machining of the as cast platform.

The radially outer surfaces **25** of successive platform portions **24** are profiled to define, together with the radially inner wall **27** of a casing **28**, in which the bladed rotor operates, a duct **29** suitable for efficient compression of the working fluid.

If individual blades are provided with separate platform portions the end faces **30** of adjacent platform portions may be treated with antifretting compounds applied for example by plasma or metal spraying techniques.

The use of a foamed resin platform portion, which has a low density in comparison with a metal may allow, despite the greater volume necessary to ensure mechanical integrity, a weight saving. It is readily seen from FIG. **2** that the foamed resin extends for some distance along the aerofoil portion **11** of the blade this ensures a good shear strength for the platform portion at its junction with the aerofoil portion **11** and prevents centrifugal force from detaching it.

Referring now to FIG. **6** the annular ring **44** or the platform portions **24** of the compressor blades are machined or cast to include seal elements **45** to reduce the leakage of working fluid between successive rotor or stator rows **46**, **47** respectively of the compressor **48**. The seal elements attached to the rotor row **46** can be seen facing seal elements **49** attached to the stator row **47**. The blades **50** of the stator row are also shown having platform portions **29**, formed in foamed polyurethane resin.

In FIG. **7** the platform portions of two successive rotor rows **46** are shown joined together, and the radially inner ends **51** of the blades **50** of the stator row face the joined together platform portions for sealing purposes.

A variety of different materials may be chosen for the platform portions of the blades of fluid flow machines constructed according to the invention. It will be appreciated that such materials should be chosen having regard to their working enviroment in particular the materials strength at the necessary operating temperature, its resistance to abrasion, its weight, its mechanical integrity and the strength of the joint with the aerofoil portion of the blade need to be considered. A particular advantage of foamed polyurethane resin lies in the fact that little damage will be caused to the fluid flow machine should it become detached from the blade. One type of foamed polyurethane resin used successfully by the applicants is Nopcofoam. (Registered Trade Mark).

The present temperature limit for foamed polyurethane resins is of the order of **120°C** above this temperature their mechanical properties are degraded to the point of being unacceptable. It is expected however that developments in the high temperature technology of resin systems in general will allow the extension of the technique to compressor blades operating at temperatures in excess of **120°C**.

Foamed polyurethane resin is a relatively flexible material in contrast to some resins which are relatively rigid. Differential thermal expansion between a blade and the platform portion can lead to cracking of the platform portion from the blade if the platform portion is made of a relatively rigid material. This cracking can be avoided by interposing a layer of relatively flexible material between the blade and the platform portion. A layer of a nitrile phenolic of approximately fifty to sixty thousandths of an inch has been found successful for this purpose.

What we claim is:

1. A rotor for a fluid flow machine comprising a rotor body; an annular array of blades connected to and extending radially from said body, each blade having an aerofoil portion whose radially inner end terminates in a position spaced from the periphery of the body and a shank extending between the aerofoil portion and said periphery; and platform means made of a cellular material arranged between adjacent shanks.

2. A rotor according to claim **1** wherein the platform means comprise in-situ moulded units extending around the individual shanks.

3. A rotor according to claim **1** wherein the platform means comprise an in-situ moulded annulus connecting the shanks of said array.

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