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[21] Appl. No. **864,021**

[22] Filed **Oct. 6, 1969**

[45] Patented **Aug. 17, 1971**

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[54] **COMPOSITE BLADE**
4 Claims, 9 Drawing Figs.

[52] U.S. Cl. **416/224,**
416/226, 416/230, 416/241

[51] Int. Cl. **F01d 5/14**

[50] Field of Search **416/230,**
229, 224, 241, 226

[56] **References Cited**

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ABSTRACT: A compressor or fan blade is made up of layers of high modulus fibers extending in parallel relation, and embedded in a metallic matrix, the successive layers of fibers varying in length and dimension so that, when stacked and compacted together, the desired blade configuration will be obtained. The blade may be made by a process including stacking the layers of fibers which are secured to a metallic supporting sheet, in the proper sequence, and then compacting the assemblage in dies under pressure and high temperature to cause the material of the several backing sheets to fill the voids among the fibers and form the matrix within which the fibers are embedded.

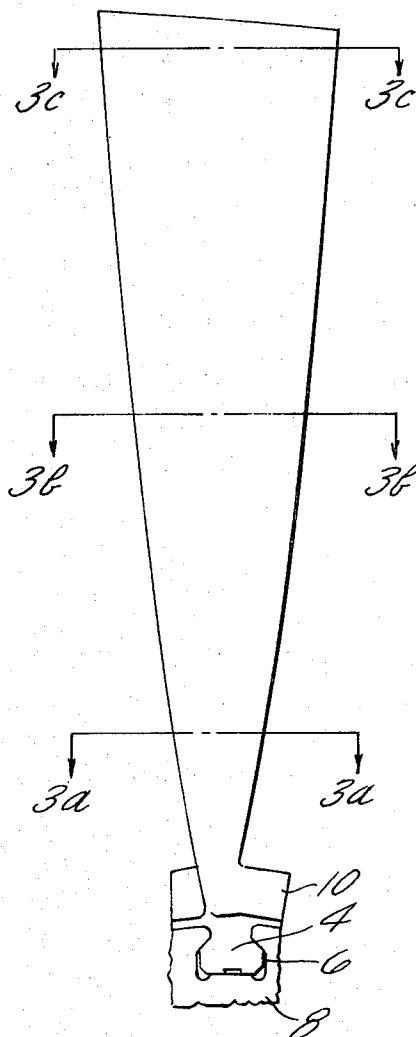


FIG. 1

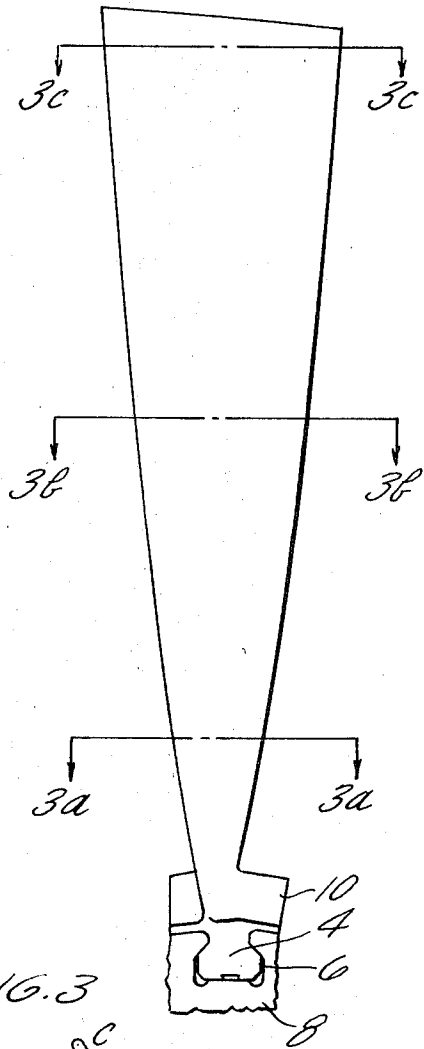


FIG. 3

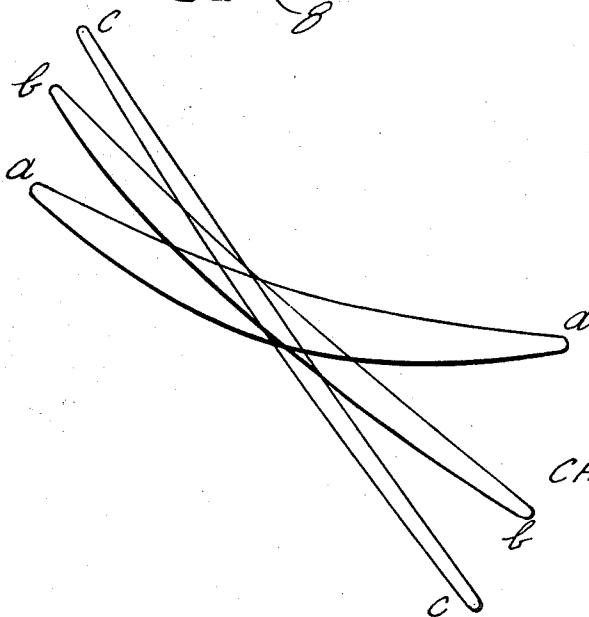
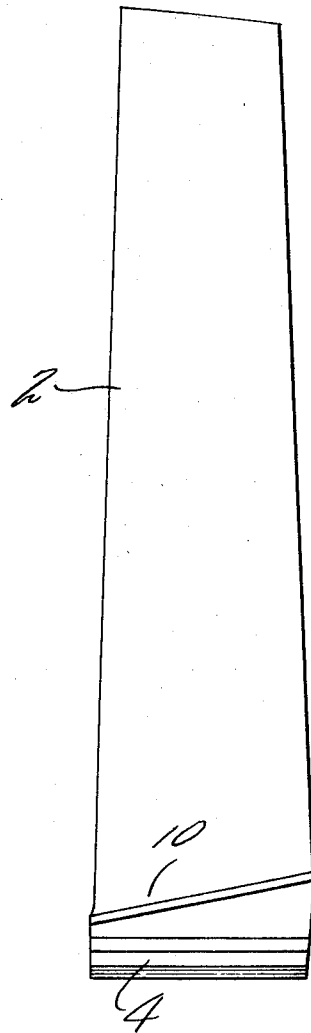


FIG. 2



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FIG. 4

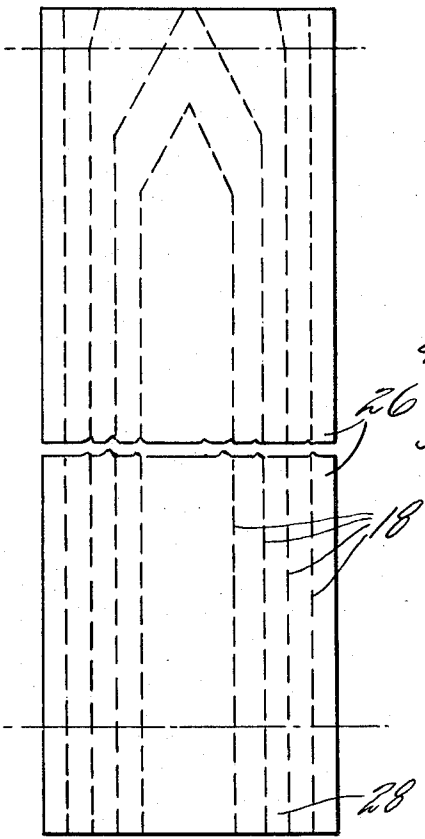


FIG. 5

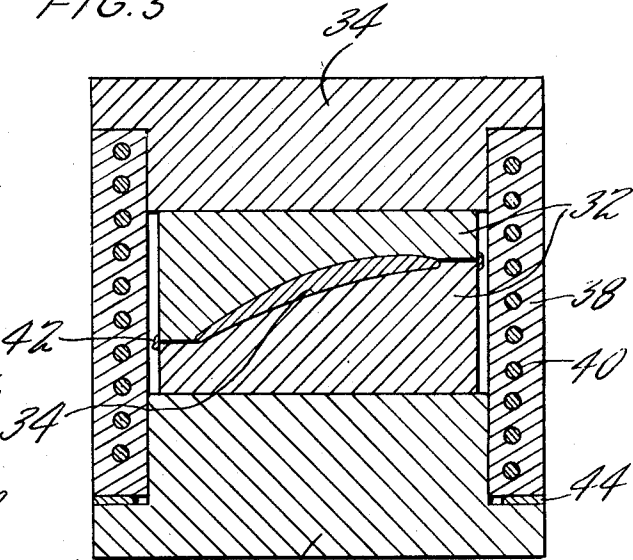


FIG. 6

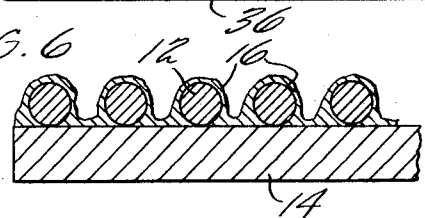


FIG. 7

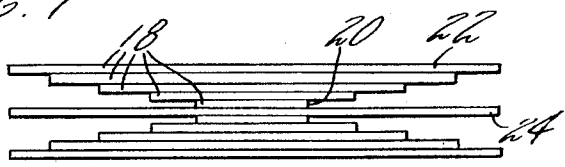


FIG. 8

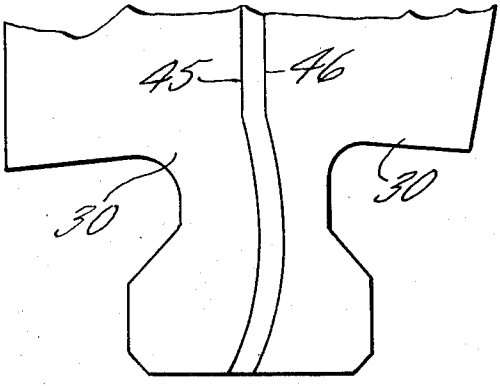
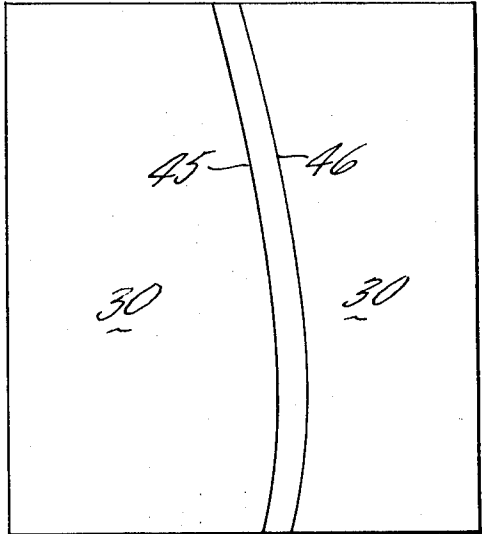


FIG. 9



COMPOSITE BLADE

BACKGROUND OF THE INVENTION

With the advent of high thrust jet engines for use in aircraft, the need for compressor and fan blades with a high modulus of elasticity has become more apparent. The higher modulus makes a stiffer blade thus reducing vibration problems, and combined with lightness in weight permits a lighter supporting structure thereby materially reducing engine weight.

SUMMARY OF THE INVENTION

One feature of the invention is a composite blade made up of several layers of high modulus fibers all embedded in a metallic matrix and with the several layers varying in plan so that when stacked together and embedded in the matrix the finished blade shape is produced. Another feature is a process for producing such composite blades.

According to the invention, the blade is made up of a plurality of layers of high modulus fibers each layer being enclosed in a metallic matrix, with the several layers shaped in plan so that when stacked and compressed in a die the compacted stack will have the shape of the finished blade, and the layers will be in substantially parallel relation in the blade, and they will all be bonded together in a metallic matrix.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an end view of a finished blade in a portion of a supporting disc.

FIG. 2 is a side view of the blade.

FIG. 3 is an assemblage of sectional views along line 3a-3a, 3b-3b and 3c-3c of FIG. 1.

FIG. 4 is a developed plan view of the blade showing the configuration of several plies in the blade.

FIG. 5 is a sectional view through a die and associated mechanism for producing the blade.

FIG. 6 is an enlarged sectional view through one of the plies of fibers.

FIG. 7 is a diagrammatic view of the assemblage of plies in forming the blade.

FIG. 8 is a fragmentary view of the end of a blade root showing a modification.

FIG. 9 is a view of the bottom of the blade root at FIG. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention is shown in a compressor or fan blade 2 for use especially in jet engines, the blade being mounted by a dovetail root portion 4 in a corresponding slot 6 in a supporting disc 8. The blade is a composite, being made up of high modulus fibers in a metallic matrix, with the matrix substantially filling all the voids to form a void-free blade. The fibers extend through the root attachment as will be described. The blade has a platform 10 at its inner end that is inclined from front to rear as shown in FIG. 2 and this platform defines the inner wall of the air path over the airfoil portion of the blade.

As above stated the fibers are high modulus fibers 12, FIG. 6, one type of which is a boron fiber coated with silicon carbide, sometimes with a tungsten core, and these fibers are secured to an aluminum alloy sheet 14 in closely and evenly spaced parallel relation to one another. These fibers are secured to the backing sheet 14 by a coating 16 applied to the side of the fibers opposite to the backing sheet. This coating may be applied as by plasma spraying an aluminum alloy onto the fibers. The assemblage forms ribbons to be used in making the blade.

The ribbon of fibers combined with the backing sheet and coating is cut into shaped plies 18 which vary in length and width as shown in FIG. 4 and these plies are stacked one above another preferably with the smallest dimension of ply 20 centrally of the blade assembly so that the outermost ply 22, which is the shape of the blade will form a continuous surface over one side of the blade. Although these plies may be

stacked directly on one another from the centerline of the blade, it is desirable to provide an aluminum core 24, which is the shape of the blade, with the individual plies stacked on opposite sides of the core. This core is preferably relatively thin, for example, 5 mils, and may be aluminum or the same aluminum alloy as the backing sheets for the plies.

The shapes of the several plies is so selected that when compacted in the formation of the blade the resulting contour will be the desired contour of the finished blade. Preferably also the same number of plies are located on each side of the core and on both sides the outer ply, when contoured to shape will be that of the finished blade surface.

When the plies have been individually cut to shape they are arranged in stacked relation, as shown in FIG. 9, each ply being desirably tack welded to the surface underneath so that each ply will remain in proper relation to the others during the build up of the plies on both sides of the centerline of the blade. As shown in FIG. 4, each ply projects beyond the airfoil portion 26 of the blade assembly into the root portion 28 in order to form a secure attachment for the blade in the supporting disc. The formation of the dovetail portion is not a part of the present invention; for the purpose of this invention the assemblage of the plies in the root portion may have dovetail and platform forming elements 30 positioned on opposite sides of the plies, as shown in FIG. 1. These elements may be secured either during the forming of the blade in the die or may be diffusion bonded or otherwise attached subsequently.

In either event, the assemblage of the several 1 as in FIG. 7, is placed in a two-part die 32, FIG. 5 in which the assemblage is compacted and unitized by heating. Although only a few plies are shown in this figure, it will be understood that this is shown by way of example, since these plies as formed are only a few mils thick and normally a large number of plies must be used in producing a blade of the desired thickness. The number of plies and the shape of the several plies may well be determined by computer after the compacted thickness of each of the plies is known and the desired configuration of the finished blade is established. The parts of the die 32, receive between them the assembled stack of plies in a cavity 34 that is the configuration of the finished blade, and heat and pressure are applied to compact the plies and to cause the aluminum alloy to flow to fill the voids. The die 30 may be placed between pressure plates 34 and 36 slidable in a housing 38, the latter having heating means therein such as an induction coil 40. In the particular embodiment shown a pressure of about 3500 p.s.i. is applied to the dies and the temperature of the dies is raised to a point about 25° below the melting point of the aluminum alloy. At this temperature the alloy will flow around the fibers and fill all the voids among the fibers. The heating and pressing is preferably done in a high vacuum and the pressure is preferably applied only when the desired temperature is reached. With the particular alloy being used the temperature is between 1020° and 1050°.

The temperature and pressure are maintained for about 1½ hours, after which the dies and blade are allowed to cool while the pressure is maintained. During the pressing of the blade into finished shape, excess aluminum alloy 42 escapes between the die halves as shown in FIG. 5. The pressure plates 34 and 36 46 of be limited in their movement toward one another by suitable stops 44 one end of the housing 38.

The thickness of the aluminum backing sheet for the fibers is selected so that in the finished blade the volume of fibers will be about 50 percent so that the volumes of fibers and surrounding matrix are about equal.

After the blade is cooled and is removed from the die, the surplusage of aluminum at the edges of the blade are removed, the tip of the blade is cut to shape and the root elements 30, if not added earlier, are secured to opposite surfaces of the root portion. In attachment of these elements it is desirable to form the mating surfaces 44 and 46 of these elements with a compound curvature for more secure retention of the blade within these elements. Thus, as shown in FIG. 8 the root portion is

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curved longitudinally from end-to-end, and as shown in FIG. 9 the root portion is also cured laterally between opposite ends. This may be accomplished during the pressing of the blade, and shaping the mating surfaces of the elements 30 to fit this compound curvature.

We claim:

1. A composite blade material for a compressor having a plurality of layers of high modulus plies stacked on each side of a thin sheet of aluminum alloy which is located centrally of the blade, the plies comprising high modulus fibers selected from the group consisting of boron and silicon carbide coated boron fibers and a matrix material which is an aluminum alloy, and the plies varying in width and length to provide a varying blade thickness chordwise and lengthwise.

2. A blade according to claim 1 wherein the plies are 15

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stacked according to size to form an assemblage of layers graduated in size, with the smaller plies central of the assemblage and the larger plies outer of the smaller plies, the outermost ply being substantially continuous over the blade surface.

3. A blade according to claim 1 having further a root portion at one end of the blade and an airfoil port on, wherein the fibers and matrix form the complete airfoil portion and extend into and form a projecting portion which is a part of the root portion.

4. A blade according to claim 1 wherein the fiber constitutes substantially 50 percent of the volume of the finished blade.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,600,103 Dated August 17, 1971

Inventor(s) David F. Gray, et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In column 2, line 14, the numeral "9" should be "7".

In column 2, line 26, the numeral "1" should be "8".

In column 2, line 41, the numeral "34" should be "33".

In column 2, line 73, the numeral "44" should be "45".

In column 3, line 2, the word "cured" should be "curved".

In sheet 2 of the drawings, the numeral "34" immediately to the left of Fig. 5 should be "33".

In column 2, line 30, the numeral "1" should be "plies".

In column 2, line 62, "46 of" should be "may".

In column 2, line 63, the word "at" should be inserted after the numeral "44".

Signed and sealed this 20th day of June 1972.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents