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W. BOYD ET AL
ELECTRICALLY HEATED BLADE AND
PROCESS OF MANUFACTURE
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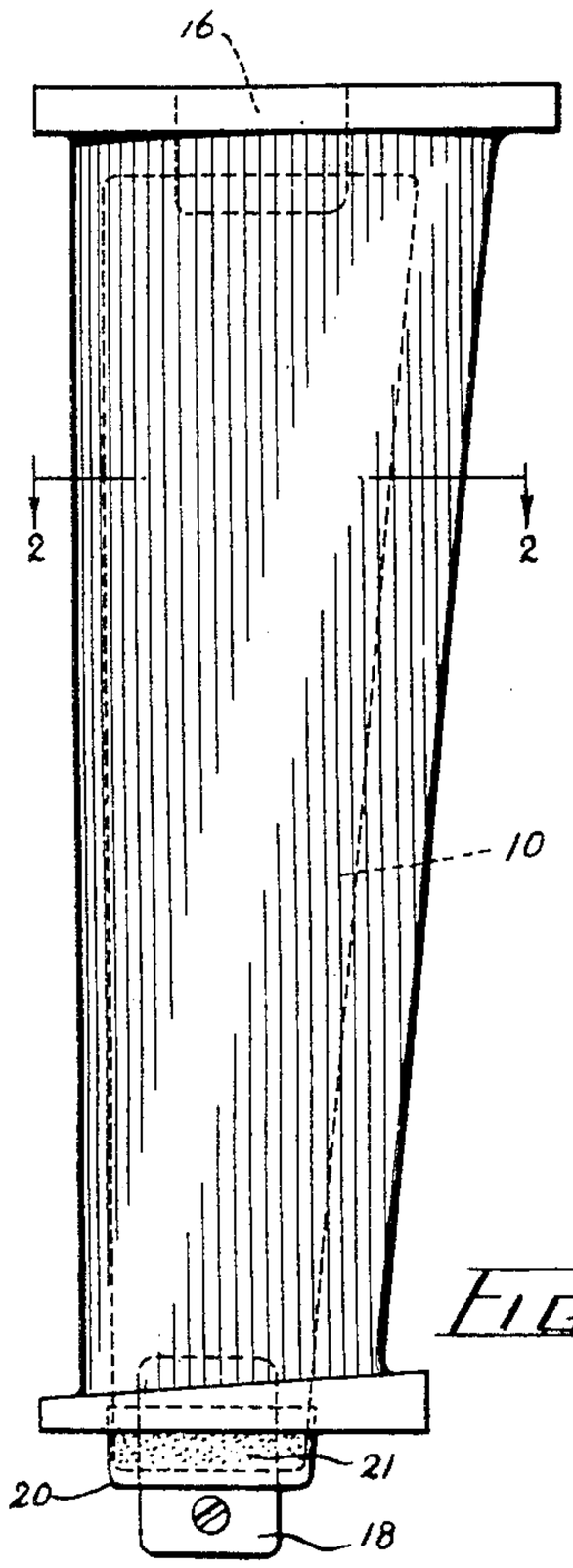


FIG 1.

FIG 2.

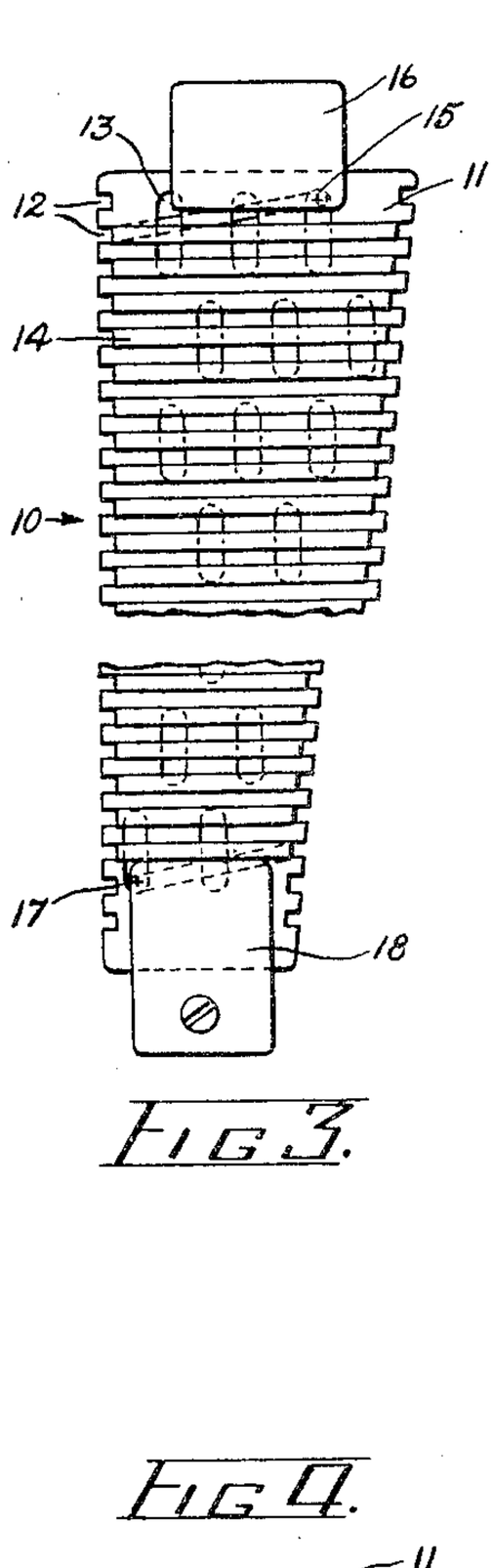


FIG 3.

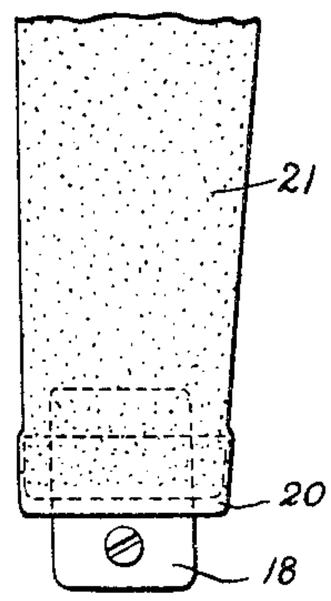
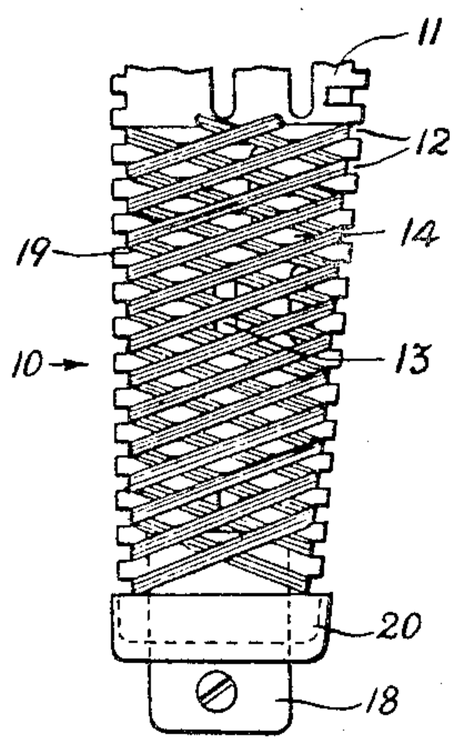


FIG 5.

FIG 4.



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ELECTRICALLY HEATED BLADE AND PROCESS OF MANUFACTURE

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7 Claims. (Cl. 219—19)

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This invention relates to means of preventing ice formation on the blades of rotary power conversion machines and particularly on the blades of axial compressors which form a component part of aircraft gas turbine engines.

The formation of ice on the inlet components of axial compressors causes serious obstruction to the flow of air passing through them and furthermore, serious damage may result from pieces of ice breaking loose and being carried by the air stream into the rapidly moving blading. A main object of this invention is therefore to provide means to raise the temperature of the compressor inlet guide vanes and of other compressor blades, when considered desirable, sufficiently to prevent the formation of ice on these parts when flying through atmospheric conditions conducive to icing.

Another object is to provide a means of anti-icing which may be readily controlled to suit atmospheric conditions and which requires only a simple electrical installation free of the bulky ducts, pumps and piping associated with other constructions which have heretofore been adopted.

Another important object is to provide, in each blade to be heated, an electrical heating element of minimum cross-sectional area so that the cavity within the blade occupied by the heater will not detract unnecessarily from the structural strength of the blade.

A further object of this invention is to provide a heating element construction which may be embedded in and form an integral part of a metal casting and also to provide a process of making such a construction.

All of the foregoing and still further objects and advantages of the invention will become apparent from a study of the following specification, taken in conjunction with the accompanying drawings, wherein like characters of reference designate corresponding parts throughout the several views and wherein:

Fig. 1 is an elevation view of a blade constructed in accordance with this invention and showing, in dotted outline, the disposition of the heating element within the blade;

Fig. 2 is a cross sectional view through the line 2—2 of the blade shown in Fig. 1;

Fig. 3 is a broken elevation of a partially completed heating element;

Fig. 4 is a broken elevation of a partially completed heating element showing the manner in which glass thread is wrapped over the wound resistance ribbon to provide electrical insulation for the latter, and

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Fig. 5 is a broken elevation of the completed heating element.

Referring to the drawings, a heating element generally indicated at 10 comprises a thin sheet 11 of mica or other suitable electrical insulating material having spaced recesses 12 in its edges, thus providing serrations, and also having perforations 13. An electrical resistance ribbon 14 is wound upon the sheet 11 in such a manner as to pass through the recesses 12, the turns being thus held in spaced relationship.

One end of the resistance ribbon 14 is spot welded at 15 to a conducting locating lug 16, and the other end is similarly spot welded at 17 to a conducting terminal lug 18.

In order to provide electrical insulation for the resistance ribbon, a double winding 19 of inorganic heat-resisting electrical insulating material is applied over the electrical resistance ribbon 14 and mica sheet 11, one winding being in a clockwise direction and the other winding being in a counter-clockwise direction; both of these windings are applied in such a manner as to pass through the recesses 12 and so that the completely wound heating element appears as shown in Fig. 4. Around a portion of the terminal lug 18 is provided an electrical insulating sheath 20.

The heating element described above is then coated or impregnated with ceramic cement 21. The double winding 19, the sheath 20 and the coat of ceramic cement 21 must be of materials which are thermally stable at the maximum temperatures that the heating element might attain. The double winding 19 is preferably made of glass threads whereas the sheath 20 is preferably woven from glass threads. A satisfactory ceramic cement is an aqueous mixture of nine parts kaolin and 1 part borax. The ceramic cement provides additional electrical insulation and moreover secures the components of the assembly, namely the mica sheet 11, the resistance ribbon 14, the glass thread winding 19 and the sheath 20 in a unitary structure. The perforations 13 enable the ceramic cement on opposite faces of the mica sheet to be bound together.

After the heating element 10 has been coated with the ceramic cement it is placed in a suitable form and heat is applied to it; this bakes the ceramic cement and at the same time gives to the element a curvature conforming to the curvature of the blade of which it is to form a part. The finished heating element is illustrated in Fig. 5.

The heating element made as described above is eventually placed in spaced relationship within a mold, and molten metal is introduced into the mold to encase the heating element with a metal-

lic structure having the form of a blade. The completed blade manufactured in accordance with this invention is illustrated in Figs. 1 and 2.

According to this invention, any of the guide vanes or blades of a compressor that may be found subject to ice formation are constructed as previously described, and obviously the electrical heating elements are suitably connected to an electrical power supply. When icing conditions are encountered, an electrical current is passed through the resistance ribbons of the heating element, causing sufficient heat to be generated within the vanes and blades to raise their surface temperature above the freezing point of water, thereby eliminating undesirable ice formation thereon.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred example of the same and that various changes in the shape, size and arrangement of the parts may be resorted to, without departing from the spirit of the invention or the scope of the claims.

What we claim as our invention is:

1. A blade for a rotary power conversion machine comprising an electrical heating element which includes a sheet of electrical insulating material, electrical resistance wiring supported by the sheet, a helix of inorganic heat resisting electrical insulating material over and around the resistance wiring and the sheet, adjacent turns of the helix being spaced apart, and a coating of ceramic material covering the aforesaid assembly and filling the spaces between the turns of the helix; and a metallic structure having the form of a blade and encasing the electrical heating element.

2. A blade for a rotary power conversion machine comprising an electrical heating element which includes a sheet of electrical insulating material, electrical resistance wiring supported by the sheet, criss-crossed helices of inorganic heat resisting electrical insulating material over and around the resistance wiring and the sheet, adjacent turns of each helix being spaced apart, this arrangement of helices providing rhombic openings, and a coating of ceramic material covering the aforesaid assembly and filling the openings; and a metallic structure having the form of a blade and encasing the electrical heating element.

3. A blade for a rotary power conversion machine comprising an electrical heating element which includes a sheet of electrical insulating material having serrations in its edges, electrical resistance wiring supported by the sheet, a helix of inorganic heat resisting electrical insulating material over and around the resistance wiring and the sheet, adjacent turns of the helix being spaced apart by the serrations, and a coating of ceramic material covering the aforesaid assembly and filling the spaces between the turns of the helix; and a metallic structure having the form of a blade and encasing the electrical heating element.

4. A blade for a rotary power conversion machine comprising an electrical heating element which includes a sheet of electrical insulating material having perforations extending through it, electrical resistance wiring supported by the sheet, a helix of inorganic heat resisting electrical insulating material over and around the resistance wiring and the sheet, adjacent turns of the helix being spaced apart, and a coating of ceramic material covering the aforesaid assembly, the ceramic material filling the spaces between the turns of the helix and also the perforations, thereby locking the coating to the inorganic heat resisting electrical insulating material, the wiring and the sheet; and a metallic structure having the form of a blade and encasing the electrical heating element.

5. A blade for a rotary power conversion machine comprising an electrical heating element which includes a sheet of electrical insulating material having serrations in its edges and having perforations extending through it, electrical resistance wiring supported by the sheet, a helix of inorganic heat resisting electrical insulating material over and around the resistance wiring and the sheet, adjacent turns of the helix being spaced apart by the serrations, and a coating of ceramic material covering the aforesaid assembly, the ceramic material filling the spaces between the turns of the helix and also the perforations, thereby locking the coating to the inorganic heat resisting electrical insulating material, the wiring and the sheet; and a metallic structure having the form of a blade and encasing the electrical heating element.

6. The process of manufacturing a blade for a rotary power conversion machine comprising making an electrical element by winding an electrical resistance wire around a sheet of electrical insulating material, winding a helix of inorganic heat resisting electrical insulating material over and around the electrical resistance wire and the sheet, adjacent turns of the helix being spaced apart, and applying a coating of ceramic material over the aforesaid assembly, the said coating filling the spaces between the turns of the helix; locating the electrical heating element so made in spaced relationship within a mould; and introducing metal into said mould to encase the heating element with a metallic structure haivng the form of a blade.

7. The process of manufacturing a blade for a rotary power conversion machine comprising making an electrical element by winding an electrical resistance wire around a sheet of electrical insulating material, winding a helix of inorganic heat resisting electrical insulating material over and around the electrical resistance wire and the sheet, adjacent turns of the helix being spaced apart, and applying a coating of ceramic material over the aforesaid assembly, the said coating filling the spaces between the turns of the helix, and applying heat to the element to bake the ceramic material thereon; locating the electrical heating element so made in spaced relationship within a mould; and introducing metal into said mould to encase the heating element with a metallic structure having the form of a blade.

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