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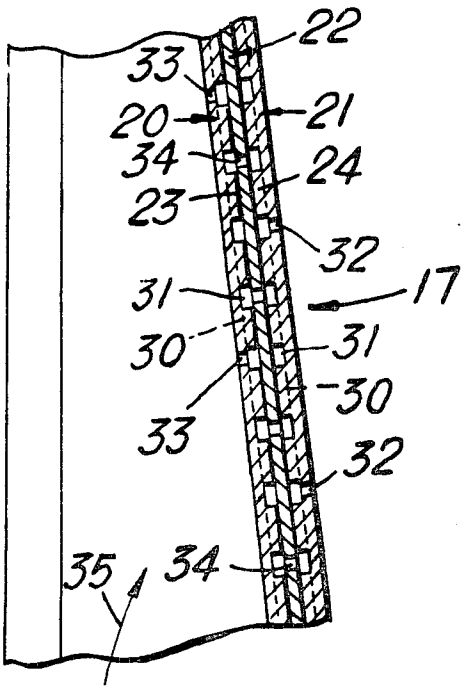
[54] **COOLING OF AEROFOIL SHAPED BLADES**
4 Claims, 4 Drawing Figs.

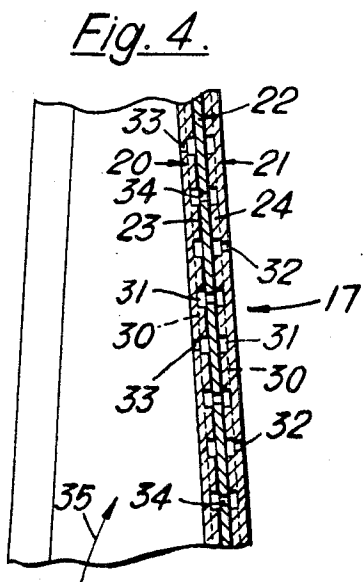
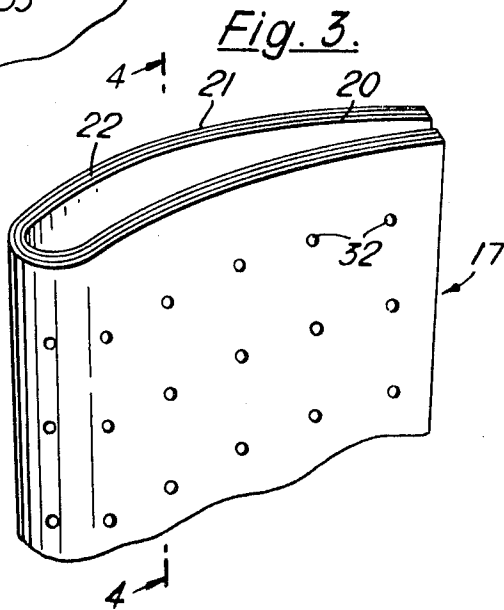
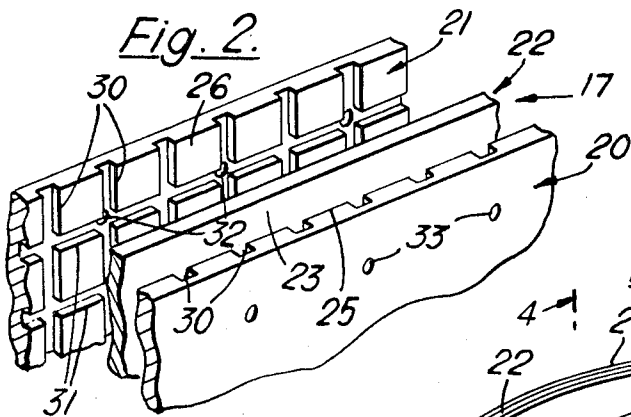
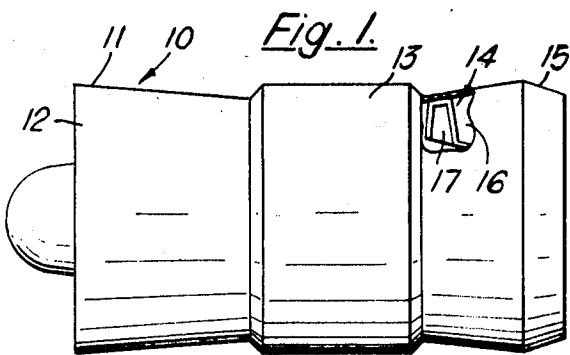
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ABSTRACT: A hollow aerofoil-shaped blade for a fluid flow machine wherein the boundary wall of the blade is made up of a plurality of sheets bonded together. The sheets define therebetween cooling fluid ducting, each sheet having defined on the concave and/or convex faces of the blade, apertures which extend through the sheet and communicate with the ducting. The apertures on adjacent sheets are out of alignment such that cooling fluid supplied to the interior of the blade may pass to the exterior thereof by way of the ducting.





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COOLING OF AEROFOIL SHAPED BLADES

This invention concerns improvements relating to the cooling of aerofoil-shaped blades for use in a fluid flow machine.

Although the invention is primarily intended for use in the cooling of a turbine rotor blade, the term "blade" is used in this specification in a broad sense to include stator vanes such, for example, as turbine nozzle guide vanes.

According to the present invention, there is provided a hollow aerofoil-shaped blade for use in a fluid flow machine, said blade having a boundary wall which is made up of a plurality of sheets which are bonded together and so formed at their adjacent faces as to provide cooling fluid ducting therebetween, each sheet having, on the concave and/or convex faces of the blade, apertures which extend through the thickness of the sheet and which communicate with said ducting such that apertures on adjacent faces are not aligned whereby cooling fluid supplied to the interior of the blade may pass to the exterior thereof by way of said ducting.

The construction is preferably such that the cooling fluid, in passing from the interior to the exterior of the blade, is constrained to follow a tortuous path through said ducting.

The or each pair of adjacent faces preferably comprises a grooved face and an ungrooved face. Thus, the grooved face may be provided with a first set of parallel grooves which intersects a second set of parallel grooves.

The said boundary wall is preferably made up of an inner sheet, an outer sheet, and an intermediate sheet therebetween.

Thus the opposite faces of the intermediate sheet may be ungrooved, the faces of the inner and outer sheets adjacent to the intermediate sheet being grooved, the intermediate sheet having apertures therein which communicate with the grooves in the inner and outer sheets but are not aligned with the apertures in the latter. Moreover, the apertures in the inner and outer sheets are preferably out of alignment.

The grooves in each grooved face have preferably been formed by spark machining, while the said apertures may also be formed by spark machining.

The said sheets may have been diffusion brazed to each other.

As indicated above, the blade may be a turbine rotor blade of a gas turbine engine and the invention also comprises a gas turbine engine provided with such blades.

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

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

FIGS. 2 and 3 are respectively a broken-away exploded view, and a broken-away perspective view of one of the turbine rotor blades, and

FIG. 4 is a broken-away diagrammatic sectional view taken on the line 4—4 of FIG. 3.

Referring to the drawings, a gas turbine jet propulsion engine 10 has an engine casing 11 within which there are provided, in flow series, a compressor 12, combustion equipment 13, and a turbine 14, the turbine exhaust gases being directed to atmosphere through an exhaust duct 15. The turbine 14 has stator blades 16 and rotor blades 17.

As shown in FIGS. 2 to 4, each of the turbine rotor blades 17 is a hollow blade having a boundary wall made up of an inner sheet 20, an outer sheet 21 and an intermediate sheet 22 therebetween. The intermediate sheet 22 has opposite faces 23, 24 which are ungrooved. The face 23, however, is disposed adjacent to a grooved face 25 of the inner sheet 20, while the face 24 is disposed adjacent to a grooved face 26 of the outer sheet 21. Each of the faces 25, 26 is provided with a first set of parallel grooves 30 which extend substantially radially, i.e., longitudinally of the blade, and intersect a set of parallel grooves 31. The grooves 30, 31 provide ducting for the flow of cooling fluid between the adjacent faces 23, 25, and the adjacent faces 24, 26.

The outer sheet 21 is provided with a plurality of apertures 32 therethrough, each alternate intersection of the grooves 30, 31 being provided with a said aperture 32 which thus com-

municates with said grooves. The inner sheet 20 is provided with apertures 33 therethrough, the spacing between which is equal to the spacing between the apertures 32. The apertures 33, however, communicate with the grooves 31 of the inner sheet 20 at points intermediate the grooves 30 thereof, and are therefore out of alignment with the apertures 32.

The intermediate sheet 22 is provided with apertures 34 whose spacing corresponds to that of the apertures 33 and that of the apertures 32, but which are not aligned with either of the latter. The apertures 34 communicate with alternate grooves 31.

Accordingly, cooling air supplied to the interior of the blade 17, as indicated by the arrow 35 in FIG. 4, may pass through the apertures 33 and grooves 30, 31 in the inner sheet 20, and thence through the apertures 34 in the intermediate sheet 22, and finally through grooves 30, 31 in the outer sheet 21 so as to pass to the exterior of the blade through the apertures 32. The cooling air, in passing from the interior to the exterior of the blade, is therefore constrained to follow a tortuous path through the said grooves, whereby to promote cooling of the blade effectively.

The grooves 30, 31 and the apertures 32, 33, 34 may all be formed in their respective sheets by spark machining.

The sheets 20, 21, 22 are bonded together, e.g., by being diffusion brazed to each other. This may, for example, be achieved by spraying each of the sheets 20, 21, 22, after the spark machining thereof, with a brazing material which may for example comprise a mixture of an alloy and of a synthetic resin material, the latter being such as to become vaporized and thus removed during the heat treatment referred to below. The brazing material, moreover, is such as to be compatible with and adapted to form a diffusion braze with the material of the sheets 20, 21, 22. Thus if for example the sheets 20, 21, 22 are formed of a nickel based alloy such as Nimonic 105 or Nimonic 118 (Nimonic being a Registered Trade Mark), the brazing material employed may consist of 60 percent by weight of an alloy sold under the Trade Name Microbraz 4775 and 40 percent by weight of an acrylic resin. After being so sprayed, the sheets 20, 21, 22 are placed together in a jig (not shown) which merely locates them without applying any gripping or positive pressure thereto. No force is therefore employed to force the sheets against each other so that there will be little tendency for the brazing material to be squeezed out of position.

The assembly of the sheets 20, 21, 22 is then heat treated by being placed in an oven (not shown) which is maintained at an elevated temperature until the brazing material melts. This heat treatment is effected in vacuo, the heating and vacuum conditions effecting removal of the acrylic binder referred to above. The brazing cycle employed is that of the normal heat treatment cycle of the blade 17. Thus, for example, if the latter is made of Nimonic 105, the assembly of the sheets 20, 21, 22 and brazing material, is given a solution heat treatment for four hours at 1,150° C. and then a further treatment of 16 hours at 1050° C.; while if the sheets 20, 21, 22 are formed of Nimonic 118, the solution treatment is for 1½ hours at 1190° C., the assembly is then allowed to cool from the temperature of 1,190° to 1,000° C., and is thereafter rapidly cooled to room temperature.

Prior to the said spraying of the sheets with brazing material, each of the grooves 30, 31 and apertures 32, 33, 34, should be coated with a coating material which prevents the adhesion of the brazing material thereto. Thus the coating material may, for example, be constituted by a thin film of the material sold under the Trade Name Microbraz Green Stop-Off Paint which is basically a suspension of chromic oxide in an organic carrier. During brazing, this paint becomes charred so as to give a black dust over which the brazing material will not flow.

The said brazing gives a joint between the various sheets which is as strong as that of the parent metal thereof at the blade working temperature.

I claim:

1. A hollow aerofoil-shaped blade for use in a fluid flow machine, said blade having a convex side and a concave side, each side being made up of an inner sheet having inner and outer faces, an outer sheet having inner and outer faces, and an intermediate sheet therebetween and respectively adjacent to the outer and inner faces respectively of said inner and outer sheets, the outer and inner faces respectively of the inner and outer sheets of at least one of said sides adjacent to the intermediate sheet being grooved, each inner sheet an outer sheet of the at least one of said sides having defined therein apertures which extend through the thickness of the sheet and communicating with the grooves therein, the apertures of the inner sheet being out of alignment with the apertures of the outer sheet, said intermediate sheet of the at least one of said sides having apertures defined therein which communicate with said grooves in the said outer and inner faces respectively of said inner and outer sheets but which are out of

alignment with said apertures in both said inner and outer sheets of the at least one of said sides, whereby in operation cooling fluid supplied to the hollow interior of the blade passes to the exterior thereof by following a tortuous path through said apertures and said grooves from the interior to the exterior of the blade.

2. A blade as claimed in claim 1 in which each grooved outer and inner face respectively of said inner and outer sheets of the at least one of said sides has defined therein first and second sets of parallel grooves, the two said sets intersecting with each other.

3. A blade as claimed in claim 1 in which said at least one of said sides is said concave side.

4. A blade as claimed in claim 1 in which said inner, outer and intermediate sheets have a diffusion brazed joint therebetween.

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