United States Patent

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[73] Assignee **General Electric Company**

[54] **TURBOMACHINERY BLADES**
5 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **416/90,** 416/232
[51] **Int. Cl.** **F01d 5/18**
[50] **Field of Search** .... 253/77 (H), 77 (I), 39.15 (B); 170/159 (M); 416/90, 95, 224, 233; 416/232 (Foreign), 248, 96, 213

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ABSTRACT: A cast, hollow, turbine blade has an opening in its tip end wall formed by a core pin which positioned the core in a mold as the blade was cast. A plate is brazed to the inner surface of this end wall and seals this opening in a manner such that the structural integrity of the blade is not dependent on a bonded joint.

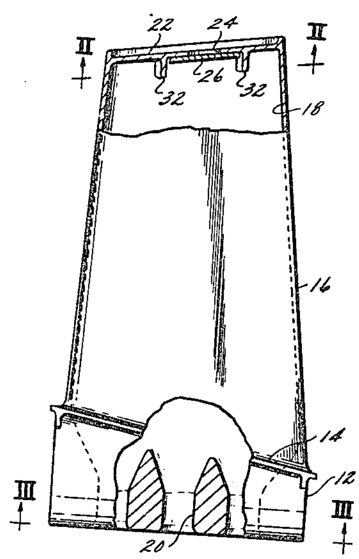

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FIG 1

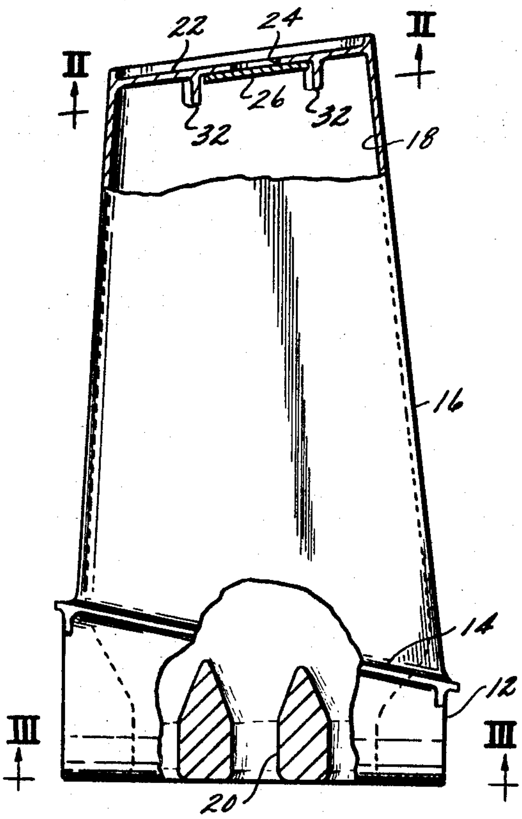


FIG 2

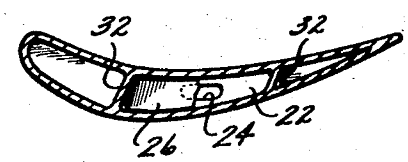


FIG 3

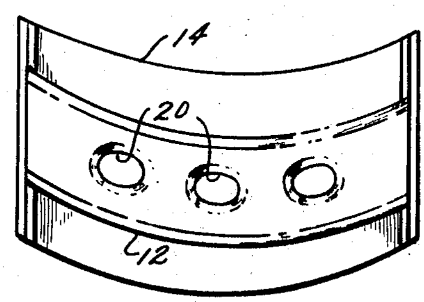
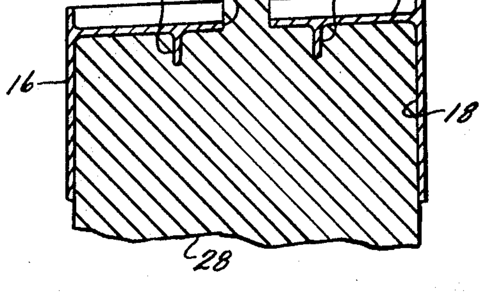


FIG 4



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TURBOMACHINERY BLADES

The present invention relates to improvements in gas turbine engines and more particularly to improved hollow blades employed in such engines.

Turbine blades are formed as hollow shells, not only to reduce their weight, but to provide a plenum chamber from which cooling air is discharged, through openings in the shell, into the hot gas stream. The arrangement of the openings and the flow of the cooling air through the interior of the blade can take many different forms to maintain the actual metal temperature of the blade substantially cooler than the extremely high temperature of the hot gas stream which passes through the blades to drive the turbine.

The most advanced alloys are employed in fabricating these blades in order to permit operation in the severe environment of high temperatures and high stresses that is inherent in high-performance engines intended for the propulsion of aircraft. The most effective and practical fabrication technique for forming hollow blades of such alloys is casting. A core is positioned within a mold to define the hollow shell of the blade which is integrally cast with a tang employed in securing it to a turbine rotor disc.

The opposite ends of this core must be supported to accurately position it within the mold. One end of the core may be supported by extensions through the attaching tang which define, in the cast blade, entrance ports for cooling air. Conventionally the other end of the core has been supported by having the core extend beyond the tip end of the blade mold. The resultant cast blade is then open at its tip end. This has necessitated attachment of an end cap, by brazing, welding or the like, in order to seal the tip end of the blade. Alternatively, such cores have been provided with one or more extensions to enable support of tip end of the core. The resultant cast blade then has openings which have been sealed by "plugs" which are brazed or welded in these openings.

In either case the structural integrity of the blade is dependent on joints between the blade and either the end caps or the "plugs." While such approaches have been adequate in the past, bonded joints formed by welding, or the like, are not wholly reliable in the severe environment of high-performance gas turbine engines.

While the motivating environment for the present invention is in the turbine section, similar problems can also be encountered in forming and sealing the tip ends of hollow compressor blades used in a gas turbine engine.

Accordingly, the object of the invention is to provide improved sealing mechanism for the tip ends of turbomachinery blades and, in so doing, to eliminate bonded joints as structural elements of the blades.

These ends are attained in an integrally cast blade having a wall defining the tip end of the blade. This wall has an opening, through which a core pin projected to support the tip end of the core, in the mold, as the blade was cast. A plate overlies this opening and is secured to the inner surface of the tip wall. The tip end of the blade is thus an integral cast structure, and the core opening is sealed by the plate without reliance on any bonded joint which would be subjected to substantial stresses.

Preferably, the opening is disposed centrally of the tip end wall and ribs project inwardly to define a recess. The plate has an outline registerable with this recess to facilitate its being positioned in sealing relation. The plate is bonded, as by brazing, in its sealing position to insure that it will remain in place, particularly while the rotor is at rest.

The above and other related objects and features of the invention will be apparent from a reading of the following description of the disclosure found in the accompanying drawing and the novelty thereof pointed out in the appended claims.

In the drawing:

FIG. 1 illustrates a blade, with portions in section, embodying the present invention;

FIG. 2 is a section, taken on line II–II in FIG. 1;

FIG. 3 is a view taken on line IV–IV in FIG. 1; and

FIG. 4 is a section, along the chord, of the tip end portion of this blade, illustrating the core employed during casting of the blade.

The blade seen in FIG. 1 is an integral casting comprising a tang **12**, a platform **14** and a cambered airfoil blade portion **16**. The blade portion is formed as a thin-walled shell defining an interior plenum chamber **18**.

The blade would be mounted on the periphery of a rotor disc by inserting the tang in a correspondingly shaped dovetail slot. Cooling air, or other cooling fluid, in known fashion, would be directed to the base of the tang. Entrance ports **20** direct the cooling air into the plenum chamber **18**. Small openings, selectively placed in the airfoil wall, discharge the cooling air along the outer surface of the blade to provide a cooling mechanism for the blade portion which projects into a hot gas stream.

The tip end of the cavity **18** is defined by an integrally cast end wall **22**. An opening **24**, in the end wall **22**, is sealed by a plate **26**. The plate **26** overlies the opening **24** and is secured, or bonded, to the inner surface of the wall **24** by brazing or the like. The use of brazing assures a tight seal and further keeps the plate **26** in sealing position when the turbine blade is in operation.

FIG. 3 illustrates the relationship of the core to the blade during the casting operation. The exterior of the blade is defined by surfaces of a conventional mold. The interior chamber **18** and ports **20** are defined by a core **28**. The portions of the core defining the ports **20** are extended into the mold to position the tang end of the core. A core pin **30**, seen in FIG. 3, extends into the mold to position the tip end of the core. When the core is removed, after casting, the opening **24** exists where the core pin **30** projected into the mold.

The plate **26** may be first coated with brazing material and then inserted through one of the ports **20**, or through the opening **24**, into the chamber **18**. Internal ribs **32**, on opposite sides of the opening **24** define a recess with which the plate **26** is registerable. After insertion in the chamber **18**, it is a simple matter to position the plate in this recess, overlying the opening **24**. After being so positioned, heat may be applied to melt the braze which coats the plate **26**, and, upon removal of the heat, the plate will be permanently secured in its sealing position.

It will be apparent that the structural integrity of the tip end of the blade is in no way dependent on the bonded joint between the plate **26** and end wall **22** when the blade is subjected to its major force loading in a direction toward its tip end, due to centrifugal forces in operation. This is due to the fact that the plate **26** bears against the inner surface of the tip end wall **22**.

Various modifications of the described embodiment will occur to those skilled in the art within the spirit and scope of the present inventive concepts which are to be circumscribed solely by the following claims.

We claim:

1. A cast, hollow, turbomachinery blade:
   having an internal chamber defined in part by an integrally cast end wall at the tip end thereof;
   said end wall having an opening therethrough formed by a supporting core pin during casting of the blade; and
   a plate bonded to the inner surface of said end wall and overlying said opening to seal said opening.
2. A turbomachinery blade as in claim 1 wherein:
   the blade further comprises an integrally cast tang at the inner end of the blade;
   the tang has at least one opening in the form of a port for admitting cooling fluid into said chamber; and
   the plate is insertable through one of said openings to permit its introduction into said chamber and positioning on said end wall for bonding thereto.
3. A turbomachinery blade as in claim 2 wherein:
   a recess is formed on the inner surface of said end wall around the opening therein and the insert is registered therein, said recess facilitating positioning of said plate on said end wall.

4. A method of sealing the internal chamber of a hollow, cast, turbomachinery blade having an end wall defining the outer bounds of the chamber, where said end wall has an opening therethrough, formed by a supporting core pin during casting of the blade, comprising the steps of:
introducing a plate into said chamber;
positioning said plate on the inner surface to said end wall, overlying said opening; and

bonding said plate to said end wall.
5. A method as in claim 4 comprising the further steps of:
introducing a plate having brazing material thereon;
subjecting the blade to heat after the plate has been so positioned to melt said braze; and
removing said heat to complete the bonding of the plate to the end wall.