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Albani

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[54] **IMPINGEMENT COOLED TURBINE BLADES AND METHOD OF MAKING SAME**

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[52] **U.S. Cl.** **416/97**
[51] **Int. Cl.** **F01d 5/18**
[58] **Field of Search** 416/92, 95–97; 415/115–116

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[57] **ABSTRACT**

A turbine blade is described which comprises an integrally formed airfoil, platform and tang. An insert extends through a chamber formed in the airfoil with its inner end being pinned to the tang. The tip end of the insert is closed by a cap which is flared into a groove peripherally of an opening in the tip end of the airfoil. Air is introduced, through the tang, into the plenum formed by the insert and then discharged through orifices to impinge against the chamber walls and cool the airfoil. The insert is assembled by introducing it through the tip end opening and an opening in the lower end of the chamber. The inner end of the insert is brought into register with openings in the tang for insertion and riveting of the retaining pin.

7 Claims, 5 Drawing Figures

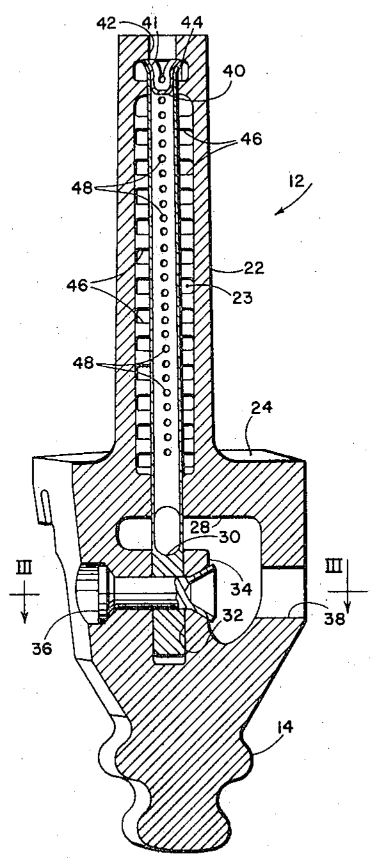

FIG 1

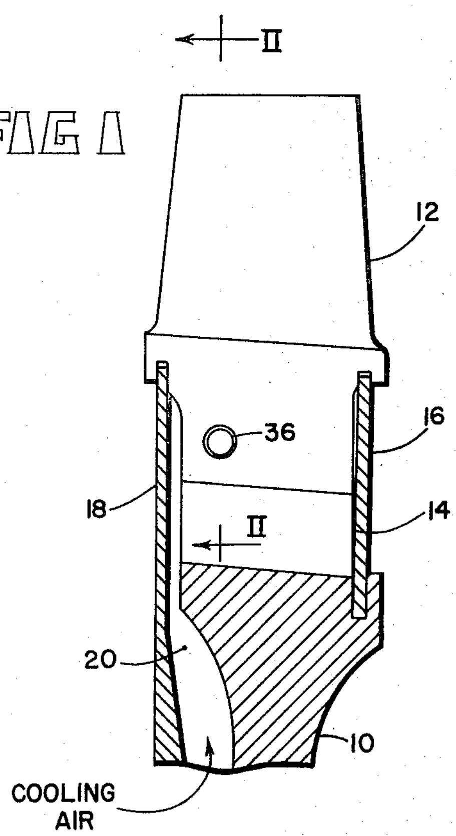

FIG 2

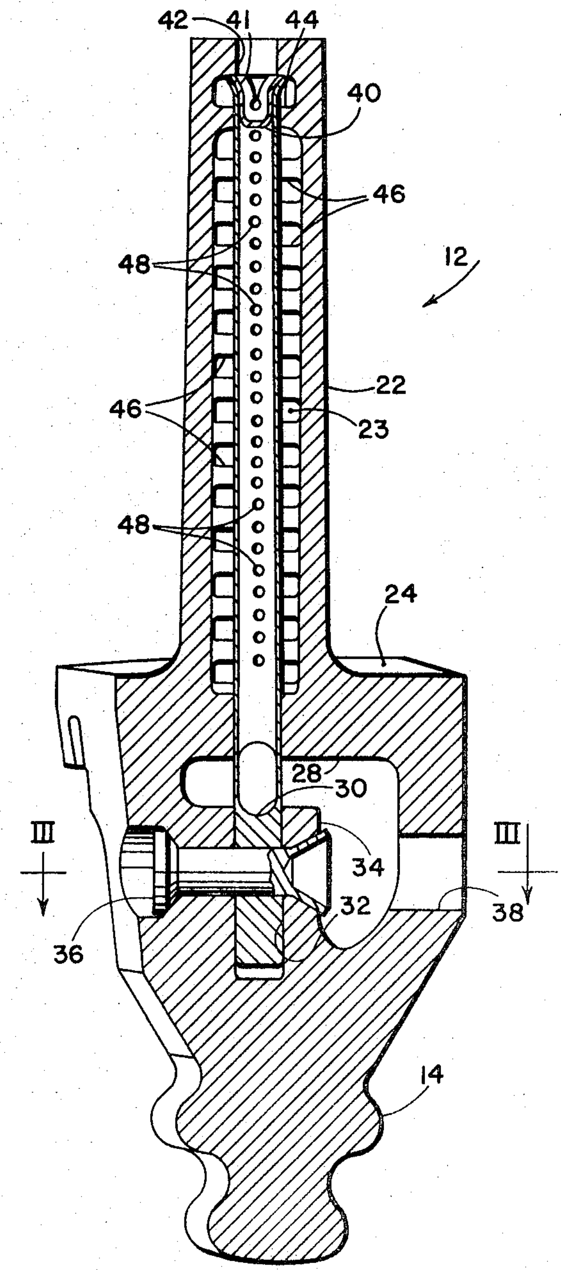

FIG 3

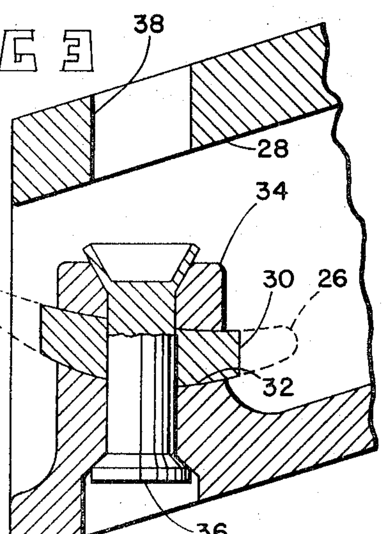

FIG 4

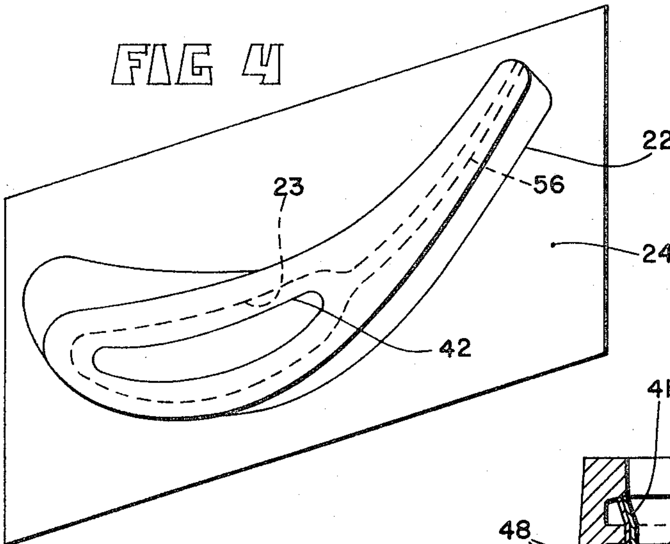
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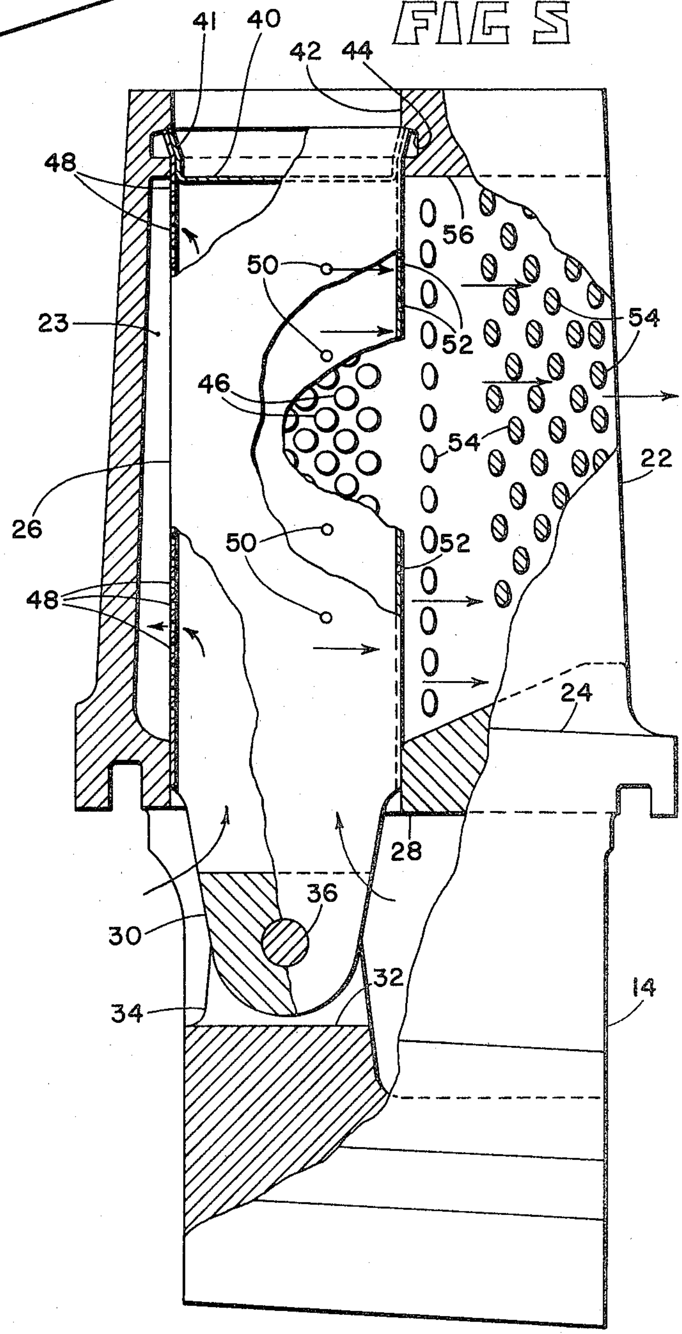
FIG 5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IMPINGEMENT COOLED TURBINE BLADES AND METHOD OF MAKING SAME

The present invention relates to improvements in turbines and more particularly to improvements in cooled blades employed in turbines driven by a hot gas stream and methods of making of same.

High performance gas turbine engines, particularly as used in the propulsion of aircraft, generate motive fluid, hot gas streams having temperatures which exceed the temperatures at which even the more advanced alloys can safely operate for any practical length of time. This is particularly true in the blades of the turbine, which in addition to being directly exposed to high temperatures of the hot gas stream are also subjected to extremely high stress loadings particularly because of the high rates of rotation of the turbine rotors and the consequent high centrifugal forces to which they are subjected.

It is long been recognized that operation of turbine blades in this adverse, high temperature environment, can be obtained through the use of a cooling mechanism for the blades. Most, if not all, practical cooling system utilize relatively cool compressor air which is flowed through the blades so that the actual metal temperature of the blades is maintained at a relatively low level and blade strength and life is thus greatly improved.

A more recent innovation in air cooling of blades, has been the so called impingement cooling of blades. In this system, a central plenum is provided from which air is discharged from relatively small holes, or orifices, to impinge against selected portions of the interior of the blade and thus provide a highly effective cooling mechanism. Usually the blade is formed as a hollow shell and the plenum is formed by a separate sheet metal insert which communicates, at its inner end, with a source of pressurized cooling air.

For many reasons well known to those skilled in the art, the blades of a turbine are generally formed as separate elements which are provided with tangs at their inner ends for attachment to the turbine rotor. This not only facilitates manufacture but also facililates maintenance and overhaul. Usually the blades are mounted on the turbine rotor by means of a dovetail slot arrangement or pins so that they can be separately replaced.

The advantages of an impingement cooling system have long been complicated, however, by the difficulties in providing a separate insert within a hollow blade. There are two primary areas of difficulty - first in providing an attachment of the insert which does not unduly affect the structural integrity of the blade itself and secondly in assuring structural integrity of the insert itself so that it first remains secure in operation and further minimizes the possibility of any portion of the insert to escape from the blade. These problems are further complicated where the turbine blades become quite small, say in the order of an inch and a half in heighth or less.

Accordingly, one object of the present invention is to provide an improved turbine blade construction incorporating an insert for impingement cooling of the blade.

Another object of the invention is to provide such a blade which further improves the overall cooling efficiency of such blades.

Another object of the invention is to provide an improved method for manufacturing turbine blades having inserts for the impingement cooling thereof.

The above ends are attained by turbine blade comprising an intergrally formed airfoil and tang. The airfoil has thin walls which define a chamber extending from its tip end to its inner end. An insert is disposed in this chamber and it extends into the blade tang with its inner end mechanically locked thereto. The insert forms a plenum sealed from the airfoil chamber. Passageway means extend from the exterior of the tang into the insert for connecting the plenum with a source of pressurized cooling air. This cooling air is discharged from a plurality of orifices directed toward the chamber wall to impinge there against and maintain the metal temperature of the airfoil at an acceptable level. The cooling air is then discharged from the chamber.

Preferably, the inner end of the insert is locked to the tang by means of a pin extending therethrough. Advantageously, the inner end of the insert, through which the pin passes is thickened or solid. Further, the passageway means for introducing cooling air into the insert may include a passageway through the upper portion of the tang, extending from one end thereof, and an opening in the lower portion of the insert above its thickened portion. A lug may be formed in the tang passageway and be slotted to receive the lower end of the insert and its retaining pin. The pin may terminate at the face of the lug within the passageway and an opening may be provided in the opposite face or opposite side of the tang to facilitate riveting of the pin.

The insert may be formed as a thin walled shell, at its outer end, having an end cap with an outwardly projecting, peripheral flange. This flange may be secured to the wall of the insert shell and then flared outwardly into an undercut peripheral groove around the tip end opening in the airfoil to positively retain the cap itself as well as to provide for sealing of the chamber from leakage through its tip end.

Another feature of the invention is found in the provision of integrally formed pins projecting from the airfoil into the chamber to engage and support the insert therein.

Aligned openings in the tip end of the airfoil and at the inner end of the chamber may be provided to permit insertion of the insert into the blade. After such insertion, the pin may be introduced through aligned openings in the tang and insert to mechanically lock the insert.

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

In the drawings:

FIG. 1 is a fragmentary cross sectional view of a turbine rotor and a blade, in accordance with the present invention, mounted thereon;

FIG. 2 is a section, on an enlarged scale, taken on line II—II in FIG. 1;

FIG. 3 is a fragmentary section taken on line III—III in FIG. 2;

FIG. 4 is a view of the blade seen in FIG. 2 from its tip end; and

FIG. 5 is a view of the blade seen in FIG. 1, from its side, with portions thereof broken away and in section.

With reference first to FIG. 1, a portion of a turbine rotor 10 is shown. A plurality of turbine blades 12 (one is shown) are mounted, in the usual configuration, around the periphery of the rotor 10. The blades are attached to the rotor by dovetail tangs 14 (FIG. 2) which are received by correspondingly shaped grooves in the rotor. The blades are axially held in place on the rotor 10 by retaining rings, or discs, 16 and 18. The disc 18 is spaced from the rotor 10 and defines a passageway 20 for pressurized cooling air which is introduced centrally from the engine's compressor. This cooling air enters the blade through a tang passageway in a manner later described to provide cooling of the blade in accordance with the present invention.

The blade comprises an aerodynamically shaped airfoil section or portion 22 which projects outwardly from a platform 24. The tang 14 then extends inwardly of the platform 24 which defines the inner bonds of the hot gas flowpath through the engine. The tang 14, as previously referenced, provides for attachment of the blade to the turbine rotor 10. These components of the blade are integrally formed as by casting or the like.

The airfoil 22 is in the form of a hollow shell, defining a chamber 23 at its relatively thick and blunt leading edge portion. The airfoil 22 in cross section, tapers down to a relatively narrow trailing end section.

An insert 26 is disposed within the chamber 23 which extends from the tip end of the airfoil to below the platform 24. The insert 26 comprises a thin walled shell which is closely spaced from the walls of chamber 23 at the leading and side surfaces of the airfoil. The inner end of the insert 26 projects into a passageway 28 which extends from one end to the other of the upper portion of the tang 14 and connects with the cooling air passageway 20 of the rotor assembly.

The inner end of the insert is preferably formed with a thick walled or solid section 30 which is positioned within a slot 32 formed in a lug 34 which projects outwardly from the basic tang portion of the blade into the passageway 28. The insert is held in place by a pin or rivet 36 which is inserted from one side of the tang. The inner end of the rivet is then flared into locking relationship with the lug 34, as is particularly indicated in FIGS. 2 and 3, by inserting a swaging or flaring tool through an aligned hole 38 provided in the opposite side of the tang 14.

Above the solid portion 30, the end walls of the insert are cut away to provide for the flow of cooling air from the passageway 28 into the interior of the insert. The insert sealingly engages a correspondingly shaped interior opening at the inner end of the chamber 23 so that the insert itself functions as a plenum for the pressurized cooling air. This, of course, takes into account the fact that the end of the insert is sealed off by a cap 40. The cap 40 has an outwardly projecting, peripheral flange 41 which may be welded or brazed to the marginal tip portions of the shell which forms the insert.

The tip end of the insert is positioned by the inner portion of a correspondingly shaped opening 42. The opening 42 has an undercut groove 44 peripherally thereof. The outer ends of the cap 40 and the insert 26 are flared outwardly into this groove. This provides further sealing of the airfoil chamber 23, and positive retention of the insert cap 40. Additionally, secondary retention of the insert itself is also provided. The insert 26 is further positioned and supported by integrally formed pins 46 which project from the airfoil 22 into the chamber 23.

The majority of the air introduced into the plenum insert 26 is discharged therefrom through a series of relatively small, closely spaced orifices, or jets, 48 along its forward edge which impinge the air against the inner surface of the leading edge of the blade shell. This is one of the areas of greatest heat concentrations on the blade during its operation. The impingement cooling effect, thus provided, helps to maintain the metal temperatures at an acceptable level. A lesser number of cooling orifices 50 may be provided on the sides of the blade to impinge against the interior surfaces of the convex and concave surfaces of the airfoil section. Similarly, orifices 52 may be provided in the insert to impinge air against pins 54 which project into a cooling air discharge slot 56 running the length of the trailing edge portion of the blade. The air impinging against the leading edge portion of the chamber 23 then flows around the insert and is discharge through the slot 56. This flow of cooling air is made more effective by the pins 46 which additionally create turbulence and increase heat transfer as the air flows around the insert. Cooling effectiveness is further enhanced by the impingement air discharged from the lateral and trailing jets 50 and 52 with additional turbulence being provided by the pins 54.

Another feature to be noted is that the described blade is readily assembled by first fabricating the insert 26, with its end cap 40 in place, then introducing the insert through the opening 42 and positioning the thickened end portion 30 within the slot 32. The rivet 36 may then be inserted and secured as previously described to positively retain the insert in place. Thereafter the tip end of the insert and the cap 40 may be flared outwardly to positively retain it in place for the advantages mentioned above.

While a prefered embodiment of the invention has been described, variations thereof will occur to those skilled in the art within the broader aspects of the invention. The spirit and scope of the invention is thus to be derived solely from the appended claims.

Having thus described the invention, what is claimed as novel and desired to be secured by Letters Patent of the United States is:

1. A turbine blade comprising:

an integral airfoil and tang at the inner end thereof, said airfoil having thin walls defining a chamber extending from its tip end to said inner end,

an insert disposed in said chamber in spaced relation to the walls thereof and extending into said tang, said insert forming a plenum sealed from the airfoil chamber and having a substantial thickness in the innermost end thereof,

said tang having a passageway from one exterior end face thereof through its upper portion to the insert, said insert having an opening registered with said passageway,

a pin extending through said tang and the inner end of said insert in a direction generally normal to the side faces of the tang for mechanically locking the inner end of said insert to said tang,

said insert having a plurality of orifices directed toward the chamber wall for impingement thereof of cooling air from said plenum, and

means for discharging cooling air from said chamber.

2. A turbine blade as in claim 1 wherein

at least the majority of said orifices are formed in spaced relation along the portion of the insert opposed to the leading edge portion of the arifoil.

3. A turbine blade as in claim 2 wherein

a slotted lug is formed in said tang passageway with an end face exposed therein,

the pin extends through and terminates on the end face of the lug and is riveted there against and

an opening is provided through the side face of said tang opposite said lug, said opening being aligned with said pin to facilitate riveting thereof.

4. A turbine blade as in claim 2 wherein

a platform is integrally formed intermediate said airfoil and tang, at the base of said airfoil,

said airfoil chamber extends beneath the level of said platform thereby providing for cooling thereof and

the means for discharging cooling air from said chamber include passageway means extending from said chamber and discharging from the trailing edge of said airfoil.

5. A turbine blade as in claim 3 wherein

aligned openings are provided between the tip end of the blade and said chamber and between the inner end of the chamber and the tang passageway,

said insert being insertable through said aligned openings and sealingly engagable therewith to seal said plenum from said chamber.

6. A turbine blade comprising:

an integral airfoil and tang,

said airfoil having thin walls defining a chamber extending from its tip end to its inner end,

an insert disposed in said chamber in spaced relation to the walls thereof and extending into said tang, said insert forming a plenum sealed from the airfoil chamber,

mechanical means for locking the inner end of said insert to said tang,

passageway menas extending from the exterior of said tang into said insert for connection of the plenum with a source of pressurized cooling air,

said insert having a plurality of orifices directed toward the chamber wall for impingement thereof of cooling air from said plenums,

means for discharging cooling air from said chamber,

the tip end of the insert including a separate cap element having an outwardly projecting peripheral flange telescope within and secured to the sidewalls of the insert,

an undercut peripheral groove being formed around said tip end opening, and

the peripheral flange and outer wall portions of the insert being flared into said undercut groove.

7. A turbine blade as in claim 6 wherein

said airfoil has integral pins projecting into said chamber and engaging and supporting said insert and

said airfoil passageway extends substantially along the height of said trailing edge and

pins project into said passageway to provide for increased heat turbulence and heat transfer.

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