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2,750,147

BLADING FOR TURBINES AND THE LIKE MACHINES

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Fig. 1.

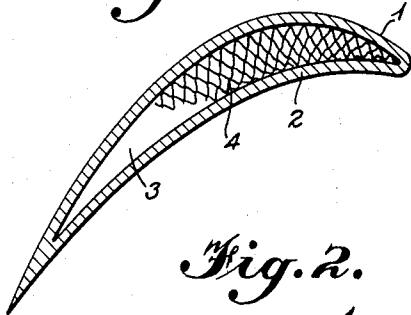


Fig. 3.

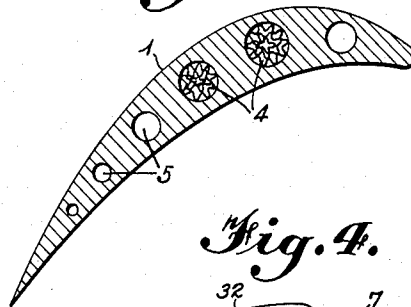


Fig. 2.

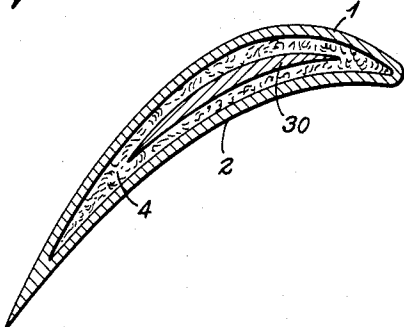


Fig. 4.

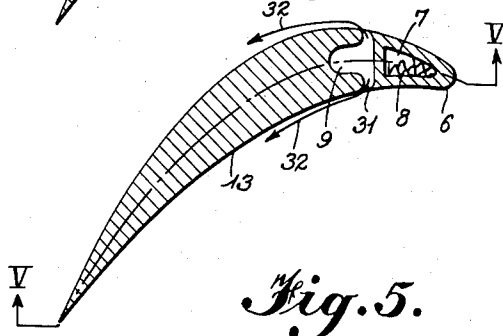


Fig. 5.

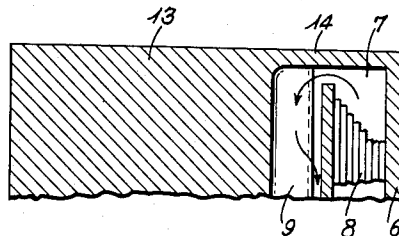


Fig. 7.

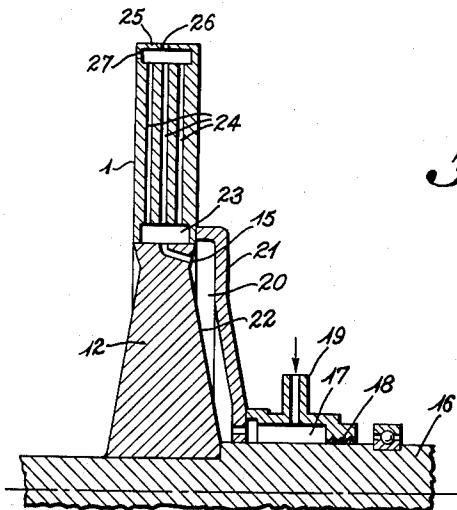
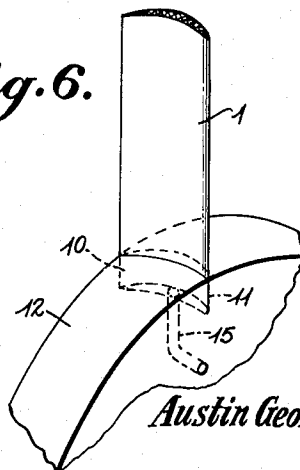


Fig. 6.



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BLADING FOR TURBINES AND LIKE MACHINES

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4 Claims. (Cl. 253—39.15)

This invention relates to improvements in blading for turbines and similarly bladed rotary machines, and is concerned more particularly, though not exclusively with turbine blading of combustion gas turbines.

The object of the present invention, stated in general terms, is to provide improved means for cooling blading of turbines and similarly bladed rotary machines which is required to be subjected to mechanically undesirable high temperatures.

Especially in relation to gas turbines, the practicable working temperature of the rotor blading is frequently a limiting factor in the performance of the machine, and it is possible to design a given machine for higher performance if the blading is effectively cooled; alternatively, for a machine of given performance, longer life may be achievable and it may be possible to use lower grade metal for the blading. Moreover, in high temperature turbines employing blade cooling it is advantageous to run at tip speeds higher than those normally considered economic for static gas turbine power plant, since it is desirable to limit the number of stages in order to minimise heat losses to the cooling fluid. In no practicable circumstances can the heat in the cooling fluid be used so efficiently as it would have been if left in the working fluid. It follows, therefore, that it is an advantage to be able to use a blade fixing which for a given turbine speed has the lowest possible maximum permissible stress, a factor which is considerably influenced by the effectiveness of the cooling.

The invention is concerned with that class of blade cooling system in which a blade to be cooled has an internal cavity through which there is a flow of coolant fluid by which heat is taken off.

According to the invention a blade cooling system of the class referred to comprises means which provide for a concentration of heat exchange surface in the internal cavity of a blade to be cooled, that is, for a surface which affords an increased effective heat exchange surface per unit of projected area as compared with a plane surface.

According to a further feature of the invention, such heat exchange surface is provided by means of a filling or matrix within the blade cavity, which matrix is preferably in heat conducting relationship with the wall of the cavity and may be composed of material such as metal foil, wire, wire wool or the like. To achieve good thermal connection between the matrix and the wall of the cavity the matrix may be suitably bonded to said wall, as for example by brazing.

By suitable choice of the wall thickness of the blade, a design may be achieved which is not appreciably inferior in strength to a solid blade, whilst a matrix of foil or similar material may have an area several times as great as that of the surface of a simple cavity within the blade, so that the internal coolant flow may be at a relatively low speed, involving correspondingly small losses in pressure and incidentally reducing or eliminating the need to use an auxiliary pump for supplying the coolant.

The invention is primarily intended for use in a system employing as coolant an air flow entering at the root of

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the blade and passing through the latter into the flow of working fluid in the machine.

By way of example various embodiments of the invention are illustrated in the accompanying drawings in which:

Figure 1 is a transverse section through one form of blade according to the invention;

Figure 2 is a similar view of a second form;

Figure 3 is a transverse section of a third form.

Figure 4 is a similar view of a fourth form.

Figure 5 is a longitudinal section on the camber line V—V of the form shown in Figure 4.

Figure 6 shows a method of attaching a blade to a turbine disc.

Figure 7 shows an arrangement for supplying coolant fluid to a turbine disc and blade.

In Figure 1 a turbine rotor blade 1 has a thin wall 2 of relatively uniform thickness, enclosing a single cavity 3 extending longitudinally of the blade which in this case may be manufactured by welding together two separate elements forming its two faces and subsequently machining to the required thickness and shape. A filling or matrix 4 consisting of an air-permeable mass of metallic material which may for example be copper foil and may be formed to shape in a variety of ways is then inserted into the cavity 3, such insertion being from either end in the case of a blade of constant thickness or from the root end in the case of a tapered blade. The foil 4 is then bonded to the blade wall 2, for example by furnace brazing, to produce an intimate thermal connection therewith. Alternatively, as shown in Figure 2, the filling or matrix 4 may be of copper wool, which is preferable in some circumstances since it can be inserted through the thin end of a tapered blade and would offer the aero-dynamic advantage of permitting chord-wise flow of the coolant. If desired, in either case, an inner core 30 may be inserted with the matrix 4 in order to fill up the aerodynamically less useful central portion of the blade cavity 3.

In Figure 3 the blade 1 has a number of longitudinal passages 5 formed therein either by drilling a solid blade, or during the course of manufacture in the case of blades made by casting or by powder metallurgy technique. In this case each passage 5 contains its own filling or matrix 4 which is bonded to the wall of the passage or cavity 5.

As described below with reference to Figure 7, each blade cavity is associated with a blade root mounting provided with air entry passages by which cooling air is led to the interior of the blade, the air being led out of the blade as may be most convenient, for example, through a downstream facing nozzle 27 or through holes 26 in a blade end cap 25.

In Figure 4 the cooling arrangement is combined with the so-called "blanket" system of cooling a blade. In the latter system, cooling air is supplied to the surface of a blade in such a way as to form thereon a cool boundary layer. Theoretically, such a system allows the entire blade surface to be kept at the temperature of the boundary layer, but in practice it is difficult to ensure satisfactory cooling of the leading edge. According to another feature of the invention it is therefore proposed to cool the leading edge portion of a blade separately and to use "blanket" cooling for the remainder of the blade.

Thus in Figure 4 the leading edge portion 6 of a blade has a longitudinal passage or cavity 7 therein containing a filling or matrix 8 bonded to the wall of cavity 7 and supplied with cooling air through the blade root. Immediately downstream of the part 6 the remaining part 13 of the blade has longitudinal passage or cavity 9 which as shown in Figure 5 interconnects with the passage 7 at the tip end of the blade and receives air emerging from passage 7 and discharges it downstream into the working fluid flow through gaps 31 along both faces of the part 13

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as indicated by the arrows 32 in Figure 4. In this case the blade is formed in two separate parts 6, 13 which are connected together at the tip by a tip portion 14.

The effectiveness of the blade cooling achieved by the invention is expected to be such as to allow the use of simpler forms of blade mounting than those in current use in conditions in which the root temperature is relatively high, since with an effectively cooled blade it is possible so to reduce the root temperature that for given conditions of speed the root mounting may be one for which the maximum permissible stress is lower than would otherwise be the case.

Thus the blade may be devoid of any large root portion and as shown in Figure 6 a blade 1 may be secured to a turbine disc 12 by entering the radially inner end 10 of the blade 1 into a slot 11 of corresponding shape milled or otherwise formed in the periphery of the rotor 12, the blade 1 being secured in the slot 11 for example by copper brazing. An inlet passage 15 must, in this case, be provided through the disc 12 and leading to the cavity within the interior of the blade.

Figure 7 shows one convenient arrangement for supplying coolant air to the passage 15. The turbine rotor 12 is mounted on a shaft 16 passing through a chamber 17 sealed off by seals 18 and having an entry conduit 19 through which air under pressure, for example from the compressor of a gas turbine engine, is led into chamber 17. From here the air flows into an annular space 20 formed between the upstream face 22 of rotor 12 and an annular shield 21 secured to the rim of rotor 12 and rotating with said rotor. Passages or inlets 15 lead from the space 20 to a transverse cavity 23 in the root of the blade 1 and from here the air is led to longitudinal passages 24 within the blade 1.

The air may be led out of the blade 1 through openings 26 or 27 in a hollow cap 25 at the tip of the blade into which the longitudinal passages 24 lead.

I claim:

1. In a turbine, a blade mounted for operation in a high temperature gaseous zone of the turbine, said blade having root and tip ends and a portion thereof defining an internal cavity, an inlet to said cavity at the root end of said blade, said blade so defining said cavity that it communicates with said zone at the tip end of said blade, means connected to said inlet to deliver a coolant fluid thereto, and a fluid-permeable mass of metallic material within said cavity, said material being bonded to the cavity defining portion of the blade.

2. In a turbine, a blade mounted for operation in a high temperature gaseous zone of the turbine, said blade having root and tip ends and a thin wall of relatively uniform thickness defining a single internal cavity extending

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from the root to the tip of said blade with the tip end of said cavity open to said high temperature zone, an inlet to said cavity at the root end of said blade, means connected to said inlet to deliver coolant fluid thereto; and a fluid-permeable mass of metallic material within said cavity, said material being bonded to said defining wall.

3. In a turbine, a blade mounted for operation in a high temperature gaseous zone of the turbine, said blade having root and tip ends and a portion thereof defining a plurality of internal cavities extending from the root to the tip of said blade, an inlet to each cavity at the root end of said blade, said blade so defining said cavities that they communicate at their tip ends with said high temperature zone; means connected to said inlets to deliver coolant fluid thereto; and a fluid permeable mass of metallic material within each said cavity, said material being bonded to the portion of said blade defining said plurality of internal cavities.

4. In a turbine, a blade mounted for operation in a high temperature gaseous zone of the turbine, said blade having root and tip ends and a leading edge, a portion of said blade defining an internal cavity extending from the root to the tip of the blade in the leading edge thereof, another portion of said blade defining a second internal cavity extending from the root to the tip of said blade immediately downstream of the leading edge cavity, an inlet to said leading edge cavity at the root end of said blade, said second internal cavity interconnecting with said first-mentioned internal cavity at the tip end of the blade, said blade having apertures therethrough establishing passageways between the second cavity and the high temperature zone; means connected to said inlet to deliver coolant fluid thereto and a fluid-permeable mass of metallic material within said leading edge cavity and bonded to the leading edge cavity defining portion of said blade.

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