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TURBINE BLADE COOLING STRUCTURE

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Fig. 1

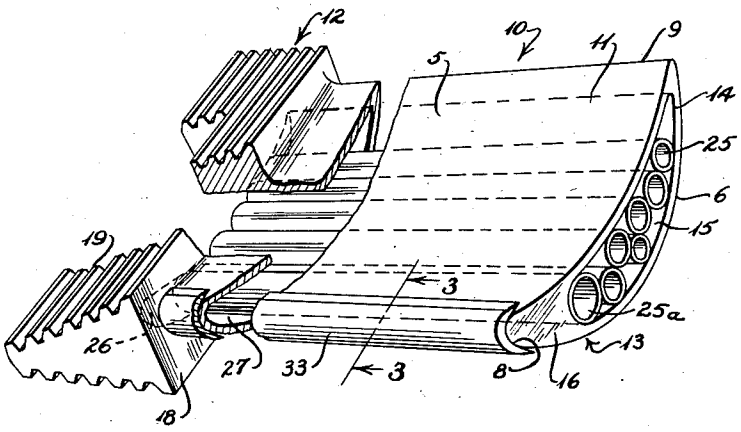
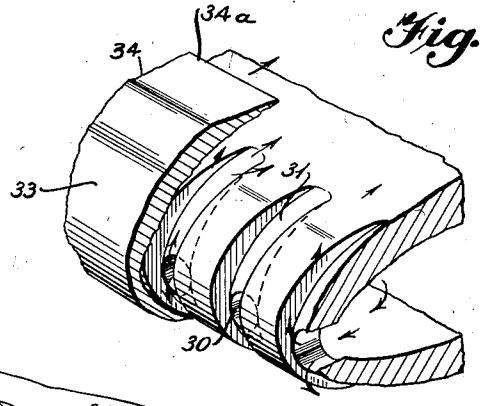


Fig. 2



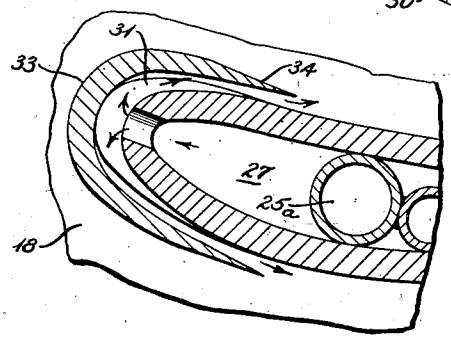


Fig. 3

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TURBINE BLADE COOLING STRUCTURE

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5 Claims. (Cl. 253—39.15)

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This invention relates to turbine blades and the like with particular reference to the cooling of the leading edges thereof.

In turbine blades subject to high gas-to-blade heat transfer with resultant corrosion and erosion of the blade metal, it becomes of considerable importance to provide effective means for cooling the leading edges. A cooling method heretofore used consists in attaching a displaced strip over the leading edge and passing air to the edge and strip through slots cut in the blade edge. A difficulty of this method lies in the pronounced pressure reduction of the air flow due to the slot area, thus reducing the cooling effect on the strip to the danger point. To overcome this deficiency, fins are inserted in the slots but their use involves difficulty in manufacture. An added deficiency in the use of slots for cooling lies in the weakening effect on the metal structure especially where it is necessary to use nonstrategic alloys.

A primary object of the present invention is to provide a blade cooling device which, while effectively cooling the blade edge, will not impart weakness to the blade structure. A further object is to insure adequate control over corrosion and erosion in turbine blades subject to high temperature gas flow. Still another object is to supply cooling arrangements such as will permit use of nonstrategic metals in turbine blade construction.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Fig. 1 is a view of the improved blade in perspective with parts cut away to show the blade construction;

Fig. 2 is a detailed perspective view of the blade leading edge with the cap broken away to show the blade holes and lateral grooves; and

Fig. 3 is a sectional detail of the blade leading edge and cap plate.

Referring to Fig. 1 there is disclosed a turbine blade unit **10** of the axial flow type consisting of the blade **11** and blade root **12**. These two blade elements as here shown consist of a single integral member. The blade is hollow and is fashioned as an air foil with concavo-convex sides **5** and **6**, a somewhat broadly rounded leading edge **8** and a sharpened trailing edge **9**. The tip end **13** of the blade includes a plate **14** provided with an arcuate opening **15** therein extending over the greater portion of the tip area, the plate section **16** adjacent the leading edge being closed.

The blade root **12** is an extension of the blade and is formed in wedge shape with the blade integral with the blunt end **18** of the wedge and the side walls of the wedge formed with lateral ribs **19** to form a sliding engagement with correspondingly shaped receiving spaces in the turbine hub.

Radially positioned in the hollow interior of the blade

are a group of tubes **25** forming passages parallel to the longitudinal axis of the blade for carrying coolant therethrough and means for connecting said tubes to a source of coolant. The tubes which are shown in Fig. 1 extend from openings in the tip plate **14** to an arcuate opening or tube **26** in the root. This latter opening communicates through hub ducts to a source of air pressure. The purpose of the tubes **25** is to supply cooling air to the blade interior so that by cooling the tube walls the entire blade is cooled. The leading tube **25***a* (Fig. 3) is oversized to form a sealing barrier between the blade walls, thereby providing a closed forward chamber **27** in the blade.

Since the leading blade edge is subjected to highest heat effects, special cooling means are required to prevent excessive heat erosion and corrosion in this area. To this end the forward blade edge is perforated by a series of air ducts **30** which are alined radially with reference to the blade root and centrally or medially along the blade leading edge and which thus extend between the blade exterior and the interior forward chamber **27** of the blade; and the leading edge material laterally of each duct **30** and transversely of the blade edge is grooved, as best shown in Figs. 2 and 3, to form side channels **31** which serve as guides to air flow for air moving outwardly through ducts **30**.

Surmounting the leading edge and secured thereto centrally along the median line joining the ducts **30**, is a blade-length U-shaped sessile cap **33**, the skirts or walls **34** thereof being tapered in section to a thin edge **34***a*. This cap is fixed solidly to the leading edge, as by spot welding, at the raised points between the ducts **30**, the side skirts or walls overlying the transverse channels **31** and a limited portion of the blade side walls **5** and **6** beyond these channel ends, thus forming lateral ducts from the outlet ends of ducts **30**. The curvature of the cap is lesser than that of the leading edge **8** so that with the cap attached in symmetrical relation to the blade, the cap skirts or walls diverge outwardly to form an increasing exit space for air passage from the outer openings of the ducts **30** to the cap edges. The channels **31** thus serve to provide direction reversing deflection of the air at the leading edge and to accelerate the air flow in the ducts **30**, thereby to provide maximum cooling at the blade areas subjected to maximum heat. It is pointed out that the cap skirts **34**, as shown in Fig. 1, are of uniform length along the blade and that the channels **31**, as shown in Fig. 2, are of approximately equal length. Hence, the lateral ducts formed by the cap skirts and channels are of approximately equal length.

In operation, air from any appropriate pressure source is fed to the hub manifold (not shown) and thence to the blade root tube **26**. From tube **26** the air flows to the tubes **25**, the forward chamber **27** and ducts **30**. The compressed air emitted from ducts **30** impinge on the cap **33** and is reversely turned through channels **31** to be discharged beyond the cap wall edges. The air reversal under pressure in contact with the cap rapidly withdraws heat from the cap and the cap in turn absorbs heat by conduction and radiation from the blade edge. Considerable convection cooling also takes place at the blade and cap surfaces. The tapered cap walls or skirts reduce the heat reservoir action thereof without affecting the air channelling action.

Obviously modifications and variations of the invention as disclosed are possible and it is to be understood therefore within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. A blade cooling device comprising a blade having a root and hollowed adjacent the leading edge thereof to form a forward chamber, a tube extending through the blade root and connecting said chamber to a source of coolant, a plurality of outwardly directed ducts formed through the leading edge of said blade and extending from said chamber to the blade exterior, a plurality of surface grooves on the leading edge of said blade extending transversely from either side of the outer end of each of said ducts to form coolant channels, and an elongated sessile cap attached to said blade edge and overlying said channels to form transverse ducts, said cap having side skirts forming a direction reversing deflector for coolant flowing out of said outwardly extending ducts.

2. The blade cooling device as defined in claim 1, said blade having therein a plurality of axially parallel passageways connected to said blade root tube for carrying coolant through said blade.

3. A cooling device for the leading edge of a turbine blade comprising a turbine blade having a leading edge, a sessile cap fixed along said leading edge having reversed side skirts extending over and spaced from the sides of said leading edge to form side spaces, a chamber within said blade adjacent said edge adapted to receive coolant, a plurality of ducts alined centrally along said leading edge connecting said chamber to the outer edge surface inside said cap, and lateral ducts formed in the leading edge surface connecting said central ducts to the said spaces between said blade and cap side skirts, whereby

coolant supplied said chamber will move through said ducts against said cap and in reverse direction along said cap skirts.

4. The cooling device for blade edges as defined in claim 3, said lateral ducts consisting of surface grooves of approximately equal length in the blade edge surface from the central duct outlets to a point short of the trailing edge of said side skirts on both sides of said blade edge, whereby said lateral ducts are of approximately equal length.

5. A cooling device for blade edges comprising a blade-length leading blade edge of a given curvature, a blade-length reversely curved cap attached medially along said edge and having rearwardly directed skirts overlying and displaced from the side surfaces of said edge and forming a discharge space with said leading edge, and a plurality of radial ducts formed medially through said edge for supplying coolant to the rearward surface of said cap, said blade edge having lateral ducts connecting each of said radial ducts to the spaces between said cap side skirts and said blade and said rearward cap surface having a curvature lesser than that of said blade edge, whereby the discharge space between cap and blade increases progressively from forward to rearward.

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