

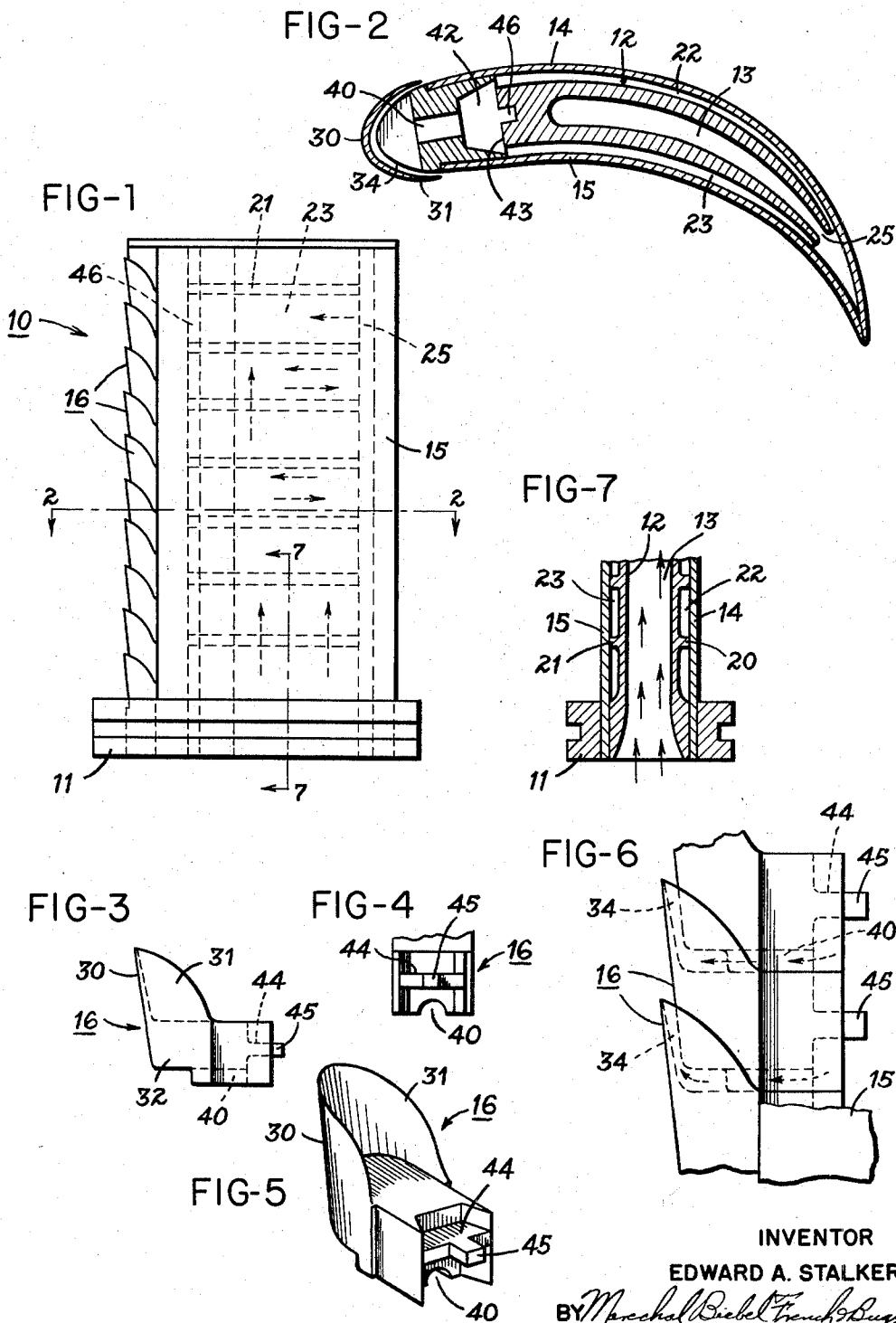
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BLADE STRUCTURE FOR TURBINES AND THE LIKE

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1

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BLADE STRUCTURE FOR TURBINES AND THE LIKE

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16 Claims. (Cl. 253—39.15)

This invention relates to turbine blades, particularly gas turbine blades, which are cooled by a film of fluid interposed between the hot motive gas and the blade surface.

An object of the invention is to provide a blade structure for a hot gas turbine incorporating slots for the emission of the film of cooling fluid and having adequate strength to withstand the severe mechanical forces to which it is subject in use.

Another object is to provide a blade structure which is readily producible by mass production methods.

Other objects will appear from the description, drawings and claims.

The above objects are accomplished by the means illustrated in the accompanying drawings in which:

Fig. 1 is a side elevation of a turbine blade according to this invention;

Fig. 2 is a section along the line 2—2 of Fig. 1;

Fig. 3 is a side elevation of a nose segment;

Fig. 4 is a rear view of the segment of Fig. 3;

Fig. 5 is a perspective view of the segment of Fig. 3;

Fig. 6 is an enlarged view of two segments in stacked relationship; and

Fig. 7 is an enlarged fragmentary view through the blade on line 7—7 of Fig. 1.

In my application Serial No. 724,103, filed January 24, 1947, now Patent No. 2,613,910, entitled Turbine Blades and Their Method of Manufacture, I have disclosed the U-shaped or chevron shaped slots in the leading edge which emit a thin layer or coolant interposed between the hot motive gas and the blade wall. Such a layer excludes the heat from the blade and thus protects the blade.

In accordance with the present invention a highly effective cooling of the blade is achieved by combining film cooling with internal cooling. Thus the coolant which is to be emitted from the blade nose as a film is first passed noseward along the inside of the skin to abstract heat from the skin. This leads to a more uniform temperature of the skin and consequently to a smaller quantity of coolant for a given maximum temperature of the skin. This is so because the protective effect of the film decreases rearwardly along the blade chord whereas the cooling effect of the internal flow decreases forwardly along the chord. Where the two flows are combined the net effect is a substantially constant blade skin temperature and a lowered consumption of coolant for the same skin maximum temperature.

It is desirable to have the internal flow bathe substantially all the blade skin with a forward flow initiated substantially at the trailing edge of the blade or as close thereto as is structurally possible. The blade therefore comprises a slot or surface means for emitting a coolant film at a locality forward of the trailing edge, preferably at the blade nose, and a chordwise passage or passages extending chordwise along each of the upper and lower sides of the blade to conduct from an internal locality substantially at the trailing edge forwardly to the slot

2

or surface opening means. Each chordwise passage lies close to the blade surface so that the blade wall or skin is thin to facilitate the maintenance of a low temperature throughout the skin.

To achieve the maximum cooling effect from a minimum amount of coolant the edges of the slots emitting the coolant should be thin so as not to cause turbulence in the coolant flow. This is difficult to do where the slots are produced in an integral piece of material. Furthermore vibratory forces may reduce the life of the blade by causing the portions of the blades between slots to crack.

The present invention provides a structure in which the slots cause relatively little turbulence in the coolant flow and the portions of the nose structure between slots have a great strength and a great resistance to vibration.

Referring now to the drawings the blade is indicated generally as 10 comprised of the blade base 11, the hollow stem 12 having internal supply passage 13, the upper or convex and lower or concave walls 14 and 15 respectively, and the nose segments 16. The stem 12 has the chordwise splines or ribs 20 in the upper side and 21 in the lower side spaced along the blade span. The walls 14 and 15 are fused to the contiguous ribs and define a plurality of chordwise flutes or channels 22 and 23 which form flow passages and convey coolant from the exit slot 25 which extends along the entire length of the trailing edge of the stem channel 13 which is fed with coolant through the blade base. The coolant in the flutes flows from the trailing edge of the blade forwardly toward the nose through the flow passages 22 and 23 adjacent the upper and lower blade surfaces respectively.

The nose of the blade is comprised of the nose segments 16. Each segment is formed with a rounded forward wall 30 with its sides 31 shaped to receive the lower body 32 of the segment above it in nested relation and in suitably spaced relation therewith defining a series of upwardly opening nose slots 34 extending over the entire nose of the blade and from the upper to the lower wall thereof. These nose slots receive coolant from the flow passages 22 and 23 for emission over the nose of the blade. The forward and side walls 30 and 31 define the vertical platelets each of which tapers to a sharp upper edge as shown from a root thickness of relatively large magnitude to confer extra stiffness on the platelet.

The bottom of each segment 16 has the channel 40 extending chordwise to conduct coolant from the flow compartments 42 defined in part by the front face 43 of the stem, the partition 44 of the nose segment and the forwardly extending blade walls 14 and 15. The partition has the lug 45 which nests in the slot 46 in the front face of the stem. Coolant from the flow passages 22 and 23 enters each compartment 42 and flows through channels 40 to the nose slots 34.

The degree to which the skin 14, 15 is cooled by the internal flow depends on the velocity of flow chordwise in the flow passages 22, 23, as well as upon the mass of the flow. Accordingly the depth of each flute is varied along the chordwise direction with the minimum depth near the end adjacent the trailing edge. It is also desirable that the tip portions of the blade be allowed to become hotter than the root portions since the stresses decline outwardly along the blade span. This is accomplished by decreasing the quantity of flow in the outer flutes as compared to the inner flutes by varying depth of the outer flutes with respect to the inner flutes.

The forward extending portions of the side walls 14 and 15 locate and retain the nose segments 16 in place since these walls come closer together at their forward ends. The lug 45 and slot 46 also serve to locate the segments which are preferably assembled into the gap

between the side walls from the outer end of the blade in a spanwise direction.

The segments 16 are preferably brazed to each other, to the side walls, and to the stem by high temperature brazing material. During this process the slots are prevented from filling with the braze material by a suitable stop-off.

The segments may be formed by die forging, coining or casting or other methods. Powder metallurgical technique is also a suitable procedure especially if the porosity of the part is filled by a suitable material.

The nose segments are formed with a thin edge even though the lower sections of the platelets are relatively thick. Hence the platelet has a high strength and a natural frequency of vibration well above the exciting frequencies. Thus the blade nose is both rugged and efficient.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having a leading edge and a trailing edge, an opening adjacent said leading edge for discharge of a flow of coolant rearwardly over the outer surface of the blade to protect the blade from said hot gaseous fluid, means defining an interior compartment having an exit slot spaced from said outer surface, means for introducing the flow of coolant into said compartment for discharge through said slot, and a passage extending forwardly from said slot to conduct the coolant forwardly for discharge from said opening in heat conducting relation with said outer surface over a major part of the chord thereof.

2. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having a leading edge and a trailing edge, a plurality of spaced openings extending over the span of the leading edge of the blade for discharge of a flow of coolant rearwardly therefrom over both outer surfaces of the blade to protect the blade from said hot gaseous fluid, means defining a spanwise supply passage having an exit slot adjacent said trailing edge, means for introducing the flow of coolant into said supply passage for discharge through said slot, and flow passages adjacent said outer surfaces extending forwardly from said slot to conduct the coolant forwardly for discharge from said openings in heat transferring relation with said outer surfaces.

3. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having outer surfaces and a leading edge and a trailing edge, openings adjacent said leading edge for discharge of a flow of coolant rearwardly therefrom over both outer surfaces of the blade to protect the blade from said hot gaseous fluid, means for introducing the flow of coolant into the interior of said blade, means confining said flow to a spanwise location and having an exit slot adjacent said trailing edge, and means defining passages adjacent both said outer surfaces of said blade and extending forwardly substantially from said trailing edge to said leading edge to conduct the coolant forwardly for discharge from said openings and over the major portion of the wall of said outer surfaces in counter current relation with the flow from said openings.

4. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having an internal stem spaced from the outer wall surface of said blade defining a chordwise extending flow passage therebetween, means for introducing a flow of coolant into said blade, said means providing a supply passage with an exit slot for directing said flow into contact with said wall surface of said blade adjacent the trailing

ing edge thereof for forward flow through said flow passage and over a major portion of the wall of said outer surface, and means adjacent the leading edge of the blade for discharging said coolant in protective relation over said outer surface of the blade.

5. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having an internal stem spaced from the outer wall surfaces of the blade defining chordwise extending flow passages therebetween, means forming a supply passage in said stem with an exit slot for introducing a flow of coolant into heat transfer relation with said wall surfaces of said blade at a location adjacent the trailing edge thereof for forward flow through said passages to traverse substantially the entire extent of said outer wall surfaces, and means adjacent the leading edge of the blade for discharging said coolant in protective relation over the outer surfaces of the blade.

6. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having an internal stem spaced from the outer wall surfaces of the blade to define forwardly extending flow passages therewith, said stem being constructed for connection with a coolant supply and having a supply passage therethrough opening into said flow passages adjacent the trailing edge of said blade, said stem preventing flow from said supply passage into said flow passages except through said opening adjacent the trailing edge of said blade forcing said flow to traverse substantially the entire extent of said outer wall surfaces, and means in communication with said flow passages for discharging said flow from the nose portion of said blade in protective relation over the outer blade surfaces.

7. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having an internal stem spaced from the outer wall surfaces of the blade to define forwardly extending flow passages therewith, the depth of the flow passages adjacent the tip portions of the blade being less than that of the passages adjacent the root of the blade, said stem having a supply passage therethrough opening into said flow passages adjacent the trailing edge of said blade, and means in communication with said flow passages for discharging said flow from the nose portion of said blade in protective relation over the outer blade surfaces.

8. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having an internal stem spaced from the outer wall surfaces of the blade to define forwardly extending flow passages therewith, said stem having a supply passage therethrough opening into said flow passages adjacent the trailing edge of said blade, a plurality of segments defining the nose of said blade, said segments being spaced from each other to provide a plurality of slot openings for the discharge of the flow of coolant therefrom, and means in communication with said flow passages for delivering said coolant to said slot openings.

9. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having an internal stem spaced from the outer wall surfaces of the blade to define forwardly extending flow passages therewith, said stem having a supply passage therethrough opening into said flow passages adjacent the trailing edge of said blade, a plurality of segments defining the nose of said blade, said segments being spaced from each other to provide a plurality of slot openings for the discharge of the flow of coolant therefrom, and chamber means between said flow passages and said slot openings for transmitting the flow of coolant from said passages into a plurality of said slot openings.

10. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having convex and concave outer wall surfaces and a leading and a trailing edge, means forming a substantially centrally located supply passage within said blade

with an exit slot adjacent said trailing edge for introduction into the interior of said blade adjacent said trailing edge of a flow of coolant, said means defining with each said wall surface an internal flow passage extending from said trailing edge forwardly toward the leading edge of said blade for forward travel of said flow of coolant therethrough, and means adjacent the forward edge of the blade forming a series of spanwise-spaced separate slot openings in communication with said flow passage and opening on said leading edge and on both said convex and concave surfaces for discharge of said coolant in a protective stream over the outer blade surface.

11. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having an outer blade surface and a leading and a trailing edge, means forming a substantially centrally located supply passage spaced from the outer walls of said blade and extending adjacent said trailing edge for introduction into the interior of said blade adjacent said trailing edge of a flow of coolant, said means defining with said outer blade surface an internal flow passage extending from said trailing edge forwardly toward the leading edge of said blade and outwardly of said supply passage for forward travel of said flow of coolant therethrough, means dividing said flow passage into a plurality of spanwise spaced channels, and means adjacent the forward edge of the blade forming slot openings in communication with said channels for discharge of said coolant in a protective stream over the outer blade surface.

12. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having outer walls and a leading and a trailing edge, means forming a substantially centrally located supply passage for introduction of a flow of coolant into the interior of said blade said passage terminating with an exit slot adjacent the trailing edge of said blade for supply adjacent said trailing edge of said flow of coolant, means defining with said outer walls internal flow passages extending from said trailing edge forwardly toward the leading edge of said blade for forward travel of said flow of coolant therethrough, means dividing said flow passages into a plurality of spanwise spaced channels, and a plurality of segments forming the nose of said blade and shaped to provide slot openings therebetween in communication with said channels for receiving and discharging the flow of coolant from said channels in a plurality of streams over the nose of said blade in protective relation with the outer surface thereof.

13. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having an internal stem spaced from the outer wall surface of the blade defining chordwise-extending flow passages therebetween, said stem having an internal supply

passage communicating with said flow passages adjacent the trailing edge of said blade, a plurality of segments forming the nose of said blade, said segments having parts interfitting with said stem and defining flow compartment means forwardly of said stem in communication with said flow passages, said segments being formed with slot openings therebetween in individual communication with said flow compartment means for discharge of said coolant in protective relation over the outer surface of said blade.

14. In combination in a turbine blade, a stem having a hollow interior and a plurality of external chordwise splines spaced along the stem span defining a plurality of chordwise flutes therebetween, a blade skin enclosing said stem and defining an outer boundary surface for said flutes, said flutes being in communication with said stem interior adjacent the trailing edge of said blade to receive a flow of coolant from said interior, a nose structure at the forward portion of said blade skin, said nose structure having a plurality of openings therein in communication with said flutes for the emission of a flow of coolant therefrom.

15. In combination in a turbine blade, a stem having a plurality of external chordwise splines defining a plurality of chordwise air flow passages therebetween extending substantially to the blade trailing edge, a blade skin enclosing said stem and defining an outer boundary surface for said air flow passages, a nose structure for said blade having a plurality of slots therein formed to provide a plurality of openings for emission of a coolant, and means within said stem forming a supply passage with an exit slot to introduce a coolant into said air flow passages substantially at their rear ends for flow forward through said air flow passages to said openings.

16. A rotatable blade structure adapted for operation in a hot gaseous motive fluid comprising a hollow blade having an internal stem spaced from the outer wall surfaces of the blade to define forwardly extending flow passages therewith, the depth of said flow passages varying in the chordwise direction and increasing toward the nose of the blade, said stem having a supply passage therethrough opening into said flow passages adjacent the trailing edge of said blade, and means in communication with said flow passages for discharging said flow from the nose portion of said blade in protective relation over the outer blade surfaces.

References Cited in the file of this patent

UNITED STATES PATENTS

2,149,510	Darrieus	Mar. 7, 1939
2,220,420	Meyer	Nov. 5, 1940

FOREIGN PATENTS

319,622	Great Britain	Dec. 18, 1930
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