United States Patent

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[72] Inventors **Ronald P. Schwedland; Jack E. White, both of Indianapolis, Ind.**

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[73] Assignee **General Motors Corporation Detroit, Mich.**

[54] **POROUS FACING ATTACHMENT**
6 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **415/115,** 416/97, 416/231
[51] **Int. Cl.** **F01d 9/02**
[50] **Field of Search** 415/115; 416/90, 96, 97, 231, 95, 229

[56] **References Cited**

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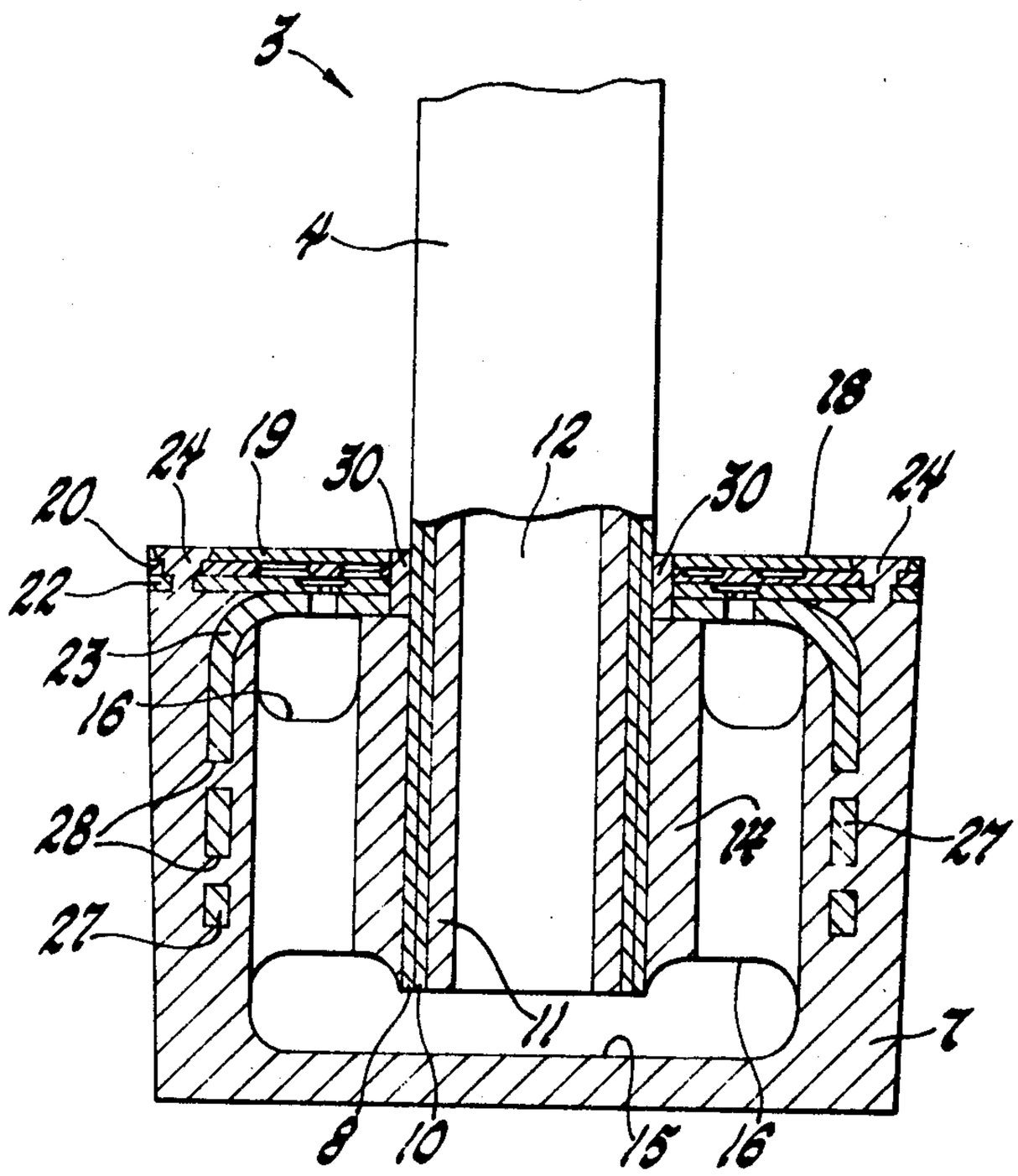
Primary Examiner—Everette A. Powell, Jr.
Attorneys—Paul Fitzpatrick and Jean L. Carpenter

ABSTRACT: A vane or blade for a turbine includes a shroud or platform defining a boundary of the motive fluid path through the turbine. The shroud or platform is of a cast structure with a laminated porous metal facing. Two modes of attachment of the facing to the cast base are described, one being headed pins or anchors cast integral with the base and the other being a flange on the innermost layer of the facing around which metal of the base is cast.



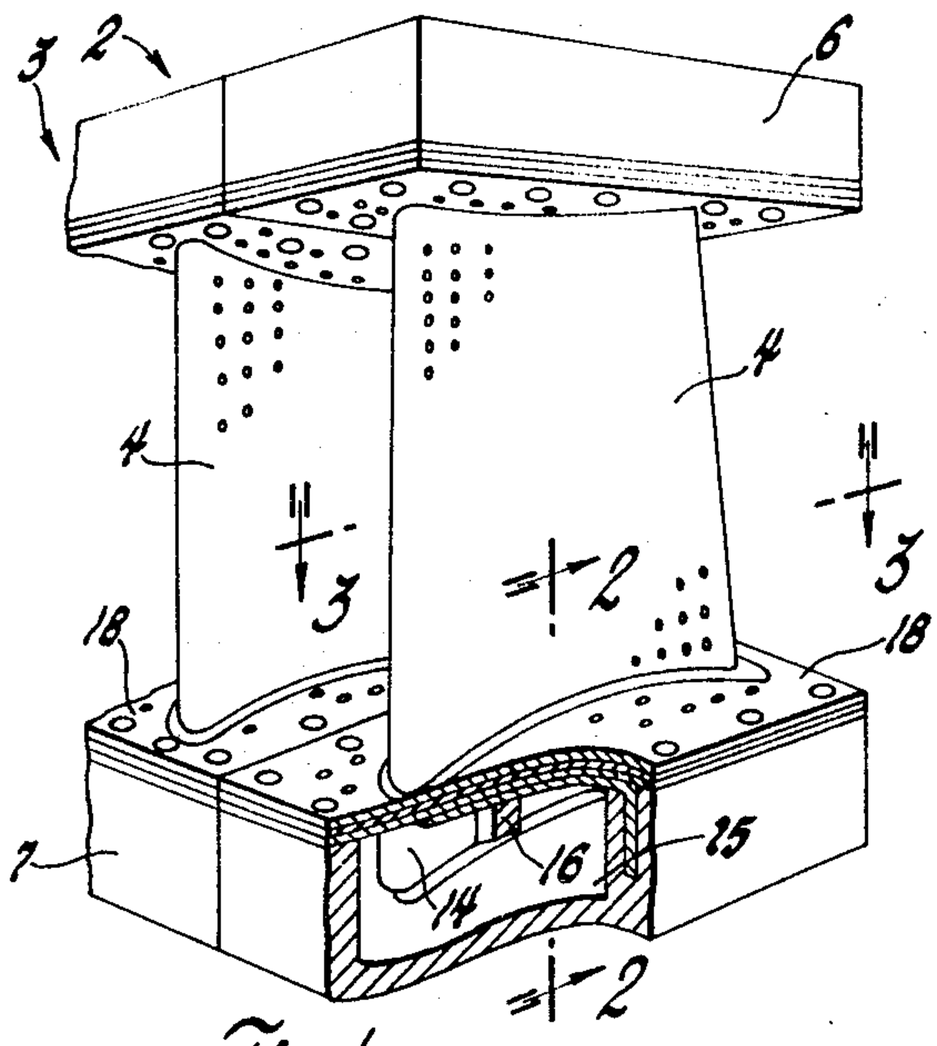


Fig. 1

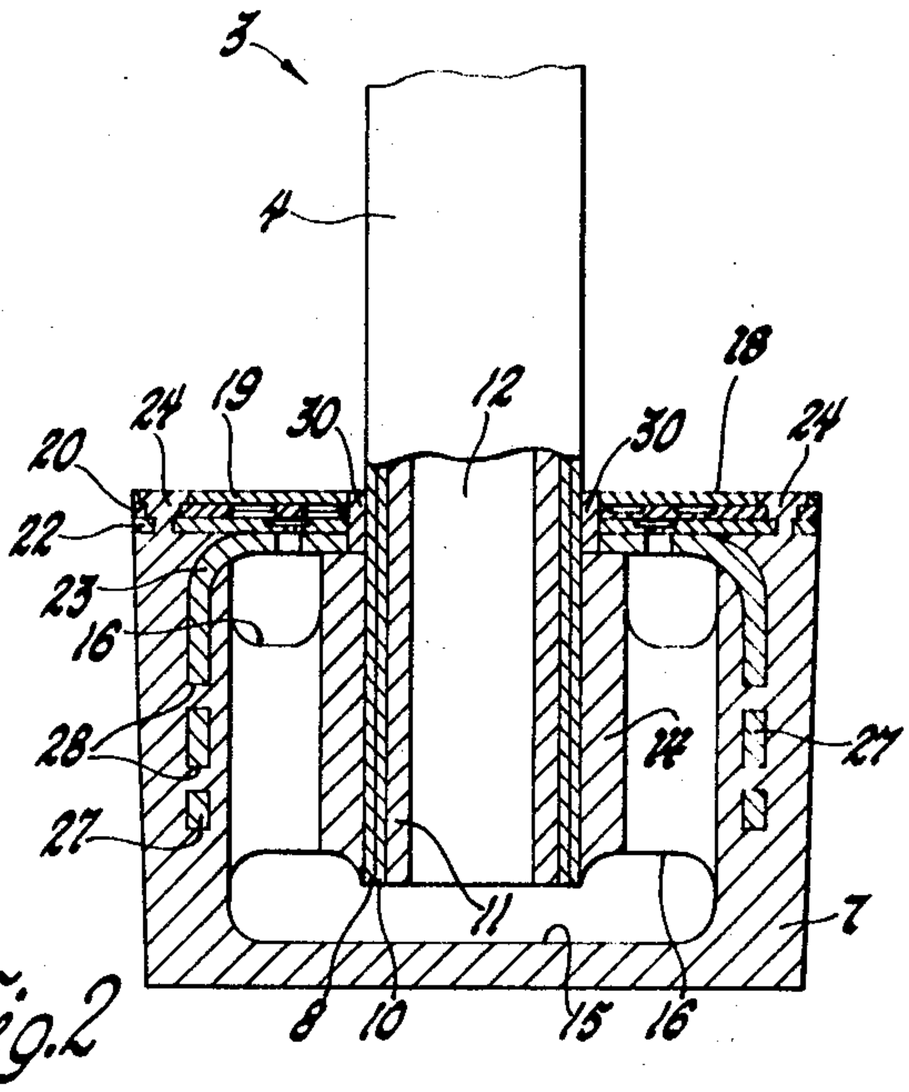


Fig. 2

Fig. 3

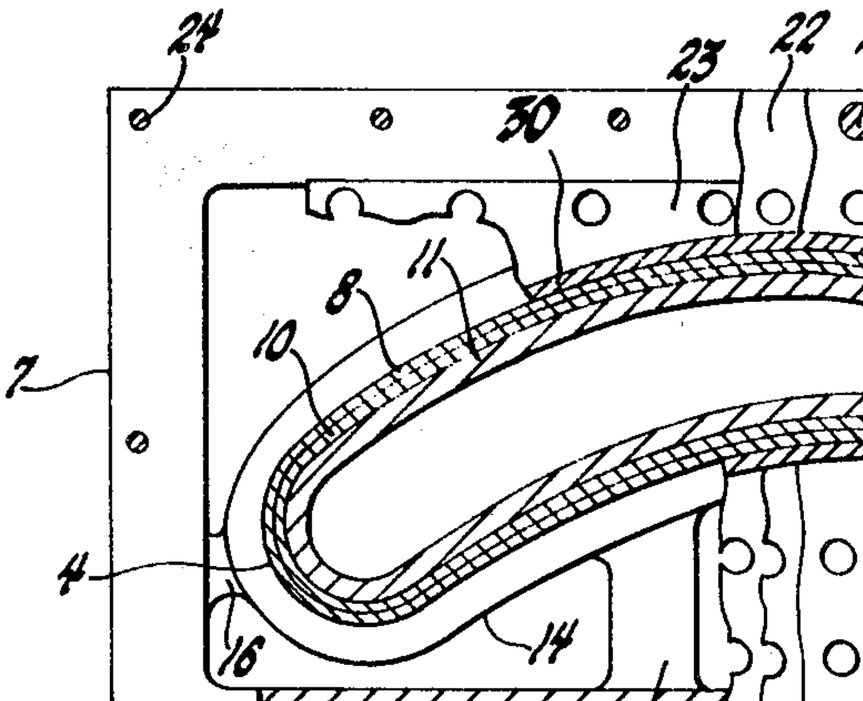


Fig. 4

INVENTORS
Ronald P. Schwedland &
BY Jack E. White
Paul Fitzpatrick
ATTORNEY

POROUS FACING ATTACHMENT

"The invention herein described was made in the course of work under a contract or subcontract thereunder with the Department of Defense."

DESCRIPTION

Our invention is directed to cooling of structures such, for example, as the base members of turbine airfoils otherwise commonly known as nozzle vane shrouds and turbine blade platforms. It is particularly directed to improved means for retaining a facing on a cast base or support.

The need for cooling of such structures as vanes, blades, blade platforms, nozzle shrouds, and the like in high temperature turbomachinery has long been recognized, and there have been various proposals to accomplish such cooling by the method known as transpiration cooling in which a cooling fluid, ordinarily air, is pumped into the interior of the structure to be cooled and allowed to flow from it through numerous pores distributed over the surface of the material. Although various types of porous material have been proposed for such transpiration cooling, we prefer to employ a laminated porous material of the type described and claimed in the copending application (of common ownership) of Bratkovich and Meginnis for Laminated Porous Metal, Ser. No. 526,207, filed Feb. 9, 1966. One form of such laminated porous material is shown in British Pat. No. 1,175,816 to Rolls-Royce Limited, published Dec. 23, 1969.

It has also been proposed to put a porous laminated material of the type referred to as a facing over a cast core of strut to provide for reinforcing the relatively thin porous sheet metal structure when used in vanes and blades.

Our invention is particularly directed to improvement of means for cooling the surfaces of nozzle shrouds and rotor blade platforms which are scoured by the hot motive fluid. Our invention is most particularly concerned with suitable means for retaining the porous facing on the shroud or platform which will be referred to hereafter as a base or support. In general terms, the application of our invention involves the production of an interlocking structure tying the facing and support positively together. In one form, this is attained by casting the material of the support into tapering or stepped holes in the facing material. In another form of the invention, the laminated facing material has its innermost layer deformed to provide a flange which extends into the support and around which the metal of the support is cast.

The principal objects of our invention are to improve high temperature turbomachinery; to improve the cooling of structures in such machines; to provide a cast structure having a porous facing adapted for transpiration cooling; to improve the retention of porous facings on cast structures.

The nature of our invention and its advantages will be clear to those skilled in the art from the succeeding detailed description of preferred embodiments of the invention and the accompanying drawings thereof.

FIG. 1 is an axonometric view of a portion of a turbine nozzle with parts cut away.

FIG. 2 is a transverse section of the same, taken in a plane generally perpendicular to the axis of the nozzle as indicated by the line 2—2 in FIG. 1.

FIG. 3 is a sectional view, with parts cut away, taken on a plane generally parallel to the axis of the nozzle as indicated by the line 3—3 in FIG. 1.

FIG. 4 is a partial view of a turbine rotor blade taken on a plane similar to the plane of FIG. 2.

The portion of a segmented annular turbine nozzle 2 shown in FIG. 1 comprises two nozzle segments 3, each of which is composed of a blade 4, usually called a vane, an outer shroud segment 6, and an inner shroud segment 7. The vane may be of any suitable structure and is joined to the shrouds which may be termed "bases" by a procedure in which the bases are cast to the vane. Preferably, the vane is of a porous structure adapted for transpiration cooling using any suitable porous material, preferably a material of the type described in the above-mentioned Meginnis and Bratkovich application and British patent. Such a material is a laminate of, usually, three sheets. The sheets, as shown in FIGS. 2 and 3, are an outer sheet 8, a middle sheet 10, and an inner sheet 11. The details of these sheets are not illustrated in the drawings since this is not necessary to an understanding of the present invention. It may be mentioned, however, that these sheets have numerous pores distributed over the surfaces in a two-dimensional array with the pores of each layer out of register with those of the adjacent layer or layers and with some form of surface relief on the sheets to provide for flow of fluid parallel to the face from one set of pores to the next. The blade, which may be of any suitable cross section such as a typical airfoil cross section illustrated most clearly in FIG. 3, is, in general, a hollow folded sheet metal member defining an interior cooling air passage 12.

The shroud 7 is a hollow boxlike structure of cast high temperature resisting metal of generally rectangular or rhomboidal outline with the side faces tapering somewhat as shown in FIG. 2 so that the shroud segments abut to define a ring of inner shroud segments. The shroud segment includes a sleeve portion 14 surrounding the vane which projects into the segment to near the bottom wall 15. The sleeve portion 14 is joined to the outer wall of the segment by ribs 16. Cooling air may enter the shroud segment through the passage 12 or may enter through any suitable opening in the segment itself. If the air enters through the passages 12 it will be introduced through the outer shroud segment 6 in any suitable manner.

The shroud segments include porous facings 18 of a laminated structure comprising, in the preferred embodiment, four thin sheet metal layers which are identified as an outer layer 19, a middle layer 20, an inner layer 22, and a base layer 23. The three layers 19, 20, and 21 constitute a sheet or facing of a porous nature as described above and in the above-mentioned application and British patent. There is one modification, however, which is concerned with the means for retaining it on the cast segment 7. Anchors 24 are defined by the cast metal solidified in a series of aligned progressively increasing diameter holes through the layer 22, 20, and 19, respectively. The anchors 24 are disposed around the margin of the shroud segment and of the facing. A two-dimensional array of pores 26 in the outer surface of the facing is also indicated in FIG. 3.

The drawings also illustrate a further anchorage or retention arrangement for the facing, which is defined by flanges 27 extending from the margins of the base layer 23 into the wall of the shroud segment 7. These flanges have a surface configuration promoting retention by the cast metal defined in this case by holes 28 through the flanges into which the cast metal may flow.

In the fabrication of the structure illustrated in FIGS. 1, 2, and 3, the blade 4 is first formed separately. The four layers of the facing are photoetched or otherwise machined to provide the surface relief and pores and bonded together. The blade and facing are located with respect to the base in a suitable mold into which the metal of the shroud segment is poured and solidified. The mold includes cores to define the interior holes within the shroud and the open end of the vane may be suitably plugged. The cast metal then fills the openings for the anchors 24 and solidifies around the flanges 27 and within the holes 28 in the flanges. There is, thus, a tight bond between the shroud base 7 and the vane and the facing. If retention by flanges 27 is not desired, the base layer 23 may be omitted.

The facing is spaced slightly from the outer surfaces of the blade or vane to define a gap which is filled by a portion 30 of the cast metal which closes the gap between the blade and facing and closes off the facing to prevent any leakage of the cooling air through the interior edge of the facing adjacent the blade.

When the nozzle is assembled, adjacent segments lie in closely abutting relation so that there is no significant undesired leakage of the cooling air at the side edges of the facings.

While both the anchors **24** and the flanges **27** are illustrated in FIGS. **2** and **3** as a means of retaining the facing, it will be apparent that either mode of retention might be employed while dispensing with the other.

The principles of the invention are applicable to other structures than the turbine nozzles shown on FIGS. **1**, **2**, and **3**. FIG. **4** is a cross section through a portion of the blade or airfoil and base of a turbine rotor blade. In this structure a porous laminated blade wall **40** of a hollow blade is made of three or more layers for transpiration cooling. The end of the blade, which may have a cross section similar to that of the vane illustrated in FIG. **3**, is mounted in the blade base **42** which comprises a platform portion **43**, a stalk **44**, and a suitable root for attachment to the rotor (not illustrated). The base defines a passage **46** by which cooling air is conducted to the hollow interior **47** of the blade portion **40**. The base is cast around the blade portion, the outer surface of which may have relief to aid in retention of the blade portion by the cast metal. The base portion of the blade wall **40** is reinforced by a cast liner **48** which is bonded to the laminated wall and welded to it by an end weld indicated at **50**.

A three-layer facing **51** similar to the facing **18** of FIGS. **1**, **2**, and **3** is fixed to the outer surface of the platform **43** over which the hot motive fluid flows. The facing **51** may be the same in all material respects as the facing **18** previously described. It is retained by anchors **52** which, like the anchors **24** previously described, are cast into progressively larger aligned holes in the several layers of the facing. In this form, no flange such as **27** in FIG. **2** is present.

The platform portion of the blade base is cast to define a cavity **54** surrounding the blade to which the cooling air is supplied from the passage **46** through a passage **55**. This cooling air then may flow through the pores and passages in the facing and flow from the upper surface of the facing into the motive fluid stream.

The facing may be of suitable high temperature-resistant material including thoria-dispersed nickel chromium alloy and the shrouds and blade bases may be cast from suitable high temperature-resisting alloys. The choice of suitable materials is not material to the principles of the invention.

It should be apparent to those skilled in the art that the principles of our invention provide cast structures with means for transpiration cooling through a laminated facing disposed on the outer surface and provide a particularly suitable mode of retention of the facing on the base material.

The detailed description of preferred embodiments of the invention for the purpose of explaining the principles thereof is not to be considered as limiting or restricting the invention, as many modifications may be made by the exercise of skill in the art.

We claim:

1. A flow-directing member comprising, in combination, a cast support, a porous laminated facing composed of mutually bonded metal layers disposed over the surface of the support, and means for retaining the facing on the support comprising holes in the facing enlarging in the direction away from the support and metal forming an integral part of the support cast in the said holes.

2. A flow-directing member comprising, in combination, a blade, a base member cast to the blade and enclosing an end of the blade, a porous facing overlying and fixed to the surface of the base member, the facing comprising a plural number of layers bonded together, the layers being formed with surface relief and through pores so as to permit flow of a cooling fluid within and through the facing, the base member defining a passage for flow of the cooling fluid to the facing, the facing defining anchorage holes each extending through a plural number of layers and being of increasing lateral dimension in the direction away from the base member, the base member including anchors cast into the anchorage holes integral with the base member.

3. A combination as recited in claim **2** in which a gap is defined between the blade and the facing and the base member includes a portion cast into and filling the said gap.

4. A cooled body comprising, in combination, a porous laminated facing comprising a sheet formed of a plural number of porous layers bonded together over an area to be cooled and an additional porous layer bonded to the sheet over a part of the said area, the said additional layer being formed to define a flange extending away from the first-mentioned layers at the margin of the said part of the area, the flange having a configuration facilitating retention by an enclosing mass, and a base member cast against the sheet and enclosing the said flange, the base member defining passages for flow of a cooling medium through the base member into the facing.

5. A flow-directing member comprising, in combination, a blade, a base member cast to the blade and enclosing an end of the blade, a porous facing overlying and fixed to the surface of the base member, the facing comprising a plural number of layers bonded together to form a sheet, the layers being formed with surface relief and through pores so as to permit flow of a cooling fluid within and through the facing, and an additional porous layer bonded to the sheet over a part of the said area, the said additional layer being formed to define a flange extending away from the first-mentioned layers at the margin of the said part of the area, the flange having a configuration facilitating retention by an enclosing mass, the base member being cast against the sheet and enclosing the said flange, the base member defining passages for flow of a cooling medium through the base member into the facing.

6. A cooled body comprising, in combination, a porous laminated facing comprising a sheet formed of a plural number of porous layers bonded together over an area to be cooled and an additional porous layer bonded to the sheet over a part of the said area, the said additional layer being formed to define a flange extending away from the first-mentioned layers at the margin of the said part of the area, the flange having a configuration facilitating retention by an enclosing mass, and a base member cast against the sheet and enclosing the said flange, the base member defining passages for flow of a cooling medium through the base member into the facing, and additional means for retaining the facing on the base member comprising holes in the facing enlarging in the direction away from the base member and metal forming an integral part of the base member cast in the said holes.