United States Patent

Moskowitz et al.

[15] **3,706,508**

[45] **Dec. 19, 1972**

[54] **TRANSPIRATION COOLED TURBINE BLADE WITH METERED COOLANT FLOW**

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[22] Filed: **April 16, 1971**

[21] Appl. No.: **134,601**

[52] **U.S. Cl.** **415/115,** 416/97

[51] **Int. Cl.** **F01d 5/18**

[58] **Field of Search** 416/90, 92, 95–97; 415/114, 115

[56] **References Cited**

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[57] **ABSTRACT**

A turbine stator blade having a porous skin covering a strut member with channels for cooling air fed from the root, and a removable metering plate attached to the root and having orifices of various sizes for transmitting air to the blade channels, the metering plate being selected for having appropriate orifices for the cooling requirements of blades in differing temperature and pressure environments.

4 Claims, 5 Drawing Figures

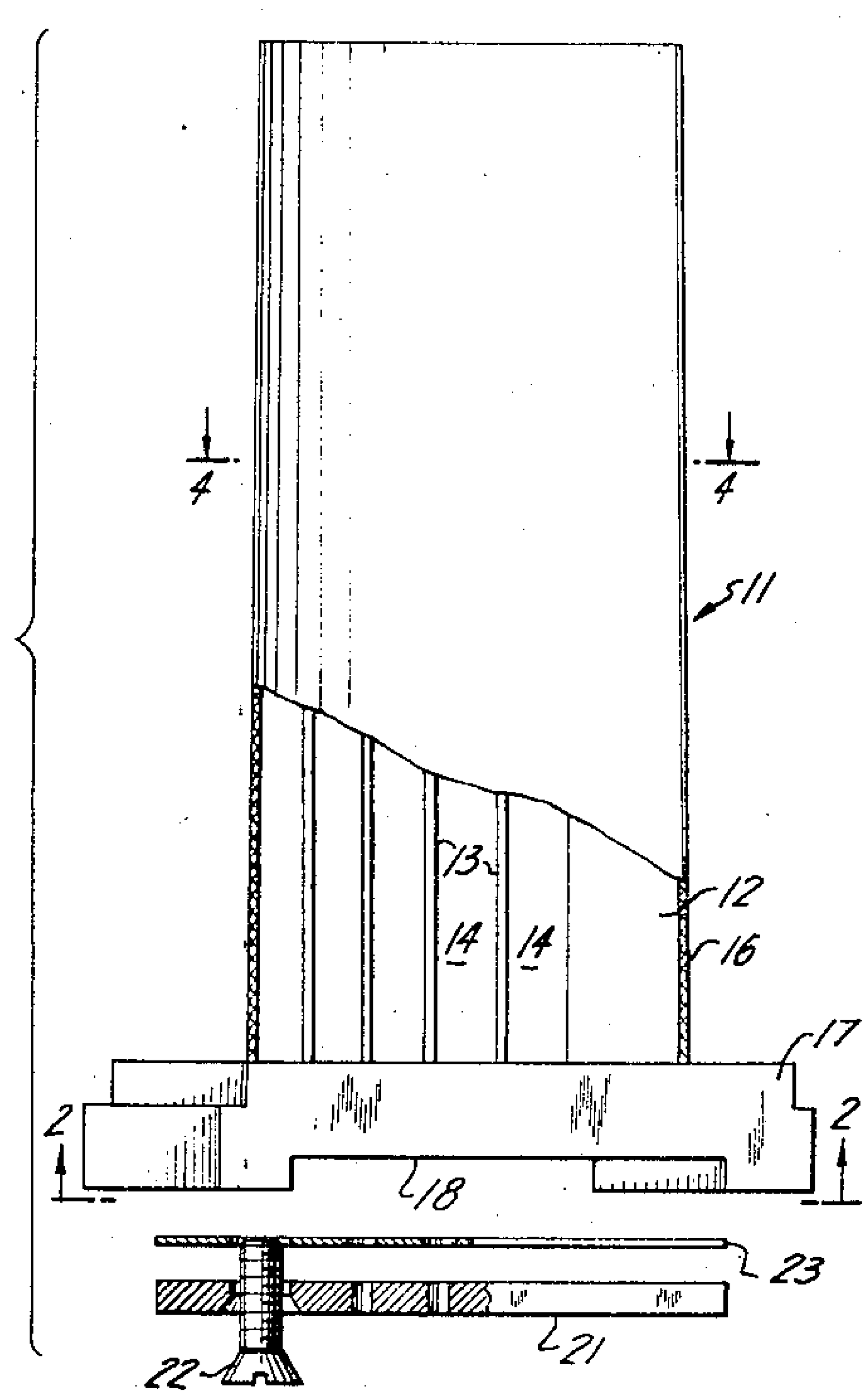


FIG. 1

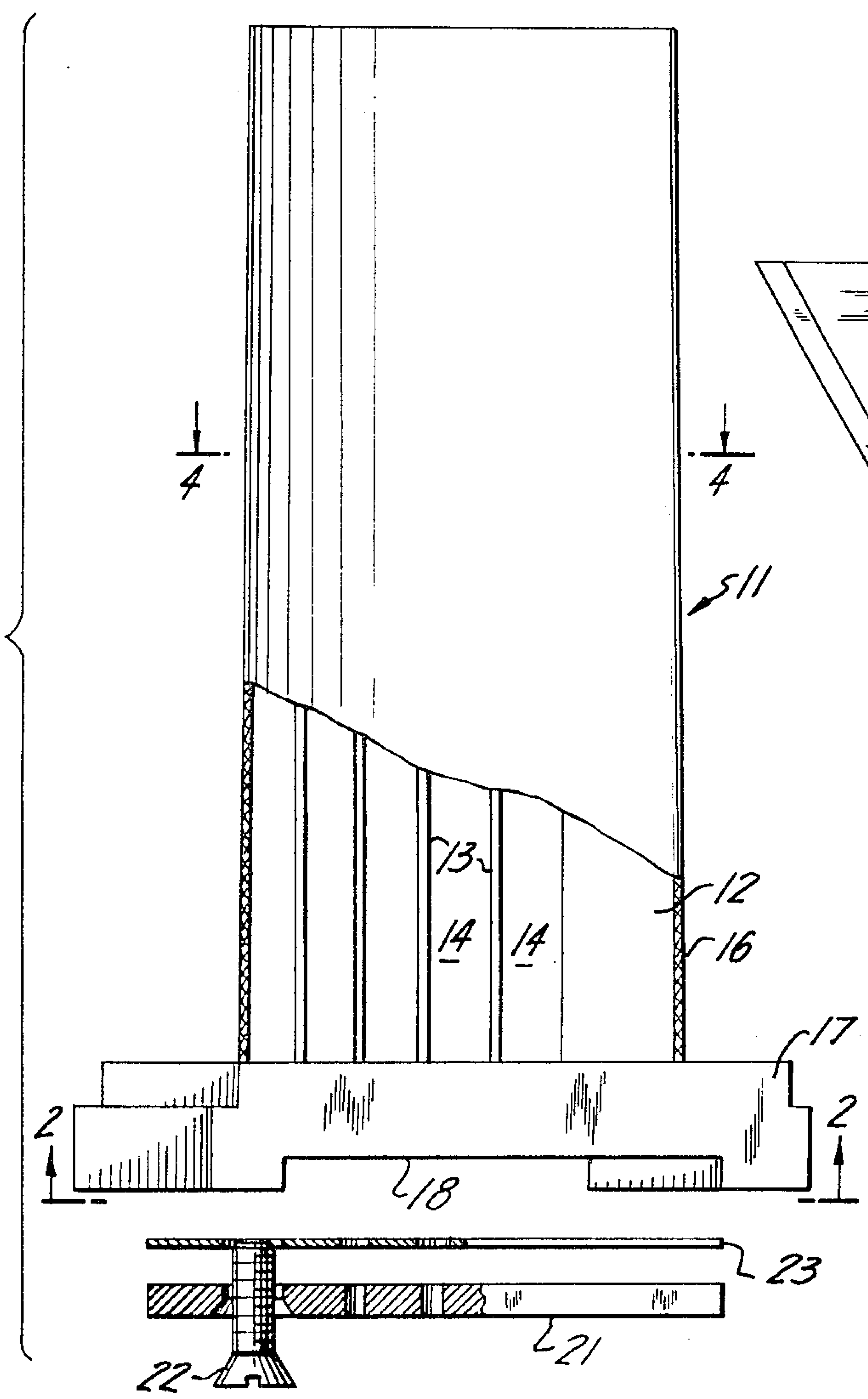


FIG. 4

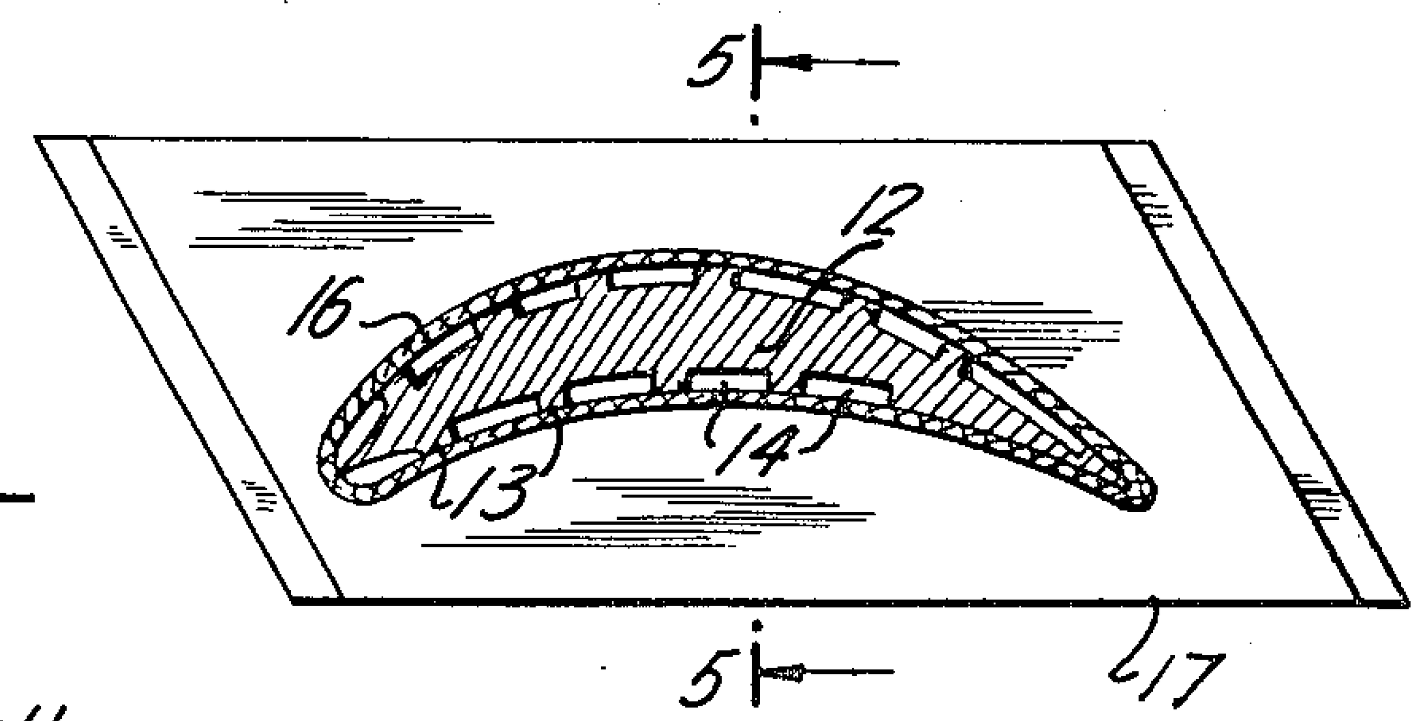


FIG. 5

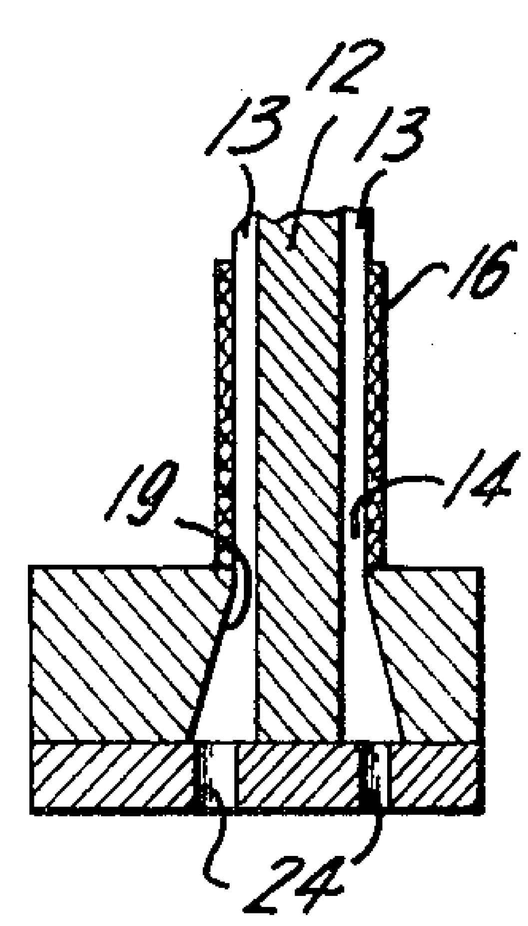
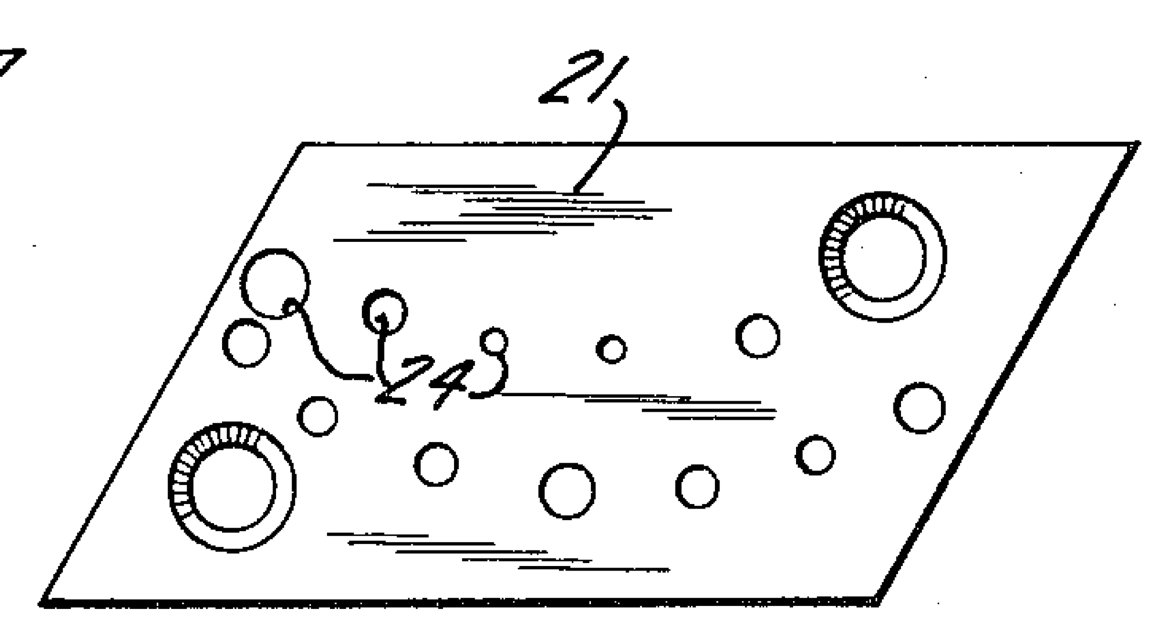


FIG. 3



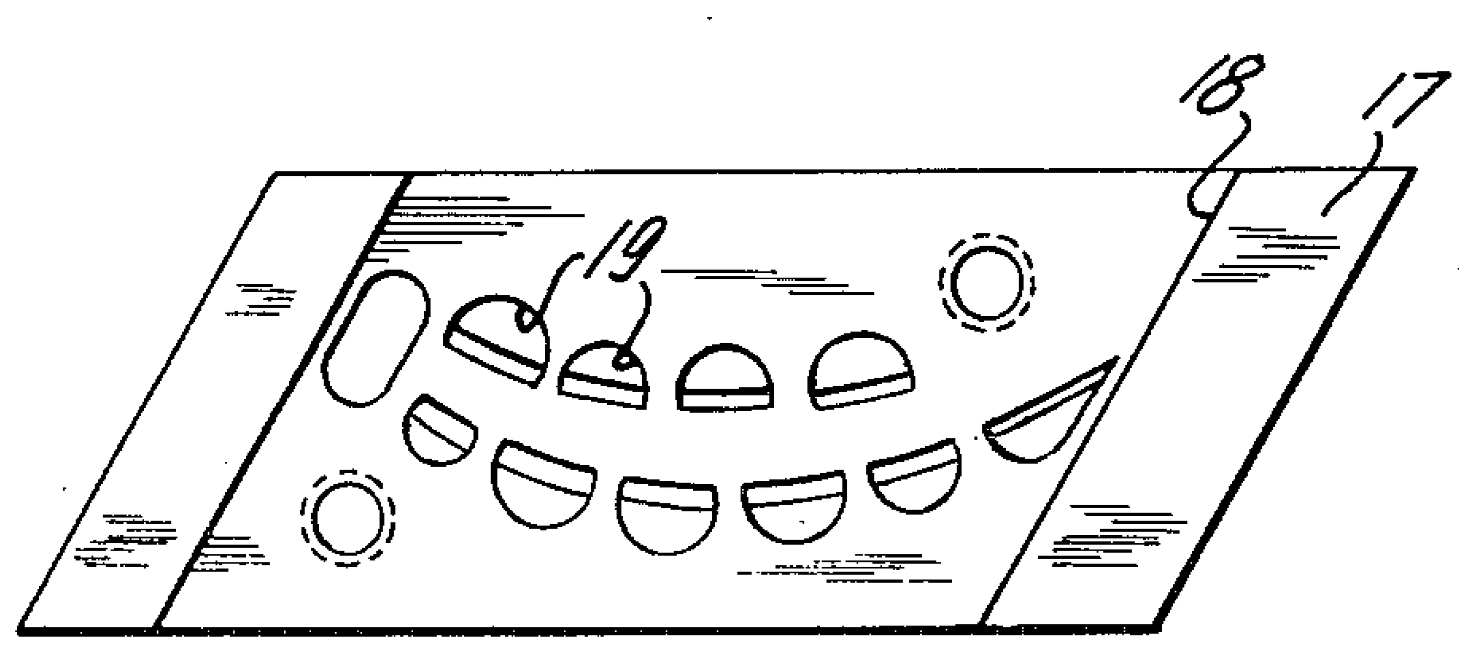


FIG. 2

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TRANSPIRATION COOLED TURBINE BLADE WITH METERED COOLANT FLOW

BACKGROUND OF THE INVENTION

The invention herein described was made in the course of or under a contract with the Department of the Air Force.

This invention relates to stator blades for gas turbines, and more particularly to such blades having a porous skin and internal passages to which cooling air is fed to bleed through the skin to provide a cooling action during operation of the blade in the flow of the combustion gases of the turbine, with particular reference to blades wherein it is desired to feed different amounts of coolant to portions of the skin which may be exposed to different temperatures and gas pressures than adjacent portions.

In U. S. Pat. No. 3,402,914 there is shown a blade having a structural spar with longitudinal air channels on its surface fed from the root, with the air bleeding through a porous skin to cool the blade. Some control of the distribution of air coming through the skin has been achieved by masking portions of the skin with flame-sprayed metal powder to diminish the permeability of the skin. Such a blade is very expensive to fabricate, and control of the degree of permeability desired is very difficult. The blade has the further disadvantage that once fabricated, no further control is possible. In a gas turbine engine there are circumferential gradients of temperature as well as chordwise and lengthwise of the blade, owing to uneven distribution of fuel and the presence of supporting struts at various locations which partially occlude or redistribute the flow of combustion gases. Also, the flow of coolant air to the blades may be nonuniform, owing to varying degrees of intricacy in the flow path the air must follow to reach the various blades, or to their varying distances from the source of cooling air. The blade of the patent has no provision for feeding its air channels with different amounts within a single blade, and since all blades are the same in a given engine they are unevenly adapted to different circumferential locations.

U. S. Pat. No. 3,240,468 displays a different approach to the problem. The blade of this patent has a hollow strut having on its surface longitudinal and transverse lands defining discrete cells under the porous skin. Coolant is fed to the interior of the hollow strut, and each cell has an aperture communicating with the strut interior, which apertures may be of various sizes whereby different amounts of coolant may be supplied to different cells. This blade, again, is expensive to fabricate, and also has the same disadvantage that once finished no changes may be made, so that all blades in a given engine are alike. Therefore, no provision can be made to accommodate circumferential gradients of temperature, and the blades are not equally well adapted to all locations in the engine. The blades are designed for the hottest spots in the engine, requiring the most coolant flow. Such a procedure wastes cooling air which is bled from the compressor, and depresses engine performance.

SUMMARY

The blade of the present invention provides coolant channels of different cross-sections distributed across the chord of the blade, in order to accommodate both temperature and pressure gradients across the chord. The limitations of the prior art are overcome by providing metering means at the base of each blade whereby a selected amount of coolant can be fed to each blade passage. The metering means being removable and replaceable, when parameters have been established for cooling requirements at various locations an appropriately selected metering means can be attached to each blade. The blades themselves being of simpler construction than those of the prior art, they are better adapted to quantity production, and the metering means being positioned at the root of the blade out of the gas stream, it may be formed of less critical and more easily worked material, and hence is susceptible of easy reworking or stocking quantities of metering plates of varying coolant distributing characteristics. In servicing an engine employing this invention the blades may be reassembled in any order, if the appropriate metering plate for a given location is used. Thus, it is possible to provide a single blade design adapted to any location in an engine, whatever the temperature and pressure variations and concomitant cooling requirements, without expensive modification of individual blades.

It is an object of this invention to provide a means of metering an appropriate amount of coolant to selected portions of a turbine stator blade.

It is another object to provide means of metering coolant appropriately to stator blades in different circumferential locations in an engine.

A further object is the provision of turbine stator blades adapted to quantity production, in combination with low cost metering means for each blade whereby any blade is suitable for any location in an engine.

Other objects and advantages will become apparent on reading the following specification in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an exploded view of an elevation of the blade and metering means of the invention;

FIG. 2 is a view of the root of the blade taken on line 2—2 of FIG. 1;

FIG. 3 is a bottom view of the metering plate to be attached to the blade;

FIG. 4 is a cross-section of the blade taken on line 4—4 of FIG. 1; and

FIG. 5 is a fragmentary elevational cross-section taken on line 5—5 of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows the concave or pressure side of a stator blade 11. The blade has a structural spar or strut member 12 of generally airfoil configuration, which may be either solid as shown or cored out hollow to reduce weight. The strut has on its surface a plurality of generally longitudinal lands 13, and is sheathed in a porous skin 16 of one of the types well known in the art, such as a metal mesh pressed and sintered to the desired degree of porosity. The skin is welded, brazed, diffusion bonded, or otherwise suitably attached to the strut at the tip and root portions and along the lands 13, and defines with the land a plurality of coolant passages

14 which are discrete from each other. Although in the embodiment shown, the lands 13 and passages 14 are straight, they may when required be curved.

The blade has a root portion 17 integral with the strut and appropriate for mounting the blade in an engine. In the base of the root, opposite the side from which the strut extends, is provided a recess 18 in which may be installed a metering plate as described below. The root has generally funnel-shaped feeder apertures 19 therethrough (best shown in FIGS. 2 and 5) communicating with passages 14, with the larger portion of the funnel opening on the base side and fairing into a slit on the strut side, each slit opening into its associated coolant channel and being of approximately the same cross-section as the channel. Where space is restricted, a single root aperture may feed two blade channels. The pressure and suction sides of the blade may have different numbers of coolant passages 14, and the passages may be of different sizes, depending on the cooling requirements at any particular location. When the coolant passages are of different sizes, the feeder apertures 19 may also vary correspondingly, so that larger amounts of coolant may be fed to larger channels.

A metering plate 21 is installed in recess 18 of the blade root, held thereto by screws 22 or other suitable means. There may be a gasket 23 disposed between the metering plate and the blade root to prevent circumferential leakage of cooling air, although if the surface of recess 18 is machined with a smooth surface no gasket is necessary.

The metering plate 21 (shown in FIG. 3) has a plurality of metering orifices 24 therethrough, disposed in a configuration congruent with the funnel-shaped root apertures 19. Orifices 24 are of various sizes, in accordance with the amount of cooling air to be metered to the corresponding blade passages, and one orifice may be used to feed two blade passages. The pattern of larger and smaller orifices 24 shown in FIG. 3 is not necessarily that of any given engine, but is thus shown only for purposes of illustration.

The leading edge of the blade is commonly the hottest portion and may therefore require the greatest flow of coolant. The blade strut may be provided with a nose portion at the leading edge, as shown in FIG. 4, which channels the coolant at that portion into discrete passages on the concave and convex sides of the blade, or the strut nose may be omitted and all the coolant at the leading edge may flow through a single channel.

The orifices 24 have a smaller cross-section than their corresponding apertures 19, and also smaller than the summative cross-section of the capillary porosity of the skin overlying any corresponding blade passage. Hence, orifices 24 constitute the governing restriction in the coolant path, and determine how much air will flow to any blade passage, in accordance with the cooling requirement at that location. The ratio of orifice cross-section to blade passage cross-section will never be greater than 1:1, and will be that large only in an occasional instance where no restriction is desired for the coolant flow to a given passage. No specific rule can be given for an optimum ratio, since the amount of restriction is a variable design consideration for each type of engine, for the location of a blade in the engine, and for specific passages in a blade. However, the ratio commonly lies somewhere in the range from 0.5:1 to 0.1:1.

The bulk of the metering plates are fabricated according to the cooling requirements of the generality of blades in a given engine. When the distribution of cooling for a specific blade differs because of the circumferential gradients of temperature and pressure brought about by the factors previously discussed, it is easy to provide a plate adapted to that blade.

If more coolant is needed for one or more passages, the corresponding orifices may be reamed out to the suitable size. Since the metering plate is made of readily workable metal, such as low alloy steel, for instance, this procedure is far simpler and cheaper than attempting to enlarge an aperture in the blade itself. Blades for high performance turbines are made of hard, tough, high temperature alloys which are machinable only with great difficulty and consequent expense in time, tool breakage, and low production. Further, in the blade material it is difficult to hold small tolerances, so that in small bores such as of the order of one-sixteenth inch or less in diameter, a departure of a few thousandths of an inch from the specified size results in a very marked percentage change in cross-sectional area.

If it is found that less air is needed at some blade locations, or for some blade passages, the corresponding metering plate may either have one or more orifices plugged and rebored, or a new plate may be installed with appropriate orifices.

What is claimed is:

1. In a gas turbine engine having circumferential temperature gradients and having a ring of circumferentially disposed stator blades having different cooling requirements at different circumferential locations, the combination comprising a transpiration cooled stator blade having a strut member of generally airfoil configuration having on the surface thereof a plurality of lands, a porous skin sheathing the strut and defining with the lands a plurality of discrete coolant passages, the strut having a root portion integral therewith mountable at any portion of the blade ring, the root having a plurality of apertures therethrough each communicating with an associated blade coolant passage, an interchangeable metering plate detachably attached to the root on the side opposite the strut, the metering plate having a plurality of metering orifices therethrough congruent with the strut apertures for metering a supply of coolant to each blade passage, each plate being selected to pass an amount of coolant to its associated blade in accordance with the coolant requirement of the blade at its respective circumferential location.

2. The combination recited in claim 1, wherein the metering orifices of each plate are of various sizes to pass different amounts of coolant in accordance with the coolant requirements of their respective blade passages.

3. The combination recited in claim 2, wherein the root apertures are generally funnel-shaped with their entrance ends facing the orifices of the metering plate and of larger size than any metering orifice, the other ends of the root apertures opening into their respective blade passages and having approximately the same shape and cross-section as their respective blade passages.

4. The combination recited in claim 3, wherein the lands on the strut are generally longitudinally disposed

and the direction of the flow path is generally from the metering plate toward the blade tip.

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