United States Patent [19]

Kirby

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[54] **COOLED TURBINE COMPONENTS AND METHOD OF MAKING THE SAME**

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[73] Assignee: **The Garrett Corporation**, Los Angeles, Calif.

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[21] Appl. No.: **308,188**

[52] **U.S. Cl.** **416/95**; 416/97; 416/181; 416/229

[51] **Int. Cl.²** **F01D 5/18**

[58] **Field of Search** 416/229, 181, 95, 231, 416/97

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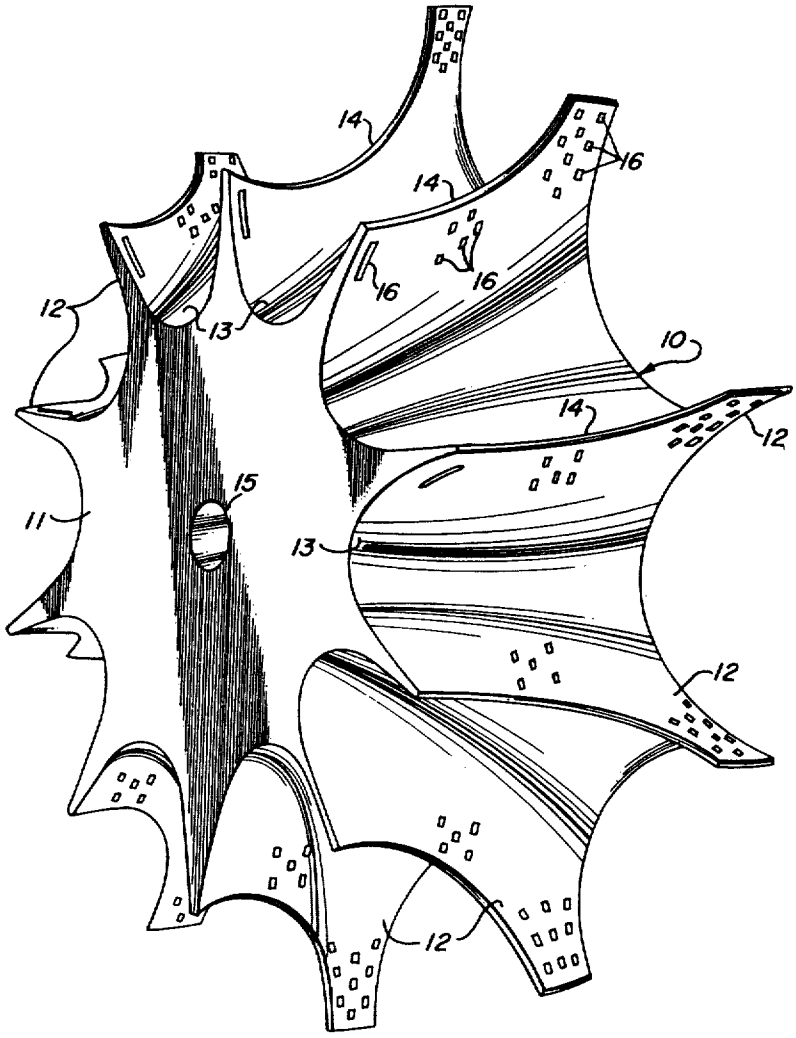
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Primary Examiner—Everette A. Powell, Jr.
Attorney, Agent, or Firm—Herschel C. Omohundro; Jack D. Puffer; Albert J. Miller

[57] **ABSTRACT**

A gas turbine component composed of thin sheet metal pieces certain of which have narrow recesses, slots or holes photoetched therein, the pieces being bonded together into an integral unit and machined to provide a body with relatively thin blades or vanes spaced thereon, the recesses, slots or holes cooperating to form cooling passages communicating in the body with an inlet and extending into the blades or vanes in a predetermined pattern to effect efficient cooling of the blades, the passages terminating at selected blade surface areas in outlets oriented in a fashion to enhance the cooling effect.

3 Claims, 8 Drawing Figures



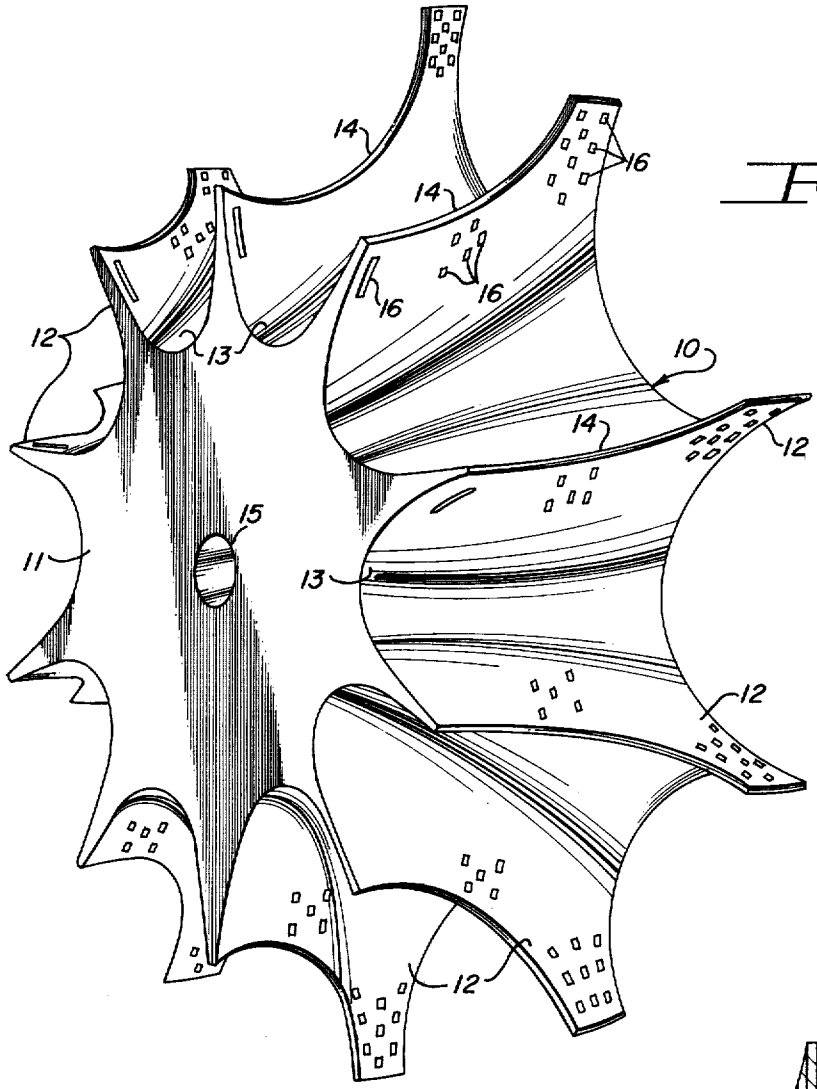


FIG. 1

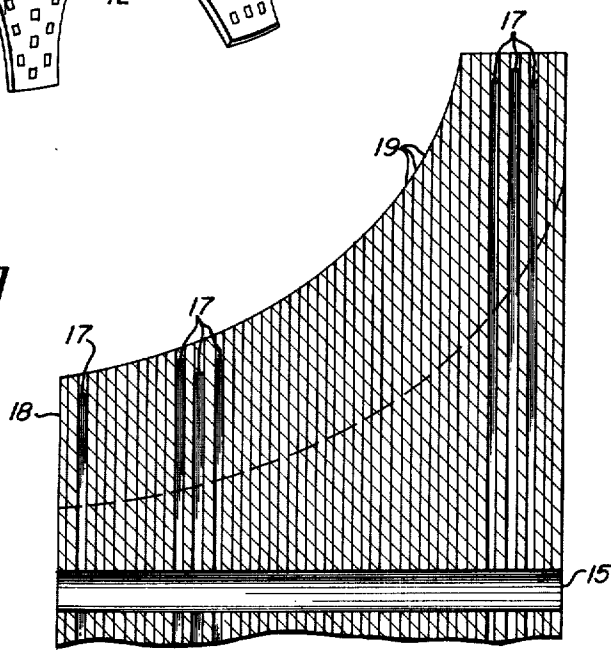


FIG. 3

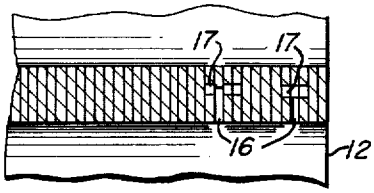


FIG. 4

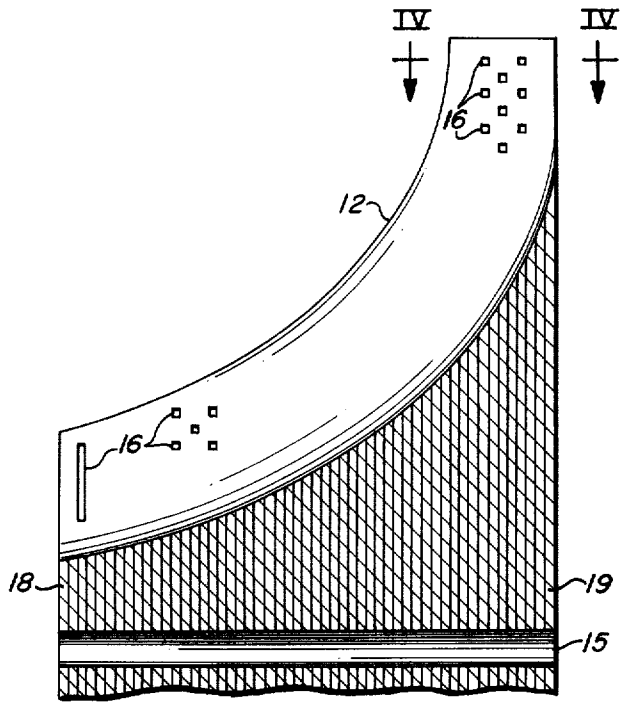


FIG. 2

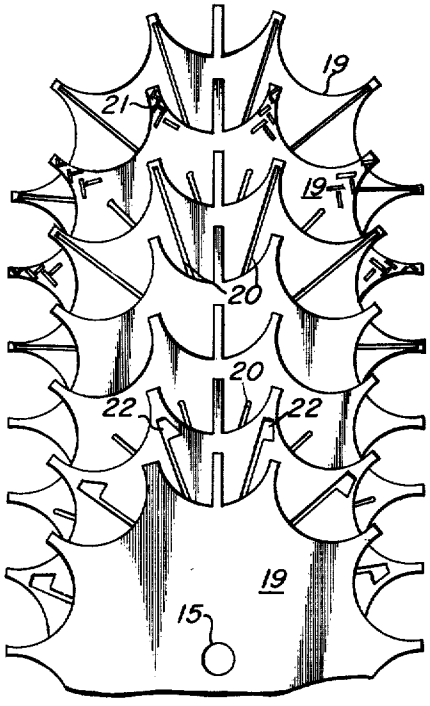


FIG. 6

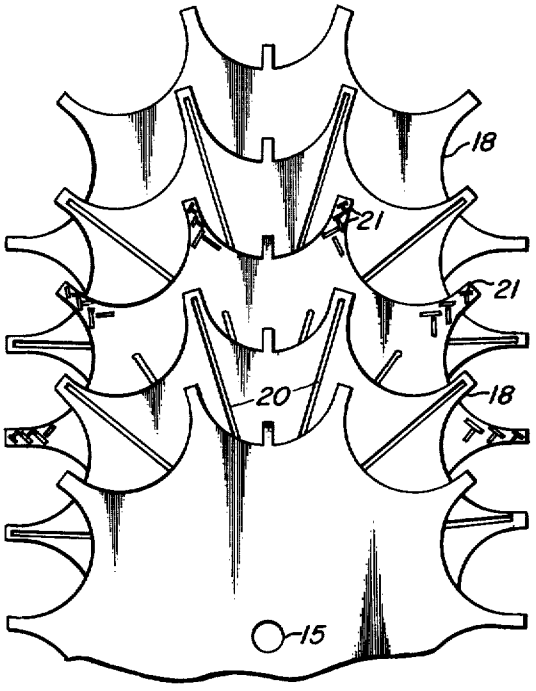


FIG. 5

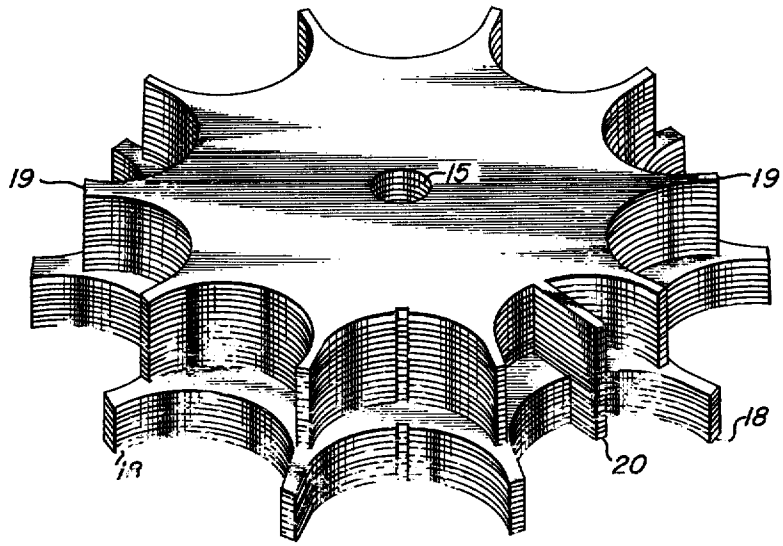


Fig. 7

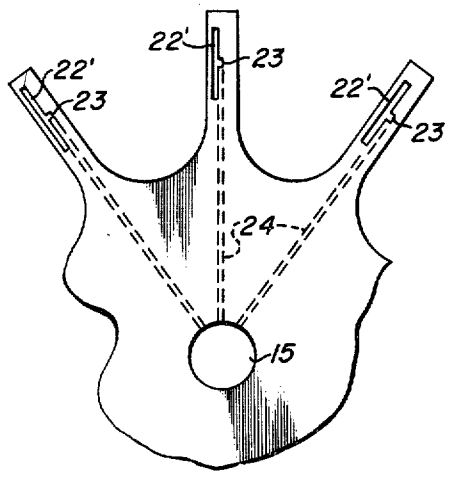


Fig. 8

COOLED TURBINE COMPONENTS AND METHOD OF MAKING THE SAME

BACKGROUND OF THE INVENTION

This invention relates generally to the gas turbine art and is more particularly directed to the production of small high-temperature gas turbine components such as wheels, nozzles and the like which are exposed to hot gases and stresses tending to destroy them or at least shorten the useful life thereof.

The general art to which this invention pertains is exemplified by U.S. Pat. No. 2,613,058 to Atkinson, No. 3,077,297 to Clarke, and No. 3,088,192 to Turner, each of which shows cooled bladed rotors for gas turbines but none of which shows small ultra-high-temperature, high-speed turbines wherein the blades are relatively thin and may be intricately shaped.

An object of this invention is to provide a cooled turbine wheel which has relatively thin blades with fluid passages of small cross-sectional area extending therethrough, the passages being arranged to secure a desired temperature profile in the blades or wheel.

An object of the invention is to provide a cooled turbine wheel having a hub with an inlet for cooling fluid, a plurality of relatively thin blades projecting from the hub in spaced order, and one or more cooling passages communicating with the cooling fluid inlet and extending through the hub into each blade, the passages terminating adjacent the ends of the blades in outlets for discharging the fluid into the gas stream applied to the blades to effect rotation of the wheel.

Another object of the invention is to provide a method of making the cooled turbine wheel mentioned in the preceding paragraph in which method the cooling passages are formed without mechanical drilling operations, the method being adaptable to relatively high-speed mass production.

Still another object of the invention is to provide the method mentioned in the preceding paragraph with steps including the use of thin sheet metal blanks, photoetching recesses, grooves, slots, and/or holes in the blanks, stacking the blanks with the recesses, grooves, slots and/or holes in predetermined relationship to form the cooling passages previously mentioned, bonding the blanks together while the stacking relationship is maintained to form a one-piece body, and machining the body by a suitable operation to form the hub and blades extending therefrom, the wheel having the cooling fluid passages in the hub and blades, as previously recited.

A further object of the invention is to provide the methods mentioned in the two preceding paragraphs with a bonding step in which the sheets are coated with a compound having a melting temperature only slightly lower than that of the material of the sheets so that when the stack of sheets is heated during the bonding operation the compound will diffuse into the sheets and unite them with a joint having a resistance to failure substantially equal to that of the sheet material.

A still further object of the invention is to provide the methods mentioned in the three preceding paragraphs with a step in which the sheets are formed with star-shaped contours and the recesses or slots extend into the points of the stars so that when the stacked and bonded into an integral body it will have radiating arms which are thereafter machined into blades, the recesses or slots combining to form cooling fluid passages substantially centrally of the blades or in any other desired pattern.

Another object of the invention is to so orient certain of the recesses or slots in the sheets that after the stacking, bonding and machining steps have been completed, the blades will have cooling passage discharge outlets which direct the cooling fluid along the blade surfaces to secure a film cooling effect.

A result and therefore an object of providing the metallic sheet blanks with star-shaped contours is to form the resulting integral body with alternate grooves and radiating arms so that the quantity of material required to be removed from the arms to make the blades will be reduced to a minimum, thus cutting the manufacturing time and cost.

It may also be desired and therefore an object to perform the machining step by an EDM (electrical discharge machining) process in which the excess material is removed by electrical discharge from the hub and blades, leaving the wheel with a precise size and shape that can be readily polished into final form.

It is within the concept of the invention also to pass etching fluid through the cooling fluid passages after the bonding step to remove sharp corners and/or obstructions which might interfere with the required flow of the cooling medium through the passages.

In order that the invention may be fully understood and readily practiced it will now be described in detail with reference to the forms of the invention illustrated in the accompanying drawings.

THE DRAWINGS

FIG. **1** is a perspective view of a gas turbine wheel formed in accordance with the present invention;

FIG. **2** is an axial sectional view taken through one half of the wheel shown in FIG. **1**, the plane of the section being taken through a groove between two blades and showing one of the latter in elevation;

FIG. **3** is a similar view taken on a plane passing axially through one of the blades to show the cooling passages formed therein;

FIG. **4** is a horizontal sectional view taken through one of the blades on a plane indicated by the line IV—IV of FIG. **2**;

FIG. **5** is a view in elevation of a plurality of the metallic sheet blanks showing the contour thereof and the cooling passage forming grooves or slots photoetched therein;

FIG. **6** is a similar view showing other blanks of a different size for use with the blanks in FIG. **5** in the formation of an integral body by the stacking and bonding step;

FIG. **7** is a perspective view of the integral body following the stacking and bonding steps; and

FIG. **8** is an elevational view of a sheet metal blank with a modified form of slot arrangement to dispose the cooling passages in a different location.

DESCRIPTION

More particular reference to the drawings and especially FIG. **1** which shows a finish-machined wheel discloses that in one form of the invention the gas turbine wheel **10** has a hub portion **11** and thin blades **12** projecting radially therefrom. The blades are spaced and provide grooves **13** therebetween through which hot gases flow after impinging on the sides of the blades in the operation of the gas turbine. The wheel shown in FIG. **1** is of the centripetal type in which the blades are

longer on the side of the wheel functioning as the inlet while the blades at the other, or outlet side, of the wheel are shorter, the outer edges of the blades being curved as at **14**.

In the operation of the turbine, hot gases are directed between nozzles vanes (not shown) against one side of the outer ends of the wheel blades to effect the rotation of the wheel. This gas flows through the grooves **13** and is exhausted from the outlet side of the wheel. Since a gas turbine is a heat engine and efficiency depends, in part, on the temperature of the gases, an objective in the art is to utilize gases of higher and higher temperatures. Obviously the high-temperature gases tend to corrode or melt and destroy the engine parts they engage. To combat this effect it is proposed to cool the parts, such as the turbine wheel, by applying air or other cooling fluids to such parts.

To apply the cooling fluids, the parts, i.e., the wheel and nozzle vanes, may be provided with passages through which the fluid flows to extract heat from the parts. In certain installations the fluid may also be caused to flow over certain surfaces, such as the blade walls, to protect them from the heat, oxidation or other chemical action.

As shown in the drawings, the wheel **10** is provided with an axial opening **15** for admitting air or other cooling fluid. The blades **12** are also formed with a plurality of outlets **16** at predetermined areas along their sides. These outlets **16** and the inlet **15** are connected within the blades and hub by fluid passages **17**. The invention herein resides in a novel method of constructing the wheel to form the passages **17** without resorting to expensive mechanical drilling operations. In fact, with certain wheel designs, those having intricately curved blades, mechanical drilling of passages is impossible. Also, because of the thin blades required, mechanically drilling the passages would be extremely difficult and time consuming even in straight radial blades.

The method forming the subject matter of this invention consists in using thin metallic sheets to produce a plurality of blanks **18** and **19**, such as shown in FIGS. **5** and **6**, which, in the form of the invention selected for illustration, have star-shaped contour. These blanks are formed from the sheets by a photoetching operation and certain ones are provided in the same operation with recesses, grooves, slots, and/or holes **20, 21** and **22** of predetermined patterns. Following the etching operation, the blanks **18** and **19** are coated on at least one side with a suitable braze of diffusion bonding alloy. This coating may be applied in various ways, such as by spraying, dusting or placing a braze alloy foil between adjacent blanks. The coated blanks are then stacked in predetermined order and vacuum diffusion bonded at a suitable elevated temperature while the stacking order is maintained. It may be found desirable or perhaps necessary to maintain the stack under a compressive force during the bonding operation.

After the bonding operation the integral body will be as shown in FIG. **7**. It will be noted that in the illustrated exemplification of the invention, blanks of two or more sizes are employed. This feature, as well as the use of the star shape, was selected to reduce the amount of material to be removed in the machining operation. The latter may be performed in any suitable manner, a preferred operation being that designated as an EDM process in which the excess metal is removed by electrical discharge from the blank to impart the desired shape to the wheel and the correct curvature to the blades and web regions. Hand-finishing operations may then be performed to obtain the final dimensions.

It will be noted from FIGS. **1** to **4**, inclusive, that the predetermined patterns of the etched grooves, recesses, slots, and/or holes and the order of stacking the blanks result in providing the finished wheel with the cooling fluid passages **17**, which communicate with the axial inlet opening **15** and extend through the hub and outwardly into the blades **12**. Certain of the blanks have the slots, recesses, or grooves **21** extending generally transversely across the points of the star. These grooves, slots or recesses **21** form the cooling fluid discharge outlets **16** adjacent the ends of the wheel blades. In the wheel illustrated, some of such discharge outlets are disposed in the surface areas directly engaged by the hot gases admitted through the inlet nozzles. In certain instances the grooves which form the discharge outlets are inclined relative to the star points so that the outlets direct the cooling fluid backwardly toward the hub of the wheel whereby the fluid will flow along the surfaces of the blades in a film cooling manner. The melting effect of the hot gases will thus be minimized.

From the description thus far it will be obvious that recesses, grooves, slots, and/or holes of any suitable size and shape may be formed in the sheet metal blanks and the latter may be stacked in such order that the recesses, grooves, slots, and/or holes will cooperate by overlapping and/or registering, in part, with one another to produce any simple or complex passage desired or required to effect the cooling profile essential to the successful operation of the turbine. The recesses, grooves, slots, and/or holes can be made with dimensions such that the passage in the blades will not noticeably reduce the strength of the blades, and if the latter are curved the passages can be made to conform.

In the construction of an actual wheel, slots 0.020 inch wide were etched in sheet blanks 0.020 inch thick and the sheets were thereafter bonded to produce the wheel with cooling fluid passages of substantially rectangular cross section therein.

It has previously been suggested in the objects that sharp corners or obstruction in the passages may be eliminated by directing an etching compound through the passages after the blanks have been bonded into an integral body.

In the modified form of the invention shown in FIG. **8**, narrow slots **22'** are formed adjacent one edge of the points of certain of the star-shaped blanks. These slots each have a branch at **23** which communicates with a groove or slot **24** formed in the next adjacent blank, as indicated by dotted lines in FIG. **8**. Slot **24** extends to and communicates with the inlet opening **15** at the center of the wheel.

It should be obvious that cooling passages of any desired configuration can be provided and such passages can be made to give cooling effects at any required location.

It should also be obvious that, although in the form of the invention selected for illustration the outlets for the cooling fluid have been located in the outer portions of the blades, they could equally well be disposed in other locations, if desired, to secure different cooling effects without departing from the spirit of the invention.

While the embodiment illustrated and described is in the form of a radial-type wheel, it should be obvious to those skilled in the art that wheels of the axial type can

be made according to the invention.

I claim:

1. A turbine wheel of the type having a hub portion and thin blades projecting radially therefrom, said blades and said hub portion defining grooves between said blades through which hot gases flow after impinging on the sides of the blades, said turbine wheel comprising:

a. a plurality of thin flat sheets, each of said sheets having a central portion corresponding to the hub of the turbine wheel and a plurality of projections extending outwardly from said central portion, said projections being substantially equally spaced around the circumference of said central portion and corresponding to said blades;

b. said sheets each having a central opening;

c. said sheets being stacked together in fact-to-face relation with said central opening and said radial projections of each sheet being aligned with the projections and central opening of adjacent sheets;

d. bonding means between each one of said adjacent sheets for securing said sheets together over the entire surface of engagement between said sheets to form a unitary turbine wheel;

e. at least one pair of said sheets having slots therein, one of said pair of sheets having a slot extending from said central opening into one of said radial projections of said one sheet and the other of said pair of sheets having a slot inclined with respect to a radius of said wheel extending from the edge of said other sheet across said projection and intersecting said slot in said one sheet, whereby said pair of slots provides fluid communication between said central opening and the channel between adjacent blades of said turbine wheel.

2. The gas turbine wheel of claim 1 in which the widths of the slots are substantially equal to the thickness of the sheets in which they are formed.

3. The turbine wheel of claim 1 wherein said sheets are bonded together over the entire surface of engagement between said sheets by activated diffusion bonding.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,927,952
DATED : Dec. 23, 1975
INVENTOR(S) : Robert F. Kirby

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 1, line 17, change "fact" to --face--

Signed and Sealed this

thirteenth Day of April 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks