April 21, 1953 C. M. McDOWELL 2,635,848

ROTOR FOR GAS TURBINES

Filed Oct. 28, 1948 3 Sheets-Sheet 1

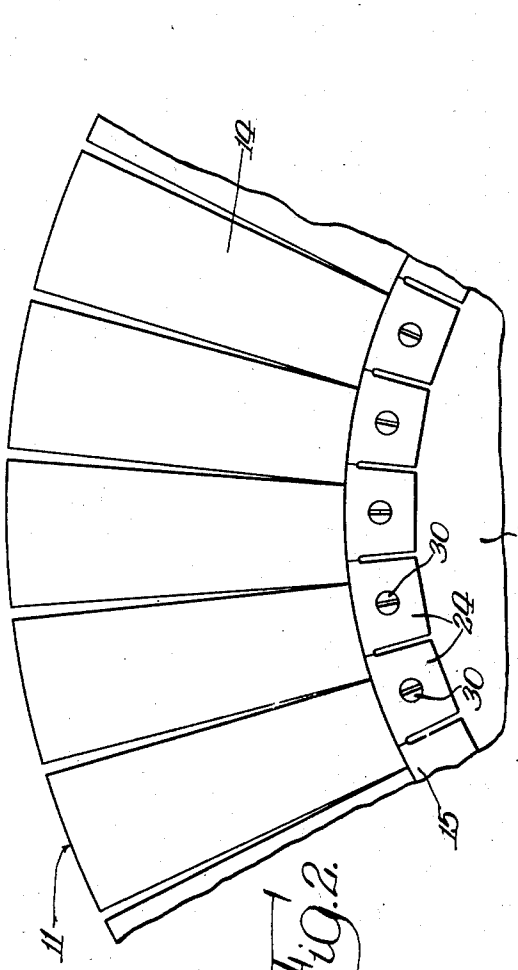

Fig. 2.

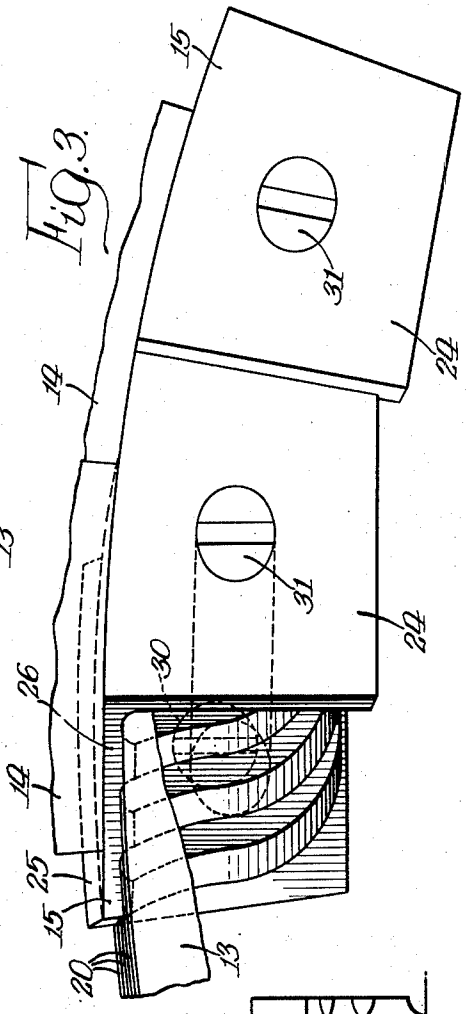

Fig. 3.

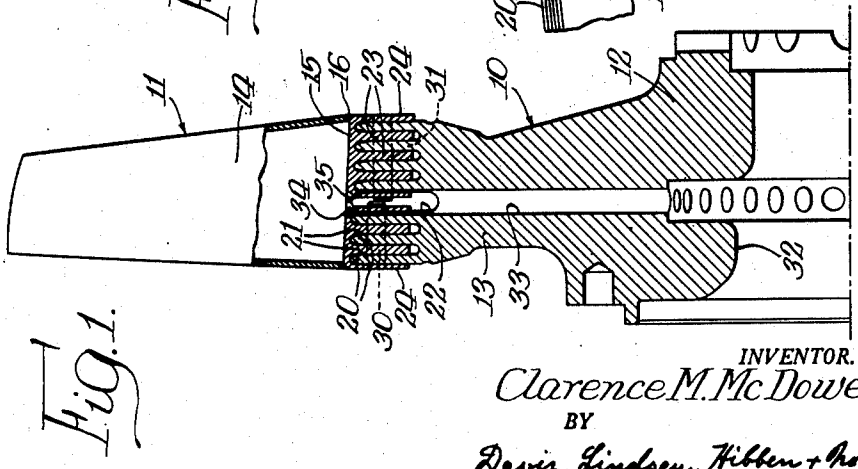

Fig. 1.

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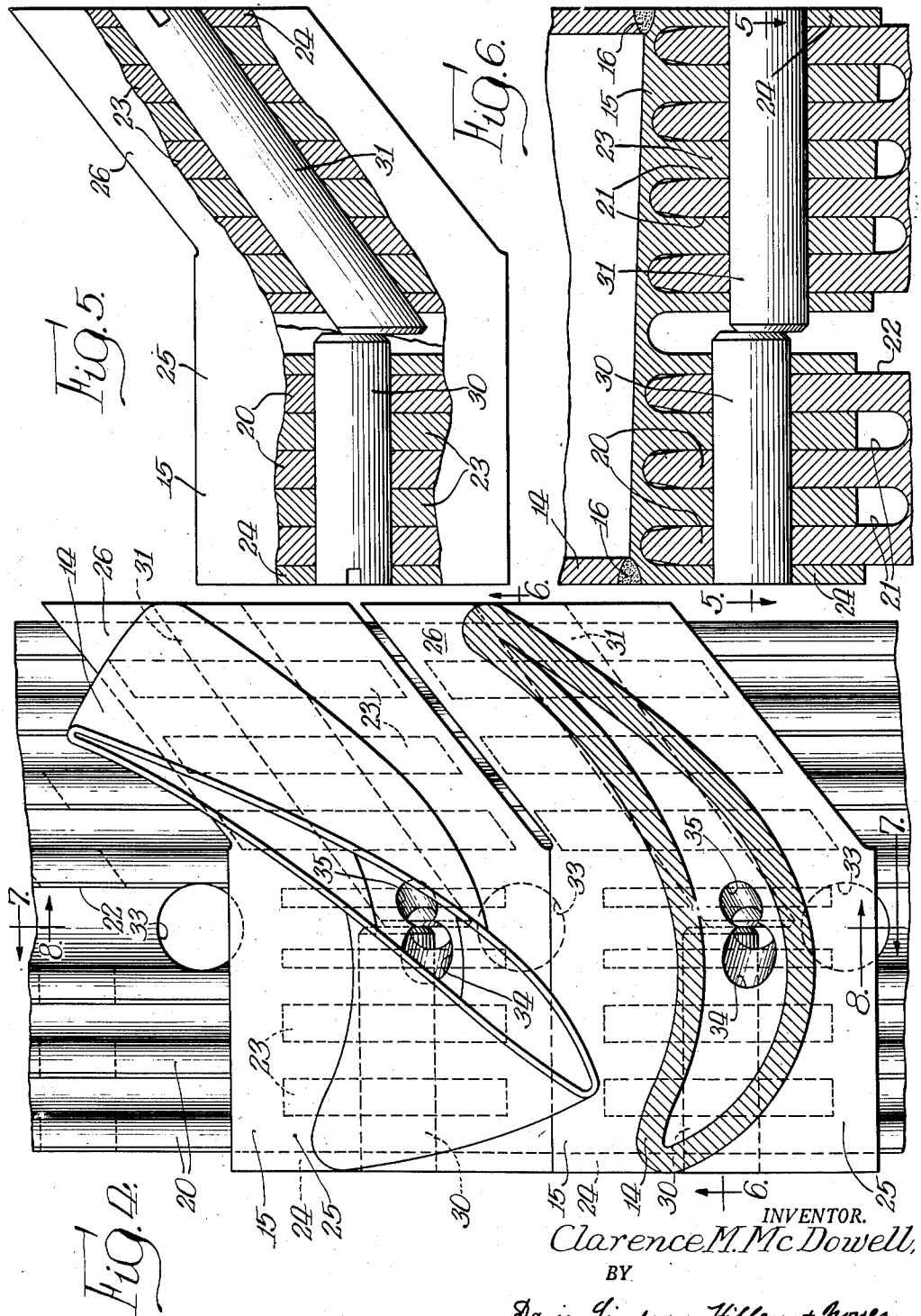

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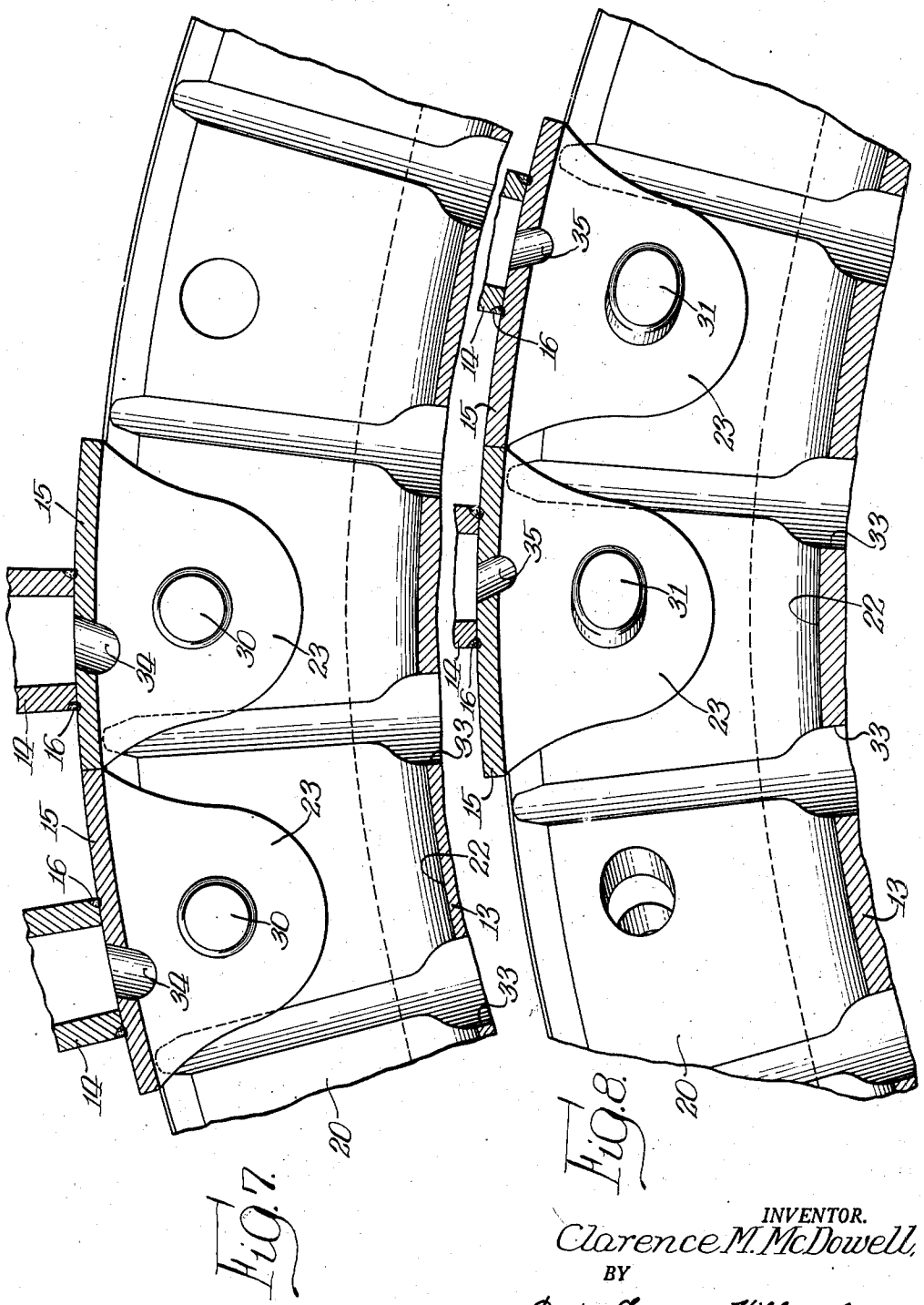

Fig. 7.

Fig. 8.

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ROTOR FOR GAS TURBINES

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12 Claims. (Cl. 253—39.15)

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The invention relates generally to turbines and more particularly to a rotor construction for a gas turbine.

The general object of the invention is to provide a novel turbine rotor construction having individually mounted blades with provision made for discharging cooling air from the body of the rotor through the blades.

Another object is to provide a turbine rotor construction having blades individually mounted on the rotor body in a novel manner whereby stresses on the connection between each blade and the body, due to the forces acting on the blades, are minimized.

More specifically, it is an object to provide a turbine rotor construction comprising a rotor body and individually mounted blades, the blades and body having tongue and groove connections secured by pins, the connections having a novel construction minimizing the stresses on the pins resulting from the forces acting on the blades.

A further object is to provide a turbine rotor construction comprising a rotor body and individually connected hollow blades, the connections between the blades and the rotor body being such that cooling air supplied through radial passages in the body may be conducted to the interior of the blades and discharged from the outer ends thereof.

Other objects and advantages will be apparent from the foregoing specification taken in connection with the accompanying drawings, in which:

Figure 1 is a radial sectional view of a gas turbine rotor embodying the features of the invention.

Fig. 2 is a fragmentary face view of the left-hand face of the rotor as shown in Fig. 1.

Fig. 3 is a fragmentary enlarged face view of the right-hand face of the rotor as shown in Fig. 1.

Fig. 4 is a fragmentary view of the periphery of the rotor and showing only two blade members mounted on the rotor body.

Fig. 5 is a view of one of the blade members, similar to the view shown in Fig. 4, but with a portion thereof sectioned along the line 5—5 of Fig. 6.

Fig. 6 is a fragmentary sectional view taken along the line 6—6 of Fig. 4.

Fig. 7 is a fragmentary sectional view taken along the line 7—7 of Fig. 4.

Fig. 8 is a fragmentary sectional view taken along the line 8—8 of Fig. 4.

The gas turbine rotor disclosed herein is of

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the type comprising a rotor body having individually mounted blade members secured to its periphery. The connection of each blade member, in this instance, is of the type comprising interfitting tangs on the blade member and periphery of the rotor body, which are pinned to each other. Usually, a single pin is employed for each blade member, with the pin extending generally parallel to the axis of the rotor.

Because of the speed at which a rotor of this character operates, stresses on the connection of the blade with the rotor body are very large, due to centrifugal force and due to the action of the power stream on each blade member. Furthermore, because of the high temperature of the gases of the power stream, to which the blades are subjected, the safe working stress of the metal of the blades is reduced. It is, of course, common practice to utilize a metal, in making these blades, which maintains a relatively high strength at elevated temperatures. Nevertheless, such safe working stresses are not as high as with cold metal.

The blade section of each blade member may be said to have a shape related to an airfoil. Thus, the facial surfaces of the blade are curved or cambered. Moreover, to properly utilize energy from the power stream, each such blade section may be positioned at an angle to a line parallel to the axis. Thus, a single straight pin positioned parallel to the axis of the rotor will be offset from the front and rear edges of the blade section if it is aligned with an intermediate portion of such section. In other words, a single pin cannot be so positioned as to follow even generally the line of curvature of the blade section. Such offsetting of the pin relative to portions of the blade section results in undue stresses from the centrifugal force and the forces of the power stream acting on the blade section. Since the pin, in such instance, is the sole connection between the blade and the rotor body, the stresses in the pin may be excessive and beyond the margins of safety. In fact, in many turbine designs, blade breakage, as well as breakage of the pins, may be attributed to the stresses arising because of such offsets.

By the present invention, such undesirable stresses are minimized by utilizing a plurality of pins to secure each blade member to the rotor body, with the pins positioned so that they follow generally the curvature or camber of the blade section. A blade member of the type herein contemplated comprises a blade section, which is that part of the member directly contacted by

the power stream, and a base section for securing the blade section to the rotor body. The pins, in this instance, of course, extend through the base section and are so located as to substantially underlie the inner end of the blade section and to conform to the curvature thereof.

With the pin type of mounting, the margin of safety is inherently rather small. For that reason, it is desirable to make the blade members as light in weight as possible, and also to make provision for cooling them so that the metal thereof may operate at a higher strength. It is, therefore, preferable to make the blade members hollow and to discharge a stream of cooling fluid, such as air, therethrough to carry away heat absorbed by the metal from the power stream. Such air may be supplied to the blade members by radial passages in the rotor body. Consequently, provision must be made in the base section of the blade for conducting such cooling air from these radial passages to the hollow interior of the blade section. The base section, with its pin connection to the rotor body, thus must also be designed to include air passages connecting the radial passages in the rotor body and the interior of the blade section.

The preferred embodiment shown in the drawings comprises a rotor body, indicated generally at 10, and a plurality of blade members, each indicated generally at 11. The rotor body 10 comprises a hub portion 12 and a radially extending flange portion 13.

Each blade member 11 comprises a blade section 14 and a base section 15. The blade section 14 is hollow, as is clearly evident from the various figures of the drawings, and may be made of sheet metal. The blade section 14, as is shown in Fig. 4, is of generally airfoil design, so that it has a curved or cambered form, and is positioned so that its front and rear edges are peripherally offset from its intermediate portion with the rear edge peripherally offset to a greater extent than the forward edge. The blade section 14 in the present instance is shown as secured to the base section 15 by welding, as indicated at 16 in Figs. 1, 6, 7 and 8.

The base section 15 of each blade member provides for securing the blade member to the periphery of the rotor body 10. This connection, in the present instance, may be described generally as of the type comprising interfitting tangs on the blade member and rotor body pinned together. Specifically, this construction comprises a plurality of flanges 20 formed on the periphery of the rotor body by a plurality of annular grooves 21. One of the grooves, indicated at 22, intermediate the side faces of the rotor body, is wider and deeper than the other grooves for purposes hereinafter discussed.

The base section 15 of each blade member is provided with a plurality of tangs 23 fitting in the grooves 21. The inner tangs 23 of each base section are of generally rounded form, as shown in Figs. 7 and 8, while the outer face tangs, indicated at 24, are of segmental form to substantially cover the peripheral portion of the rotor body at the two faces thereof.

Because of the curvature or camber of each blade section 14 and the peripheral offset of the edge portions thereof, each base section 15 comprises two portions, indicated respectively at 25 and 26, which are so positioned as to conform generally to the position of the adjacent portions of the blade section 14 and may, therefore, directly underlie the adjacent portions of the blade section. Thus, as is evident in Figs. 4 and 5, the two portions 25 and 26 are angularly related to each other with the portion 25 extending substantially parallel to the axis of the rotor and the portion 26 extending off at an angle to the portion 25. The portions 25 and 26 of each blade member nest or interfit with the corresponding portions of adjoining blade members so as to substantially enclose the periphery of the rotor body.

If the base section 15 of each blade member comprised only a single generally rectangular piece, it is obvious that portions of such base section would be peripherally offset by quite a large amount from the adjacent portions of the blade section 14. With the particular form of blade section shown herein, each base portion would have to be substantially wider in a peripheral direction than is shown herein to support the entire inner end of the blade section. Widening of the base section 15 would, of course, reduce the number of blades that could be mounted upon the periphery of the rotor body. However, by making the base section 15 in the two angularly related portions 25 and 26, each portion may be of reduced peripheral width and may be so located relative to the blade section 14 that the latter lies substantially along the center line of the blade section for all points along its curvature. This is evident by an inspection of Fig. 4 where the blade section 14 on the lower blade member is shown in cross section. In this figure, it will be noted that the blade section 14 lies substantially along the center line of the two portions 25 and 26.

The tangs 23 and 24 of the base section 15 are adapted to be secured to the flanges 20 of the rotor body by being pinned thereto. If a single pin were utilized for each blade member, as has heretofore been customary, it would be obvious that such pin would be, at certain points, considerably offset in a peripheral direction from the adjacent or inner portion of the blade section 14. A single pin in such position would give rise to undesirable stresses resulting from centrifugal force and the force of the power stream acting on the blade section 14. The invention, therefore, contemplates the use of a plurality of pins for each blade member, which may be positioned so that they conform generally to the curvature of the blade. In the present instance, I have shown two such pins, indicated at 30 and 31. The pin 30 extends substantially parallel to the axis of the rotor so that it conforms generally to and underlies the front portion of the blade section 14. The pin 31 is located at an angle to the pin 30 so that it conforms to and underlies the rear portion of the blade section 14. The two pins 30 and 31 project inwardly to the enlarged groove 22 in the rotor body and are shown as in contact with each other. While only two pins are employed in the present instance, it is contemplated that with some forms of the blades, it may be advantageous to use more than two pins. The fundamental features of the use of a plurality of pins is to permit positioning them so that they underlie the adjacent portions of the blade section. Thus, the pins conform generally to the curvature of the blade section without any substantial peripheral offset, so that undesirable stresses resulting from centrifugal force and the force of the power stream acting on the blade section are minimized.

With a construction as heretofore described, it is desirable to provide for cooling of the metal

of the blade so as to reduce the operating temperature of the metal and thereby increase its allowable working stress. In the present instance, cooling is accomplished by means of an air flow discharged through each blade section 14. To this end, the hub 12 of the rotor body is provided with an internal chamber 32 to which air is supplied, and the air is discharged therefrom through a plurality of radial passages 33, preferably one for each blade member. The radial passages 33 open into the enlarged groove 22 in the periphery of the rotor body but are peripherally offset from the center line of the pin 30 and the inner end of the pin 31, as is evident by an inspection of Fig. 7. The enlarged groove 22 thus serves as an air supply chamber from which air is to be discharged through the blade section 14. For so discharging the air, each base section 15 is apertured to provide communication between the enlarged groove 22 and the interior of the blade section. In the present instance, a pair of apertures are provided, such apertures being indicated at 34 and 35 in Figs. 1, 4, 7 and 8. The aperture 34 is positioned at an angle to a radius of the rotor body so as to direct air toward the front edge portion of the blade section 14, while the aperture 35 is positioned at such an angle as to direct a stream of air toward the rear edge of the blade section. Thus, cooling air may flow from the chamber 32 in the interior of the hub of the rotor through the radial passages 33 and the enlarged groove 22 in the periphery of the rotor body, and then through the apertures 34 and 35 into the interior of the blade section 14 for discharge through the outer end thereof. The air, in passing through the enlarged groove 22 in the periphery of the rotor body, also contacts the ends of the pins 30 and 31 to assist in keeping them cool and thus prevent excessive decrease in the strength thereof due to a high temperature.

I claim:

1. A turbine rotor comprising a rotor body having a plurality of circumferentially extending grooves and flanges on its periphery, a plurality of blade members each comprising a blade section having its leading portion extending generally axially and curving to position its trailing portion at an angle to the leading portion, and a base section comprising an axially extending portion and a portion at an angle thereto whereby the base conforms generally to the curvature of the blade, said base portions having a plurality of tangs interfitting with the grooves and flanges on the rotor body, and a pair of pins for each blade member extending through said flanges and tangs to secure the blade member to the body, one pin extending axially through the tangs on the axially extending portion of the base section and the other pin at an angle thereto to extend through the tangs on the angularly positioned portion of the base section whereby said pins substantially underlie the adjacent portions of the blade section.

2. A turbine rotor comprising a rotor body having a plurality of circumferentially extending grooves and flanges on its periphery, a plurality of blade members each comprising a curved blade section and a base section comprising two angularly related portions conforming generally to the curvature of the blade section, said base section having a plurality of tangs interfitting with said grooves and flanges, and a pair of pins extending through the tangs of each blade member and through the flanges for securing the blade member to the body, said pins being in alignment with the respective portions of the base section to substantially underlie the adjacent portions of the blade section.

3. A turbine rotor comprising a rotor body, a plurality of blade members mounted on the periphery of the rotor body and each having a blade portion of curved contour in a plane transverse to the length of the blade, each blade member and the rotor body having interfitting tang portions, and pin means extending through the tang portions on each blade member and the rotor body along lines, said pin means being shaped to conform generally to the curved contour of the blade portion, said pin means being interfitted with the tangs of said blade members in general alignment with the respective curved portions of said blade members.

4. A turbine rotor comprising a rotor body, and a plurality of blade members mounted on the periphery of the rotor body, each blade member comprising a curved blade section and a base section from which said blade section extends, said base section comprising portions angularly related to each other to conform generally to the curvature of the blade section whereby the circumferential width of said portions may be confined to the area adjacent the blade section, said angularly related portions and rotor body having interfitting tang portions, and pin means extending through said tang portions, said pin means being shaped to conform generally to the curvature of the blade, and said pin means engaging with said tang portions along lines conforming generally to the curvature of the blade section.

5. A turbine rotor comprising a rotor body, and a plurality of blade members mounted on the periphery of the rotor body, each blade member comprising a curved blade section and a base section from which said blade section extends, said base section comprising portions angularly related to each other to conform generally to the curvature of the blade section with the blade section located substantially on the center lines of said portions, said portions and said rotor body having interfitting tang portions, and a plurality of pins extending through said tang portions said pins being disposed in angular relation to each other and in substantial alignment with the center lines of said base portions to underlie the adjacent portions of the blade section.

6. A turbine rotor comprising a rotor body having a plurality of circumferentially extending grooves and flanges on its periphery, a plurality of blade members mounted on the periphery of the rotor body, each blade member comprising a curved blade section and a base section comprising a plurality of angularly related portions conforming generally to the curvature of the blade section, said portions having a plurality of tangs extending in axially spaced planes transverse to the axis of the rotor body and fitting within said grooves, and a plurality of pins, one for each of said portions, extending through said tangs and said flanges, said pins underlying and conforming generally to the curvature of said blade section.

7. A turbine rotor comprising a rotor body, and a plurality of blade members mounted on the periphery of the rotor body, each blade member comprising a curved blade section and a base section from which said blade section extends, said base section comprising portions angularly related to each other to conform generally to the curvature of the blade section, the base sections of adjoining members nesting with each other

and forming a rim about the periphery of the rotor body, said angularly related portions having tangs on their inner sides interfitting with tangs on the rotor body and pin means shaped to conform generally to the curvature of the blade, and said pin means engaging with said tang portion along lines conforming generally to the curvature of and underlying said blade section.

8. A turbine rotor comprising a rotor body having a plurality of circumferentially extending grooves and flanges on its periphery and a plurality of radially extending air supply passages opening into one of said grooves, a plurality of blade members mounted on the periphery of said rotor body, each blade member comprising a curved hollow blade section and a base section comprising a pair of angularly related portions conforming generally to the curvature of the blade section and merging into each other adjacent said one groove, said angularly related portions having tangs interfitting with said flanges, and a pair of pins for each blade member extending through the tangs of the respective angularly related portions and following generally the curvature of the blade section with the inner ends of said pins located in said one groove, the base section of each blade member having an aperture providing communication between said one groove and the interior of said blade section to permit the air from said radial passages to be discharged through the blade section.

9. A turbine rotor comprising a rotor body having a circumferentially extending groove in its periphery intermediate the sides thereof and a plurality of radially extending air supply passages opening into said groove, and a plurality of blade members, each comprising a curved hollow blade section and a base section mounted on and interfitting with the peripheral portion of the rotor body, and a pair of pins angularly related to each other to follow generally the curvature of the blade section and securing the base section to the rotor body, said pins terminating at said groove, the base section having an aperture extending from said groove to the interior of the blade section to permit air from said radial passages to be discharged through the blade section.

10. A turbine rotor comprising a rotor body having a circumferentially extending groove in its periphery intermediate the sides thereof and a plurality of radially extending passages for supplying cooling air to said groove, and a plurality of blade members each comprising a hollow blade section and a base section mounted on and interfitting with the peripheral portion of the rotor body and secured thereto, each base section having a pair of apertures extending from said groove to the interior of the blade section to discharge air from said groove through the blade

section, said apertures being respectively inclined toward the leading and trailing edges of the blade section to direct the air toward said edges.

11. A turbine rotor comprising a rotor body having a circumferentially extending groove in its periphery intermediate the sides thereof and a plurality of radially extending passages for supplying cooling air to said groove, and a plurality of blade members each comprising a hollow blade section and a base section mounted on and interfitting with the peripheral portion of the rotor body and secured thereto, each base section having a pair of apertures intersecting each other and opening at their point of intersection into said groove and extending to the interior of the blade section, said apertures being respectively inclined toward the leading and trailing edges of the blade section to direct air from said groove toward said edges.

12. A turbine rotor comprising a rotor body having a circumferentially extending groove in its periphery intermediate the sides thereof and a plurality of radially extending passages for supplying cooling air to said groove, and a plurality of blade members each comprising a curved hollow blade section and a base section comprising a pair of angularly related portions conforming generally to the curvature of the blade section, said angularly related portions being mounted on and interfitting with the peripheral portion of the rotor body on the respective sides of said groove and being secured thereto, each of said angularly related portions having an aperture extending from said groove to the interior of the blade section to discharge air from said groove through the blade section, said apertures being respectively inclined toward the leading and trailing edges of the blade section to direct the air toward said edges.

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