July 14, 1936. F. A. WETTSTEIN 2,047,502

SHEET METAL BLADE FOR STEAM OR GAS TURBINES

Filed April 24, 1935 2 Sheets-Sheet 1

Fig. 1.

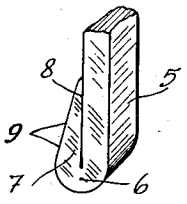


Fig. 2.

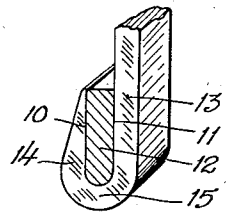


Fig. 3.

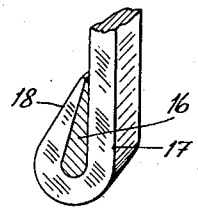


Fig. 4.

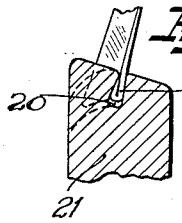


Fig. 5.

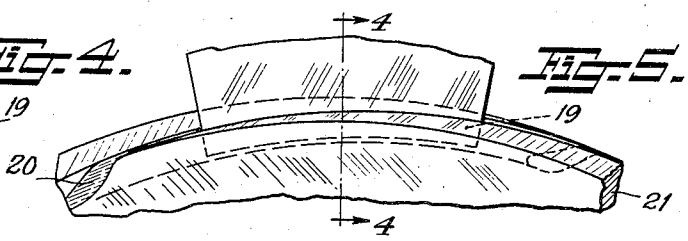


Fig. 6.

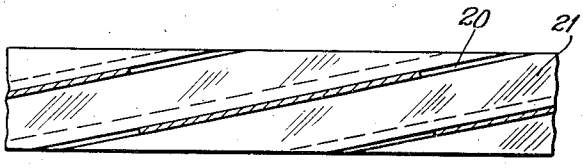


Fig. 7.

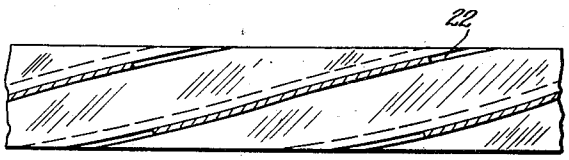


Fig. 9.

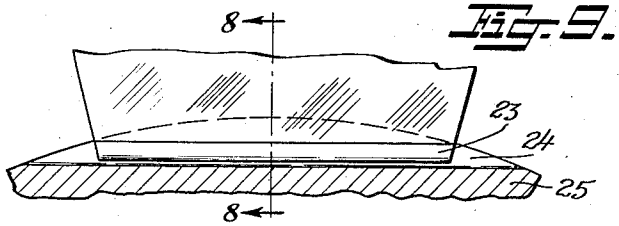


Fig. 8.

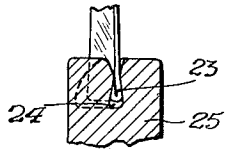




Fig. 10.

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July 14, 1936. F. A. WETTSTEIN 2,047,502

SHEET METAL BLADE FOR STEAM OR GAS TURBINES

Filed April 24, 1935 2 Sheets-Sheet 2

Fig. 11.

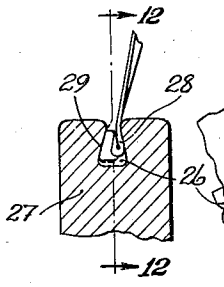
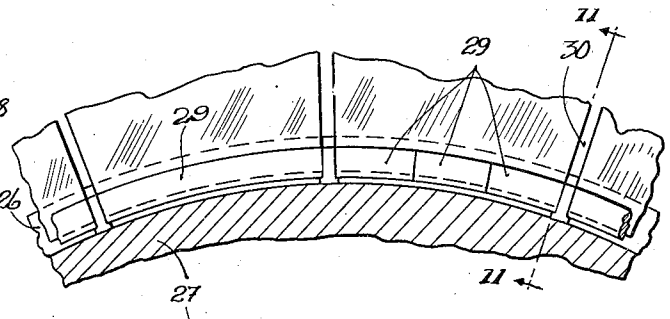


Fig. 12.



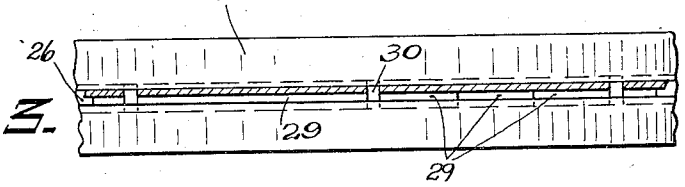


Fig. 13.

Fig. 14.

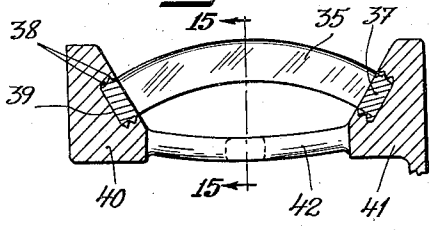


Fig. 15.

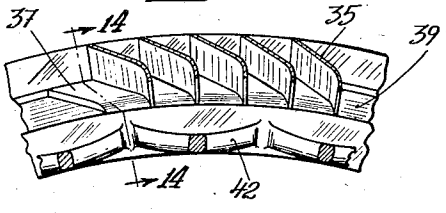
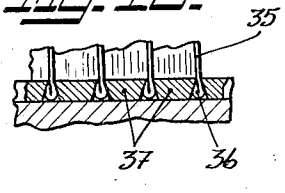


Fig. 18.



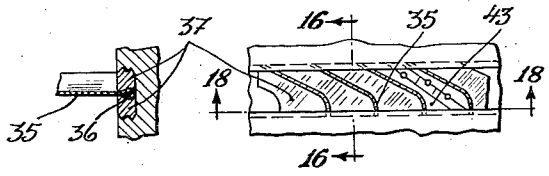


Fig. 16.

Fig. 17.

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UNITED STATES PATENT OFFICE

2,047,502

SHEET METAL BLADE FOR STEAM OR GAS TURBINES

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Application April 24, 1935, Serial No. 18,052
In Germany May 3, 1934

14 Claims. (Cl. 253—77)

The present invention relates to sheet metal blades for steam or gas turbines having enlarged blade ends and to means for securing said blade ends to the carrier rings of a turbine.

It is one of the objects of the invention to provide an improved form of attachment of the blades to the blade carrier which presents significant advantages particularly in connection with the disclosures of the U. S. Patent to Ljungstrom, No. 1,942,608, and my copending application, Serial No. 708,290, of January 25, 1934.

Blades of this type are characterized by their extraordinarily light weight in comparison with conventional turbine blades, a condition which makes it possible to rotate said blades at appreciably higher peripheral speeds than can be attained with ordinary blades. The large centrifugal forces which are produced during such high speed rotation require a particularly strong and reliable attachment between blade and carrier ring, which attachment should also be as light as possible. The Ljungstrom patent referred to discloses a blade attachment of this type wherein the blade end is bent around a filler member approximately in the form of a loop, the resultant enlarged blade base being securely wedged into a correspondingly shaped groove in the blade carrier ring by the action of centrifugal force.

It is one of the objects of the present invention to improve this type of construction by providing a blade base which is simpler in mechanical structure, easier and less expensive to manufacture and more readily and reliably locked in proper position with respect to a blade carrier ring.

Another object is to provide both a novel form of turbine blade base and an improved construction for securing such a base to a blade carrier ring.

The improved blade base of the invention is characterized by the fact that a wedge form of base is produced by sharply bending over the blade end and by cutting off the latter obliquely or pointedly. This form of construction makes it possible to produce a lighter blade base, taking up correspondingly less room, and to eliminate, if desired, the use of a separate wedge member in the formation of the base whereby a particularly simple, light and inexpensive structure is produced.

Further objects, characteristic features and advantages of the invention will become apparent upon consideration of the detailed description of the invention which follows. Although several different embodiments of the invention are described and illustrated in the accompanying drawings, it is to be expressly understood that these drawings are for purposes of illustration only and are not to be construed as defining the limits of the invention, reference being had to the appended claims for this purpose.

In the drawings, wherein like reference characters indicate like parts throughout the several views:

Fig. 1 is a perspective view of a portion of the blade base of a sheet metal blade constructed in accordance with the present invention;

Figs. 2 and 3 are perspective views of additional forms of rotor blade bases embodying the invention;

Figs. 4 to 7 illustrate the manner in which a sheet metal blade base is secured to a blade carrier ring according to the present invention; Fig. 4 is a cross section along line 4—4 of Fig. 5; Fig. 5 is a side elevation of a portion of the carrier ring and an attached blade base, viewed in the direction of the turbine axis; Fig. 6 is a top plan view of Fig. 5 with the blade shown in section, while Fig. 7 is a similar view of a somewhat modified construction;

Figs. 8 to 10 show another modification of the attachment of the blade base to the carrier ring; Fig. 8 is a cross section along line 8—8 of Fig. 9; Fig. 9 is a longitudinal vertical section through the blade base with the blade and base shown in full; Fig. 10 is a top plan view of Fig. 9 with the blade shown in section;

Figs. 11 to 13 illustrate still another embodiment of the invention; Fig. 11 is a cross section along line 11—11 of Fig. 12; Fig. 12 is a section taken substantially along line 12—12 of Fig. 11; Fig. 13 is a top plan view of Fig. 12 with the blades shown in section;

Figs. 14 to 18 illustrate the application of the invention to arched blades of the type having a relatively shallow arch in the longitudinal direction of the blade and a relatively sharply curved profile in the direction of flow of the turbine driving medium; Fig. 14 is a cross section along line 14—14 of Fig. 15; Fig. 15 is a section along line 15—15 of Fig. 14; Fig. 16 is a section along line 16—16 of Fig. 17; Fig. 17 is a view of Fig. 16 as seen from the left, the blades being shown as cut off directly at the attachment; and Fig. 18 is a section along line 18—18 of Fig. 17.

In the preferred form of the invention shown in Fig. 1, reference numeral 5 designates the lower part or base of a sheet metal blade which is sharply bent over upon itself at 6, the inner

surface 8 of the bent-over portion or blade end 7 being in direct contact with the corresponding wall or surface of the blade base 5. The bent-over blade end 7 is tapered or beveled at 9 in such a manner that a wedge-shaped blade base is produced. It is evident that this form of construction makes it possible to obtain an enlarged wedge-shaped blade base on sheet metal blades in a very simple manner. The taper of the blade end 7 may be produced either before or after the bending operation. In the former event, the taper may obviously also be produced by beveling on the side of the blade end which is designated 8.

By avoiding the use of a separate insert, spacer member or wedge between the blade base and the bent-over end 7, the resultant construction is simple and inexpensive and requires a minimum of space, an additional advantage being that correspondingly small blade receiving grooves may be used in the blade carrier ring. It is evident that a similar enlarged blade base may also be produced by making the blade initially of sheet metal of double thickness, the entire blade with the exception of the enlarged end then being reduced in suitable manner to the same thickness as in the embodiment shown in Fig. 1. In comparison with a blade produced by such a method, the blade of the present invention represents an appreciable saving in material of about 50% as well as a great saving in the time and cost of manufacture.

In the event that the sheet metal used in making the blade cannot be bent as sharply as indicated in Fig. 1, the blade base may conveniently be made as shown in Fig. 2. In this form of the invention, a spacer member 12 having parallel side walls 10 and 11 and a rounded bottom is inserted between the blade base 13 and the bent-over blade end 14, so that the bend at 15 is correspondingly more gradual.

The same result may be attained by the embodiment illustrated in Fig. 3, wherein the spacer member 16 itself is also wedge-shaped. This modification offers the further advantage that the wedge angle measured between the outer walls 17 and 18 may be increased as desired without decreasing the height or length of the wedge and the size of the surfaces of contact.

Figs. 4, 5, 6, and 7 illustrate a complete blade attachment, including a blade base 19 of the form shown in Fig. 1 and a tapered or wedge-shaped groove 20 in blade carrier ring 21 for retaining the blade base. In the embodiment shown in Figs. 5 and 6, the bottoms of blade groove 20 and blade base 19 are arcuate in form when viewed in side elevation, but are straight in plan. The curve of groove 19 may be substantially concentric with that of the periphery of the blade carrier ring 21 so that said groove will extend to the same or substantially the same depth in the carrier ring 21 throughout its entire length. Instead of being arcuate in side elevation and straight in plan, blade groove 22 may also be spiral or helical in form, as shown in Fig. 7—that is, arcuate in elevation and sinusoidal in plan.

Figs. 8, 9, and 10 show another embodiment of blade attachment according to the invention. As shown in Fig. 9, the bottom edges of blade base 23 and groove 24 extend rectilinearly in side elevation although, as shown in Fig. 10, they may be more or less curved or bent when viewed in plan. This embodiment is characterized by the feature that the grooves 24 merge gradually into the outer peripheral surface of the blade carrier ring 25 and do not cut through the side surfaces thereof, a construction which is advantageous from the standpoint of maintaining the solidity and strength of the ring at a maximum. On the other hand, groove 24 extends more deeply into the blade ring than does an arcuate bottom groove like 20. It is evident that other modifications may be produced by a gradual conversion of the arcuate form of blade attachment shown in Fig. 5 to the rectilinear form shown in Fig. 9.

Figs. 11, 12, and 13 illustrate another form of the invention wherein a single circular blade receiving groove 26 is formed in the center of and extends entirely around the periphery of the blade carrier ring 27, said groove being dovetail shaped in cross section. To enable the enlarged wedge-shaped blade base 28, constructed in accordance with the invention, to be inserted in the circular groove 26, the latter is somewhat wider at its norrowest part than the maximum width or thickness of the blade base 28. The blade base is then retained in the groove 26 by means of a filler member 29, the combined thicknesses of said filler member and blade base being greater than the width of groove 26 at its narrowest point. It will be noted that the bottom portion of filler member 29 is deeper in the groove than the bottom of blade base 28 and is wider than the space between said blade base and the wall of groove 26. This construction prevents either of these elements from being pulled out of the groove by centrifugal force. By providing a certain play 30 between successive blades, it is possible to move all of the blades together so as to leave sufficient space for the introduction of relatively short filler members 29 for the last-inserted blade.

Figs. 14 to 18 illustrate the application of the invention to arched blades 35 of the type having a relatively shallow curvature in their longitudinal direction but which are provided with a bent-over wedge-shaped blade base 36, according to the present invention. Blade bases 36, as shown in Figs. 16 and 18, are securely retained in grooves 39 of blade carrier rings 40 and 41 by means of intermediate filler and locking members 37, the opposite sides of which are tapered to correspond to the wedge angles of the blade bases. Intermediate members 37 are in turn securely retained in the circular grooves 39 of blade carrier rings 40 and 41 by means of thread-like ridges or teeth 38 formed on the opposite ends thereof, said teeth engaging corresponding recesses formed in the side walls of grooves 39. Carrier rings 40 and 41 are connected together in known manner by means of struts 42, the centrifugal forces arising upon rotation of the blade rim producing a pressure on the struts 42, while arched blades 35 are subjected essentially only to tractive or tensile stress. This tensile stress effects a secure wedging action between blade bases 36 and intermediate members 37, thereby preventing the blades from being pulled out of the carrier rings during rotation.

The illustrated blade attachment is particularly suitable for blades which are relatively sharply curved in the direction of flow of the driving medium. Of course, this curvature may be of any desired form since the blades are not inserted into permanently formed, pre-existing grooves, as in the previous embodiments—referring to the grooves which actually encompass and run parallel to the blade bases—but rather the individual

blade-receiving grooves are formed, so to speak, only after insertion of the blades into grooves **39** and the clamping thereof between the intermediate members **37**. Introduction of the last intermediate member **43** into groove **39** is made possible in known manner by subdividing said member into a plurality of parts which are held together after insertion by means of retaining screws. In this case, the blades are preferably made in such manner that the blade base is formed immediately after cutting out the blade, i. e., in the flat state, whereupon the final arcuate arched configuration is imparted to the blade by a pressing operation.

It will be obvious that the present invention is not limited in its scope to the particular constructions described and illustrated, but that various changes, in addition to those suggested above and which will now become apparent to those skilled in the art, may be made in the form, details of construction and arrangement of the parts of the disclosed embodiments without departing from the spirit of the invention. Reference is therefore to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. A rotor blade for steam or gas turbines formed of relatively thin sheet metal with two relatively narrow sides and two other surfaces of materially greater width than said sides and having its bottom edge portion doubled over through an angle of approximately 180°, one of said wider surfaces in the doubled over portion being beveled to produce an enlarged wedge-shaped blade base, said blade base being solidly metallic in cross section.

2. A rotor blade for steam or gas turbines formed of relatively thin sheet metal with two relatively narrow sides and two other surfaces of materially greater width than said sides and having its bottom edge portion doubled over through an angle of approximately 180°, one of said wider surfaces in the doubled portion beyond the point of doubling over being beveled to produce an enlarged wedge-shaped blade base, said blade base being solidly metallic in cross section.

3. A rotor blade for steam or gas turbines formed of relatively thin sheet metal with two relatively narrow sides and two other surfaces of materially greater width than said sides and having its bottom edge portion doubled over through an angle of approximately 180°, the outer wider surface of the doubled portion beyond the point of doubling over being beveled to produce an enlarged wedge-shaped blade base, said blade base being solidly metallic in cross section.

4. A rotor blade for steam or gas turbines formed of relatively thin sheet metal with two relatively narrow sides and two other surfaces of materially greater width than said sides and having its bottom edge portion doubled over upon itself so that the inner wider surfaces of the doubled portion are in intimate contact with one another, one of said wider surfaces in the doubled portion beyond the point of doubling over being beveled to produce an enlarged wedge-shaped blade base.

5. A rotor blade for steam or gas turbines formed of relatively thin sheet metal with two relatively narrow sides and two other surfaces of materially greater width than said sides and having its bottom edge portion doubled over upon itself so that the inner wider surfaces of the doubled portion are in intimate contact with one another, the outer wider surface of the doubled portion beyond the point of doubling over being beveled to produce an enlarged wedge-shaped blade base.

6. A rotor blade for steam or gas turbines formed of relatively thin sheet metal with two relatively narrow sides and two other surfaces of materially greater width than said sides and having its bottom edge portion doubled over upon itself so that the inner wider surfaces of the doubled portion are substantially parallel to one another, one of said wider surfaces in the doubled portion beyond the point of doubling over being beveled to produce an enlarged wedge-shaped blade base, said blade base being solidly metallic in cross section.

7. A rotor blade for steam or gas turbines formed of relatively thin sheet metal with two relatively narrow sides and two other surfaces of materially greater width than said sides and having its bottom edge portion doubled over upon itself, and a spacer member interposed between and in intimate contact with the inner wider surfaces of the doubled portion, one of the wider surfaces in the doubled portion beyond the point of doubling over being beveled to produce an enlarged wedge-shaped blade base.

8. A rotor blade for steam or gas turbines formed of relatively thin sheet metal with two relatively narrow sides and two other surfaces of materially greater width than said sides and having its bottom edge portion doubled over upon itself, and a wedge-shaped spacer member interposed between and in intimate contact with the inner wider surfaces of the doubled portion, one of the wider surfaces in the doubled portion beyond the point of doubling over being beveled to produce an enlarged wedge-shaped blade base.

9. A turbine rotor blade according to claim 1 wherein the enlarged wedge-shaped blade base is curved in the direction of its length, viewing said blade base in side elevation.

10. A turbine rotor blade according to claim 1 wherein the enlarged wedge-shaped blade base is curved along the arc of a circle in the direction of its length, viewing said blade base in side elevation.

11. A turbine rotor blade according to claim 1 wherein the enlarged wedge-shaped blade base is curved in the direction of its length, viewing said blade base in plan.

12. A turbine rotor blade according to claim 1 wherein the enlarged wedge-shaped blade base is helically curved in the direction of its length, being arcuate when viewed in side elevation and sinusoidal in plan.

13. In a blade rim for a steam or gas turbine, a blade having an enlarged wedge-shaped base, a rotatable blade carrier ring having a groove formed in the periphery thereof to receive said blade base, said groove being wider at its narrowest point than the maximum width of said blade base, and means for retaining said blade base in proper position within said groove comprising a filler member interposed between said blade base and one of the side walls of said groove, the width of said groove at its narrowest point being less than the combined widths of said blade base and said filler member at some point deeper in the groove than said narrowest point, the bottom portion of said filler member extending deeper into said groove than said blade base and being wider than the space between said blade base and said side wall of the groove.

14. In a blade rim for a steam or gas turbine,

a plurality of blades each having an enlarged base wedge-shaped in a plane substantially perpendicular to the longitudinal dimension of said base, a rotatable blade carrier ring having a circumferentially extending groove formed in the periphery thereof to receive said blade bases, the longitudinal dimension of said blade bases lying at a substantial angle to the direction of extension of said groove, and means for retaining said blade bases in proper position within said groove comprising filler members interposed between adjacent blade bases and having their side edges beveled to correspond to the wedge angles of said blade bases, the end edges of said members having outwardly extending thread-like elements engaging corresponding recesses formed in the side walls of said groove so as to lock said members and blades to said carrier ring.

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