June 9, 1953 S. B. WILLIAMS 2,641,440

TURBINE BLADE WITH COOLING MEANS AND CARRIER THEREFOR

Filed Nov. 18, 1947 5 Sheets-Sheet 1

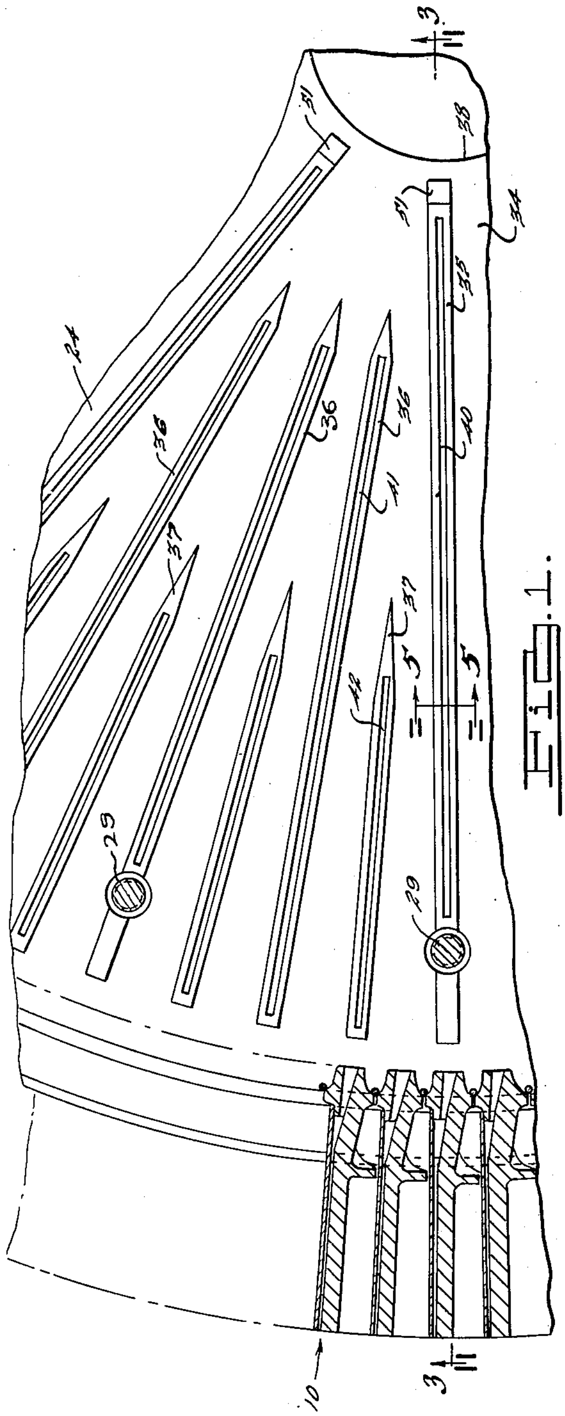

FIG. 1.

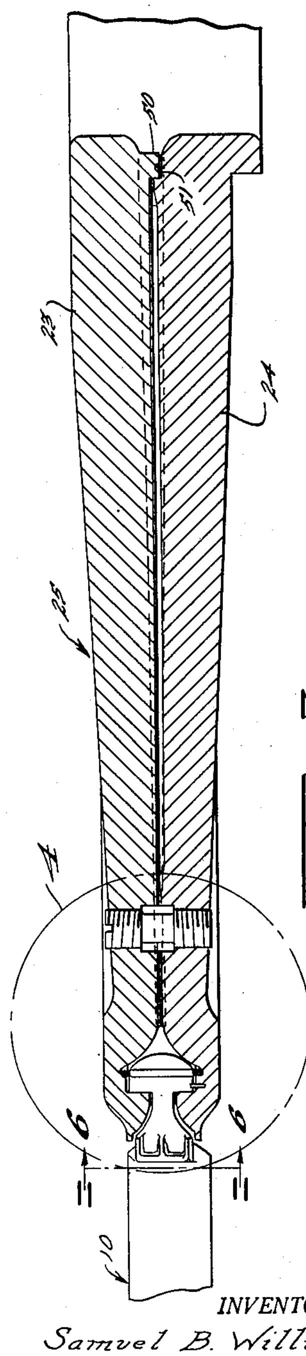

FIG. 3.

INVENTOR.

Samuel B. Williams.

BY

Harness and Harris

ATTORNEYS.

June 9, 1953 S. B. WILLIAMS 2,641,440

TURBINE BLADE WITH COOLING MEANS AND CARRIER THEREFOR

Filed Nov. 18, 1947 5 Sheets-Sheet 2

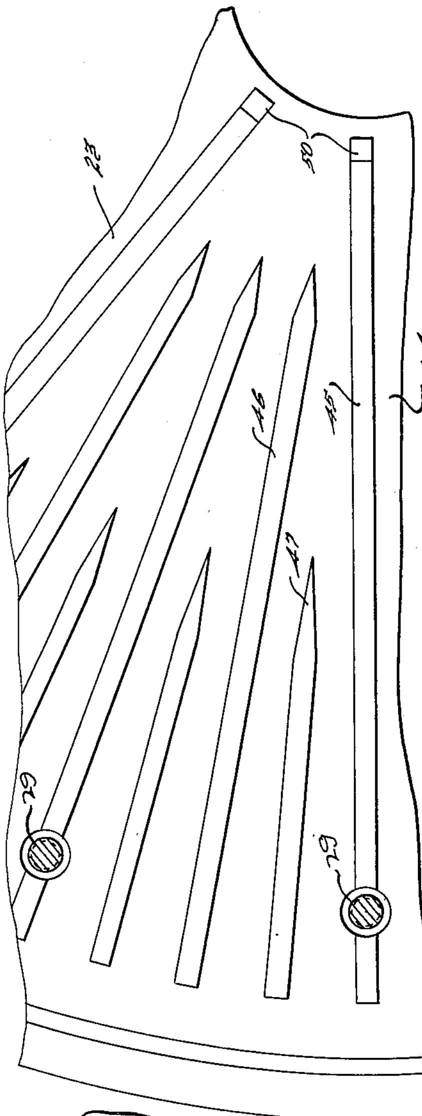

FIG. 2

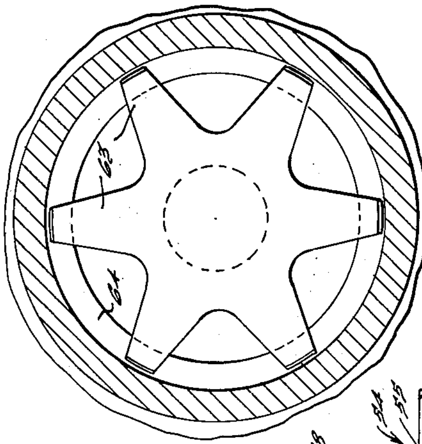

FIG. 14

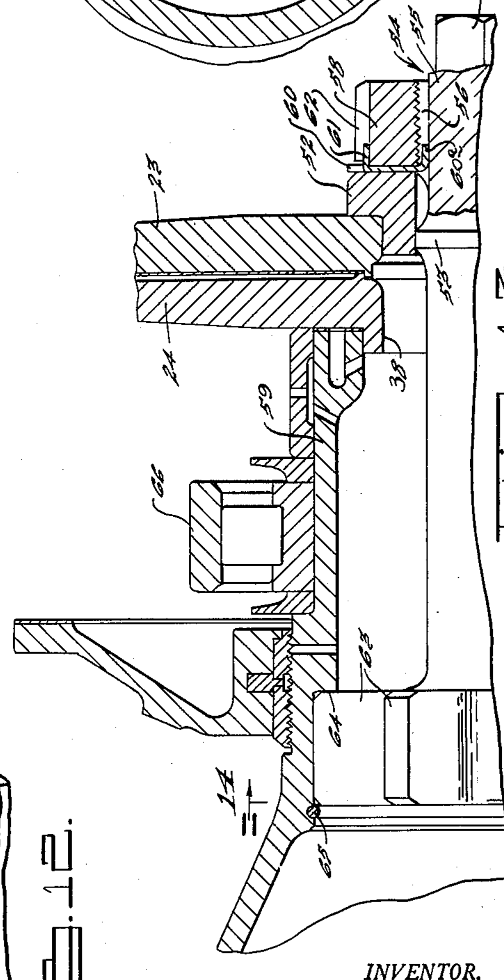

FIG. 13

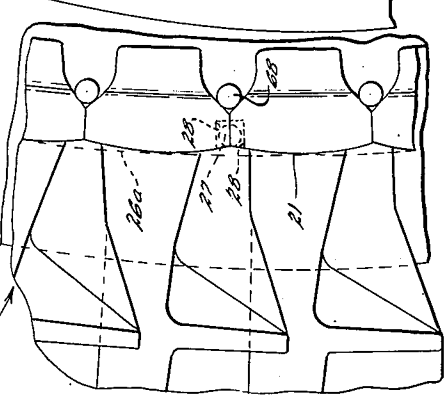

FIG. 12

INVENTOR.

Samuel B. Williams

BY

Harness and Harris

ATTORNEYS.

TURBINE BLADE WITH COOLING MEANS AND CARRIER THEREFOR

Filed Nov. 18, 1947 5 Sheets-Sheet 3

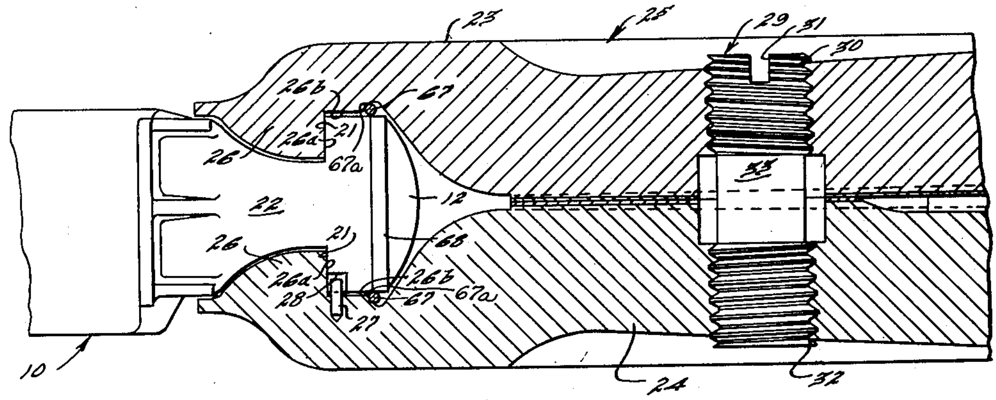

FIG. 4.

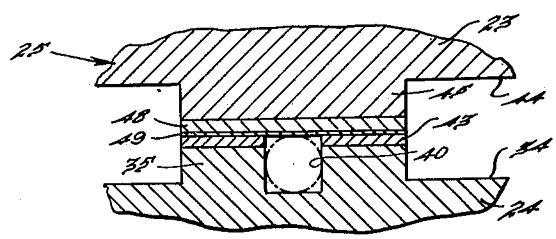

FIG. 5.

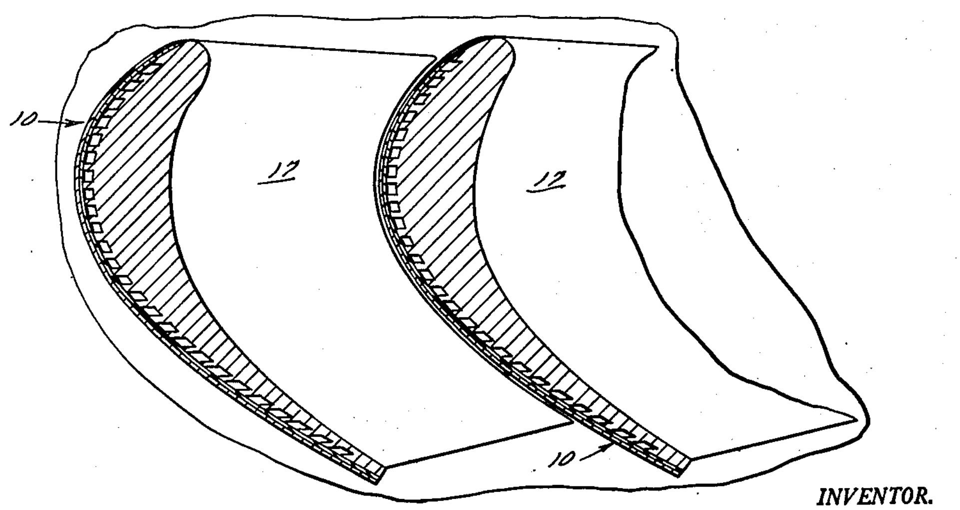

FIG. 6.

INVENTOR.

Samuel B. Williams

BY

Harness and Harris

ATTORNEYS.

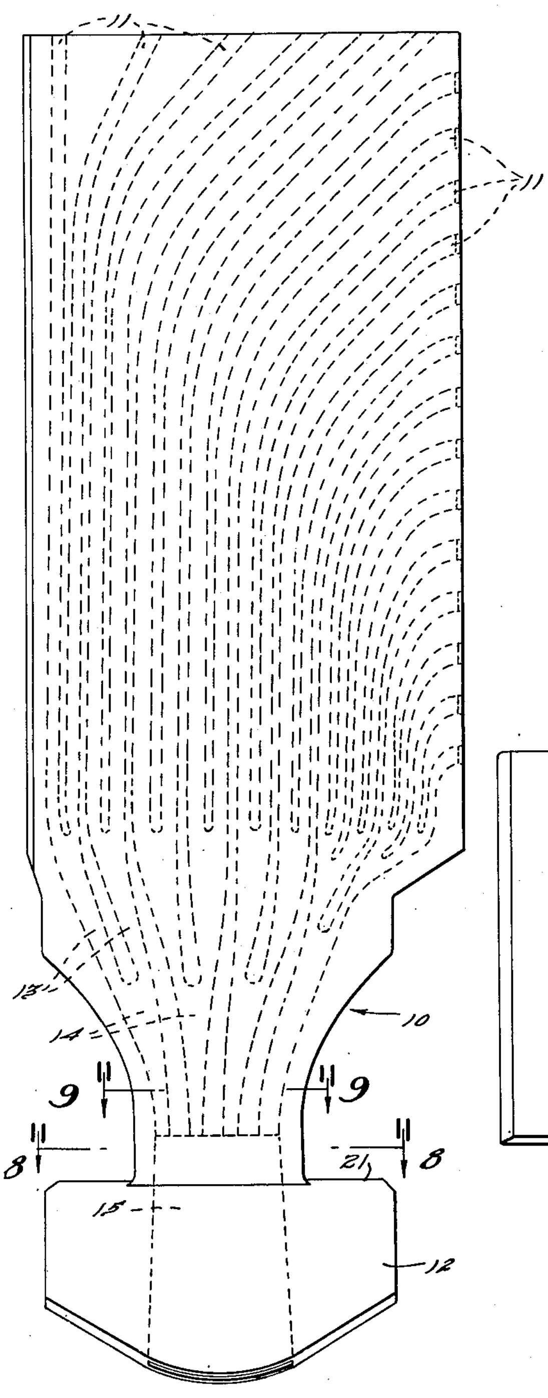

FIG. 7.

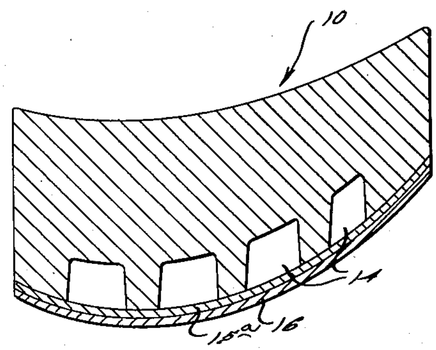

FIG. 9.

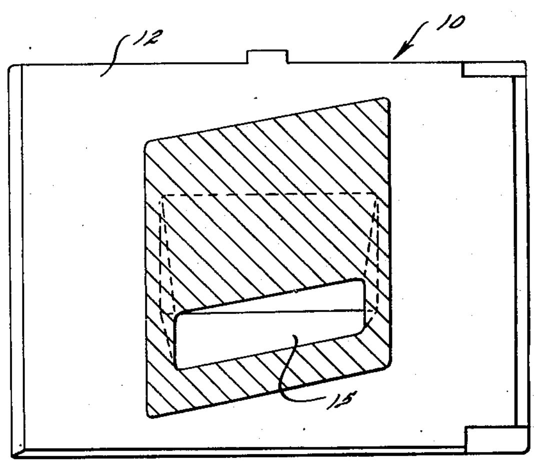

FIG. 8.

INVENTOR.
Samuel B. Williams.
BY
Harness and Harris
ATTORNEYS.

June 9, 1953 S. B. WILLIAMS 2,641,440

TURBINE BLADE WITH COOLING MEANS AND CARRIER THEREFOR

Filed Nov. 18, 1947 5 Sheets-Sheet 5

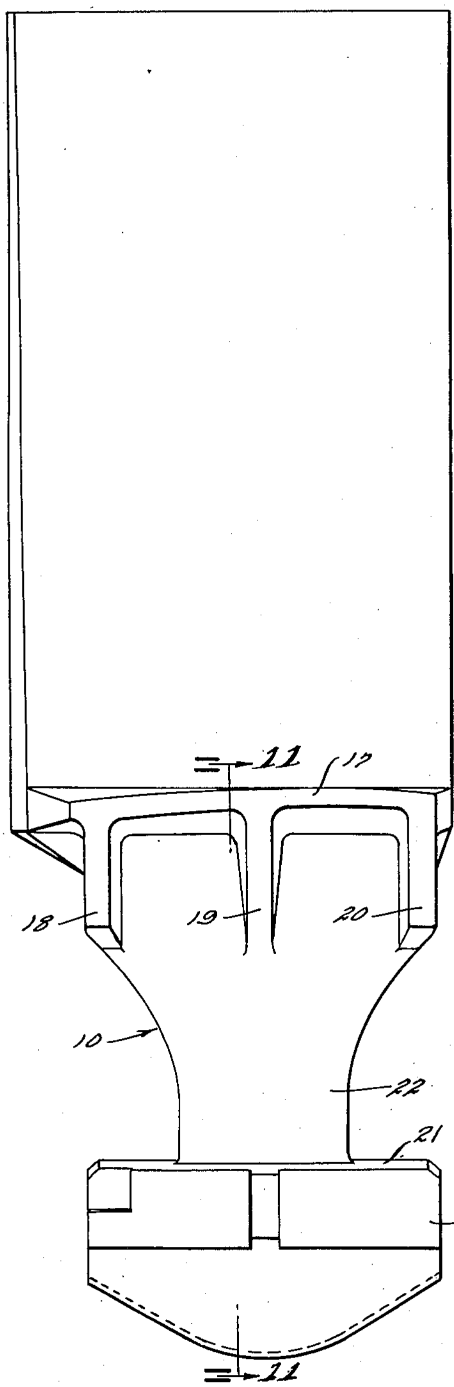

FIG. 10.

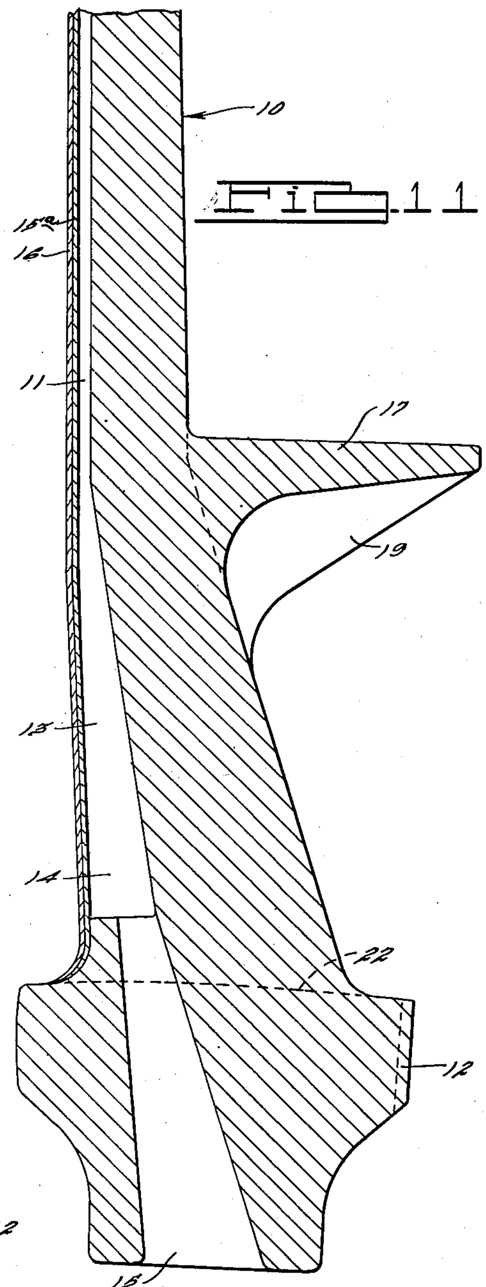

FIG. 11.

INVENTOR.
Samuel B. Williams.
BY
Harness and Harris
ATTORNEYS.

Patented June 9, 1953 2,641,440

UNITED STATES PATENT OFFICE

2,641,440

TURBINE BLADE WITH COOLING MEANS AND CARRIER THEREFOR

Samuel B. Williams, Birmingham, Mich., assignor to Chrysler Corporation, Highland Park, Mich., a corporation of Delaware

Application November 18, 1947, Serial No. 786,679

12 Claims. (Cl. 253—39.15)

1

This application relates to a turbine blade having passages therein for cooling purposes and to a carrier for a plurality of such blades constructed so as to enable the cooling passages to function.

In gas turbines, it is a problem to construct the blades in such a way that they will not be adversely affected by the hot gases driving the turbine. I propose to construct the blade in such a way that it is provided with passages through which air will pass under centrifugal action and an existing pressure difference as the blades rotate. I also propose to construct the carrier in such a way that it has passages for cooling air leading to the blades from intake openings adjacent the hub. I also plan to provide a novel mounting for blades in a carrier so that the blades are capable of some movement with respect to the carrier, and thereby stresses are reduced.

An object of the present invention is to provide an improved gas turbine having passages therein for air for cooling purposes.

A further object is to provide an improved carrier for air-cooled turbine blades, adapted to provide passageways for the cooling air to the blades.

Another object is to provide an improved arrangement for mounting turbine blades in the carrier, whereby they are enabled to have movement with respect to the carrier.

A further object is to provide an improved method of producing a carrier for a turbine blade.

Other objects will appear from the disclosure.

In the drawings:

Fig. 1 is a plan view of a portion of one part of an improved carrier for turbine blades of the present invention, several of the latter being in place on the carrier part and shown in section;

Fig. 2 is a plan view of a corresponding portion of the other part of the carrier;

Fig. 3 is a sectional view on lines 3—3 of Figure 1 through the carrier and the turbine blades;

Fig. 4 is a sectional view showing the portion of Fig. 3 within the circle 4;

Fig. 5 is a sectional view on lines 5—5 of Figure 1 through a portion of the carrier;

Fig. 6 is a sectional view taken along the line 6—6 of Fig. 3;

Fig. 7 is a plan view of a turbine blade taken from its convex side;

Fig. 8 is a sectional view taken along the line 8—8 of Fig. 7;

Fig. 9 is a sectional view taken along the line 9—9 of Fig. 7;

2

Fig. 10 is a plan view of the turbine blade taken from its concave side;

Fig. 11 is a sectional view taken on the line 11—11 of Fig. 10;

Figure 12 is a plan view like Figure 1, but drawn to an enlarged scale and showing the exteriors of the nested blades;

Fig. 13 is a sectional view showing the structure on which the blade carrier is mounted; and

Fig. 14 is a sectional view taken on the line 14—14 of Fig. 13.

The reference character 10 represents a concavo-convex turbine blade, as shown in Fig. 7. This blade has a plurality of passages 11 therein terminating in the tip and in one edge thereof. The blade portion proper, of the conventional streamline form characterized by a rounded leading edge and tapered trailing edge, is of substantially uniform width throughout its length, and adjacent the end thereof near a root portion 12 the passages 11 combine with one another in two's to form passages 13. Near the root portion 12 the passages combine in pairs to form passages 14, which finally combine into a single passage 15 extending through the root 12.

The passage 15 is formed in the metal itself, which may be cast Stellite. The passages 11, 13, and 14 originate in the cast blank from which the turbine blade 10 may be formed. The aforesaid passages may be made from the grooves by a process involving filling the grooves with a suitable material, successively plating layers of nickel 15a and chromium 16 on the ridges between the grooves and on the filling material, and thereafter removing the filling material. However, this process of manufacture forms per se no part of the present invention and is fully described in the copending application of Samuel B. Williams, Serial No. 777,310, filed October 1, 1947. As seen in Figs. 10 and 11, the turbine blade 10 has at one side a shelf-like portion 17, from which depend reinforcing flanges 18, 19, and 20. The purpose of the portion 17 of the various blades is to form one side of the gas-flow channel between blades. The root 12 of the blade has curved surfaces 21 at each side of a narrow neck 22 connecting the blade portion proper with the root. The surfaces 21 have radii of curvature shorter than those of surfaces in the carrier about to be described, with which they engage in such a way as to allow limited angular movement of each blade with respect to the carrier.

Fig. 4 shows the blade 10 held by its root portion 12 in cooperating members 23 and 24 forming a carrier 25. The carrier members may be formed of a stainless steel having a composition such as 16% chromium, 25% nickel, 6% molybdenum, and the balance iron. The neck portion 22 of the blade fits within suitably shaped portions 26 of carrier members 23 and 24, which portions form shoulders having curved surfaces 26a engaging the curved surfaces 21 on the blade roots 12. The surfaces 26a form the outer sides of grooves 26b in the carrier member receiving the blade roots 12.

As shown in Fig. 12, the blade surfaces 21 have a smaller radius of curvature than the carrier surfaces 26a have, and thereby some rolling movement of the blades with respect to the carrier is permitted.

As shown in Figs. 4 and 12, a dowel pin 27 fits in an unnumbered opening in the carrier member 24 and into grooves 28 in an adjacent pair of blade roots to retain the blades against peripheral movement with respect to the carrier 25. Not every turbine blade 10 receives a dowel pin 27 but only at every fourth or fifth blade around the carrier are adjacent pairs of blade roots fitted with dowel pins in the manner described, this being sufficient to prevent undesirable peripheral movement of the blade. The carrier members 23 and 24 are held together by a plurality of bolts 29, one of which is shown in detail in Fig. 4. This bolt has a portion 30 having a right-hand thread engaging the carrier member 23, a slot 31 in the portion 30 to be engaged by a suitable tool such as a screw driver, a portion 32 having a left-hand thread engaging the carrier member 24, and an intermediate smooth portion 33 joining the threaded portions 30 and 32. As shown in Figs. 1 and 5, the carrier member 24 has integrally formed on an inner surface 34, a plurality of lands 35, 36, and 37. The land 35 is relatively long, extending almost from the outer periphery of the carrier 24 almost to an opening 38 of the hub portion of the carrier member 24. The bolts 29 extend through the lands 35 and alternate lands 36. The land 36 is somewhat shorter than the land 35, terminating a greater distance from the hub opening 38, and the land 37 is still shorter in length, terminating a still greater distance from the hub opening. The long lands 35 have the greatest angular spacing, being separated by four short lands 37, and three intermediate lands 36 spacing the short lands 37 from one another. Lands 35, 36, and 37 are grooved and receive, respectively, silver soldering wires 40, 41, and 42 of lengths suited to the lands. The soldering wire 40 in the groove in land 35 extends outwardly only to the bolt 29. As indicated in Fig. 5 for land 35, each land carries a coating or plating 43 of nickel. The carrier member 23 mating with the carrier member 24 has on an inner surface 44, lands 45, 46, and 47, mating respectively with lands 35, 36, and 37, in the manner shown for the lands 35 and 45 in Fig. 5. The lands in the carrier member 23 correspond in width and length to the lands with which they mate in carrier member 24 and differ therefrom in having no groove for soldering wire. However, each land in the carrier member 23 has a nickel coating 48, which is spaced a very small amount from the nickel coating 43 on the mating land, except that the nickel coatings on the portions of the lands 35 and 45 beyond the bolts 29 are in direct contact with one another.

After the carrier members 23 and 24 have been assembled and fastened together by the bolts 29, they are heated to a brazing or soldering temperature for a sufficient time to cause the soldering wires 40, 41, and 42 to be drawn into the slight spaces between the nickel platings 43 and 48 on the lands and bonded therewith by alloying through diffusion.

In Fig. 5 the melted soldering wire drawn between the nickel coatings 43 and 48 is indicated by the reference character 49. Likewise, the nickel coatings 43 and 48 will have alloyed by diffusion to some extent with the lands, either during the brazing process because of its length, or during a previous heat treatment, or during a subsequent heat treatment. As indicated in Fig. 3, the inner end of each land 45 on the carrier member 23 is increased in thickness to form a projection 50, and the inner end of the mating land 35 on the carrier member 24 is reduced in thickness, as indicated at 51, so as to receive the projection 50 on the land 45. Thus indexing of the carrier members 23 and 24 is facilitated.

The mating lands on the carrier members 23 and 24 by being bonded together form radial passages for cooling air leading from the hub openings 38 to the root portions 12 of the blades 10, lets the air pass out through the passages 11, 13, 14, and 15 therein, cooling the blades. The carrier member 23 is mounted on a flanged ring 52 which is in turn mounted on a rib 53 on a bolt 54 somewhat spaced from one end. Nearer the end of the bolt is an enlarged threaded portion 55 provided with a plurality of slots 56. The end of the bolt 54 has a polygonal shape 57. A nut 58 engaging the threaded portion 55 acts through the ring 52 to press the carrier 25 against the end of the casing 59. Between the ring 52 and the nut 58 is a washer 60 having a plurality of tangs 60a fitting in the grooves 56 in the threaded portion of the bolt and tangs 61 fitting in grooves 62 in the nut 58. Thus the nut 58 is locked against rotational movement on the bolt 54. The left end of the bolt 54, as viewed in Fig. 13, carries outwardly extending spokes 63, which engage a shoulder 64 formed in the casing 59 and cooperate with the nut 58 to hold the carrier 25 against the end of the casing 59. A retaining ring 65 fitting in a groove in the casing engages the spokes 63 on the bolt 54 to hold the bolt against accidental displacement when the nut 58 is loosened. The casing 59 is mounted for rotation in a bearing 66. Air reaches the central opening 38 in the carrier 23 from the left end of the casing 59 through the spaces between the spokes 63 on the bolt 54.

As seen in Fig. 4, the root portion 12 of each blade 10 rests in the groove 26b in each carrier member. Each of these grooves has a small groove having a surface 67a extending approximately 45° to the radial plane of the carrier 25. In each small groove there is a circular sealing ring 67 which extends about the particular carrier member to which it is positioned and engages the angled surface 67a and the end of each blade root 12 to provide sealing of each blade to this region. Centrifugal force due to rotation of the carrier 25 causes sealing rings 67 to be pressed radialy outwards to insure proper sealing. Betweeen adjacent edges of the roots 12 of adjacent blades 10, there are relatively short, straight seals 68 moved outwardly under centrifugal action to provide sealing between the blades. This is shown in Figure 12. The ring seals 67 and the rod-like seals 68, being round in cross-section, offer no opposition to the previously described rocking movement of the blade with respect to the carrier 25 made possible by the difference in radii of curvature between the surfaces 21 on the blade roots 12 and the surfaces 26 on the carrier members 23 and 24.

As seen in Fig. 6, the edge of the shelf-like portion 17 of one blade 10 is shaped to conform to the adjacent side of the next turbine blade 10, with a small amount of clearance therebetween permitting the aforementioned rocking movement of blade on carrier.

I claim:

1. An assembly comprising a row of circumferentially aligned successive turbine blades each having an enlarged root provided with curved shoulder surfaces curving in the direction of the circumferentially aligned blades on both sides, and a carrier formed of mating parts embracing the root portions and including grooves receiving the root portions of the blades, the grooves having circumferentially curved surfaces formed according to a cylindrical path of revolution and engaged by the curved surfaces of the blade roots, the radius of curvature of the blade-root curved surfaces being smaller than that of the carrier-part-groove curved surfaces to provide for angular rolling movement of the blades with respect to the carrier and in the plane of the latter due to rocking of the aforesaid root curved surfaces on the aforesaid carrier curved surfaces.

2. The assembly specified in claim 1 in which every two adjacent blades in the row define an intervening gas flow channel, there being a shelf-like gas flow channel portion between every two said adjacent blades projecting from a part of one of the blades radially outward of the carrier toward the other blade and terminating in spaced adjacency complementally thereto to form the radially inner side of the gas flow channel between blades and at the same time to limit relative movement of the blade with respect to the carrier.

3. An assembly comprising a plurality of turbine blades having enlarged roots disposed in a row defining an annular path, a carrier composed of mating parts having grooves adjacent the periphery engaging the turbine roots, the grooves having portions on either lateral side of the annular path extending beyond the ends of the turbine roots at acute angles thereto, and sealing rings defining circular paths transversely alignable with the annular row of blade roots so as to register axially with the ends of the latter and being positioned in the said angled groove portions for being urged outwards under centrifugal force due to rotation of the assembly so as to press against the groove portions of the carrier and the blade root ends.

4. An assembly comprising a plurality of turbine blades having enlarged roots, a carrier composed of mating parts having grooves adjacent the periphery engaging the blade roots, each blade root increasing in width when considered in a radial direction about the carrier from the inner end of the blade to an intermediate region of the blade root radially outward of the end so as to form with an adjacent blade a groove, and a plurality of rod-like seals positioned in the grooves and urged into the grooves radially outwards under centrifugal force due to rotation of the carrier to seal the adjacent edges of the turbine blades.

5. An assembly comprising a plurality of turbine blades having enlarged roots at their inner ends, a carrier composed of mating parts having grooves adjacent the periphery engaging the turbine blade roots, the grooves having portions beyond the ends of the turbine roots at acute angles thereto, sealing rings disposed between said groove portions of the blade roots urged outwards under centrifugal force due to rotation of the assembly so as to press against the groove portions of the carrier and the blade root ends, each blade root increasing in width when considered in a radial direction about the carrier from the inner end of the blade to an intermediate region of the blade root radially outward of the end so as to form with an adjacent blade a groove, and a plurality of rod-like seals positioned in the grooves and urged into the grooves radially outwards under centrifugal force due to rotation of the carrier to seal the adjacent edges of the turbine blades.

6. The assembly specified in claim 5, the blades having passages for air cooling extending from the roots, the carrier parts having cooperating portions forming passages for air cooling communicating with the blade roots.

7. An assembly comprising a row of circumferentially aligned successive turbine blades each having an enlarged root at the blade end provided with curved shoulder surfaces curving in the direction of the circumferentially aligned blades on both sides, a carrier composed of mating parts having grooves adjacent the periphery engaging the turbine roots, the grooves having circumferentially curved surfaces formed according to a cylindrical path of revolution and engaged by the curved surfaces of the blade roots, the radius of curvature of the blade-root curved surfaces being smaller than that of the carrier-part-groove curved surfaces to provide for angular rolling movement of the blades with respect to the carrier and in the plane of the latter due to rocking of the aforesaid root curved surfaces on the aforesaid carrier curved surfaces, the grooves having portions beyond the ends of the turbine roots at acute angles thereto, sealing rings in the groove portions urged outwards under centrifugal force due to rotation of the assembly so as to press against the groove portions of the carrier and the blade root ends, each blade root increasing in width when considered in a radial direction about the carrier from the inner end of the blade to an intermediate region of the blade root radially outward of the end so as to form with an adjacent blade a groove, and a plurality of rod-like seals positioned in the grooves and urged radially outwards under centrifugal force due to rotation of the carrier to seal the adjacent edges of the turbine blades, the sealing rings and the rod-like seals being of round cross section so as to offer no opposition to the aforesaid angular movement of the blades with respect to the carrier.

8. An assembly comprising a plurality of turbine blades each having an enlarged root and passages for cooling extending from the root and terminating in a tip and an edge, and a carrier for the blades comprising a pair of axially alignable complementary parts having opposed grooved peripheral portions engaging the blade roots and central hub openings adapted to register with one another when said parts are axially aligned, said parts being provided with surfaces extending between the central openings and the grooved peripheral portions in facing spaced relationship and each incorporating radially extending lands raised therefrom, the radially extending raised lands on at least one of said parts being grooved to define solder chambers and mating with the raised lands on the other part and being bonded thereto with solder from said solder

chambers, thereby coöperating with the facing surfaces to form radial passages for air forced by centrifugal action from the central openings and through the blades for cooling purposes.

9. The assembly specified in claim 8 in which the solder used is of the silver wire type and in which the carrier parts contain nickel and chromium, the lands on the facing surfaces of the carrier parts being joined to one another through nickel bonded to the lands and through the silver solder bonded to the nickel, the carrier additionally including bolts at certain lands and joining the complementary parts.

10. The assembly specified in claim 8, some mating pairs of lands on the carrier parts terminating near the registering openings in the carrier, other mating pairs of lands between the aforesaid pairs of lands terminating farther from the registering openings, and still other lands between said other mating pairs terminating still farther from the registering openings.

11. A cooled turbine blade comprising lengthwise a neck, a root, and a blade having a tip edge, a relatively thin edge and a relatively thick edge, said neck being remote from said tip edge and merging with the root at laterally extending shoulders on the latter between the lateral sides of the same, the root having a base portion of substantially rectangular section presenting said shoulder surfaces and extending longitudinally therefrom to an end of the base portion, and a convex crown on said end of the base portion comprising a portion of a cylindrical surface extending to and merging with the said lateral sides of the base portion, and flanks disposed transversely to said convex crown extending from one said lateral side to the other, said shoulder being formed with arcuate convex surfaces transversely disposed to said convex crown and being of a predeterminedly limited radius of curvature, said blade proper being passaged longitudinally and further comprising a shelf-like portion disposed between the thick and thin edges of the blade and being normal thereto, and flanges depending from the sides of the shelf-like portion in the direction of the root and presenting opposed and outwardly facing parallel plane surfaces one adjacent each of said thick and thin edges.

12. A cooled turbine blade comprising lengthwise a neck, a root, and a blade having a tip edge, a relatively thin edge and a relatively thick edge, said neck being remote from said tip edge and merging with the root at laterally extending shoulder surfaces on the latter between the lateral sides of the same, the root having a base portion of substantially rectangular section presenting said shoulders and extending longitudinally therefrom to an end of the base portion, and a convex crown on said end of the base portion comprising a portion of a cylindrical surface extending to and merging with the said lateral sides of the base portion, and flanks disposed transversely to said convex crown extending from one said lateral side to the other, said shoulders being formed with arcuate convex surfaces transversely disposed to said convex crown and being of a predeterminedly limited radius of curvature.

SAMUEL B. WILLIAMS.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,325,208	Rice	Dec. 16, 1919
1,366,119	Darling	Jan. 18, 1921
1,603,966	Lorenzen	Oct. 19, 1926
1,657,192	Belluzzo	Jan. 24, 1928
1,891,948	Rice	Dec. 27, 1932
2,038,670	Noack	Apr. 28, 1936
2,149,510	Carrieus	Mar. 7, 1939
2,220,420	Meyer	Nov. 5, 1940
2,297,446	Zellbeck	Sept. 29, 1942
2,401,826	Halford	June 11, 1946
2,407,164	Kimball	Sept. 3, 1946
2,436,087	Benson	Feb. 17, 1948
2,473,899	Murphy	June 21, 1949
2,489,683	Stalker	Nov. 29, 1949

FOREIGN PATENTS

Number	Country	Date
55	Great Britain	Jan. 1, 1901
143,471	Switzerland	Jan. 16, 1931
302,953	Great Britain	Dec. 21, 1928
319,622	Great Britain	Dec. 18, 1930
391,880	Germany	July 29, 1924
516,781	Great Britain	Jan. 11, 1940
557,860	Germany	Aug. 29, 1932
878,999	France	Nov. 2, 1942