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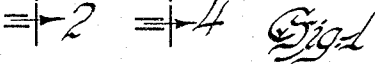
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2,823,894

AIR-COOLED TURBINE BUCKETS

Filed June 9, 1952

3 Sheets-Sheet 1



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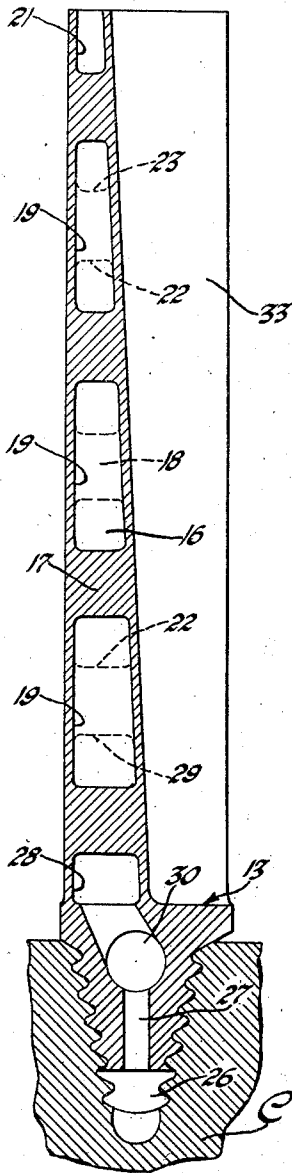


Fig. 4

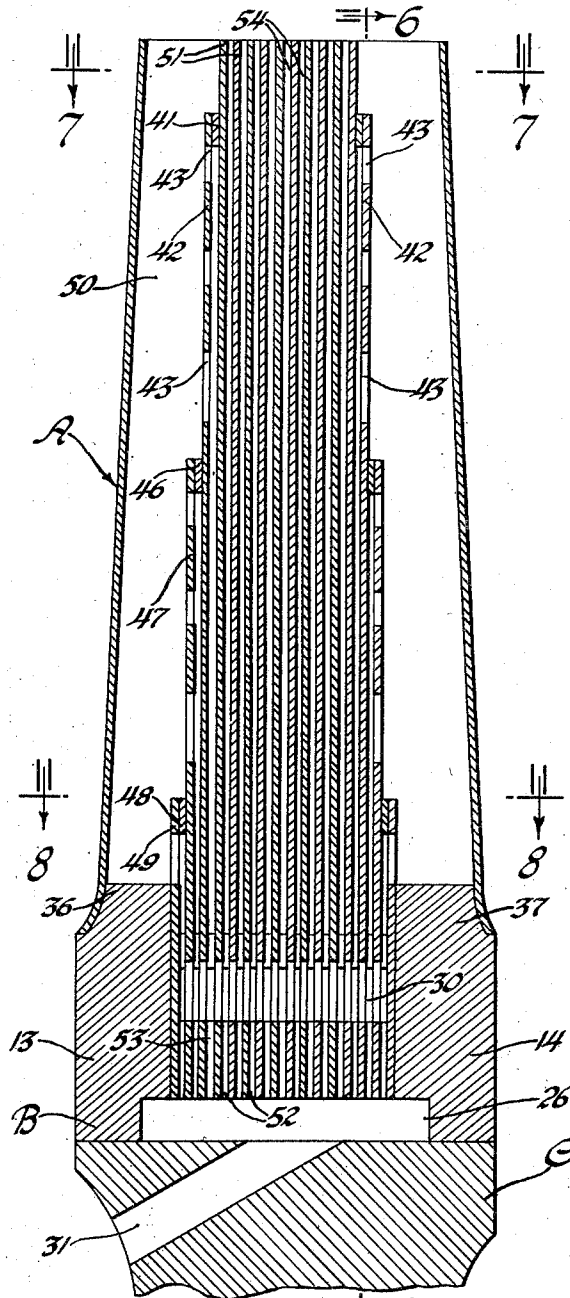


Fig. 5

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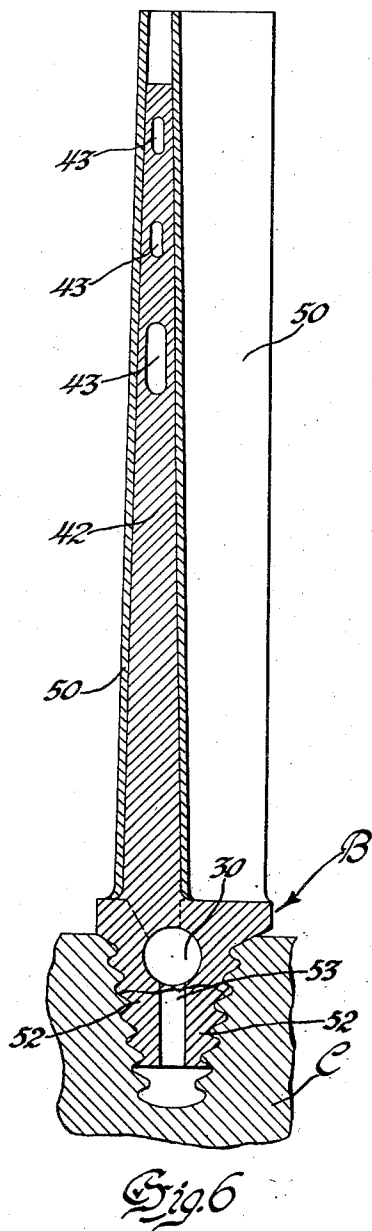
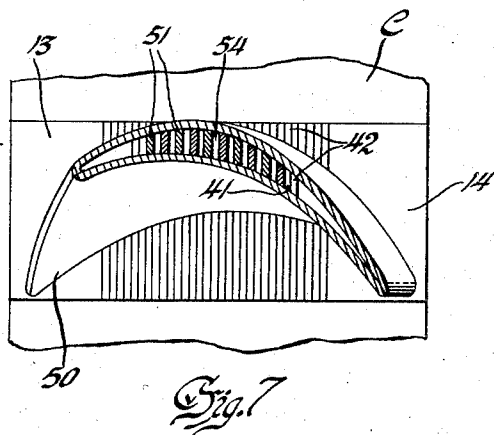
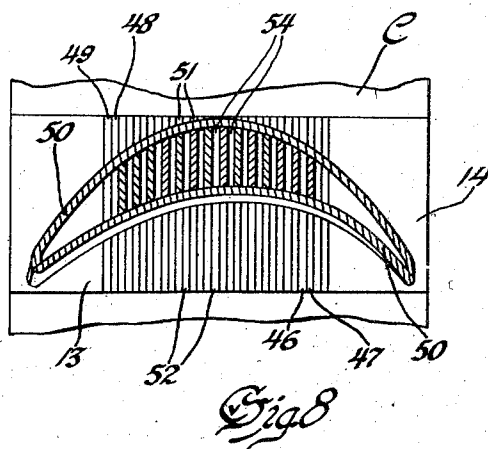
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AIR-COOLED TURBINE BUCKETS

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Application June 9, 1952, Serial No. 292,547

12 Claims. (Cl. 253—39.15)

Our invention relates to fluid-directing elements for turbomachines such as are generally known by the terms "buckets," "blades" and "vanes" and, more particularly, to those which are adapted for use in axial flow compressors or turbines of known type.

The invention has particular relation to turbines of high temperature types, since one of the primary objects of the invention is to provide a bucket or the like which is particularly adapted for cooling.

It is generally recognized that the principal factor limiting the efficiency and power output of gas turbines is the limited temperature of the motive fluid imposed by the turbine buckets. It has long been realized that adequate provision for cooling turbines buckets could be beneficial either in increasing the temperature limitation of the engine or in permitting reduced use of critical materials, or both. As a result, many proposals for structures adaptable for cooling have been advanced and some have been used to some extent. Despite the long period of awareness of the need for a satisfactory cooled bucket, progress in this respect has not been satisfactory.

The principal objects of our invention are to provide a turbine bucket or the like having superior characteristics so far as cooling is concerned, which is of high strength, and which is readily adapted to simple production techniques.

This result is attained by the use of sheet metal for the major portion, if not all, of the bucket. A particular feature of the invention is the utilization of laminated sheet metal construction for the major part of the bucket, the laminae being so disposed as to provide channels for cooling air. This invention is related to those described and claimed in our copending applications for "Turbine Buckets," Serial No. 292,545, filed June 9, 1952, and "Laminated Turbine Buckets," Serial No. 292,546, filed June 9, 1952. The subject matter of this application differs from those of the copending applications primarily in differences in the structure to provide modified arrangements for circulating cooling air through the buckets. A feature of the present invention is a provision for diverting cooling air from the laminated structure which forms the central portion of the blade chordwise to the portions of the blade adjacent the leading and trailing edges. Another feature of the present invention lies in providing a laminated structure such that the path for flow of air is somewhat tortuous so that greater turbulence is set up in the current of cooling air flowing through the blade.

The principal objects of the invention are to provide a turbine bucket or other flow deflecting element for use in turbomachines which is particularly well adapted for cooling, which is strong and light in weight, and which may be conveniently manufactured, both from the standpoint of the convenience of the process of manufacture and the reduction in the requirements of critical materials for the buckets.

The nature of the invention, the advantages thereof, and the preferred manner in which the objects are realized, will be apparent to those skilled in the art from the suc-

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ceeding detailed description of preferred embodiments of the invention and the accompanying drawings, in which Fig. 1 is a longitudinal section of a turbine bucket in accordance with the invention, mounted in a fragmentary portion of a turbine wheel, the section being taken approximately on the main camber line of the blade; Fig. 2 is a partial longitudinal section thereof taken on the plane 2—2 indicated in Fig. 1; Fig. 3 is a transverse section of the same taken on the plane 3—3 indicated in Fig. 1; Fig. 4 is a longitudinal section of the same taken on the plane 4—4 indicated in Fig. 1; Fig. 5 is a sectional view similar to that of Fig. 1 of a modified form of blade; Fig. 6 is a longitudinal section thereof taken on the plane 6—6 indicated in Fig. 5; and Figs. 7 and 8 are transverse sectional views taken on the planes 7—7 and 8—8, respectively, indicated in Fig. 5.

Referring first to Figs. 1 to 4, the turbine bucket comprises a blade portion A and a base portion B, the latter being mounted in the rim of a turbine wheel C. The blade may be mounted in any suitable manner as by the conventional multiple dovetail arrangement illustrated in Fig. 2 in which the turbine wheel is formed with a serrated slot 11 and the blade root is provided with serrations or dovetails 12 engaging in the wheel. The base B comprises a central part of laminated construction and end blocks 13 and 14. The laminated structure extends from the base portion of the bucket into the blade portion to constitute a core for the blade portion, most of the laminae extending to the tip of the blade, the laminated structure defining the central part of the blade.

The laminae are of several types so that when stacked and brazed together they define passages for circulation of cooling air from the base of the bucket to the tip. The laminae 16 of the first group extend from one face of the blade to the other, the edges of these laminae constituting elements of the outer surface of the blade and root portions. Between adjacent laminae 16 are disposed perforated laminae 17 and 18. One of the laminae 17 is shown in section in Fig. 4. The edges of the laminae 17 and 18 also form elements of the sides of the assembly. The outer end of the lamina 17 is bifurcated as indicated at 21 and a number of openings 19 are distributed along the length. These openings are preferably as wide as the thickness of the blade will permit. The typical lamina 18, shown behind the lamina 17 in Fig. 4, is formed with openings 22 similar to the openings 19 in the lamina 17 but disposed so as to overlap an extent beyond the bridge portions between the openings 19. The outer end of the laminae 18 are cut out or bifurcated as indicated at 23. Thus, a continuous passage for flow of air is provided between the adjacent laminae 16 of the first group by the overlapping openings 19 and 22 of the intermediate laminae.

Air is supplied to the passages from a chamber 26 in the base of the bucket through passages 27 provided by bifurcating the base portion of the laminae 17 and 18. The air flows from the passage 27 into passages 28 in the laminae 17 and 29 in the laminae 18 from which it continues upward to the tip of the blade. All the laminae 16 are punched to provide a continuous passage 30 extending through the stack of laminae.

Air may be supplied to the chamber 26 in any convenient manner, as by a passage 31 in the turbine wheel.

The portions of the fluid-directing service blade ahead of the foremost lamina 16 and rearwardly of the rear-most lamina 16 are defined generally by V-shaped sheet metal pieces 32 and 33 which thus define the leading and trailing edge portions of the blade surface, respectively. These parts 32 and 33 are brazed or welded to the abutting laminae 16 and to the end blocks 13 and 14. It may be noted that the blocks 13 and 14 are formed with projections 36 and 37 extending from their upper

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surfaces which extend into the lower ends of the parts 32 and 33, thus additionally locating these parts and providing a greater surface for brazing to withstand the centrifugal force pull along these parts when they are mounted on a rotating wheel.

It will be noted that the portions 32 and 33 of the blade define spaces or passages 32' and 33' within them which provide for circulation of cooling air out the open tip of the blade. A feature of the invention is the arrangement for distributing cooling air into these spaces or passages at points distributed along the length of the passage. Referring to the leading edge portion of the blade, it will be noted that immediately adjacent the foremost lamina 16 is a lamina 41 which extends nearly to the tip of the blade and which is open through the middle except at the extreme outer end of the lamina. Adjacent the lamina 41 is a lamina 42 which extends from wall to wall of the sheet 32 and is unbroken except for a number of cooling air outlets 43 in the outer half of the blade length. Thus, air may be brought through the channel 44 defined by the laminae 42, 41 and 16 and discharged through the openings 43. A second set of laminae 46 and 47 abutting the lamina 42 similarly distribute air into the portion of the blade nearer the base. A further set of laminae 48 and 49, which are quite short, provide for discharge of air into passages 32' and 33' immediately adjacent the solid base portion 13 of the blade. This structure will be more clearly apparent from the illustration of the laminae 47 and 49 in Fig. 2, the lamina 42 being similar. It will thus be seen that air is discharged from a number of openings distributed along the span of the blade to cool the leading edge portion. A similar laminated structure 41, 42, 46, 47, 48, 49 is disposed within the trailing edge portion 33 to cool it in similar manner.

In summary, it will be seen that each two juxtaposed laminae 17 and 18 constitute a set of laminae the overlapping openings in which define a continuous (that is, unbroken) conduit for cooling medium extending through the core. The laminae 16 nearest the edges of the blade are mutually spaced from laminae 42, laminae 42 are mutually spaced from laminae 47, and laminae 47 are mutually spaced from laminae 49. Conduits for cooling air are thus defined between laminae 49 and 47, between laminae 47 and 42, and between laminae 42 and the adjacent laminae 16. This cooling air is discharged through the openings in laminae 49, 47, and 42 into the passages 32' and 33'. Laminae 16 may also be regarded as mutually spaced, being spaced by the intervening laminae 17 and 18.

The form of air cooled bucket shown in Figs. 5 to 8, inclusive, differs from that previously described in several respects. The outer surface or sheath of the blade is entirely defined by a sheet metal sheath which extends from the leading edge to the trailing edge of the blade. Also, the laminated structure of the central portion of the blade is of different type. The provision for directing air to the leading and trailing edge portions of the blade, however, is the same as in the embodiment previously described.

Parts shown in Figs. 5 to 8 which are the same as those previously described are identified by the same reference numerals and do not require detailed description. Alternate laminations in the central part of the blade identified as 51 extend from end to end of the blade and from interior wall to interior wall of the blade sheath 50, which sheath may be formed of two sheets brazed or welded together at the leading and trailing edges as illustrated. In the base of the blade, only, the laminae 51 have between them laminae 52, each of which is in two parts (Fig. 6), each part forming a part of one of the serrated faces of the blade root. The two parts of the laminae 52 define a cooling air channel 53 between the opposed edges thereof, which is also bounded by the faces of the laminae 51. A passage 30 extend-

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ing through the laminae interconnects the passages 53 and connects them with channels 54 defined by the spaces between the laminae 51. The passages through the blade root are thus similar to those of the previous form except that each passage is defined by a single lamina. The laminated structure includes laminae 41, 42, 46, 47, 48, and 49 at both the leading and trailing edges, which may be identical to those previously described. A lamina 42 is shown in section in Fig. 6, illustrating the openings 43 therein for discharge of air into the trailing edge portion of the blade. It will be understood that the laminations are stacked and brazed together, and that the sheath 50 is fitted to the laminated portion structure and brazed thereto as well as to the blocks 13 and 14 of the base.

It will be seen from the foregoing that the forms of sheet metal blade structure described herein are particularly well adapted to provide a strong structure and provide adequate cooling of the entire blade portion which is subject to the effect of a hot motive fluid.

While we have described in detail the preferred embodiments of our invention for the purpose of illustrating the principles thereof, it is to be understood that various modifications may be made within the scope and principles of the invention, which is not to be considered as limited by the detailed description.

We claim:

1. A fluid-directing blade for turbomachines and the like, said blade having fluid-directing faces and comprising a number of laminae extending in the directions lengthwise of the blade and from face to face of the blade, at least some of said laminae defining a core for the blade, the blade also comprising leading and trailing edge portions abutting the core and recessed adjacent the core to define with the core passages for a cooling medium extending lengthwise of the blade within the leading and trailing edge portions, the laminae of the core being mutually spaced to define conduits for the cooling medium within the core lengthwise of the blade, the laminae adjacent the said passages being formed with openings to direct cooling medium from the conduits adjacent the last-mentioned laminae into the passages.

2. A fluid-directing blade as recited in claim 1 in which the edges of at least some of the laminae constitute elements of the fluid-directing faces of the blade.

3. A fluid-directing blade for turbomachines and the like, said blade having fluid-directing faces and comprising a number of laminae extending in the directions lengthwise of the blade and from face to face of the blade, at least some of said laminae defining a core for the blade, the blade also comprising leading and trailing edge portions abutting the core and recessed adjacent the core to define with the core passages for a cooling medium extending lengthwise of the blade within the leading and trailing edge portions, the laminae of the core adjacent the passages being mutually spaced to define conduits for the cooling medium within the core lengthwise of the blade, the laminae adjacent the said passages being formed with openings to direct cooling medium from the conduits adjacent the last-mentioned laminae into the passages, and the laminae of the core remote from the passages being provided in sets with overlapping staggered openings therein to define sinuous conduits for cooling medium through the core, each said set comprising at least two juxtaposed laminae.

4. A fluid-directing blade for turbomachines and the like, said blade having fluid-directing faces and comprising a number of laminae extending in the directions lengthwise of the blade and from face to face of the blade, at least some of the laminae being formed with a plurality of openings therethrough, and the openings in mutually adjacent ones of said some laminae being in staggered overlapping relation so that the openings define a continuous sinuous conduit for cooling medium extending lengthwise of the blade.

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5. A fluid-directing blade for turbomachines and the like, said blade having fluid-directing faces and comprising a number of laminae extending in the directions lengthwise of the blade and from face to face of the blade, some of the laminae being formed with openings therethrough, the openings in mutually adjacent ones of said some laminae constituting a set being in staggered overlapping relation so that the openings define a continuous sinuous conduit for cooling medium extending lengthwise of the blade, and laminae without openings being provided between each set of the laminae with openings.

6. A fluid-directing blade for turbomachines and the like, said blade having fluid-directing faces and comprising a number of laminae extending in the directions lengthwise of the blade and from face to face of the blade, at least some of said laminae defining a core for the blade, the blade also comprising leading and trailing edge portions abutting the core, at least some of the laminae of the core being formed with a plurality of openings therethrough, and the openings in mutually adjacent ones of said some laminae being in staggered overlapping relation so that the openings define a continuous conduit for cooling medium extending lengthwise of the blade.

7. A fluid-directing blade for turbomachines and the like, said blade having fluid-directing faces and comprising a number of laminae extending in the directions lengthwise of the blade and from face to face of the blade, at least some of said laminae defining a core for the blade, the blade also comprising leading and trailing edge portions abutting the core and recessed adjacent the core to define with the core passages for a cooling medium extending lengthwise of the blade within the leading and trailing edge portions, at least some of the laminae of the core being formed with a plurality of openings therethrough, and the openings in mutually adjacent ones of said some laminae being in staggered overlapping relation so that the openings define a continuous sinuous conduit for cooling medium extending lengthwise of the blade.

8. A fluid-directing blade for turbomachines and the like, said blade having fluid-directing faces and comprising a number of laminae extending in the directions lengthwise of the blade and from face to face of the blade, at least some of the laminae being formed with a plurality of openings therethrough, and the openings in mutually adjacent ones of said some laminae being in staggered overlapping relation so that the openings define a continuous sinuous conduit for cooling medium extend-

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ing lengthwise of the blade alternately through one lamination and the other of said some laminae.

9. A fluid-directing blade for turbomachines and the like, said blade having fluid-directing faces and comprising a number of laminae extending in the directions lengthwise of the blade and from face to face of the blade, at least some of said laminae defining a core for the blade, the blade also comprising an edge portion abutting the core and recessed adjacent the core to define with the core a passage for a cooling medium extending lengthwise of the blade within the said edge portion, the laminae of the core being mutually spaced to define conduits for the cooling medium within the core lengthwise of the blade, the laminae adjacent the said passage being formed with openings to direct cooling medium from the said conduits adjacent the last-mentioned laminae into the passage.

10. A fluid-directing blade for turbomachines and the like, said blade comprising a number of laminae extending lengthwise of the blade, the laminae comprising at least one set of two juxtaposed laminae, provided with spaced openings therethrough, the openings in the respective ones of said set being in staggered overlapping relation to define a continuous conduit through the openings alternating from one lamina of the set to the other.

11. A blade as recited in claim 10 in which the openings are disposed from end to end of the blade so that the said conduit extends from end to end of the blade.

12. A fluid-directing blade for turbomachines and the like, said blade having fluid-directing faces and comprising a number of laminae extending in the directions lengthwise of the blade and from face to face of the blade, at least some of said laminae defining a core for the blade, the blade also comprising a tubular sheath covering the core of the blade and abutting the core, the sheath including leading and trailing edge portions spaced from the core to define with the core passages for a cooling medium extending lengthwise of the blade within the leading and trailing edge portions, the laminae of the core being mutually spaced to define conduits for the cooling medium within the core lengthwise of the blade, the laminae adjacent the said passages being formed with openings to direct cooling medium from the conduits adjacent the last-mentioned laminae into the passages.

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