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TURBINE BLADE LASHING

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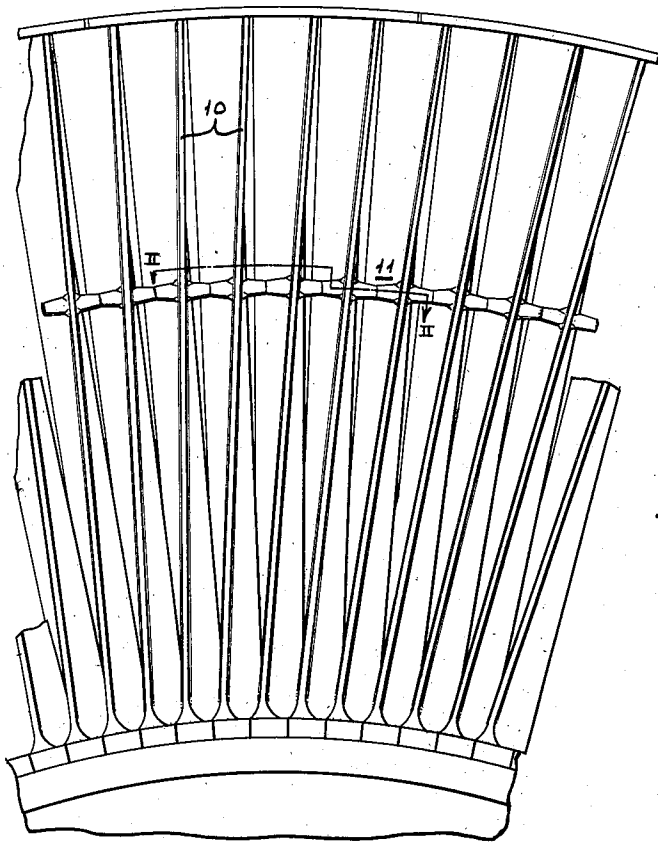


FIG. 1.

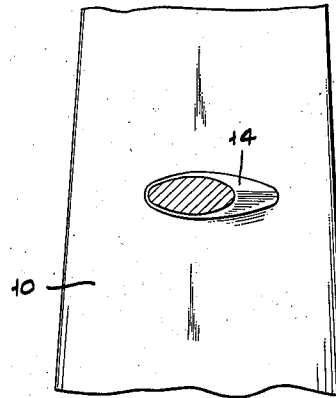


FIG. 4.

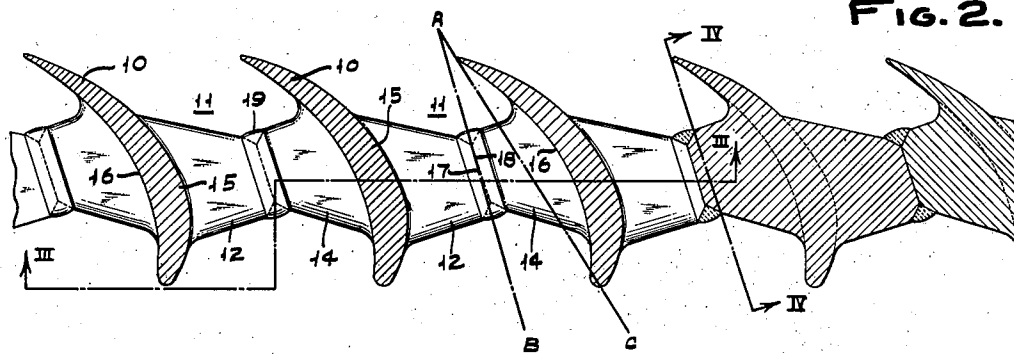


FIG. 2.

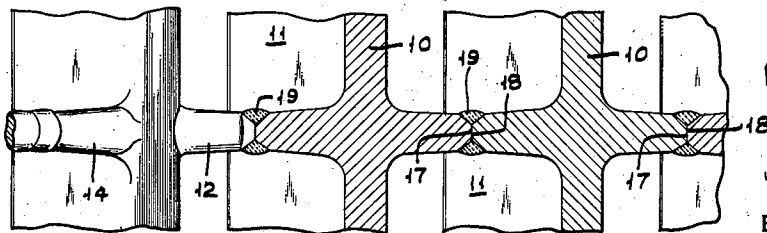


FIG. 3.

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TURBINE BLADE LASHING

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3 Claims. (Cl. 253-77)

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The invention relates to turbine blade lashing and it has for its object to provide forged blades having integral lashing projections extending from opposite blade faces so that, with the blades assembled in a row, the ends of the projections may be joined substantially midway between the blades, the draft required for forging the projections also serving the purpose of giving strength to the lashing.

The longer rotating turbine blades are usually lashed together to increase the natural frequency of blade vibration and thereby avoid vibration difficulties over the range of operating speeds; however, lashing ordinarily adversely affects the mechanical or physical properties of the blade. Lashing wire openings weaken the blade section; and fastening of the lashing to the blades may involve sacrifice in blade strength or impairment of physical properties thereof, particularly where the blades are made of alloy steels, such as stainless steel, which may be injured because of heating involved incident to soldering or welding. We overcome these difficulties by forging lashing projections integrally with the blades and by connecting adjoining projection ends approximately midway between the blades; but, to enable this to be done, with the inter-blade lashing spaces usually encountered, we provide projections characterized by features contributing to making it possible to forge relatively long projections incident to forging of the blades and which projections, when joined, constitute strong lashing structures connecting adjacent blades.

Turbine blade lashing is subject to bending moments due both to centrifugal force and to steam or blade vibration force, such moments being a maximum at the junction of a projection and a blade and a minimum midway between blades. While the moment due to steam or blade vibration force is zero midway between the blades, that due to centrifugal force, for a uniform lashing section, would be one-half of the maximum. By tapering the projections, the lashing is strengthened according to the need, the bending moment midway between blades being reduced to less than one-half of the maximum existing at the blade and projection junction. By providing projections which terminate midway between blades, the joints are located where the bending moments are least, thereby restricting any reduction of physical or mechanical properties made necessary by operations in blade assembly, to locations approximately midway between blades. To enable the projections to be forged, not only must the necessary draft be provided, but heed

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must be given to the parting line of the forging dies. Therefore, the projections are properly related to the blades with respect to the die parting line and are tapered to give the necessary draft, tapering for this purpose assuring of the maximum thickness where strength is most required, that is, at the blade and projection junction, and minimum thickness and location of projection joints where the bending moment is the least, namely, at a section approximately midway between the blades.

The foregoing and other objects are effected by the invention as will be apparent from the following description and claims taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a fragmentary view of a blade row having the improved lashing:

Fig. 2 is a developed sectional view taken along the line II-II of Fig. 1;

Fig. 3 is a sectional view taken along the line III-III of Fig. 2; and

Fig. 4 is a sectional view taken along the line IV-IV of Fig. 2.

In the drawing, there is shown a row of forged blades 10 having a lashing comprising lashing structures, at 11, connecting adjacent blades.

Each lashing structure, at 11, includes projections 12 and 14 forged integrally with the blades and extending outwardly from the blade convex and concave faces 15 and 16, respectively, and having their respective outer ends 17 and 18 disposed contiguously and connected by a joint 19, for example, a welded connection, located approximately midway between blades.

The projections 12 and 14 are tapered and connected so as to satisfy strength considerations and to provide the draft required for forging. The lashing must resist centrifugal force as well as steam or vibration force.

With respect to centrifugal force, the maximum bending moment occurs at the junction of a projection and a blade and the minimum bending moment exists at a section midway between blades. With a lashing structure of uniform section, the bending moment midway between blades would be about one-half the maximum. Tapering of the projections, therefore, gives a thick section where strength is most required and a thin section where the strength requirements are least, tapering having the advantage of lessening the bending moment at the section midway between blades—instead of being one-half of the maximum, it is less than one-half, for example, about one-third.

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While the bending moment due to steam and vibration force is also a maximum at the blade projection junction, the bending moment midway between blades is zero.

Therefore, tapering to provide the draft required for forging the lashing projections integrally with the blades also assures of strong lashing constructions.

Where, as shown, the blade section is asymmetrical, or of the reaction type, at the projection locations, the end faces of the projections are slanted generally in the same direction as the blade chord passing through the inlet and outlet edges of the section, not only to avoid an excessive side dimension, or an excessive side dimension differential of a projection from the blade surface to its end face, to make forging easier, but the stress area of bonding material of the joint is thereby increased and the joint better satisfies an average condition of blade connections over the minimum stress zone. In this connection, in Fig. 2, it will be noted that the slant line *a-b* of the projection end faces extends generally in the same direction as the chord line *a-c*, these lines including only a small angle.

Interference with flow of elastic fluid in the blade passage is minimized by having the projections of streamlined section in the direction of flow or blade width. In this connection, the projection end faces are slanted, not only for the reasons already given, but to provide for projection forging to a streamlined section with full peripheral draft, as will be seen from Fig. 4, and with regard to the parting line of the blade forging dies.

While the invention has been shown in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. In combination, a plurality of forged blades of a moving row and lashing means for connecting the blades; said lashing means comprising lashing structures connecting adjacent blades, each lashing structure including projections which are forged integrally with the blades as the latter are forged and extending from convex and concave blade faces so that their outer ends adjoin approximately midway between the blades

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and a joint for connecting the adjacent projection ends, said projections tapering from the blade faces to the joint.

2. In combination, a plurality of forged blades of a moving row and lashing means for connecting the blades; said lashing means comprising lashing structures connecting adjacent blades, each lashing structure including projections which are forged integrally with the blades as the latter are forged and extending from convex and concave blade faces so that their outer ends adjoin approximately midway between the blades and the outer projection ends being slanted, relative to the plane of blade rotation, generally in the same direction as the slant, relative to said plane, of the blade chord passing through the inlet and outlet blade edges at the projection blade section and a weld joint for connecting the slanted projection ends, said projections tapering from the blade faces to the joint.

3. In combination, a plurality of forged blades of a moving row and lashing means for connecting the blades; said lashing means comprising lashing structures connecting adjacent blades, each lashing structure including projections which are forged integrally with the blades as the latter are forged and extending from convex and concave blade faces so that their outer ends adjoin approximately midway between the blades and the outer projection ends being slanted, relative to the plane of blade rotation, in the same direction as the slant, relative to such plane, of the blade chord passing through the inlet and outlet blade edges at the projection blade section and a weld joint for connecting the slanted projection ends, said projections tapering from the blade faces to the joint and being of streamlined section in the direction of blade width.

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