

April 1, 1941.

S. S. STINE ET AL
TURBINE BLADE SHROUDING
Filed Sept. 26, 1939

2,237,121

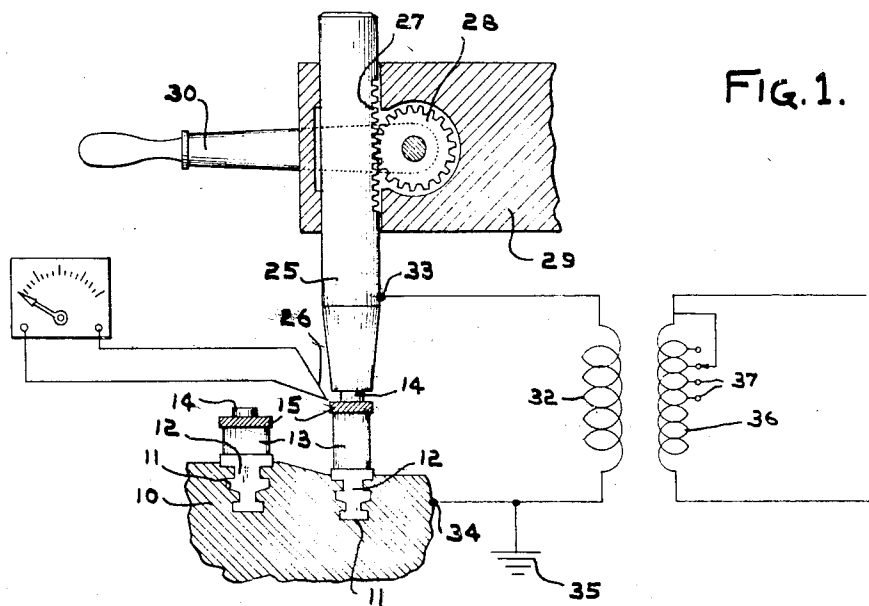


FIG. 1.

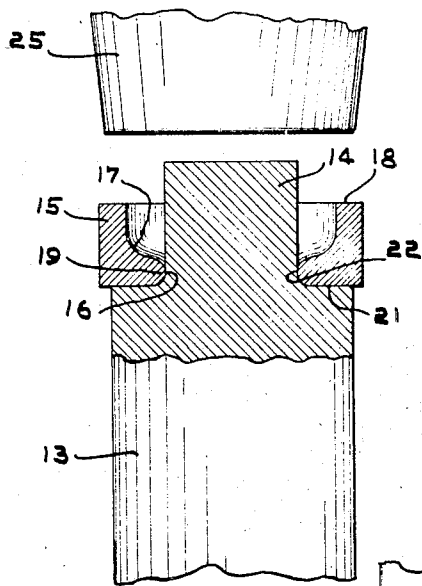


FIG. 2.

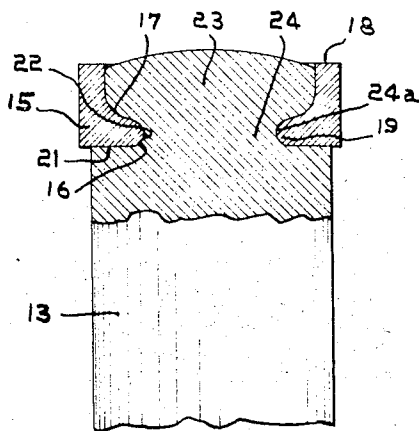
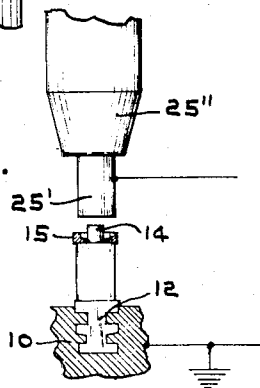


FIG. 3

FIG. 4.



WITNESSES:
Ralph T. French
James L. Mosser

INVENTORS
SAMUEL S. STINE AND
WILLIAM E. BROWN.
BY
A. B. PEARSON
ATTORNEY

UNITED STATES PATENT OFFICE

2,237,121

TURBINE BLADE SHROUDING

Samuel S. Stine, Lansdowne, and William E. Brown, Chester, Pa., assignors to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application September 26, 1939, Serial No. 296,566

2 Claims. (Cl. 253—77)

The invention relates to elastic fluid turbines and it has for an object the provision of improved turbine blade shrouding.

Tenon heads for connecting shroud strips in place with respect to turbine blades have been formed by welding, by spinning or peening the metal, or by cold riveting. Welding is objectionable because of changes effected in physical characteristics of the metal; spinning or peening may result in breaking down the metal or subjecting the latter to localized overstrengthening; and cold riveting may involve loosening of the blades in their rotor grooves. In accordance with the present invention, these objections are overcome by forming the shroud strip tenon openings of bulbous contour to conform approximately to the bulbous shape freely assumed by a tenon deformed by pressure applied to its outer end, the tenon being heated to a temperature below the critical and having pressure exerted thereon, while heated, in order that it may be deformed to fit the opening.

A further object of the invention, therefore, is the provision of deformed blade tenons for connecting a shroud strip to blades or vanes wherein the strength of the tenon material is preserved.

A further object of the invention is the provision of a row of elastic fluid turbine blades having a shroud strip connected thereto by means of blade tenons and wherein the tenon openings are formed with bulbous cavities conforming to the natural bulbous shape which a tenon tends to assume under pressure so that the tenons may be deformed to connect the strip to the blades with a minimum of stress concentration on account of deformation.

A further object of the invention is to provide a tenon and shroud connection wherein each shroud tenon opening is formed with a bulbous enlargement adjacent to the outer surface of the shroud and a neck, the bulbous enlargement having a contour conforming approximately to the natural bulbous shape which the tenon tends to assume under pressure and the neck having a convex surface joining the bulbous cavity with the inner surface of the shroud.

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

Fig. 1 is a somewhat diagrammatic representation of apparatus for forming the novel connection between the blade tenons and their

shrouding, which comprises the subject-matter of this invention;

Fig. 2 is a fragmentary sectional view showing the assembly of a shroud structure and turbine blade prior to formation of a head on the tenon;

Fig. 3 is a view similar to Fig. 2 after formation of the tenon head; and,

Fig. 4 shows a modified form of apparatus.

Referring now to the drawing more in detail, there is shown a blade-carrying member, or rotor, 10 provided with circumferential grooves 11 for the reception of the root portions 12 of a plurality of rows of blades 13, each blade having at its outer or free end a radially-extending tenon 14.

Shroud strips 15 are provided with openings 16 for the reception and passage therethrough of the tenons 14, these openings being of novel shape in cross section when considered in rotor axial planes. As shown in Figs. 2 and 3, these openings are formed with interior bulbous contours, as at 17, such contours preferably conforming to the natural bulbous shape which the tenons would take if subjected to deforming pressure with freedom thereof to bulge laterally. As shown, each tenon opening includes a bulbous enlargement 17 arranged adjacent to the outer surface 18 of the shroud strip and a neck 19 arranged between the enlargement and the inner surface 21 of the strip, the neck having an annular convex surface 22 joining the concavity 17 and the inner surface 21.

In the process of forming the heads 23 on the tenons, the latter are heated to a temperature below the critical point; and, while heated, pressure is applied to the outer end of each tenon to deform it. As the enlargements or cavities 17 are bulbous in contour and conform approximately to the natural bulbous formation which the tenon assumes under the influence of pressure applied to the outer end thereof, it will be apparent, that with the application of pressure to a heated tenon, the latter will be deformed to fill the enlarged or concave portions 17 of the openings 16.

From a consideration of Fig. 3, it will be apparent that there is formed a head 23 for retaining the shroud strip 15 against the outer ends of the blades 13, said head being spaced from the blade 13 by a neck portion 24 of reduced diameter. The neck portion, except for the annular concave fillet 24a, is substantially undeformed, not only because bulging tends to occur outwardly thereof and adjacent to the outer end

of the tenon, but also because of the restraining effect of the neck 19 of the opening.

The tenons may be heated in any suitable manner so long as care is observed to keep the temperature below the critical. As shown, heating is accomplished electrically by the inclusion of the ram 25 and the tenon 14 engaged thereby in a heating circuit. Assuming completion of the circuit with contact of the ram and a tenon, then the latter is heated; and, we prefer to use a pyrometer 26 to indicate the temperature so as to avoid overheating.

As the resistance may be relatively higher at the region of contact of the ram with the outer end of the tenon than at other points, the possibility exists of providing the highest temperature at this point, with the result that the tenon may be heated rather rapidly to the desired temperature without overheating the tenon or its blade. In this connection, the ram itself has a fairly large capacity for heat storage and this is advantageous where the ram is used repeatedly for deforming several tenons in succession, the stored heat and the heat due to the resistance effect assuring of a tenon being heated to the desired temperature.

The ram 25 is moved in any suitable manner to provide sufficient pressure or contact for the heating circuit and to exert pressure on the heated tenon to effect its deformation. For example, the ram may have a rack 27 engaged by a pinion 28 carried by the ram guide 29 and operated by means of a lever 30.

Preferably, the ram 25 and the tenon 14 are arranged in a circuit including the secondary 32 of a transformer, the circuit being connected, at 33, to the ram, at 34, to the rotor, and being grounded at 35. The transformer includes a primary 36 equipped with a series of taps 37 providing for change in secondary current to change the heating effect.

In Fig. 4, there is shown a further modified form of the invention wherein the ram 25' constitutes the ram element of a suitable portable percussive tool 25''. With this arrangement, the ram may be caused to engage the outer end of the tenon and the circuit completed for heating the tenon; and, after the tenon is heated to the required extent, then the percussive or ramming

operation of the tool is started to effect tenon deformation.

After forming the tenon or rivet head as above indicated, where the shroud strip is made of certain materials, such as a ferrous alloy which includes around 12 to 13% of chromium and which air hardens above 1400 to 1600° F. and anneals just below this temperature, by leaving the heating current on for a sufficient time after completing deformation of the tenon to provide the head 23 fitting the concavity 17 and the neck 24 fitting the neck 19, then the head 23, or at least the outer portion thereof, may be hardened and the neck region 24 may be annealed, this providing for relief of cooling stresses and being of particular advantage in connection with tenons of small diameter.

While we have shown our invention in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof, and we desire, therefore, that only such limitations shall be placed thereupon as are specifically set forth in the appended claims.

What we claim is:

1. In combination with a blade-mounting element, a row of blades mounted on said element; tenons integral with and projecting radially from the free ends of the blades; and a segmental shroud strip at the free ends of said blades, said shroud strip having openings therethrough for reception of the tenons, the contours of said openings, when considered in axial planes, being such as to conform to the natural bulbous shape which the tenons would take if subjected to deforming pressure with freedom thereof to bulge laterally, and said tenons conforming to the shape of said openings and filling the same.

2. A structure as specified in claim 1, wherein the bulbous portions of the tenons are spaced a material distance from the juncture of said tenons with the blades, whereby deformation of the tenons at said juncture, and consequent rupture thereof, is avoided.

SAMUEL S. STINE.
WILLIAM E. BROWN.