United States Patent

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[54] **SHROUDED ROTOR BLADE STRUCTURE**
10 Claims, 3 Drawing Figs.

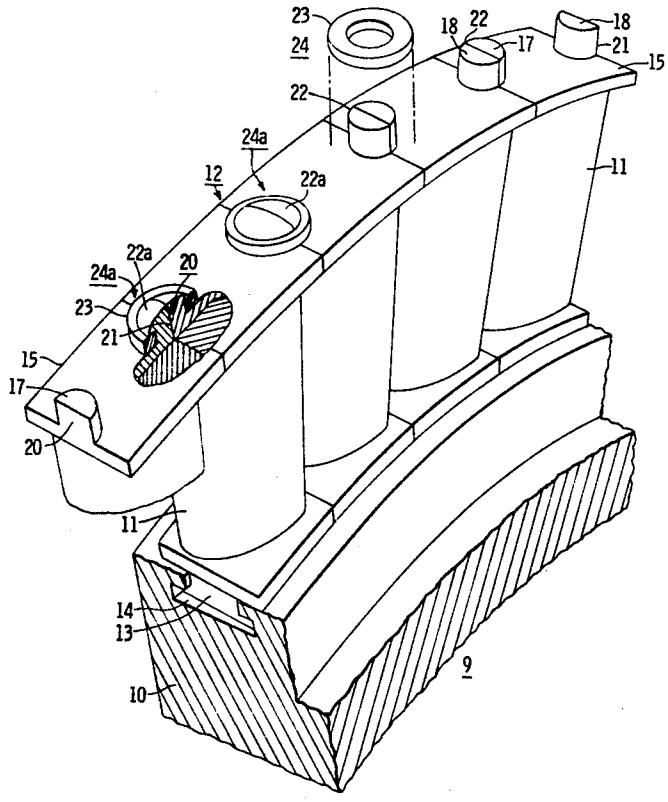
[52] **U.S. Cl.** **416/191,** 416/195
[51] **Int. Cl.** **F01d 5/22**
[50] **Field of Search** 416/191, 189, 195, 196

[56] **References Cited**
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ABSTRACT: A shrouded rotor blade structure for an elastic fluid axial flow turbine or compressor comprising an annular series of segments arranged in end-to-end abutment with each other. Each segment has two tenons of semicylindrical shape, which hereinafter will be called semitenons, one on each end, extending radially outward wherein the flat faces of the semitenons abut their mating halves on the adjacent segments forming two-piece tenons. Rings tightly encircle the tenon structures to maintain the semitenons in abutment. The tenons are deformed locking the rings in place.



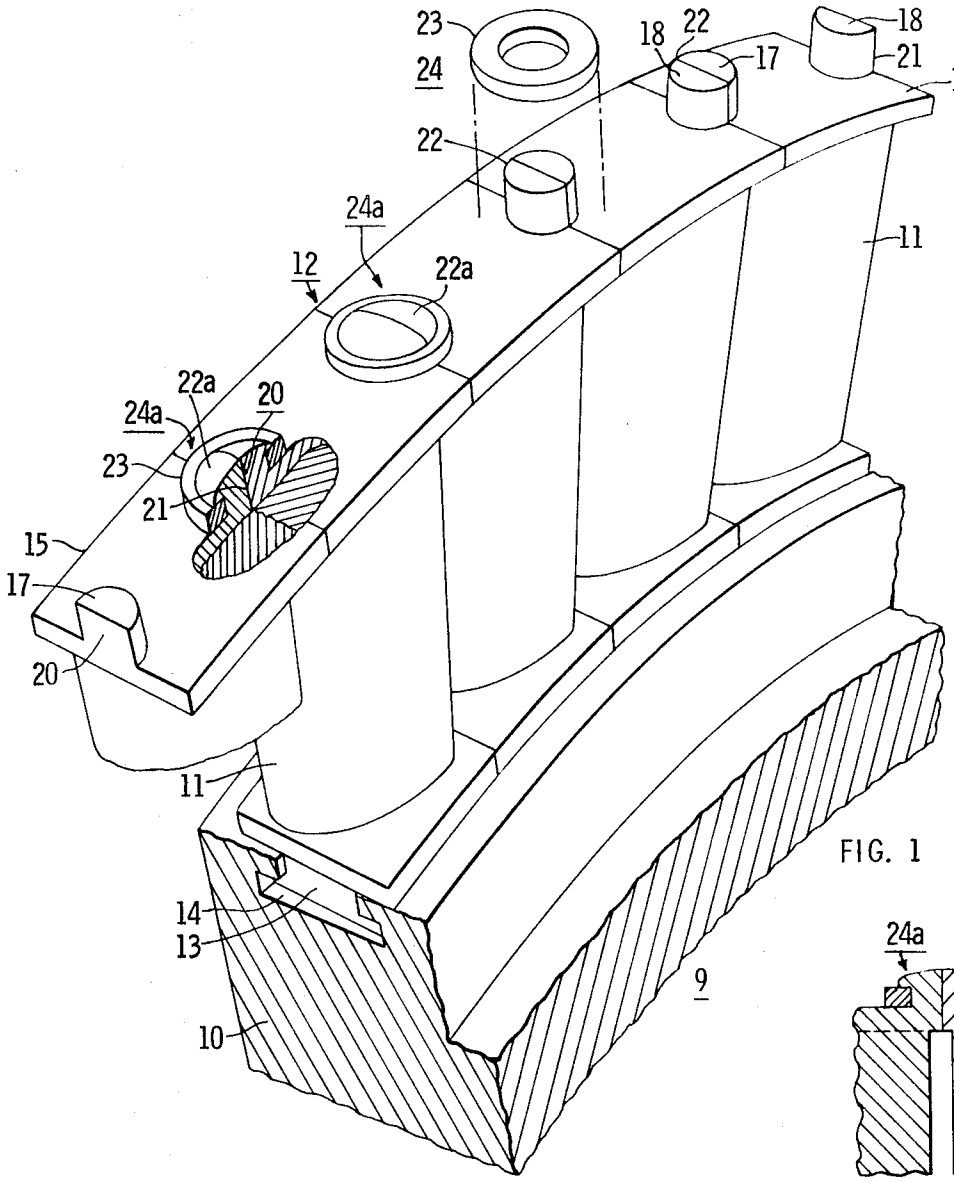


FIG. 1

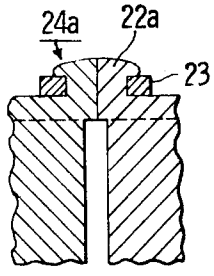


FIG. 3

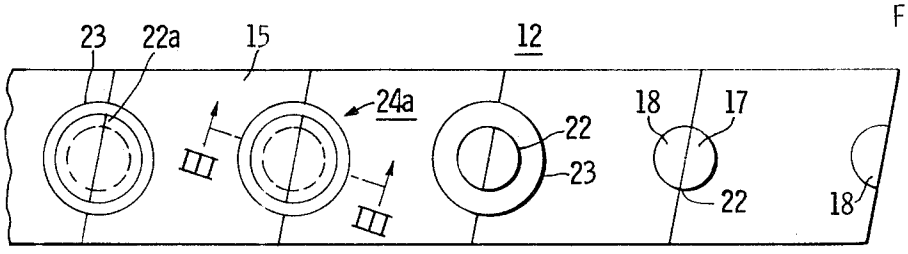


FIG. 2

WITNESSES
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SHROUDED ROTOR BLADE STRUCTURE

BACKGROUND TO THE INVENTION

This invention relates generally to elastic fluid axial flow turbines and compressors and more particularly to shrouded rotor blade structure utilized in such machines.

Many blade failures in turbines have occurred in the first rotating blade row which are attributable to vibrational stresses due to the periodic forces associated with the nozzles and the shock loads attained during operation in the partial-admission mode. The primary purpose of continuous shrouding is to minimize these stresses. Earlier inventions of this type are A. J. Partington, U.S. Pat. No. 3,367,629 and P. D. Saunders, U.S. Pat. No. 3,367,630 both issued on Feb. 6, 1968 and both assigned to the same assignee as this invention.

This invention provides a novel structure employing a continuous shroud which minimizes vibrational stresses and minimizes thermal-fatigue strains in the blade structure.

SUMMARY OF THE INVENTION

In accordance with this invention a turbine or compressor is provided with an annular row of rotor blades and a shroud structure surrounding the blades. The shroud consists of an annular series of segments which are on the outermost portion of the blades tips and integral therewith, arranged in end-to-end abutment with each other. On the opposite ends of each segment is a semitenon extending radially outward with respect to the axis of rotation of the rotor. Each semitenon has a flat face flush with the edge portion of the segment facing the flat face of the semitenon on the adjacent segment. The semitenons are substantially identical to each other in size and shape. A two-piece tenon is formed when the flat face of a semitenon abuts its mating half on the adjacent segment. A cincture encompasses the semitenons to insure the abutting relation. The tenon is deformed, holding the cincture in compressive abutment between the tenon and the shroud segment.

Elastic fluid flows axially through the turbine at high temperature and pressure, driving the rotor structure. As the shroud expands or contracts due to the centrifugal and thermal forces, the stresses concentrate in the extruding portions of the shroud which are the tenon structures. The semitenons are flexible and deflect, relieving part of the forces transferred to the cincture and minimizing the centrifugal and thermal induced strains in the blade structure.

DESCRIPTION OF THE DRAWINGS

Reference may be had to the following drawings for a better understanding of the nature and objects of the invention in which:

FIG. 1 is a view in perspective of a portion of a bladed rotor structure in accordance with the invention shown in the various stages of fabrication;

FIG. 2 is a developed view in plan of the shroud portion shown in FIG. 1; and

FIG. 3 is an enlarged sectional view of the tenon structure taken along line III–III in FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows a fragmentary view of a rotor structure **9**, only part of which has been shown, it being understood that the structure is part of an elastic fluid axial flow turbine or compressor (not shown). The FIG. shows the construction of the invention from the initial to the final stages where in sequential order from the top of the FIG. there is a semitenon **18**, a two-piece tenon **22** before riveting, an exploded view of a tenon structure **24**, a tenon structure **24***a* after riveting, and a sectional view of a riveted tenon structure **24***a*.

The rotor structure includes a portion of a rotor **10**, a transverse annular row of blades **11**, which are substantially identical to each other, and a shroud structure **12** surrounding the outermost tips of the blades **11**. The blades **11** are of the usual

air foil contour, as well known in the art, and are attached to the rotor **10** by means of root portions **13** disposed in a suitable groove **14** in the rotor The blades **11** extend radially outward relative to the longitudinal axis of rotation of the rotor (not shown) and they may constitute one row of a multistage axial flow turbine.

The shroud **12** comprises an annular series of segments or blade covers **15**, which are integral with the outermost tips of the blades **11**. The segments **15** are substantially identical to each other, and, as best indicated in FIG. **2**, for purposes of illustration, are of parallelogram shape in plan. The segments are in end-to-end relationship forming a continuous 360° shroud.

Each blade **11** has two semitenons **17, 18** integral therewith which may also be integral with the segment **15**. The semitenons **17, 18** are formed in mating halves. There is one semitenon **17** on the left end of segment **15** and one semitenon **18** on the right end. The left semitenon **17** has a flat face **20** and the right semitenon **18** has a flat face **21** which are longitudinal of the blade **11**. The flat faces **20, 21** of the semitenons **17, 18** are flush with the edge portions of the segment **15** and are oriented towards the flat faces **21, 21** of the adjacent semitenons **18, 17**. The faces **21, 21** of the semitenons **17, 18** abut the faces **21, 20** of their mating halves **18, 17** on the adjacent segments forming a two-piece tenon **22**. From a view looking into either edge of the segment **15**, the semitenons **17, 18** and the edge portions of the segment **15** form an inverted T. This is best illustrated in FIG. **1** from a view looking into the leftwardmost face **20** of the semitenon **17** on segment **15**. The semitenons **17, 18** are arranged in an annular row along the center of the segments **15** and the row is curved conforming to the curvature of the shroud **12**. The two-piece tenon **22** may be an irregular, nonsymmetrical solid, or a regular solid in which all angles and sides are equal, such as a polygon, or the tenon may be a solid of revolution which has circular cross section taken parallel to the axis of rotation of the rotor, such as a cylinder as shown in FIGS. **1** and **2**.

Fastening means **23** may be a cincture which conforms to the shape of the tenon **22** and interacts therewith to firmly hold the abutting semitenons **17, 18** together and to thereby secure the adjacent segments **15** in abutting end-to-end relationship. For purposes of illustration, and as best shown in the exploded view of FIG. **1**, the cinctures are cylindrical rings **23**. Each ring **23** fits over the cylindrical tenon **22** to securely encircle it to maintain the semitenons **17, 18** and the segments **15** in abutting relationship.

As best illustrated in the sectional view in FIG. **1** and in FIG. **3**, the tenon **22** is deformed as indicated by **22***a* by riveting and mushrooms over the fastening means or cincture **23** to maintain the cincture in compressive abutment between the tenon **22***a* the segment **15**. The riveting locks the cincture **23** in place to prevent loss of the cincture in operation.

The resulting structure is a continuous 360° shroud which eliminates the resonant condition and thereby the resulting stresses and minimizes the effect of the partial admission loading stresses. Furthermore, as the structure goes through a thermal cycle, thermal strains and stresses will result due to the temperature differential between the rotor **10** and the shroud **12**. The semitenons **17, 18** will flex minimizing the thermal strains and stresses and because the cincture **23** is in abutment with the semitenons, it absorbs some of the thermal forces, further minimizing the thermal strains.

Although the tenon **22** has been shown for purposes of illustration to be a two-piece tenon, and has been defined as semitenon, the tenon need not be limited to two-pieces. Accordingly, in some of the claims, the term partial-tenon has been employed.

Since numerous changes may be made in the above-described construction, and different embodiments of the invention may be made without departing from the spirit and scope thereof, it is intended that all the matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. In elastic fluid utilizing apparatus,
a rotor having a transverse annular row of blades,
a continuous shroud surrounding the radially outermost tips of the blades,
said shroud comprising an annular series of segments arranged in end-to-end abutment with each other,
partial-tenons extending radially outward on opposite ends of said segments,
said partial-tenons abutting the partial-tenons on the adjacent segments forming multipiece tenons,
and fastening means connecting said multipiece tenons to firmly secure the segments in abutting relationship.

2. The structure defined in claim 1 wherein the shroud segments are integral with the blades and substantially identical to each other.

3. The structure defined in claim 1 wherein the partial-tenons are substantially identical mating halves.

4. The structure defined in claim 1 wherein the partial-tenons are integral with the blades.

5 The structure defined in claim 1 wherein the partial-tenons have flat faces and the edge portions of the segments and the flat faces form T's.

6. The structure defined in claim 3 wherein the partial-tenons abut their mating halves on the adjacent segments to form two-piece tenons.

7. The structure defined in claim 3 wherein the partial-tenons are of semicylindrical shape.

8. The structure defined in claim 1 wherein the fastening means are cinctures which encompass the tenons.

9. The structure defined in claim 8 wherein the tenons are deformed by riveting to thereby hold the cinctures in compressive abutment.

10. The structure defined in claim 1 wherein the partial-tenons are substantially identical mating halves,
said partial-tenons abutting their mating halves on the adjacent segments to form two-piece tenons,
said partial-tenons being semicylindrical in shape, and
the fastening means being rings encircling the two-piece tenons.