Dec. 6, 1960 H. W. WELSH 2,963,272

ROTOR BLADE SHROUDING

Filed July 19, 1957 2 Sheets-Sheet 1

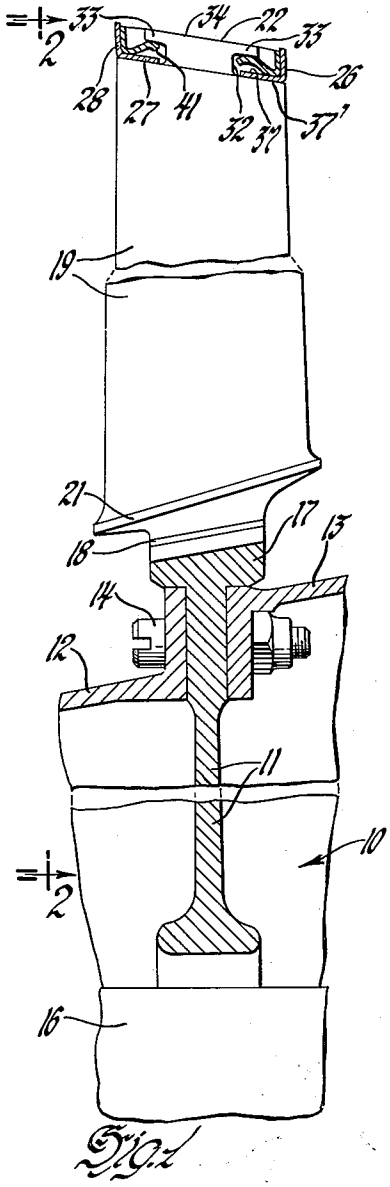


Fig. 1

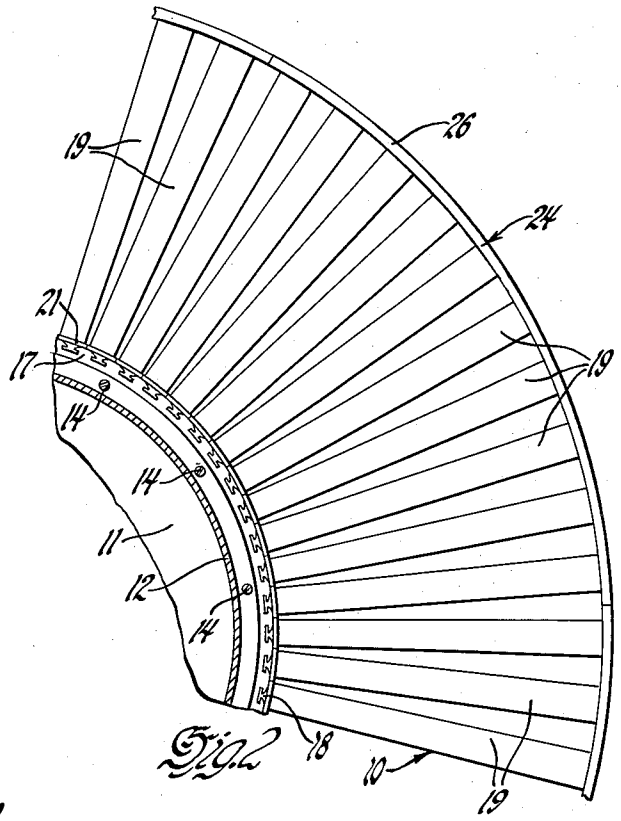


Fig. 2

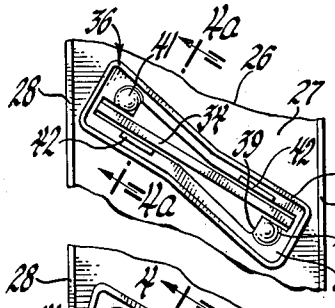


Fig. 3

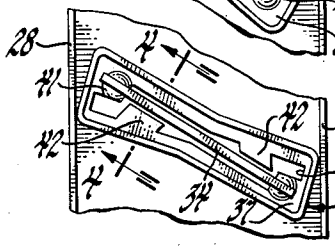


Fig. 3a

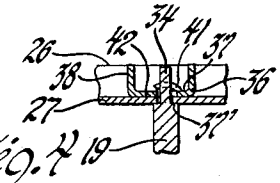


Fig. 4

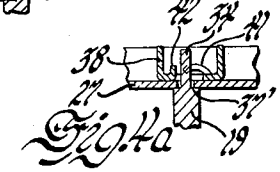


Fig. 4a

INVENTOR.
Harvey W. Welsh
BY
Paul Fitzpatrick
ATTORNEY

Dec. 6, 1960 H. W. WELSH 2,963,272

ROTOR BLADE SHROUDING

Filed July 19, 1957 2 Sheets-Sheet 2

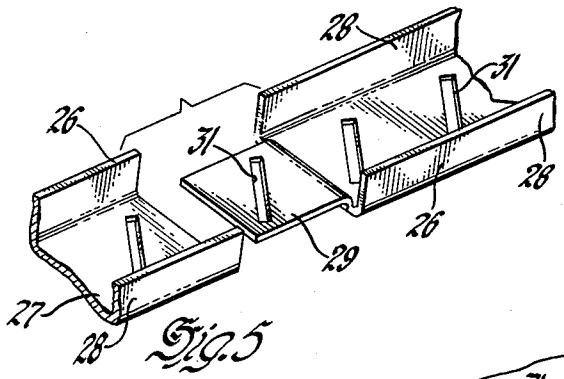


Fig. 5

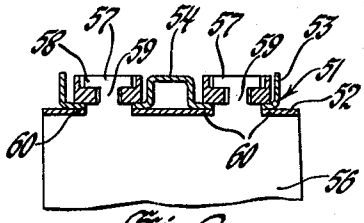


Fig. 6

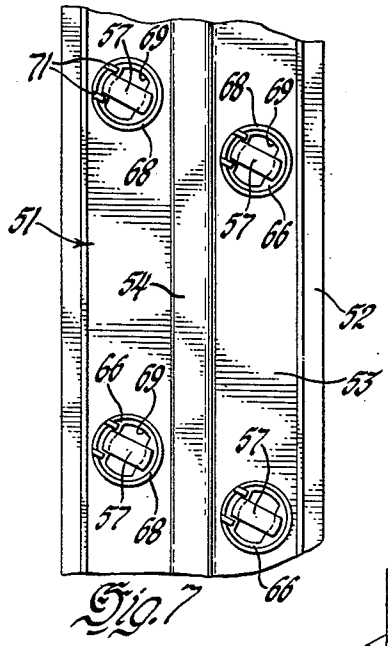


Fig. 7

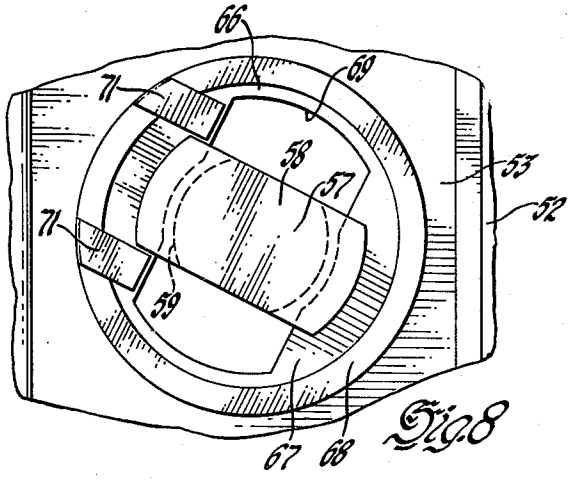


Fig. 8

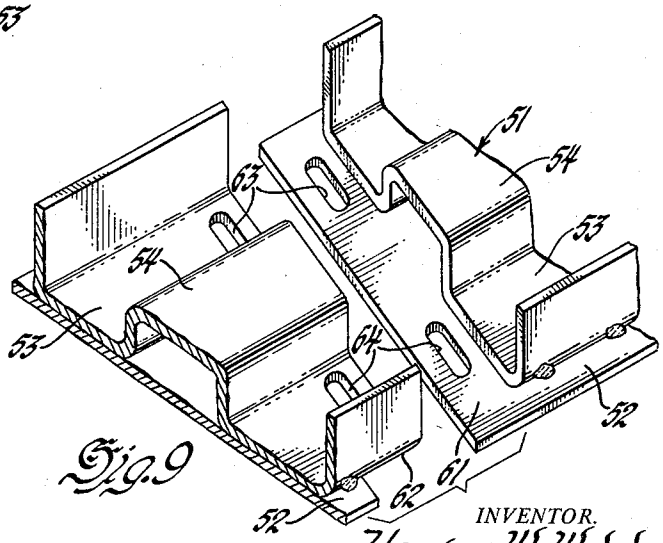


Fig. 9

INVENTOR.
Harvey W. Welsh
BY
Paul Fitzpatrick
ATTORNEY

United States Patent Office

2,963,272

Patented Dec. 6, 1960

2,963,272

ROTOR BLADE SHROUDING

Harvey W. Welsh, Indianapolis, Ind., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Filed July 19, 1957, Ser. No. 673,055

2 Claims. (Cl. 253—77)

My invention relates to shrouded blade structures for the rotors of fluid-dynamic machines such as axial-flow compressors and turbines.

Certain advantages of providing shrouding on the tips of compressor and turbine rotor blades have long been appreciated. The provision of a satisfactory shrouded blade structure involves substantial difficulties, however, particularly in the case of compressor blading of low hub radius to tip radius ratio. In such a case, the blades may be closely spaced at the hub, but are widely spaced at the tip. Since such machines may be of considerable diameter and rotate at high speed, there is a high centrifugal force on the shroud. My invention is directed primarily to the provision of a suitable lightweight shroud structure which will not put a heavy radial load on the blades and yet which is sufficiently rigid that it will not bow out to a harmful extent between the blades, and to a simple, lightweight, reliable, and readily applied attachment for the shroud which makes it practicable to remove the shroud for replacement of damaged blades.

The nature of the invention and the advantages thereof will be apparent to those skilled in the art from the succeeding detailed description of two preferred embodiments of the invention and the accompanying drawings thereof.

Figure 1 is a fragmentary sectional view of the rotor of an axial-flow compressor taken on a plane containing the axis of the rotor.

Figure 2 is a fragmentary transverse sectional view of the same taken on the plane indicated by the line 2—2 in Figure 1.

Figure 3 is a fragmentary view of the exterior of a rotor stage during assembly.

Figure 3*a* is a similar view after assembly.

Figure 4 is a sectional view taken on the plane indicated by the line 4—4 in Figure 3*a*.

Figure 4*a* is a sectional view taken on the plane indicated by the line 4*a*—4*a* in Figure 3.

Figure 5 is a fragmentary axonometric exploded view of the shroud.

Figure 6 is a fragmentary sectional view of a second embodiment of the invention taken in a plane containing the axis of the compressor.

Figure 7 is an external view of a portion of the shroud of Figure 6.

Figure 8 is a greatly enlarged detail of a portion of Figure 7.

Figure 9 is a fragmentary axonometric exploded view of the shroud of Figures 6 to 8.

It may be noted that the drawings illustrate only the rotor structure of the compressor and only one stage, since the details of the stator structure are immaterial to the invention, and the structure of one stage may be duplicated for a number of stages of the compressor.

Referring to Figures 1 and 2, the rotor **10** may be of any suitable structure, but is illustrated as a composite rotor including a disk **11** and spacer rings **12** and **13** fixed

to the disk by a ring of bolts **14**. The spacer rings may be similarly fixed to similar disks to provide a multistage rotor which may include a central shaft or tiebolt **16**. The rim **17** of the wheel is provided with slots to receive the dovetail roots **18** of compressor rotor blades **19**. The blades may include platforms **21** adjacent the roots of the blades.

The blades extend radially outward from the disk and terminate at the blade tips **22**. The blade tips are disposed in a ring. A blade shroud or rotor shroud **24** made up of a number of arcuate segments **26** extends around the tips of the blades. The number of segments may be varied, but a suitable number of segments is six. The shroud segments are disposed end-to-end with the ends overlapping to provide the equivalent of a continuous shroud.

The shroud **24** of Figures 1 to 5 is of channel section with a web **27** and outwardly extending flanges **28**. At one end of each shroud segment, a tongue **29** extends from the web **27** and is slightly offset radially so as to overlie the web **27** of the adjacent section. Rectangular openings **31** are punched in the web **27** and one such opening is punched in the tongue **29**. These openings are disposed at such an angle to the axis of the compressor as to accord generally with the angle of the tip of the blade with respect to the compressor axis. The tip of each blade is machined to provide a neck **32** and a head **33**, the neck and head together constituting a headed tang **34** at the end of the blade. The blade shroud is dropped over the headed tang **34** of each blade with the tang extending through the opening **31**.

The shroud is retained on the blade by a locking clip **36** which may readily be attached and removed and which holds the shroud seated against the shoulders **37'** at the base of the tang. Figures 3, 3*a*, 4, and 4*a* illustrate two stages in the mounting of the locking clip. The locking clip in Figures 3 and 4*a* has been dropped over the blade tang and the clip in Figures 3*a* and 4 has been rotated so as to engage between the head **33** of the tang and the shroud in a bayonet lock and has been locked against displacement. Each clip **36** is a formed sheet metal part including a base **37** and an outwardly extending flange **38**. An opening **39** of irregular contour is cut in the base **37** of the clip. The greatest dimension of the opening is such that the clip may be dropped over the tang **34** of the blade. Portions **41** of the base of the clip at each end are deformed upwardly and are disposed so that upon rotation of the clip to the position shown in Figures 3*a* and 4, the portions **41** engage under the shoulders **33** of the tang, as illustrated in Figure 1. When the clip has been rotated into this position, it is locked against disengagement by bending down two tabs **42** extending upwardly from the base **37** so that the tabs will engage the neck **32** of the blade tang and prevent the clip from rotating into the position which frees the shroud. The deformed portions **41** will yield slightly and thus provide a slight tolerance in the fit. They are too stiff to yield under centrifugal force.

As will be apparent, the shroud is easily attached and removed. After the blades have been mounted in the disk, the segments of the shroud are put over the ends of the blades. The clips are put over the ends of the blades and rotated to fit under the tangs and are locked in place by bending down the tabs **42**. If it is desired to remove blades for any reason, any or all segments of the shroud may easily be removed by bending up the tabs **42**, rotating the clips, and lifting them off to free the shroud for removal.

The second form of shroud structure, illustrated in Figures 6 to 9, is similar in general to that previously described in that it involves a sheet metal shroud with

overlapping segments fixed to the blades by locking clips. The differences are in the structure of the shroud, the provision of two tangs on each blade, and the use of a different locking clip. Considering first the structure of the shroud **51**, this comprises a flat arcuate strip **52** and an outer strip **53** which may be described as being of W-shaped cross section. This strip has flanges at the edge like segments **26** shown in Figure 5, but also has a raised portion **54** at the center so that there are a total of four radial webs in the strip **53**. The strips **53** abut the strips **52** and are brazed or spotwelded to them to provide a strong, stiff and lightweight shroud segment. Each blade **56** may be mounted in the same manner as shown for blades **19** in Figure 1, and the shroud **51** extends around the blades as does shroud **24** as shown in Figure 2. Each blade **56**, however, has two tangs **57**, each including a head **58** and a neck **59**. The blade defines a shoulder **60** between the tangs and adjacent the leading and trailing edges against which the strip **52** bears. The strip **53** terminates short of one end of strip **52** and extends beyond the other end, as shown in Figure 9, so that the end portion **61** of strip **52** may underlie the end portion **62** of strip **53**. Two rows of holes **63** and **64** are punched through the strips **52** and **53** to receive the tangs **57**. At the joint between the shroud segments, the tangs go through the strip **52** of one shroud and the strip **53** of the other.

After the shrouds have been fitted over the tips of the blades, they are retained by locking clips **66**, two for each blade. The clips **66** are cup-shaped, with a base **67** and a flange **68**. An elongated opening **69** is punched in the base of the clip of such dimensions as to pass over the head **58** of the tang. Upon rotating the clip 90 degrees, the base of the clip engages under the head of the tang to provide a bayonet lock joint. Two small deformable tabs **71** brazed to the flange of the clip and standing upwardly from the flange before the clip is installed may then be bent down into the position shown in Figure 8 where they lie at each side of the head **58** and prevent the clip from rotating so as to release the shroud.

As will be seen, the advantages of this form of the invention are similar to those of the form previously described.

In both forms of the invention, a shroud which is light in weight and yet rigid is provided. Because it is rigid, it will not be deformed significantly from its circular shape because of centrifugal force; because of its light weight, it will not put too heavy a centrifugal load on the blades. Both forms of shroud are beneficial in improving the air flow characteristics at the tip of the blade, in improving the seal between the blade tips and the compressor case, in greatly increasing the fundamental frequency of vibration of the blades, and in reducing the load on the blade root due to gas loads. The flanges at the edges of the shrouds may be ground to size and concentricity with the disk axis after the shrouds have been put on the blades to provide a close seal to the case.

The invention is not to be considered as restricted by the detailed description of the preferred embodiments thereof presented for the purpose of explaining the principles of the invention, as many modifications may be made by the exercise of skill in the art within the scope of the invention.

Certain structure illustrated but not claimed herein forms the subject matter of my divisional application for patent, Serial No. 9,995, filed February 19, 1960, entitled "Attaching Devices."

I claim:

1. A shrouded turbomachine rotor structure comprising, in combination, a rotor, a ring of blades extending from the rotor, a shroud mounted on the tips of the blades, the shroud comprising a number of segments mounted end-to-end to provide a shroud around the tips of the blades, each shroud segment being of fabricated sheet metal comprising an arcuate strip of flat cross-section and an arcuate strip of W-shaped cross-section providing four radially extending webs stiffening the segments, the two strips being rigidly united to provide a composite arcuate shroud segment, and means for attaching the shroud to the blade comprising tangs with heads at the free ends of the blades, each blade providing an outwardly facing shoulder adjacent the tang head, the shroud abutting the shoulders and having openings for the tangs, the tangs extending through the openings, and clips lodged between the outer surface of the shroud and the heads of the tangs retaining the shrouds on the blades.

2. A rotor shroud comprising, in combination, a plurality of arcuate shroud segments disposed in overlapping end-to-end relation, each segment comprising an arcuate strip of flat cross-section and an arcuate strip of W-shaped cross-section providing four webs extending radially to the axis of the arc of the strip, the two strips being united to provide a composite arcuate shroud segment with one end of each strip extending beyond the end of the other strip, the shroud segments having openings therein to provide for attachment to blades of a rotor blade row.

References Cited in the file of this patent

UNITED STATES PATENTS

764,452	Geisenhoner	July 5, 1904
875,644	Barth	Dec. 31, 1907
1,371,328	Schneider	Mar. 15, 1921
1,720,754	Baumann	July 16, 1929
1,930,645	Ellis	Oct. 17, 1933
2,221,684	Smith	Nov. 12, 1940
2,502,539	Tinnerman	Apr. 4, 1950

FOREIGN PATENTS

202,313	Australia	June 27, 1956