Nov. 26, 1968 W. B. MOYER ET AL 3,412,977

SEGMENTED ANNULAR SEALING RING AND METHOD OF ITS MANUFACTURE

Filed April 15, 1965

FIG. 1.

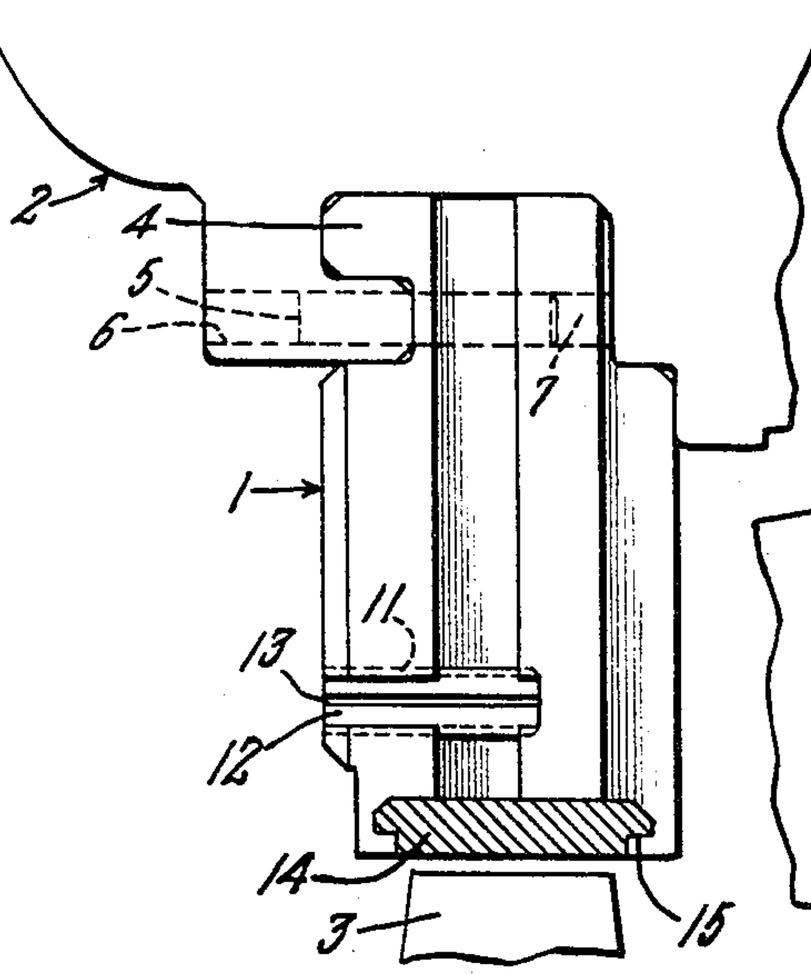



FIG. 4.

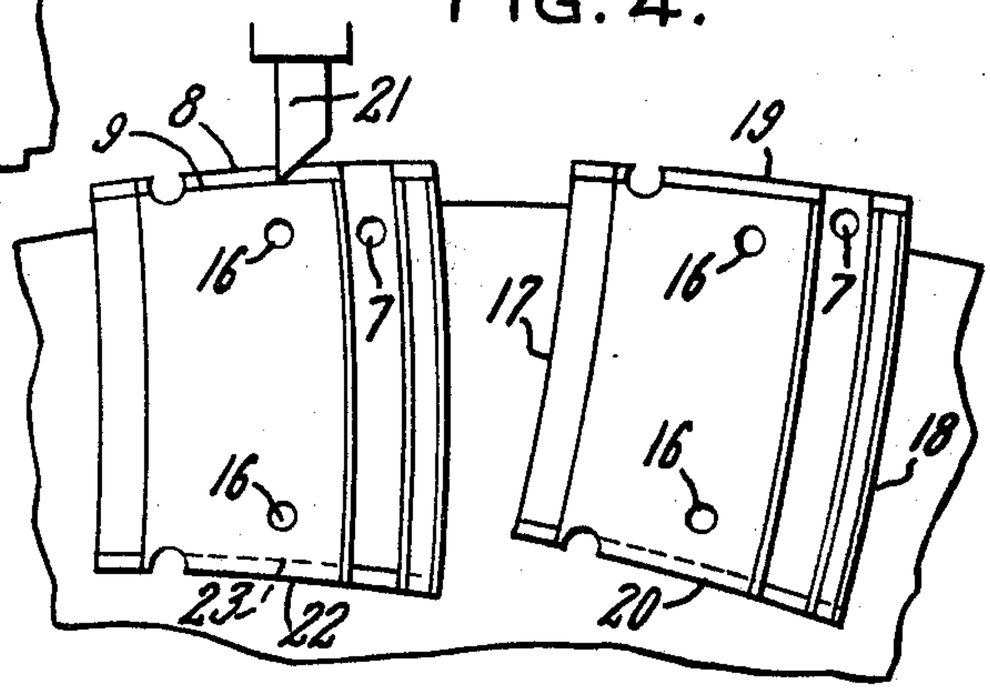



FIG. 2.

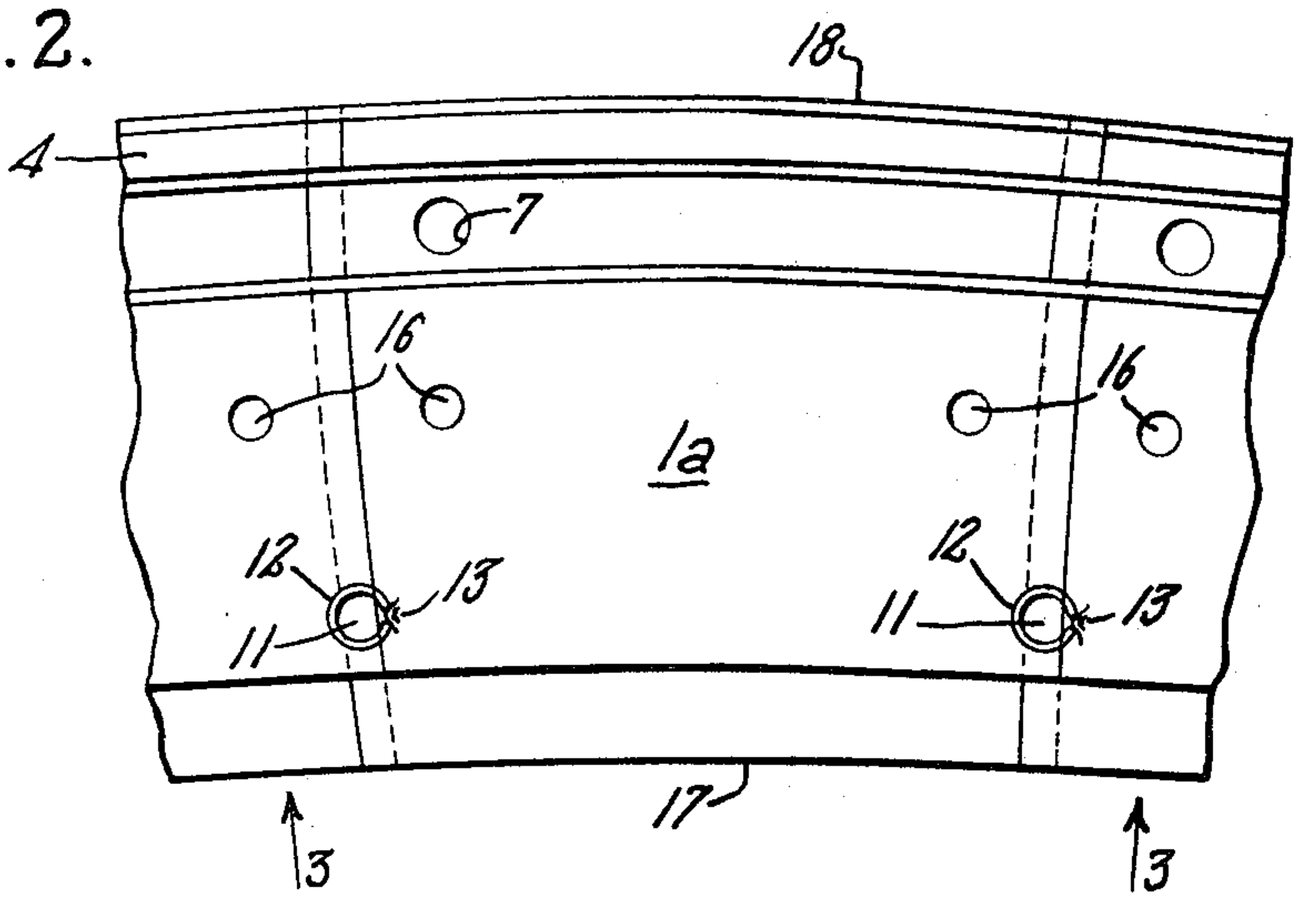
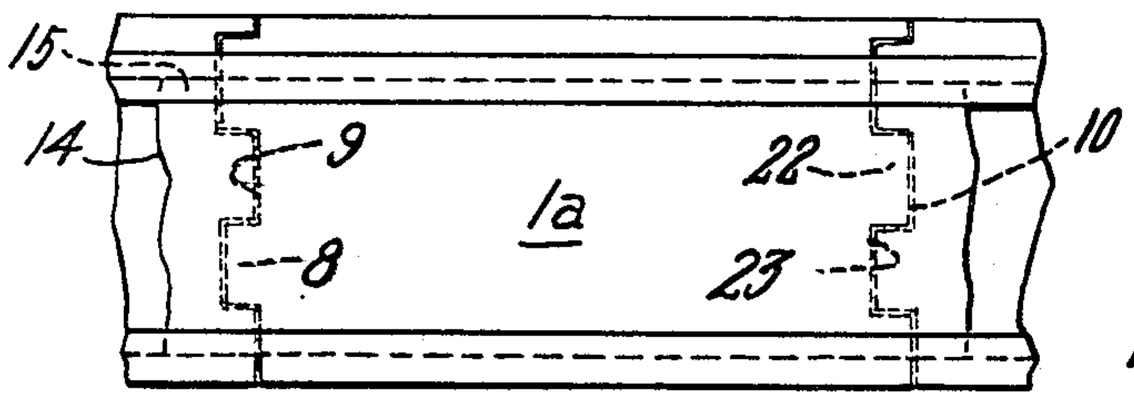



FIG. 3.

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# SEGMENTED ANNULAR SEALING RING AND METHOD OF ITS MANUFACTURE

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3 Claims. (Cl. 253—39)

## ABSTRACT OF THE DISCLOSURE

Annular ring of plural segments whose adjoining faces are made by turning about axes parallel to ring axis.

## Background of the invention

This invention relates generally to segmented annular rings and more particularly to a new and improved segmented annular turbine shroud and the simplified method of its manufacture which the improvement permits.

By way of example, one use for such an annular ring is as a shroud in a turbine. A turbine shroud is a liner member which is supported by the turbine casing or shell and extends radially inwardly into close proximity to the rotor blades. Its purpose is to prevent leakage of the motive fluid around the blades and in order to allow thermal expansion without radial growth, it is often made up of arcuate segments.

Some turbine shrouds which are in present use are machined from castings in relatively long circumferential segments. The segments are long to minimize leakage at their interfaces and because of their length, they suffer greater distortion or curling due to a radial temperature gradient, causing increasing blade tip clearance at some points and rubs at others. The hooks or flanges which hold the long segments to the turbine shell must be short and spaced intermittently. This is to prevent high stresses in the flanges due to circumferential curling which would cause binding in the turbine shell. These intermittent shroud hooks can be easily obtained by using a sand cast segment with raised bosses for hooks. The sand cast segment is slab milled on one side so as to establish a reference plane. Radial planes are then milled on the ends of the shroud segment. The shroud hooks, I.D., O.D. and remaining flat side are subsequently turned in a fixture. Following this additional milling is performed on end radial planes to provide radial and axial sealing key grooves. Casting has the attendant disadvantages of pattern maintenance, loss due to casting flaws, long time cycle, and lower design stress levels consistent with casting quality control problems. These extensive milling operations require specialized cutting tools, with associated high tool maintenance, repetitive handling, setup, and machining time. Together, casting and milling of shroud segments is an expensive manufacturing method. Reduction of turbine tip clearances is made possible by use of relatively shorter segments which are advantageous with respect to the distortion and hook stress problems. However, short shrouds possess the basic disadvantage of high gas bypass leakage through the increased number of interfaces and, made in the manner just described, their cost would be appreciably increased.

Accordingly, it is an object of this invention to provide an improved segmented annular ring for use as a shroud for higher efficiency and higher pressure turbines, and which will provide a high strength flange to withstand increased temperatures and pressures.

Another object of this invention is to provide an improved segmented annular ring which will minimize radial and axial leakage through its interfaces.

Another object of this invention is to provide an improved segmented annular ring for use as a turbine shroud which will permit smaller clearances between itself and the rotor blades by minimizing the effect of shroud curling.



Another object of this invention is to provide an improved segmented annular ring with relatively short segments which can be machined from bar stock at reasonable cost without the necessity for using castings or expensive milling operations.

Another object of this invention is to provide a new method of manufacturing segmented annular rings by which the above and other objects can be achieved at a minimum cost.

Briefly stated, in accordance with one of its aspects, this invention comprises an annular ring of a plurality of segments whose adjoining faces, though substantially radial, are arcuate permitting a simplified method of manufacturing them by turning.

These and other objects, advantages and features of this invention will be readily appreciated from the following description when considered in connection with the accompanying drawing, wherein:

FIG. 1 is a fragmentary longitudinal elevation, partly in section, of a turbine shell and one segment of a turbine shroud according to this invention.

FIG. 2 is a front elevation of a portion of a turbine shroud according to this invention.

FIG. 3 is a radial view looking in the direction of arrows 3—3 of FIG. 2, and

FIG. 4 is a plan view showing two of the segments of a segmented annular ring on the table of a machine tool.

## Description of the invention

Referring now to FIG. 1, a segment of a turbine shroud **1** is shown in its environment as it is mounted on a turbine shell **2** within which rotor blades **3** move. The segments are held to the turbine shell by means of a flange **4** and by fasteners **5** extending through holes **6** in the shell and holes **7** in the segments. Each individual segment **1***a* of shroud **1** as shown in FIGS. 2 and 3 is made with tongues **8** and grooves **9** on both sides for respective mating of adjoining faces at interfaces **10**. These tongues **8** and grooves **9** provide a labyrinth seal to minimize axial leakage through the shroud **1** at the segment interfaces. In a preferred embodiment of this invention, tongues **8** and grooves **9** are rectangular as shown in FIG. 3. Upon thermal expansion or contraction, they will continue to provide an effective seal since their relationship in the axial direction will be unaffected. Adjacent each segment interface **10**, an axial hole **11** extending partly through the shroud segment, is made with a diameter at least as great as the depth of grooves **9**. The axis of each hole **11** lies between tongue **8** and groove **9**. A resilient tube **12** with a longitudinal aperture **13** fits into each hole **11**. When the segments are assembled into a complete shroud, tubes **12** prevent radial leakage at interfaces **10** as can be clearly seen in FIG. 2. The longitudinal aperture **13** serves two purposes. It facilitates pressing tubes **12** into holes **11** for a tighter fit and therefore a better seal. It also enables the tubes **12** to give and take during thermal expansions and contractions in the shroud segments. Another means of preventing radial leakage, which can be used either in conjunction with tubes **12** as shown in FIG. 1, or in the alternative, comprises a strip **14** of a dissimilar metal, disposed in a dovetail **15** on the inside circumference of the shroud and spanning the interfaces **10** as shown in FIGS. 1 and 3. The material of strip **14** is preferably softer and of a lower melting temperature than that of the shroud segments and/or blades as it is also used as a wear member. Location holes **16**, as shown in FIGS. 2 and 4, extend partially through the segments on both end

faces thereof, for the purpose of positioning the segments on a jig or fixture for machining.

The method of manufacturing the segments will now be described. Rectangular bar stock workpieces, large enough in section to machine therefrom one complete shroud segment, are ground to a finish on both end faces to the desired thickness, which will equal the thickness of the turbine shroud. The segments are then positioned in a jig or fixture and holes **7**, **11**, and **16** are drilled. The segments are then mounted in a circular array relative to a machine tool such as a vertical turret lathe or vertical boring mill by means of jigs or fixtures and by locating holes **16**.

Convex faces **19** with their tongues and grooves **8** and **9** are then formed by turning relative to a cutting tool such as **21**.

The next step is to invert all the segments, positioning them in the same jigs or fixtures by the opposite set of locating holes **16**. Concave faces **20** with their tongues and grooves **22** and **23** are then formed by turning about another cutting tool, not shown.

The segments are then positioned in a circular array on another fixture so that tongues and grooves **8**, **9**, **22**, and **23** are mating and locating holes **16** are mounted on locating pins in the fixture. Concentric faces **17** and **18**, dovetail **15** and flange **4** are then turned relative to cutting tools not shown. Since all faces are turned while the segments are flat on fixtures on the machine worktable, the axes of all arcs so turned will be parallel.

It should be noted that by the method just described the segments can be turned in lots, an entire shroud annulus being machined at one time. This method of manufacturing shroud segments is clearly simpler and more economical than the casting and milling operations required by previous shroud segments as discussed earlier.

It will be appreciated that the foregoing description discloses a segmented annular ring which has more strength and dimensional stability, allows less leakage, and is easier and more economically manufactured than the prior art structures.

While, for purposes of description, this invention has been related to its use and manufacture as a turbine shroud, it will be obvious to those of ordinary skill in the art that the inventive concept embraces all uses of segmented annular members such as packing rings, bearings, turbine nozzle arcs or any such member which prevents leakage and is required to expand and contract. Accordingly, it is intended that the invention be not limited by the environment in which it has been described, but that it encompass all within the purview of the following claims.



What we claim as new and desire to secure by Letters Patent of the United States is:

**1.** A turbomachine shroud comprising a segmented annular ring, said ring comprising a plurality of arcuate segments adjoining one another at interfaces, the faces of adjoining segments being defined by arcs, the axes of said arcs being substantially parallel to the axis of said ring, said faces having mating grooved surfaces at the interfaces to allow for relative movement under changes in temperature, means to fasten adjacent segments together and obstruct radial flow through said interfaces, and means to mount said ring within the casing of a turbomachine.

**2.** A segmented annular ring as defined in claim **1** said means to fasten adjacent segments and obstruct radial flow comprising axial holes extending partially through said segments at their interfaces, and resilient tubes extending into said holes, the diameter of said holes being greater than the depth of the grooves in said surfaces, the axis of each such hole passing through the segments defining the same so that said tubes provide positive fastening of adjacent segments.

**3.** A segmented annular ring as defined in claim **1**, further comprising a plurality of wear strips mounted on said annular ring on the inner circumference thereof and overlapping said segments to obstruct radial flow therebetween.


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