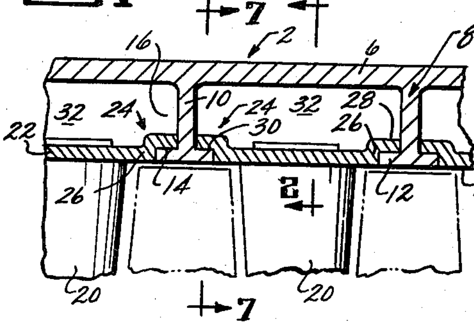
July 19, 1960 E. J. WALSH 2,945,290

STATOR VANE HALF RING ASSEMBLIES

Filed Sept. 16, 1957

Fig 1



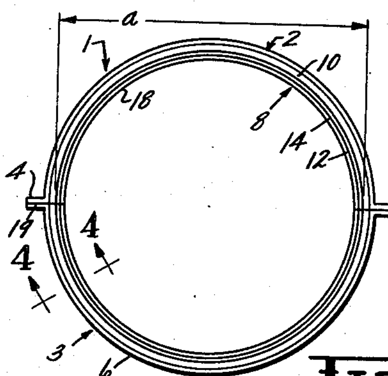
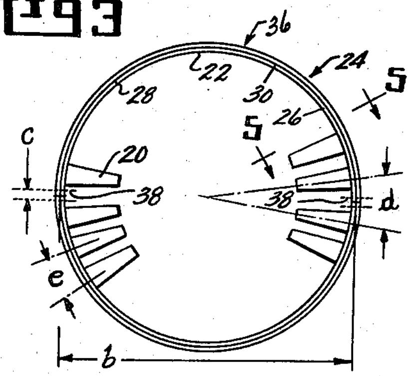


Fig 2

Fig 3



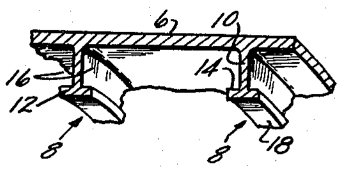


Fig 4

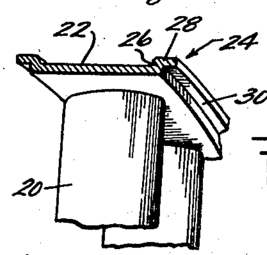
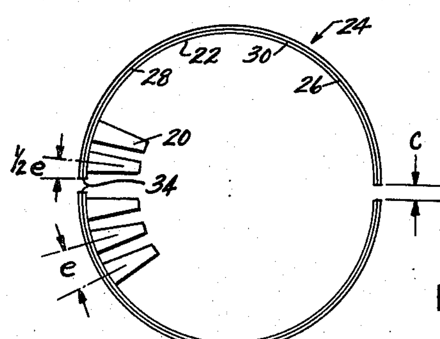


Fig 5



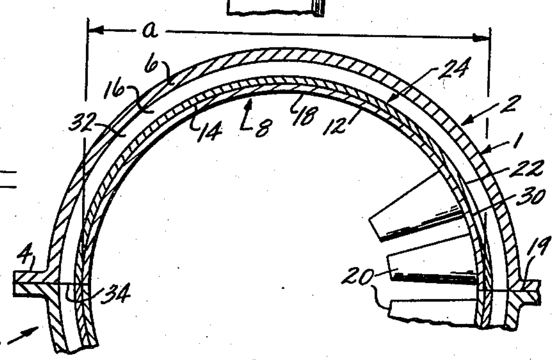


Fig 6

Fig 8

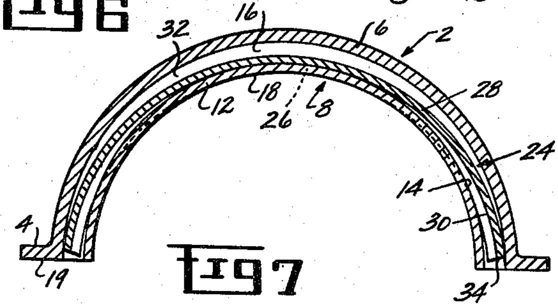


Fig 7

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STATOR VANE HALF RING ASSEMBLIES

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5 Claims. (Cl. 29—156.8)

The present invention relates to a method of making segmental, stator vane ring assemblies for use in compressors and turbines or the like, particularly compressors and turbines used in gas turbine engines.

In application Serial No. 663,297 filed by Oscar E. Ridley and Edward J. Walsh and assigned to the same assignee as this application there is described a stator vane assembly in which the stator vanes of each stage are carried by a flexible stator vane ring made up of two halves. The casing is also made up of two halves and each half of the ring is supported in its half of the casing by means of a semi-annular ring rabbet having a semi-annular supported surface adapted to be supported by a semi-annular supporting surface of a semi-annular casing rabbet. When the unit is assembled and in operation, the two semi-annular halves of the casing rabbet form an annular rabbet having an annular ring supporting surface and the two halves of each ring rabbet supported by such casing rabbet form an annular ring rabbet having an annular supported surface resting against and supported by the annular supporting surface of such casing rabbet. The supported surfaces of the ring rabbets of the flexible half rings are forced against, and conform to the shape of, the annular supporting surface of the casing rabbet, the two half rings thereby being forced into an annular shape with the edges thereof abutting against each other.

An object of the present invention is to provide an improved inexpensive method for manufacturing segmental stator vane ring assemblies of the type described above, which method simplifies and reduces the cost of manufacture and lends itself to mass production techniques.

Briefly stated and in accordance with one aspect of the invention, such method comprises forming a full 360° circular or annular stator vane ring which is relatively flexible as compared to the relatively stiff stator vane casing and casing rabbet. The stator vanes are attached to the full ring and it is cut in at least two places and into at least two segments. The circumference of the annular supported surface of the ring rabbet of the full ring before it is cut into segments is larger than the circumference of the annular supporting surface of the casing rabbet preferably by an amount substantially equal to the sum of the circumferential thicknesses of the cuts. Consequently, when the relatively flexible segments are subsequently inserted in the casing and the supported surfaces thereof are forced into engagement with, and to conform to the contour of, the annular supporting surface of the relatively rigid casing rabbet to thereby force the segments into an annular or circular shape corresponding to the shape of the casing rabbet and cut edges into abutting relationship with each other, the diameter and circumference of the resulting annular or circular supported surface of the ring rabbet is substantially the same as the diameter and circumference of the supporting surface of the casing rabbet.

Put in another way, the diameter of the circular or annular supported surface of the ring rabbet of the full ring before it is cut into segments is larger than the diameter of the circular or annular supporting surface of the casing rabbet by an amount substantially equal to the sum of the circumferential thicknesses of the cuts divided by π.

When the ring is cut into halves it is cut at two places and consequently the circumference of the supported surface of the ring rabbet of the full ring is greater than the circumference of the supporting surface of the casing rabbet by twice the circumferential thickness of each cut.

By making the full ring oversized by an amount equal to the sum of the circumferential thicknesses of the cuts, the material removed by the cutting is compensated for and it is possible to subsequently form from the flexible segments a circular ring in which the cut edge of the segments abut against each other and the circular supported surface of the ring rabbet fits snugly against the circular supporting surface of the casing throughout the circumferential length thereof.

The adjacent vanes between which each cut is to be made are circumferentially spaced further away from each other than the other adjacent vanes by an amount which is equal to the circumferential thickness of the cut so that after the cuts are made and the ring segments are in assembled operating position in the casing these vanes are circumferentially spaced from each other a distance equal to the circumferential spacing between the other vanes.

Other objects and advantages of the method of the present invention will be apparent from the following description and claims and the accompanying drawings all of which describe by way of illustration only and without limitation what is now considered to be a preferred embodiment of the present invention.

Fig. 1 is a partial section in elevation through a compressor stator vane assembly having segmental stator vane ring assemblies made in accordance with the method of the present invention.

Fig. 2 is a section taken along the line 2—2 of Fig. 1 between two adjacent casing rabbets and with the stator vane ring assemblies removed.

Fig. 3 is a side view of the full, oversized stator vane ring prior to cutting it into segments, the locations at which it is to be cut being shown in dotted lines.

Fig. 4 is a view in perspective of a partial section taken along the line 4—4 of Fig. 2.

Fig. 5 is a view in perspective of a section taken along the line 5—5 of Fig. 3.

Fig. 6 is a view similar to Fig. 3 showing the ring after it has been cut.

Fig. 7 is a view taken along the line 7—7 of Fig. 1 showing the position of an upper stator vane half ring after it has been inserted in its half of the casing but before it has been forced into its proper semi-circular shape around the casing rabbet.

Fig. 8 is a view similar to Fig. 7 showing the position of the upper half ring and its corresponding lower half ring in the casing during operation of the turbine when they are forced into proper circular shape around the casing rabbet.

Referring to the figures, **1** comprises a stator vane casing made up of an upper half **2** and a lower half **3** connected together by bolts (not shown) passing through the abutting flanges **4**.

Each of the halves of the casing is made up of a relatively thin semi-cylindrical casing wall **6** having a plurality of spaced T-shaped rabbets **8** extending radially inwardly thereof and circumferentially therearound. Each T-shaped rabbet comprises a stem **10** which extends into flange or tongue portions **12** forming the web of the T and extending at right angles from the stem **10** in opposite axial directions. Each tongue has a radially outwardly facing supporting surface **14** and forms with stem **10** and casing shell **6** a recess **16** so that each rabbet has a pair of recesses **16** on opposite sides thereof. Surface **18** of the web of rabbet **8** faces radially inwardly and forms part of the gas passage through the unit. When the halves of the casing are assembled, as shown, the edges **19** thereof abut against each other as shown in Fig. 8 and the semi-annular rabbets **8** of the casing halves form annular rabbets having annular supporting surfaces **14** of a diameter equal to *a* as shown in Figs. 2 and 8.

A plurality of stages or rows of stator vanes **20** are mounted on a plurality of flexible half rings **22** made up of a thin flexible and resilient steel as compared to the rigid material and construction of the casing and casing rabbets. Each half ring is in turn mounted in its casing half in spaced relationship with casing wall **6** by means of a pair of offset, semi-annular rabbet portions **24**, which are located along opposite sides of the half ring **22**, each of which comprises a portion **26** extending radially outwardly and a portion **28** extending in an axial direction from portion **26** and which are received in oppositely facing recesses or spaces **16** of adjacent casing rabbets **8**, as shown in Figs. 1 and 8, with the radially inwardly facing supported surfaces **30** of the portions **28** thereof engaging, and supported by, the radially outwardly facing supporting surfaces **14** of the adjacent casing rabbets **8**. The casing rabbet recess is radially wider than the thickness of portion **28** (Fig. 1).

During operation, the supported surfaces **30** of the half rings are held against the supporting surfaces **14** of the casing rabbets thereby forcing the flexible half rings to conform to the circular shape of the supporting surfaces of the more rigid casing rabbets with the edges **34** of the upper and lower half rings abutting against each other as shown in Fig. 8 in the same plane that the edges **19** of the casing halves abut against each other. Thus, the half rings form full rings and the semi-annular ring rabbets form annular ring rabbets which have circular supported surfaces **30** of diameters substantially equal to the diameters of the supporting surfaces **14** against which they are snugly held.

Keys (not shown) are associated with the edges **19** and **34** to lock the ring halves from rotating in the casing.

The above construction is described in detail in the above mentioned application, it being especially adapted for use in small compressors and turbines used in small engines of the type described in U.S. application Serial No. 548,987, filed by G. W. Lawson on November 25, 1955, and assigned to the same assignee as this application.

The present invention provides a novel inexpensive method of making the half ring assemblies.

In accordance with the present invention a 360° full ring **36** (Fig. 3) is formed out of flexible, resilient material and a plurality of vanes **20** are mounted on it. The diameter of the circular supported surface **30** of this full ring is indicated as *b* in Fig. 3. Thereafter the full 360° ring **36** is cut at **38** into halves **22**, the thickness of each cut being indicated as *c* and being exaggerated in Figs. 3 and 6. Fig. 6 shows the two half rings **22** which are obtained. The circumferential thickness of the material removed by each cut is the same as the thickness of the cut. In the drawings since the full ring is cut into two halves there are two cuts whereas if the number of the segments was four there would be four cuts, the number of cuts therefore depending on the number of segments into which the ring is cut. The greater the number of cuts the greater the total amount of material removed by the cuts.

The circumference of the circular supported surface **30** of each ring rabbet of the full ring **36** before it is cut and hence before any material is removed therefrom by the cuts is larger than the circumference of the circular supporting surface **14** of the casing rabbet **8** of the assembled casing halves by an amount equal to the sum of the circumferential thicknesses *c* of the cuts. Consequently, when each half of the cut ring is placed in the casing half and the semi-annular surfaces **30** thereof are forced into engagement with, and to conform to the contour of, the supporting surfaces **14** after the halves of the casing are assembled, the cut edges **34** are forced into abutting relationship with each other as shown in Fig. 8 and the surfaces **30** of the two half rings form circular surfaces having substantially the same circumference and diameter as the surface **14**. Thus, where K_2 is the circumference of the surface **30** of the full ring, K_1 is the circumference of the surface **14**, *n* is the number of cuts and *c* is the circumferential thickness of each cut, K_2 is substantially equal to K_1+nc.

In terms of diameter the diameter of the surface **30** of the full ring **36** is larger than the diameter of the surface **14** by an amount equal to the sum of the circumferential thicknesses of the cuts divided by π, or *b* is substantially equal to

$$a+\frac{nc}{\pi}$$

Furthermore, in the full ring **36** the circumferential distance *d* (Fig. 3) between the two vanes **20** between which each saw cut is to be made is greater than the circumferential distance *e* between the other vanes by an amount which is equal to the circumferential thickness of the saw cut so that after the ring has been cut and the two halves are inserted in the casing halves and are forced to conform to the circular shape of the supporting surfaces of the casing rabbets with their cut edges abutting against each other, the distance between these two vanes is the same as the distance between the other vanes.

Each half of the cut ring is inserted into place in its casing half by inserting one end of the half ring into one end of the space **32** with the rabbets **24** of the ring being inserted into the oppositely facing recesses **16** of adjacent rabbets **8**, whereafter the flexible and resilient half ring is slid circumferentially around the recesses and space into the position shown in Fig. 7. The flexibility of the half ring permits it to be bent sufficiently to be so inserted and the resiliency thereof causes the ends of the ring to spring outwardly as shown in Fig. 7. After all the half rings are in place the two halves of the casing are bolted together.

Means are provided (not shown) so that at least during operation the surfaces **30** of the half rings are yieldably forced into engagement with the supporting surfaces **14** of the casing rabbets so as to closely conform thereto whereupon the cut edges **34** of the two half rings are forced into abutting relationship with each other as shown in Fig. 8 to form a complete circular ring, the circular ring rabbet surfaces **30** of which have a diameter substantially equal to the diameter *a* of the circular casing rabbets **8**. One convenient way of doing this is by means of air or other gas under pressure in the spaces **32**. In the case of a compressor this can be done by means of bleed holes in the downstream portion of the rings leading from the main compressor gas passage into the spaces **32**, such spaces being made otherwise substantially gastight. Such a construction is described in application Serial No. 629,075, filed by Robert M. Oppenheimer on December 18, 1956, and assigned to the same assignee as the present application.

The preferred embodiment of the present invention requires a flexible ring because if a rigid, oversized 360° ring is used the cut halves thereof will not subsequently take on the contour of the casing rabbet supporting surfaces. However, when the ring is flexible, the cut segments can be forced into a circular shape conforming to the contour of the casing rabbet supporting surface although the full ring originally has a different diameter. These thin, flexible and resilient rings are advantageous because of their light weight. In small engines this is an important factor.

The method of the present invention provides an inexpensive and easy way to make segmental, stator vane ring assemblies as compared to methods in which each segment must be made, and hence machined, separately.

Although in the drawings the ring is separated into halves and hence requires two cuts **38**, it may be separated into any number of segments. However, the greater the number of segments, the greater the number of cuts required. Consequently, the sum of the circumferential thicknesses of such cuts is increased and the diameter of the full ring **36** must be increased accordingly.

The terms "circular" and "annular" as referred to herein with respect to supporting surface **14** and supported surface **30** include embodiments in which the tongues **12** and the rabbet portions **28** are notched so that such surfaces are not continuous.

The circumference of circular surface **30** in the assembled unit is equal to the circumference of the surface **14** when the two surfaces are in intimate contact with each other along their circumferential lengths, which is the most desirable arrangement. In practice, however, it is sometimes difficult to achieve this intimate contact so that these circumferences are not always exactly equal. However, so long as they are substantially equal the construction is satisfactory. The same applies to the circularity of the various parts.

I claim:

1. A method of making a segmental stator vane ring adapted to be supported in a stator vane casing by a substantially circular supporting surface of a substantially circular casing rabbet associated with said casing, said method comprising forming a substantially circular, flexible ring having a substantially circular ring rabbet with a substantially circular supported surface, cutting said circular ring in at least two places and into at least two segments, the diameter of said supported surface before said ring is cut into segments being larger than the diameter of said supporting surface by an amount equal to substantially the sum of the circumferential thicknesses of said cuts divided by π, inserting said flexible segments in said casing and forcing the supported surfaces thereof into engagement with, and to conform to the contour of, said supporting surface of said casing rabbet.

2. A method of making a segmental stator vane ring adapted to be supported in a stator vane casing by a substantially circular supporting surface of a substantially circular casing rabbet associated with said casing, said method comprising forming a substantially circular, flexible ring having a substantially circular ring rabbet with a substantially circular supported surface, cutting said ring in at least two places and into at least two segments, the circular supported surface of said ring before it is cut having a circumference greater than the circumference of said supporting surface of said casing rabbet by an amount equal to the sum of the circumferential thicknesses of said cuts, inserting said flexible segments in said casing, and forcing the supported surfaces thereof into engagement with, and to conform to the contour of, said supporting surface of said casing rabbet.

3. A method according to claim 2 wherein said flexible segments are forced into a circular shape with the cut edges thereof abutting against each other.

4. A method according to claim 3 wherein said supported surfaces of said flexible ring segments are forced into a circular shape having a diameter substantially equal to the diameter of the supporting surface of the casing rabbet.

5. A method according to claim 2 wherein a plurality of vanes are assembled on said ring before it is cut into segments, the distance between the adjacent vanes which are to be separated by each cut being greater than the distance between the other vanes by an amount equal to the circumferential thickness of the cut, whereby in the assembled segmental ring, said vanes are spaced from each other a distance equal to the distance between said other vanes.

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