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TURBINE SHROUD SUPPORT STRUCTURE

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Fig 1

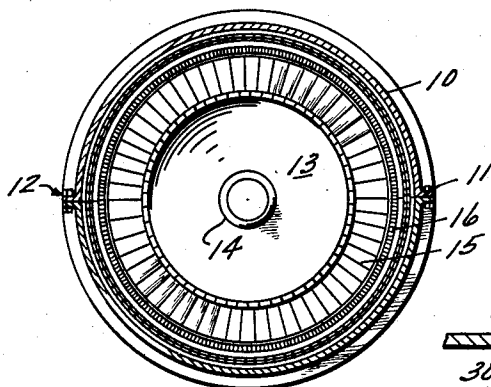


Fig 3

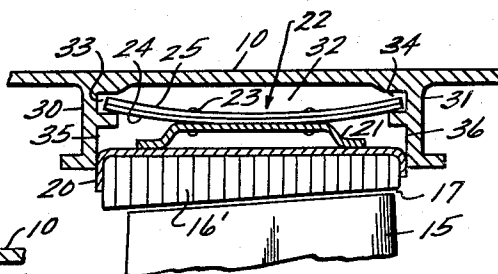
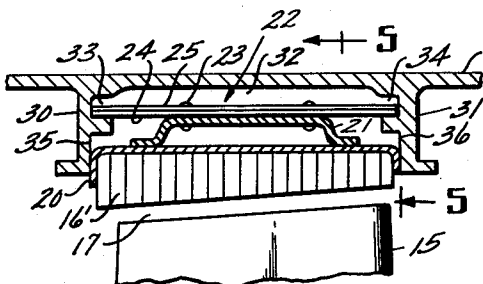
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Fig 4

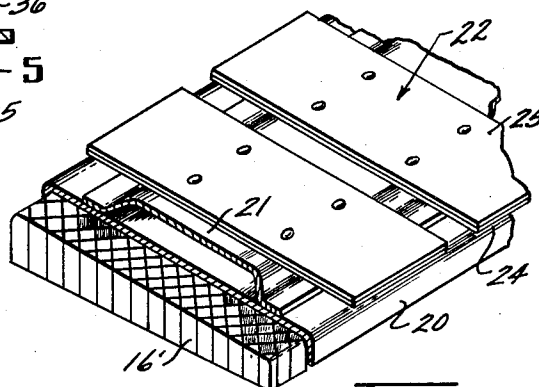


Fig 5

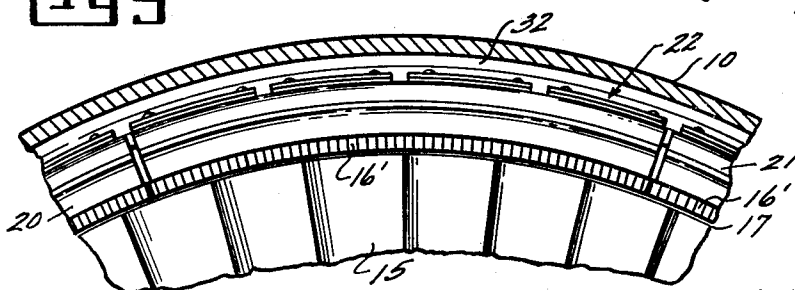


Fig 2



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TURBINE SHROUD SUPPORT STRUCTURE
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This invention relates to a shroud ring structure for a turbine and, more particularly, to an improved shroud ring support structure for providing desired clearances between the shroud ring and the tips of the buckets of an associated turbine wheel.

Conventional shroud rings are supported in the turbine casing such that the casing and the shroud ring expand and contract as an integral unit in response to changes in operating temperatures. The casing and shroud ring assembly, which has substantially less mass than the turbine wheel, responds to changes in turbine operating temperature at a more rapid rate than the turbine wheel. Due to the difference in expansion and contraction rates, the clearance between the shroud ring and the bucket tips varies under different operating conditions. Since it is desirable to prevent rubbing between the shroud ring and the turbine wheel, the turbine is generally designed to avoid rubbing at the most extreme condition of relative thermal expansion and contraction which may be encountered. The most severe condition occurs during a rapid shut-down, or, in the case of a gas turbine engine, "throttle chop," when the shroud ring contacts very rapidly. It is therefore necessary with conventional shroud structures to provide a relatively large clearance at the normal operating condition of the turbine in order to prevent rubbing during a rapid shutdown. An abradable shroud ring is sometimes used to permit intentional rubbing during shut-down, but this expedient does not avoid increased clearances during subsequent engine operation at the normal operating temperatures.

With such conventional shroud ring structures, the clearance necessary to prevent rubbing may be sufficient to cause poor efficiency by allowing excessive leakage of operating fluid around the bucket tips. Recognizing this problem, efforts have been made in the past to provide shroud ring support structures for maintaining both the desired minimum tip clearance at the normal operating condition of the turbine and a clearance sufficient to prevent rubbing during a rapid shut-down. To obtain such clearance at the various operating conditions, the shroud ring must be moved relative to the casing in an inward direction to provide the minimum tip clearance at the normal turbine operating condition and in an outward direction to prevent rubbing during engine shut-down. In other words, the casing and shroud ring are no longer allowed to expand and contract as an integral unit. The clearances may be obtained by means of a control system which positions the shroud ring in accordance with changes in a selected engine operating parameter such as, for example, temperature. For certain engine applications, such a control system is undesirable, although it may be extremely accurate in maintaining the desired clearances, since it greatly increases both the expense of manufacturing the engine and the complexity of the completed engine. It also has been proposed in the past to obtain the desired clearances by means of shroud support members of a material having a higher coefficient of linear expansion than the casing material. The support members move the shroud ring inwardly relative to the casing in response to an increase in temperature as the expanding casing moves outwardly relative to the bucket tips. Similarly, the shroud ring moves outwardly relative to the casing when the temperature decreases. As a practical matter, however, it is difficult to obtain the necessary movement relative to the casing since the diameter of the casing is

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much greater than the space between the shroud ring and the casing in which the support members are conventionally located. Therefore, the support members must have an extremely high coefficient of expansion, which is not easily attained, or must extend outwardly through the engine casing in order to obtain the length necessary for the desired movement. In view of these difficulties, support members of this kind are not normally used.

Accordingly, it is an object of this invention to provide means for maintaining desired clearances between a shroud ring and the tips of the associated turbine buckets at different operating conditions of the turbine.

Another object of this invention is to provide means for maintaining both a desired minimum tip clearance at the normal operating condition of the turbine and a clearance sufficient to prevent rubbing during a rapid turbine shut-down.

A further object of this invention is to provide simple and inexpensive means for maintaining desired tip clearances which neither adds to the expense of manufacturing the turbine nor increases substantially the complexity of the turbine.

Briefly stated, in accordance with an illustrated embodiment of the invention, bimetallic thermal support strips are provided for maintaining desired clearances between a circumferentially extending segmented shroud ring and the tips of a row of turbine buckets. The bimetallic support strips are supported by their ends in the space between the segmented shroud ring and the casing, each strip being positioned with its layer having the lower coefficient of expansion adjacent the casing. The unsupported center portion of each bimetallic support strip is connected to a respective one of the shroud ring segments. With increasing turbine operating temperature, the bimetallic support strips deflect to move the shroud ring segments inwardly relative to the casing. Similarly, the bimetallic support strips deflect to move the shroud ring outwardly relative to the casing with decreasing temperature.

While the invention is distinctly claimed and particularly pointed out in the claims appended hereto, the invention, both as to organization and content, will be better understood and appreciated, along with other objects and features hereof, from the following detailed description taken in conjunction with the drawing, in which:

FIGURE 1 is an end view of an axial flow turbine utilizing this invention;

FIGURE 2 is a fragmentary pictorial view of a shroud assembly including as a part thereof the bimetallic support element of this invention;

FIGURE 3 is a view of the shroud assembly of FIGURE 2 mounted in the turbine casing;

FIGURE 4 is a view similar to FIGURE 3 showing the shroud assembly in a moved position; and

FIGURE 5 is a view taken along line 5—5 of FIGURE 4.

Referring now to the drawing, an axial flow turbine is illustrated in FIGURE 1. The turbine, which is of a lightweight type particularly suited for use in aircraft gas turbine engines, has a casing 10 which is preferably split as shown along a horizontal line 11 into halves in order to facilitate assembly and disassembly of the turbine. The casing halves are joined to form the unitary casing 10 by means of a flange and bolt connection indicated generally at 12. A turbine wheel 13 having a plurality of radially extending turbine buckets 15 secured to its periphery in a well known manner is rotatably mounted in the casing 10, the turbine wheel 13 driving a shaft 14. A shroud ring 16 comprised of a plurality of circumferentially extending arcuate segments 16', as best shown in FIGURE 5, is supported in the casing 10 in circumferentially spaced relation to the tips of the turbine buckets 15. In this description, the space 17 between the shroud ring

16 and the tips of the turbine buckets 15 will be referred to as either the "clearance" or the "tip clearance."

Referring now to FIGURES 2 through 5, each of the arcuate shroud ring segments 16', which may be fabricated if desired from an abradable material such as the honeycomb material illustrated, is provided with a backing plate 20 having a mounting bracket 21 mounted thereon. At least one, and preferably several as shown in FIGURE 3, bimetallic support elements or strips 22 are secured to the mounting bracket 21 by rivets 23 or other suitable fastening means. Each of the bimetallic support strips 22 is comprised of two layers 24 and 25 having different coefficients of thermal expansion bonded or otherwise suitably joined together so as to react as a unitary structure in response to changes in temperature. The bimetallic support strip 22 is fastened to the mounting bracket 21 by the rivets 23 with the layer 24 having the higher coefficient of thermal expansion adjacent the mounting bracket 21. The action of the bimetallic support strips 22 in response to changes in temperature will be described in detail at a later point in this description.

Turning to FIGURES 3 and 4 in particular, it will be seen that the turbine casing 10 has circumferentially extending flanges 30 and 31 which extend radially inwardly from the casing 10 to form with the casing a circumferential channel 32. The upstream flange 30 and the downstream flange 31 are provided with circumferentially extending grooves 33 and 34, respectively, opening into the channel 32. The shroud ring segments 16' are positioned in the channel 32 with the ends of each of the bimetallic support strips 22 received in the grooves 33 and 34. The backing plate 20 is slidably engaged between the downstream face 35 of the upstream flange 30 and the upstream face 36 of the downstream flange 31, the flanges thereby permitting radial movement of the shroud ring segments 16' while preventing axial movement relative to the centerline of the turbine.

As described previously, the bimetallic support strips 22 are comprised of two layers 24 and 25 having different coefficients of thermal expansion. The layers 24 and 25 are bonded or otherwise suitably secured together to react as a unitary structure in response to changes in temperature. Since the layers are not free to move relative to each other, the support strip 22 will change its shape when heated or cooled. The support strip 22, its layers 24 and 25 having been secured together at a specific reference temperature to form a flat structure, will bend into a curve whenever the temperature is varied from the reference temperature, the transverse motion of the support strip 22 being very much larger than the change in length of either of the layers 24 and 25. The actual selection of materials for the layers 24 and 25 in any particular application will depend upon a number of factors such as, for example, the amount of deflection desired and the ability of the materials selected to withstand the high turbine temperatures.

Referring specifically to FIGURE 3, the arcuate shroud ring segment 16' is shown in its position for normal turbine operating conditions. With the layer 25 having the lower coefficient of thermal expansion adjacent the casing, the high turbine operating temperatures cause the bimetallic element 22 to deflect into the position shown. With the ends of the support element 22 secured in the circumferential grooves 33 and 34, only the center of the element 22 is free to move, the bimetallic support element 22 thereby moving the shroud ring segment 16' inwardly relative to the casing with increasing temperature. With the shroud ring segment 16' positioned as shown, the turbine operates efficiently since the clearance 17 between the shroud ring segment 16' and the tips of the turbine buckets 15 is quite small.

Assuming now that the turbine is rapidly shut-down, it will be clear that the casing 10 will contract at a greater rate than the turbine wheel 13 because of its much smaller mass. If the shroud ring 16 were constrained to contract integrally with the casing 10 as in conventional struc-

tures, the shroud ring segments 16' would move into rubbing contact with the tips of the turbine buckets 15. Even if the segments 16' are fabricated of abradable material as shown, inefficient operation would thereafter result because of increased tip clearance 17 at normal operating conditions. The bimetallic support strips 22 of this invention eliminate rubbing by moving the shroud ring 16 in response to temperature changes independently of the casing 10 and in an opposite direction. When the temperature drops, the bimetallic support strips 22 react to the change by deflecting to the flat position shown in FIGURE 4, thereby increasing the tip clearance 17. The casing 10 can therefore contract relative to the turbine wheel 13 without resulting in rubbing contact between the shroud ring 16 and the tips of the turbine buckets 15. When the turbine is again returned to its normal operating condition, the bimetallic support strips 22 will return the shroud segments 16' to the position shown in FIGURE 3 to provide a minimum tip clearance.

It is thus seen that the bimetallic support elements of this invention provide simple and inexpensive means for maintaining both a desired minimum tip clearance at the normal operating condition of the turbine and a clearance sufficient to prevent rubbing during a rapid turbine shut-down.

While the invention is particularly applicable for use in high temperature turbines and has been so described, it will be obvious to those skilled in the art that the invention may likewise be practiced in connection with other turbomachines which are subjected to substantial temperature variations, such as axial flow compressors. It will also be understood that the invention is not limited to the specific details of construction and arrangement of the embodiment illustrated and described herein. It is intended to cover in the appended claims all such changes and modifications which may occur to those skilled in the art without departing from the true spirit and scope of the invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In a turbomachine, a cylindrical casing, a turbine wheel rotatably mounted in said casing, a row of radially extending turbine buckets peripherally mounted about said turbine wheel, a shroud ring circumferentially surrounding said row of turbine buckets in spaced relation thereto, said shroud ring comprised of a plurality of separate circumferentially extending arcuate segments, a plurality of bimetallic support strips mounted in said casing, said bimetallic support strips each comprised of two layers having different coefficients of thermal expansion, means connecting the center portion of each of said bimetallic support strips to a respective one of said arcuate shroud segments, said bimetallic support strips disposed so as to deflect with temperature changes to move said arcuate shroud segments inwardly relative to said casing with increasing turbine operating temperature and outwardly with decreasing temperature.

2. In a turbomachine, a cylindrical casing, a turbine wheel rotatably mounted in said casing, a row of radially extending turbine buckets peripherally mounted about said turbine wheel, a shroud ring circumferentially surrounding said row of turbine buckets in spaced relation thereto, said shroud ring comprised of a plurality of separate circumferential extending arcuate segments, first and second circumferentially extending flanges extending radially inwardly from said casing and forming therewith a circumferential channel surrounding said shroud ring, a plurality of bimetallic support strips, said bimetallic support strips, said bimetallic support strips each comprised of two layers having different coefficients of thermal expansion, each of said bimetallic support strips mounted between said flanges so that the center of the support strip spans said channel with the layer having the lower coefficient of thermal expansion adjacent said casing, means connecting the center portion of each of

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said bimetallic support strips to a respective one of said arcuate shroud segments, whereby said bimetallic support strips are deflected to move said arcuate shroud segments inwardly relative to said casing with increasing turbine operating temperature and outwardly with decreasing temperature.

3. In a turbomachine, a cylindrical casing, a turbine wheel rotatably mounted in said casing, a row of radially extending turbine buckets peripherally mounted about said turbine wheel, a shroud ring circumferentially surrounding said row of turbine buckets in spaced relation thereto, said shroud ring comprised of a plurality of separate circumferentially extending arcuate segments, first and second circumferentially extending flanges extending radially inwardly from said casing and forming therewith a circumferential channel surrounding said shroud ring, a first circumferentially extending groove in said first flange opening into said channel, a second circumferentially extending groove in said second flange opening into said channel, said first and second grooves being in radial alignment, a plurality of bimetallic support strips, each of said bimetallic support strips comprised of two layers having different coefficients of thermal expansion, the ends of each of said bimetallic support strips being received in said first and second grooves so that the center of the support strip spans said channel with the layer having the lower coefficient of thermal expansion adjacent said casing, means connecting the center portion of each of said bimetallic support strips to a respective one of said arcuate shroud segments, whereby said bimetallic support strips are deflected to move said arcuate shroud segments inwardly relative to said casing with increasing turbine operating temperature and outwardly with decreasing temperature.

4. In a turbomachine, a cylindrical casing, first and second circumferentially extending flanges extending ra-

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dially inwardly from said casing and forming therewith a circumferential channel, a cylindrical shroud ring positioned radially inward of said channel, said shroud ring comprised of a plurality of separate circumferentially extending arcuate segments, a first circumferentially extending groove in said first flange opening into said channel, a second circumferentially extending groove in said second flange opening into said channel, said first and second grooves being in radial alignment, a plurality of bimetallic support strips, each of said bimetallic support strips comprised of two layers having different coefficients of thermal expansion, the ends of each of said bimetallic support strips being received in said first and second grooves so that the center of the support strip spans said channel with the layer having the lower coefficient of thermal expansion adjacent said casing, means connecting the center portion of each of said bimetallic support strips to a respective one of said arcuate shroud segments, whereby said bimetallic support strips are deflected to move said arcuate shroud segments inwardly relative to said casing with increasing temperature and outwardly with decreasing temperature.

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