

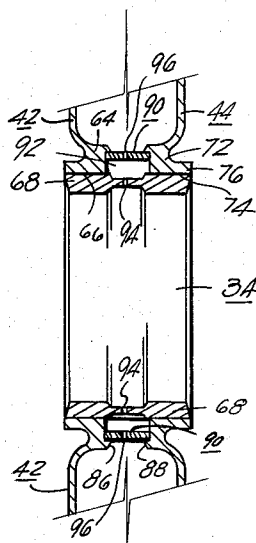
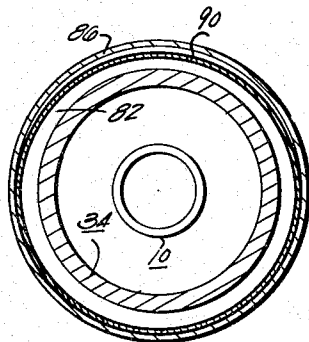
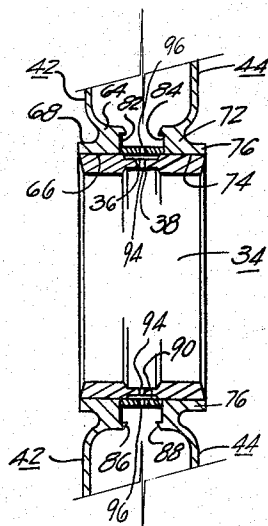
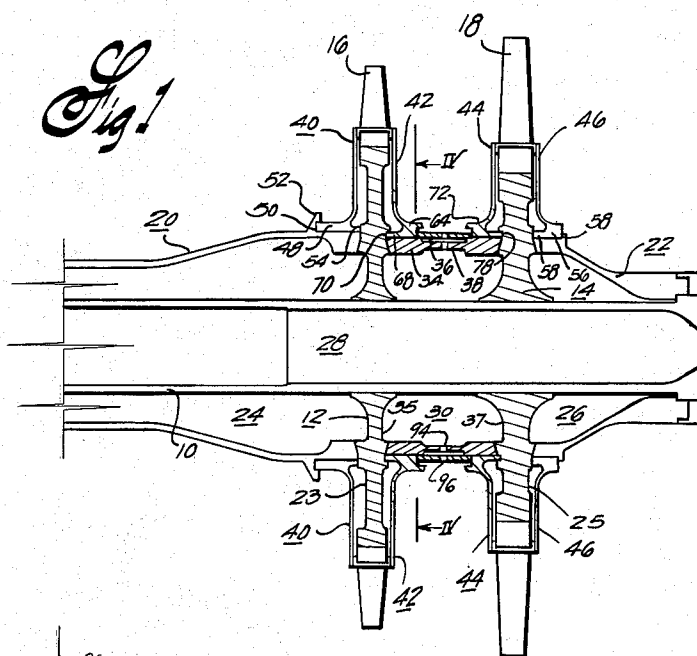
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HEAT SHIELD

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HEAT SHIELD

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This invention relates to heat shields and more particularly to a heat shield for the rotor discs and shafts of a multi-stage gas turbine engine or the like.

Heretofore, great difficulty has been experienced in designing a heat shield for turbine rotor discs and shafts which would not rupture or fail in operation. These heat shields usually took the form of a hoop or ring which extended between and was rigidly connected to the opposing faces of adjacent rotor discs. During the operation of the turbine, the heat shield would undergo a thermal expansion but would not expand symmetrically, i.e., one part or portion of the shield would experience a substantially greater radial expansion than the remainder thereof. This unsymmetrical expansion would of course produce high localized bending stresses which eventually would result in the failure or rupture of the shield.

The present invention contemplates a heat shield which will operate stresswise as a free or floating ring and thus will not be subjected to high localized stresses. The heat shield in its preferred embodiment takes the form of a hoop or ring which is carried by a coupling shaft connecting adjacent stage rotor discs. Space for thermal expansion of the hoop is provided by a pair of annular recesses in cooling plates operatively connected to the opposing faces of adjacent rotor discs and the annular recesses are each bound by an annular flange. The annular recesses are of sufficient size to permit the hoop to operate at the lowest possible stress, that of a free hoop, and the annular flanges serve to limit the unbalance introduced into the rotor by the thermal expansion of the hoop to a predetermined and permissible quantity.

Accordingly, one object of the present invention is to prevent the failure of a rotor disc heat shield as a result of the thermal expansion thereof.

Another object of the invention is to provide a heat shield which operates at the lowest possible stress.

Another object of the invention is to limit the unbalance introduced into a rotor by the thermal expansion of a heat shield.

These and other objects of the invention will become readily apparent from the following detailed description of a preferred embodiment thereof taken in connection with the accompanying drawings, wherein:

FIG. 1 is a side elevation in section of a turbine rotor assembly embodying the present invention;

FIG. 2 is an enlarged section of a detail of the turbine rotor assembly with the heat shield shown in its fully contracted position;

FIG. 3 is another enlarged section of a detail of the turbine rotor assembly with the heat shield shown in its fully expanded position; and

FIG. 4 is a transverse section taken substantially along the line IV—IV of FIG. 1 and showing the heat shield in an unbalanced state due to the unsymmetrical expansion thereof.

Referring more particularly to FIG. 1, there is shown a two-stage rotor assembly including a hollow turbine shaft 10 which carries or mounts a pair of axially spaced rotor discs, a first stage rotor disc 12 and a second stage rotor disc 14. The discs 12 and 14 are rigidly connected to the shaft 10 by any suitable means (not shown) such as a spline or a shrink fit and are adapted to rotate with

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the shaft 10 about a fixed axis of rotation. Blades or vanes 16 and 18 are mounted on the peripheries of rotor discs 12 and 14, respectively, and when impinged by high temperature gases or the like flowing past the rotor assembly impart rotation to shaft 10 through the discs 12 and 14. The blades 16 and 18 likewise are rigidly connected to the peripheries of discs 12 and 14 by any suitable means (not shown), the particular type of connection for attaching the blades 16 and 18 to the discs 12 and 14 as well as the type of connection for mounting the discs 12 and 14 on the shaft 10 forming per se no part of the present invention.

Shaft 10 is partially enclosed by a pair of housings 20 and 22 which are attached to the outside faces 23 and 25 of rotor discs 12 and 14 respectively, by any suitable means (not shown) and are supported by bearings (not shown) for rotation with the discs. Housings 20 and 22 are spaced from shaft 10 and thus define passageways or jackets 24 and 26 for a suitable cooling medium. The cooling medium may be supplied under pressure from any suitable source (not shown) and is adapted to flow through both jackets 24 and 26 as well as through the hollow interior 28 of shaft 10. Passages (not shown) in the rotor discs 12 and 14 permit the flow of the cooling medium through the space 30 between the discs and thus establish communication between the jackets 24 and 26.

Rotor discs 12 and 14 are connected or united intermediate their connections to shaft 10 and their outer peripheries by a hollow coupling shaft 34. The ends of coupling shaft 34 are attached or anchored to the inside or opposing faces 35 and 37 of discs 12 and 14, respectively, by any suitable means (not shown), the specific means of attachment forming per se no part of the present invention. Coupling shaft 34 is reduced in cross-section intermediate the ends thereof by a pair of opposed peripheral recesses 36 and 38.

The face portions of rotor discs 12 and 14 exterior of housings 20 and 22 and coupling shaft 34 are protected from a direct exposure to hot gases by a plurality of annular cooling plates 40, 42, 44 and 46. Cooling plate 40 is carried by the housing 20 and includes a hub portion 48 which is connected to both the housing 20 and the disc 12. One end of the hub portion 48 is received in an annular recess 50 in a projecting flange 52 on housing 20 to thereby provide a mechanical interlock between the cooling plate 40 and housing 20. The opposite end of hub portion 48 terminates in an annular flange 54 which is connected or anchored to the outside face 23 of rotor disc 12 by any suitable means (not shown), the connecting means of course providing an effective seal between the flange 54 and the face 23 of the disc. Similarly, cooling plate 46 is carried by the housing 22 and includes a hub portion 56 which is connected to both housing 22 and rotor disc 14. One end of hub portion 56 is adapted to abut an annular flange 58 on the periphery of housing 22 and is connected to the flange 58 by any suitable means such as welding or brazing. The opposite end of hub portion 56 terminates in an annular flange 58 which is operatively connected to the outside face 25 of disc 14 by any suitable means (not shown), the connection between flange 58 and the face 25 of disc 14 providing an effective seal.

Referring to FIGS. 1, 2 and 3, it can be seen that the annular cooling discs 42 and 44 cover the opposing or inside faces 35 and 37 of rotor discs 12 and 14, respectively, and are both carried by coupling shaft 34. Cooling plate 42 includes a hub portion 64 which is provided with a bore 66 therein that is adapted to tightly fit the outer periphery of coupling shaft 34 to thereby connect the cooling plate 42 to the coupling shaft. Hub portion 64

terminates in a flange portion 68 at one end thereof which is adapted to seat within an annular recess 70 in the inside face 35 of disc 12 to thereby provide a mechanical interlock between the disc 12 and cooling plate 42. Cooling plate 44 similarly includes a hub portion 72 which is provided with a bore 74 therein that is correspondingly adapted to tightly fit the outer periphery of coupling shaft. Hub portion 72 terminates also at one end thereof in a flange portion 76 which is adapted to seat within an annular recess in the inside face 37 of disc 14 to thereby provide a mechanical interlock between the cooling plate 44 and the rotor disc.

As best seen in FIGS. 2 and 3, the opposing faces of the hub portions 64 and 72 of the cooling plates 42 and 44 are rabbeted, or stated in another manner, are provided with counterbores 82 and 84, respectively, therein which define a pair of opposed annular flanges 86 and 88 on the opposed hub portions 64 and 72. The counterbores 82 and 84 in combination with the peripheral surface of coupling shaft 34 and the opposed annular flanges 86 and 88 thus provide a pair of opposed annular recesses in the opposing hub portions 64 and 72.

The opposed counterbores or annular recesses 82 and 84 are adapted to provide space to accommodate the thermal expansion and contraction of the heat shield of the present invention, which in this instance takes the form of a ring or hoop member 90. The hoop member 90 is carried on the outer periphery of coupling shaft 34 and is constructed so that in a cold or unexpanded state, it snugly fits the outer periphery of shaft 34. The hoop member 90 is also of sufficient width to establish small clearances between the ends thereof and the opposed faces of the counterbores 82 and 84 when transversely or axially expanded and the end walls or end surfaces of the hoop member are sufficiently "square" in order to insure effective close clearances between the hoop member and the opposed faces of the counterbores. This feature precludes the establishment of axial compressive stresses in the hoop member that would result if it expanded axially into contact with the opposing counterbores. A small quantity of cooling medium is bled under pressure into the space 92 (FIG. 3) between the coupling shaft 34 and the heat shield 90 through a plurality of small holes or passages 94 (only two shown) in the coupling shaft 34 and out through the close clearances at the ends of the heat shield 90 and also through a plurality of small holes or passages 96 (only two shown) in the heat shield 90. The presence of the pressurized cooling medium in space 92 eliminates the possibility of any hot gases entering the space between the heat shield 90 and the coupling shaft 34. The hoop member is preferably made of sheet metal and in this particular embodiment is made of a suitable corrosion-resistant, high temperature steel, although it will be readily apparent to those skilled in the art that any other suitable material could be successfully employed.

In operation, referring to FIGS. 2, 3 and 4, the heat shield or hoop member 90 will radially expand more than the coupling shaft 34 due to its greater thermal expansion and due to its operation as a free hoop. The hoop member will radially expand in the space provided by the opposed counterbores 82 and 84 and is capable of expanding from its fully contracted position shown in FIG. 2 to its fully expanded position shown in FIG. 3 wherein it is in peripheral engagement with the opposed flanges 86 and 88 on hub portions 64 and 72. Whether in its fully contracted or fully expanded position, the hoop member will engage the opposed surfaces of counterbores 82 and 84 with close clearance and will thus effectively shield the coupling shaft 34 and a portion of the inside faces 35 and 37 of rotor discs 12 and 14 from a direct exposure to the hot and corrosive gases flowing past the turbine rotor assembly.

In the event the radial expansion of hoop member 90 is unsymmetrical or produces a greater displacement or expansion in one portion of the hoop member than in

another, as is shown in FIG. 4 wherein only one half or 180° of the hoop member has expanded into contact with the flanges 86 and 88, the amount of displacement of this portion will be limited by the flanges 86 and 88 on the cooling plates 42 and 44. Maximum unbalance in the hoop member 90 occurs with this unsymmetrical expansion. However, any further thermal expansion of the hoop member 90 will then produce an expansion in the diametrically opposed or opposite side of the hoop member to thus decrease the unbalance due to the initial unsymmetrical expansion.

Thus, by closely fitting the hoop member 90 on the coupling shaft 34 when in an expanded state and permitting its expansion, as a free hoop under thermal and dynamic loads, the hoop member is permitted to operate at the lowest possible stress, that of a free hoop, hence eliminating the development of high localized bending stresses within the member. At the same time, by limiting the possible unsymmetrical displacement of the hoop member by the pair of opposed flanges 86 and 88, the unbalance introduced in the rotor by said displacement is limited to a permissible and predetermined quantity.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In a multi-stage turbine adapted to be driven by hot gases or the like, a rotatable shaft, first and second stage rotor discs carried by said rotatable shaft and spaced axially therealong, a coupling shaft connecting said first and second stage rotor discs intermediate said rotatable shaft and the outer peripheries thereof, radial cooling plates operatively connected to said rotor discs and being operable to shield the opposing faces of said rotor discs outward of said coupling shaft, each of said radial cooling plates shielding the opposing faces of said rotor discs having a hub portion engaging said coupling shaft with each of said hub portions having a counterbore therein defining an annular flange on each hub portion, and a hoop member carried by said coupling shaft and extending between said counterbores in said hub portions of said radial cooling plates to thereby shield said coupling shaft and a portion of said rotor discs against a direct exposure to said hot gases, said counterbores in said hub portions constructed and arranged to permit thermal expansion of said hoop member whereby said hoop member operates as a free ring stresswise, said hoop member being dimensioned to closely fit said coupling shaft when in an unexpanded state and said flanges being so constructed as to limit the thermal expansion of said hoop member to a predetermined amount to thereby limit the unbalance introduced into the hoop member as a result of an unsymmetrical thermal expansion thereof.

2. In a multi-stage turbine as claimed in claim 1 wherein said hoop member is made of sheet metal.

3. In a high temperature gas turbine having a rotatable shaft with a plurality of stages of turbine blades thereon and in which the surface of said shaft between said adjacent stages is directly exposed to high temperature gas flow through said turbine, a coupling shaft having a reduced cross-section intermediate its ends and being connected between adjacent blades intermediate said rotatable shaft and the outer peripheries of said blades; radial cooling plates operatively connected to said blades and being operable to shield the opposing faces of said blades outward of said coupling shaft, each of said radial plates having a hub portion engaging said coupling shaft and a counterbore located along an edge of said hub portion defining an annular flange on each hub portion; and the combination therewith of an improved heat shield for substantially eliminating high localized bending stresses which result in the failure of the shield, said improved

shield including a metallic hoop member carried by said coupling shaft and extending between said counterbores in said hub portions of said radial cooling plates to thereby shield said coupling shaft and a portion of said rotor discs against a direct exposure to said hot gases, said counterbores in said hub portions being constructed and arranged to permit thermal expansion of said hoop member whereby said hoop member operates as a free ring stresswise, said hoop member being dimensioned to closely fit said coupling shaft when in an unexpanded state and said flanges being constructed and arranged to limit the thermal expansion of said hoop member to a predetermined amount to thereby limit the unbalance introduced

into the hoop member as a result of an unsymmetrical thermal expansion thereof.

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