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VANE RING FOR TURBO-ENGINES

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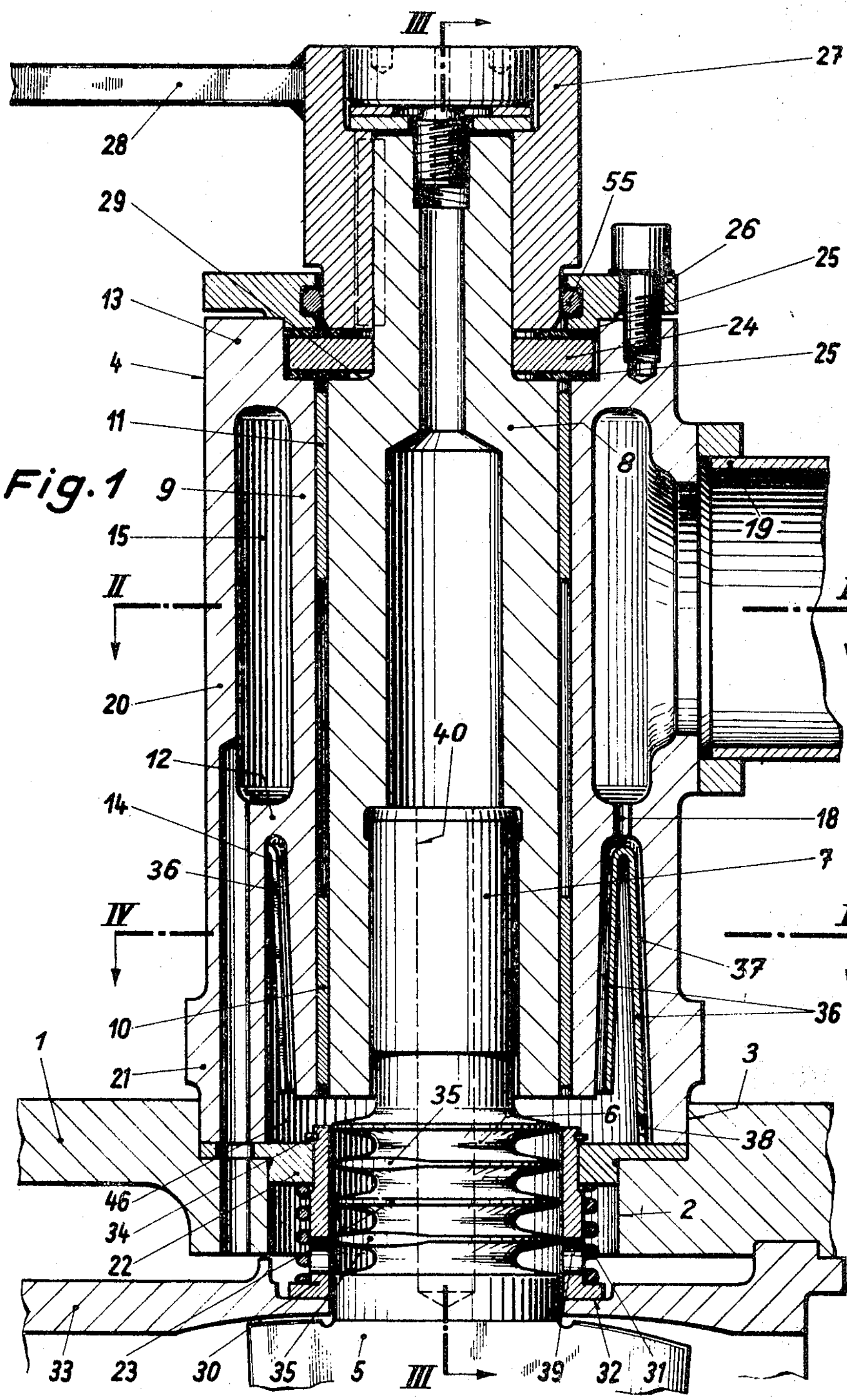

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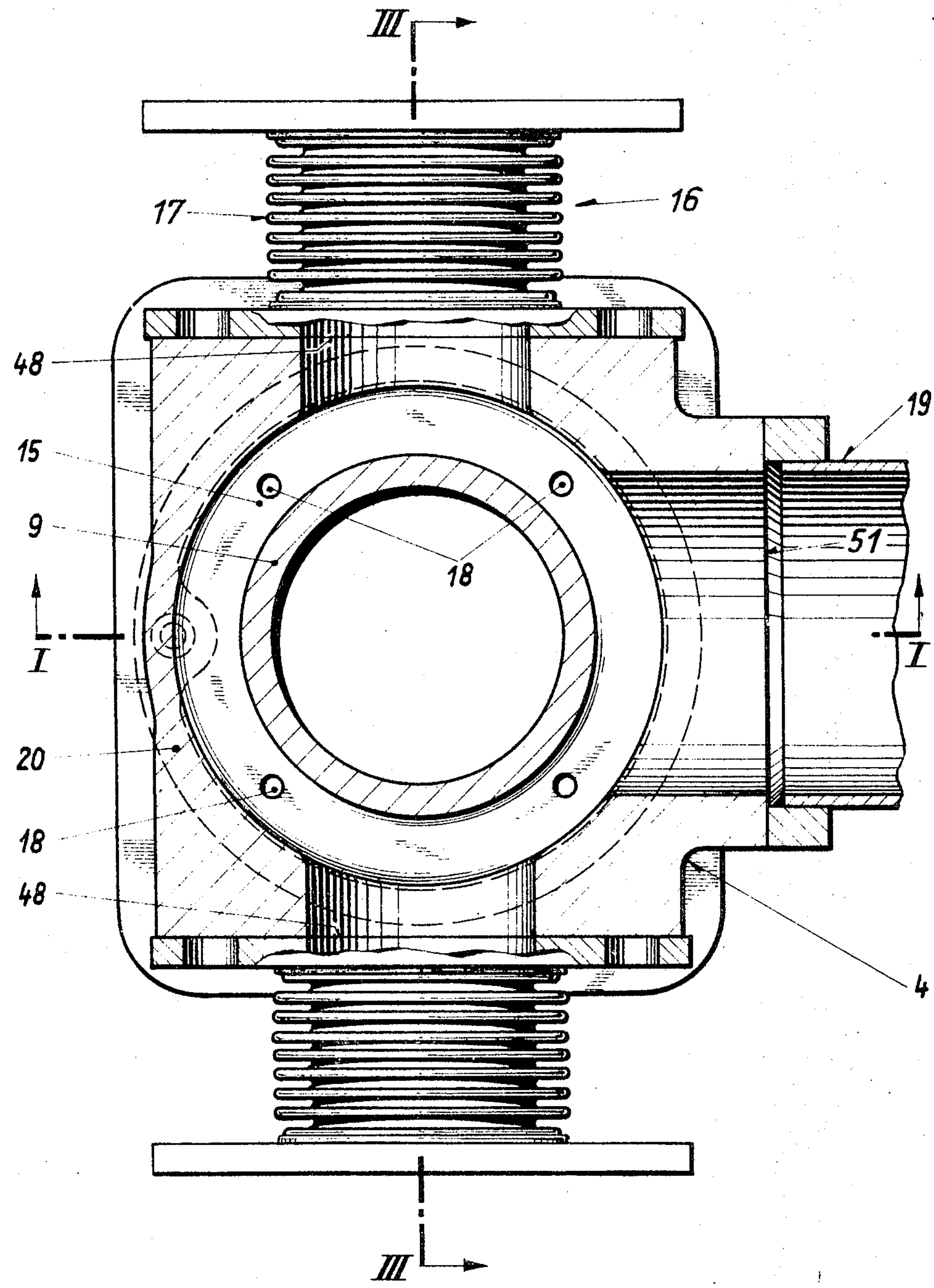

Fig. 2

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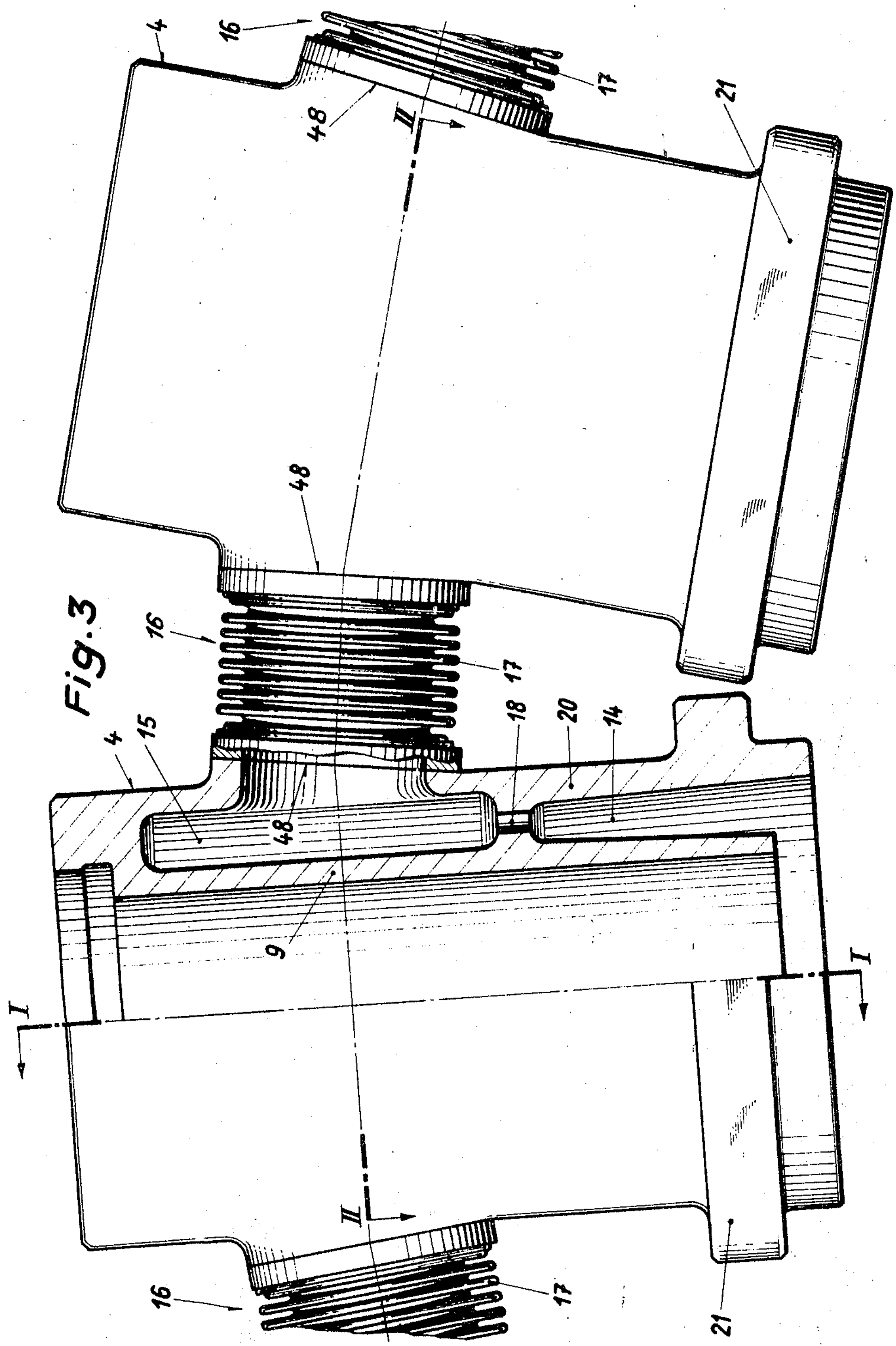
VANE RING FOR TURBO-ENGINES

Filed Nov. 27, 1968 6 Sheets-Sheet 3



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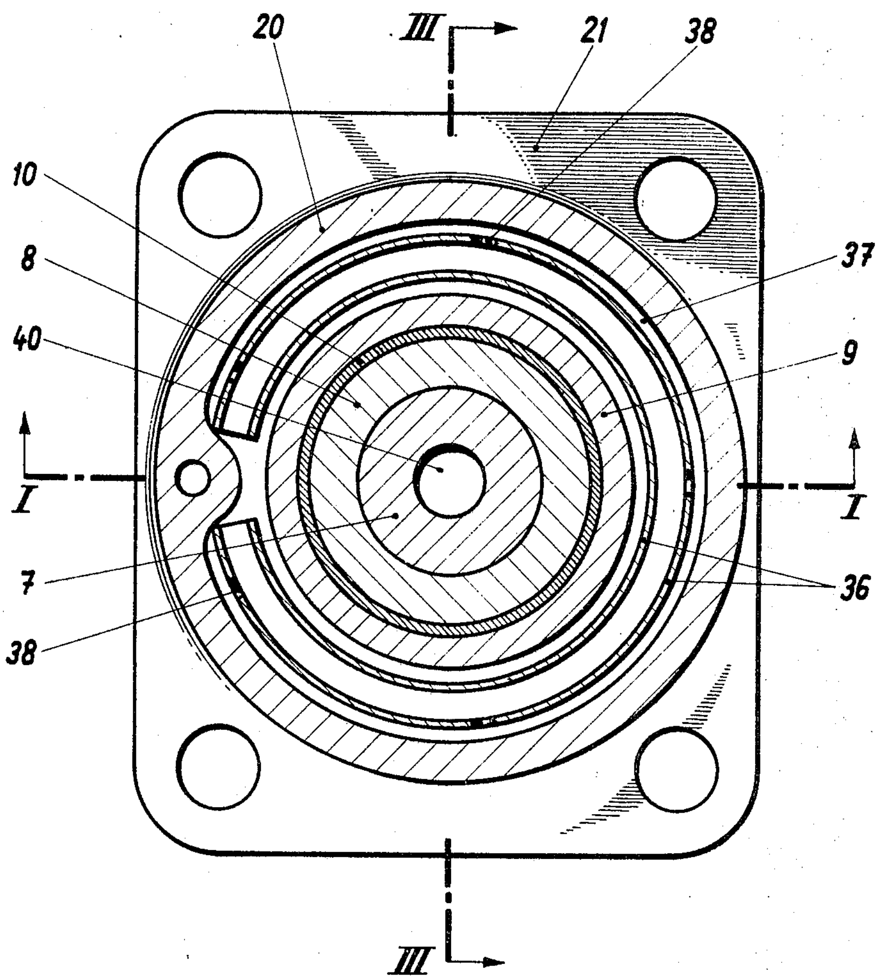

Fig. 4

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Fig. 5

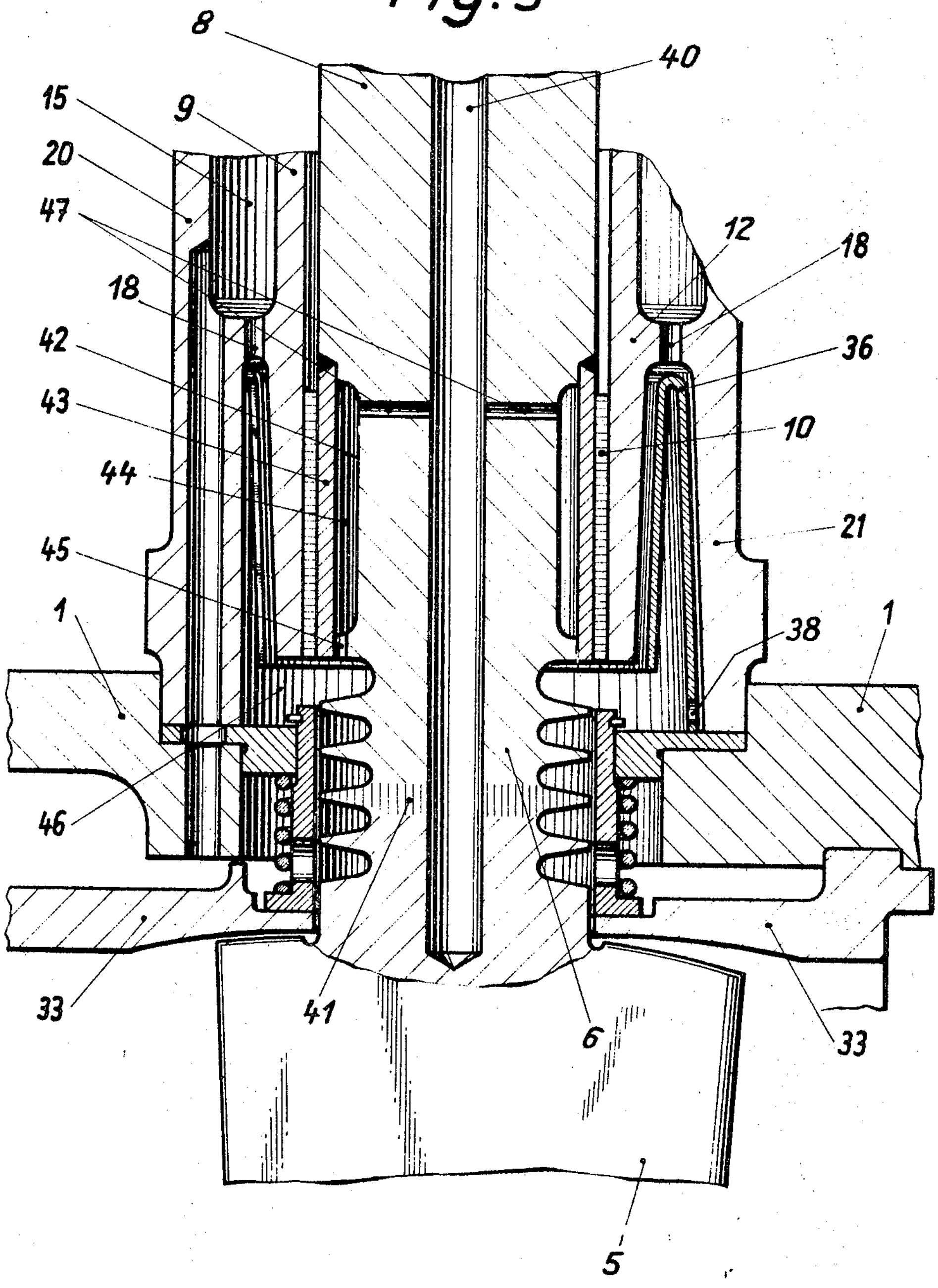

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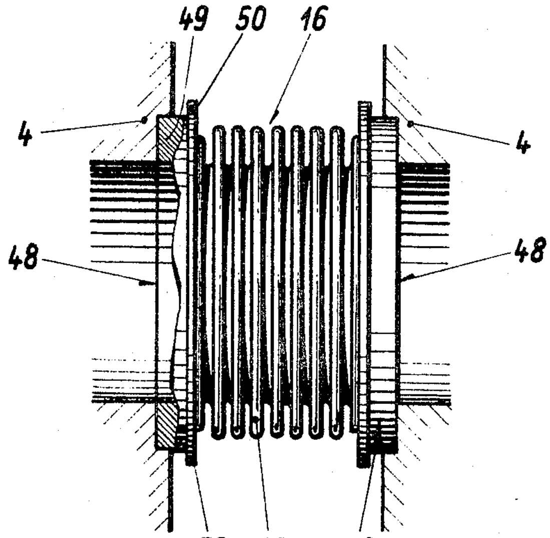
Fig. 6



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1

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VANE RING FOR TURBO-ENGINES

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U.S. Cl. 415—115 7 Claims

ABSTRACT OF THE DISCLOSURE

Groups of bearing housings for the turbo-engine blades are interconnected by expansion pipes so that coolant can flow through the individual housings of the groups. At least one housing in each group is supplied with coolant through a supply pipe. The expansion pipes can be made of bellows-type hoses and are preloaded in place.

This invention relates to a vane ring for turbo-engines. More particularly, this invention relates to a coolant system for a vane ring for turbo-engines.

Vane rings for turbo-engines have been known to carry a plurality of angularly adjustable blades so as to adapt to changes in load conditions. Because of the mountings which have been used in securing these blades in place, it has in some cases been difficult to obtain a sufficient cooling of the blade mountings in a simple manner.

Accordingly, it is an object of the invention to effectively cool the blade mountings of a vane ring in a simple and efficient manner.

It is another object of the invention to cool the bearing mounting of a vane ring from outside the vane ring.

It is another object of the invention to cool groups of bearing housings on a vane ring from a common source.

Briefly, the invention provides a cooling system for a vane ring for turbo-engines wherein blades are journalled in axle housings outside of a blade carrier supporting the blades. The cooling system is constructed to deliver a coolant to at least the bearing zones of each axle housing in order to cool the bearings as well as the axle housings. To this end, the axle housings are arranged in groups with each housing in a group having connection apertures for the introduction of coolant into suitable spaces within the housing about the bearing zones. Each connection aperture is situated perpendicularly to the vane ring plane in mutually facing relation to the connection aperture of an adjoining housing. Further, an expansion pipe is disposed between each pair of adjoining housings to interconnect the opposed connection apertures of the housings so that coolant can pass between the housings. Also, in order to supply coolant to each group of housings, at least one of the axle housings is provided with a port for introduction of a coolant, such as a cooling gas, from an outside source.

The expansion pipes in one embodiment are provided at their extremities with joining rings or flanges to facilitate connection to the respective axle housings. Also, the length of an expansion pipe in a relaxed state is preferably greater than the distance between the two mutually facing connection apertures so that the expansion pipe is preloaded upon insertion between the connection apertures. As a result of the preload, the expansion pipes are tightly connected to the axle housings about the connection apertures in sealed relation.

Preferably, the expansion pipes are formed by bellows-type hoses whose junction points are additionally pressed against the connection apertures beyond the preload as a result of their internal pressure.

The axes of the connection apertures of adjoining axle housings can alternatively be arranged in planes inclined with respect to the housing axis in such a way that the mutually facing apertures of adjoining housings are parallel with respect to one another and that, as a result, the expansion pipe axis remains straight.

2

These and other objects and advantages of the invention will become more apparent from the following detailed description and appended claims taken in conjunction with the accompanying drawings in which:

FIG. 1 illustrates a fragmentary cross-sectional view of a vane ring incorporating a cooling system according to the invention taken on line I—I of FIGS. 2 to 4;

FIG. 2 illustrates a view taken on line II—II of FIG. 1;

FIG. 3 illustrates a view taken in the plane of line III—III of FIG. 1 of two adjacent axle housings;

FIG. 4 illustrates a view taken on line IV—IV of FIG. 1;

FIG. 5 illustrates a cross-sectional view of a modified blade design and coolant passageway according to the invention; and

FIG. 6 illustrates a modified connection between adjacent bearing axle housings for the coolant flow.

Referring to FIG. 1, the vane ring includes an annular blade carrier **1** and a plurality of blades, for example, twenty-eight, which are circumferentially spaced and carried on the blade carrier **1** substantially radially of the rotor shaft (not shown) in the ring plane III—III. The blade carrier **1** is formed with a bore **2** for each blade as well as with a recess **3** about the bore **2** for receiving an axle housing **4** of a bearing mount. Each blade is formed with a part **5** which contacts the working medium, a neck **6** substantially within the plane of the blade carrier **1**, a blade journal **7** and an axle journal **8** secured about the blade journal **7**. The part **5** merges into the neck **6** at the lower end while the neck **6** which is provided with cooling ribs **23** merges into the blade journal **7** to form a one-piece blade. This blade is further either forced into the journal **8** or is shrunk on by undercooling. Alternatively, the blade and journal **8** can be made as a compound cast element, for example, by precision casting and by forming part **5** of a heat resistant steel and by forming the other parts, particularly at the bearing surfaces, of a material having suitable dry operation properties.

Each axle housing **4** is individually secured to the blade carrier **1** and is formed with an inner wall **9** of tubular shape which carries a pair of bearings **10, 11** in supporting relation to the axle journal **8**. The axle housing **4** is also formed with an outer wall **20** by which the axle housing **4** is supported in the recess **3**. The outer wall **20** also supports the inner wall **9** at two spaced points via annular supports **12, 13** while forming an open hollow space **14** and a closed hollow space **15** between the walls **9, 20**. The open hollow space **14** is situated at a point closer to the blade carrier **1** than the closed hollow space **15** while being in facing relation to the blade carrier **1**.

Referring to FIGS. 2 and 3, the closed hollow spaces **15** of at least one group of axle housings **4** are interconnected by means of connection apertures **48** in opposite surfaces of the outer wall **20** and expansion pipes **17** and together constitute a distribution line **16** which supplies each one of the connected axle housings **4** of the group with a partial amount of a gaseous coolant, for instance, air. In addition, at least one of the axle housings **4** of a group is further connected via a port **51** in the outer wall **20** with a supply line **19** (FIG. 2) which provides the total amount of gas required for the cooling of all the housings **4** of the group connected to the distribution line **16**. Alternatively, two supply pipes can be attached to the lower half of the blade carrier and connected to the two axle housings **4** next to their respective axial separating planes. Following joining of the lower and upper half of the blade carrier and installation of the connecting pipes 17, an inherently closed distribution line 16 is produced with two substantially diametrically opposite supply connections. During inspection and cleaning operations of the vane rings, the supply lines need not be removed.

Referring to FIG. 3, each expansion pipe 17 is provided with annular rings at the ends which serve to mount the pipe 17 on the axle housings 4 coaxially of the connection apertures 48. Each annular ring is secured to a axle housing, for example, by means of bolts (not shown).

Alternatively, referring to FIG. 6, the expansion pipes 17 can be of a length that is greater than the spacing between adjoining axle housings 4. That is, the expansion pipes 17 can be installed between the axle housings 4 by means of a suitable tool and then expanded against the housings 4. The expansion tubes 17 are thus urged elastically against the apertures 48 of the axle housings 4 and are also pressed against the apertures 48 in a preloaded state as a result of internal pressure. In order to facilitate gripping and compression by a special tool, connecting rings 49 are connected to the ends of the expansion pipes 17 and are preferably provided with collars 50 to form gripping surfaces. Also, the connecting rings 49 can be seated in recesses about the connection apertures 48 as shown. Further, the connection apertures can be disposed in planes inclined to the axle housing axes so that the opposed apertures of adjacent housings are parallel to each other. This allows the expansion pipes to remain straight instead of being slightly curved to the radius of the vane ring.

Referring to FIG. 1, the open hollow space 14 and the closed hollow space 15 which forms a part of the distribution conduit 16 in each housing are interconnected by means of bores 18. These bores 18 allow the partial amount of the cooling gas required for each axle housing 4 to be branched off from the distribution line 16 to the individual cooling sites.

Referring to FIGS. 1 and 4, a displacement body 39 of U-shaped cross-section and discontinuous length is mounted in the open space 14 in inverted manner to form a pair of narrow coolant flow passages with the walls 9, 20. The outer leg of the body 39 is of greater length than the inner and rests on a plate 22 in the recess 3 of the blade carrier 1. Bores 38 are provided in the lower end of this outer leg to permit coolant flow towards the blade neck 6.

With regard to the bearings 10, 11 affixed at both ends of the cylindrical bore formed by the inner wall 9, such are formed of a plastic capable of withstanding dry operation free of lubricants as well as elevated temperatures, for example, a plastic known as DU. Such plastics are able to withstand temperatures up to 200° C. and above without suffering any damage, and exhibit slide properties which do not make it necessary to provide for a special supply of lubricants. Likewise, the axle journal 8 designed for these bearings is of a material capable of sliding without wear and without a special supply of lubricant on the bearing plastic selected without either impairing itself or the bearings 10, 11.

Each axle housing 4 includes a peripheral flange 21 near the base of the outer wall 20 which facilitates tightening of the housing 4 against the blade carrier 1 and the plate 22 positioned therebetween. The flange 21 surrounds the axle housing 4 at a distance from the blade carrier 1 so as to minimize the transmission of heat from the blade carrier 1 to the axle housing 4.

Additionally, the opposite end of the axle housing 4 has a thrust bearing mounted between the axle journal 8 and the housing 4. The thrust bearing includes a rotor disk 24 secured to the journal 8, a pair of sliding disks 25 on opposite sides of the rotor disk 24, and a mounting plate 26 secured on the housing 4 over the disks 24, 25. A sealing ring 55 is further mounted in a groove of the disk 26 to prevent an escape of cooling gas out of the axle housing 4 along the journal 8 into the space surrounding the blade carrier 1.

A hub 27 of an adjustable lever 28 is keyed over the end of the journal 8 to sealingly engage the sealing ring and to clamp the rotor disk 24 and the sliding disks 25 together against a shoulder 29 of the axle journal 8 so that the disks 24, 25 follow the rotational motions of the journal 8 and lever 28.

The cooling ribs 23 on the neck 6 of the blade are surrounded by a sleeve 30 mounted with a slight clearance within the plate 22. The sleeve 30 is compressed at one end by means of the spring 31 against a recess 32 of a ring segment 33 of the blade carrier 1 and is prevented from falling out of the plate 22 by means of a circlip 34 in a groove at the other end. On the other hand, the sleeve 30 is fitted tightly onto the cooling ribs 23 so as to be centered by the blade free of resistance in the plate 22. A plurality of bores 39 are provided in the sleeve 30 to communicate the opposite sides of the sleeve with each other. The cooling ribs 23 are provided with milled sections 35 alternating from rib to rib by a semi-circumference and thereby face each other in two groups.

In operation, cooling air is supplied over the supply line 19 (FIG. 1), for instance at a temperature of approximately 130° C., and distributed into hollow space 15. Portions of the cooling air are then passed through each of the connection apertures 48 and bores 18 in the housing 4. The portions of cooling air passing through the connection apertures 48 flow through the expansion pipes 17 connected to the sides of the housing 4 (FIG. 3) into the adjoining axle housings 4 of the housing group for subsequent passage and distribution in the other housings of the group. At the same time the portion of the cooling air passing through the bores 18 enters the open ended space 14 to pass with increased speed in a thin layer between the displacement body 36 and the inner and outer walls 9 and 20, respectively, toward the blade neck 6; the cooling air flowing along the outer wall 20 being directed by means of the bores 38 in the displacement body leg toward the blade neck 6. This flow of cooling air is then subdivided into two halves between the cooling ribs 23 by means of the milled section 35 and passes aronud the opposite sides of the blade neck substantially tangentially. Opposite the input point at the first cooling rib 23, the two halves of coolant flow join again in the milled section 35 of the second cooling rib 23. Following passage through this second milled section 35, the air separates again into two halves and flows in this manner between the second and third ribs of the blade neck. After leaving the intermediary space bordering the last rib, the air passes on through the bores 39 of the sleeve 30 into the space surrounding these bores and flows then through ducts (not shown) into the flow passage of the work medium within the blade carrier 1.

As a result of the structural design described and the guidance of the cooling air, the bearing points of the blades, in particular the bearing 10 situated closest to the blade carrier 1 and, hence, to the flow of the work medium, can be kept at a temperature capable of insuring trouble-free operation.

The cooling gas also acts simultaneously as a blocking gas for the axle housing 4 in view of the fact that its pressure must always be greater than the pressure of the working medium in the rotor space. This prevents the penetrating of working medium or residues thereof into the axle housing 4 and, as a result of impurities or foreign substance that are carried along, in particular upon running in of the engine, the soiling of the bearing surfaces of the axle journal 8. In addition, because of the seal 55, the space between the inner wall 9 and the axle journal 8 is sealed off with respect to the space surrounding the blade carrier 1 so that even in the case of a possible overpressure of the working medium, the working medium is prevented from passing through along the bearing surfaces.

During some phases of operation of the turbo-engine, the part **5** contacted by the working medium can have a temperature up to 600° C. and more. As a result, a flow of heat can be produced over the blade neck **6**, the blade journal **7**, the axle journal **8**, and the bearings **10**, **11** against areas of a lower temperature at the outside of the engine. However, this heat flow is substantially reduced ahead of the bearing **10** as a considerable amount of heat is drawn off by the cooling air at the cooling ribs **23** before the heat reaches the blade journal **8**. An additional heat transmission loss of the heat flow can be achieved by reducing the cross-section of the blade journal **8** and blade neck **6** by means of a central bore **40** in the blade and, as a result, the conduction cross-section of the heat flow.

Further, during operation, the bearing sleeve **10** is cooled from the outside by means of the cooling air passing along at the free end of the inner wall **9**. At the same time, the part of the cooling air passing along the inner side of the outer wall **20** reduces the influx of heat from the blade carrier **1** through the outer wall **20** onto the supports **12**, **13** of the inner wall **9** and hence to the bearing sleeves **10**, **11**.

The combination of these above provisions guarantees a temperature for the bearings **10**, **11**, that is, below 200° C. and thereby removes the risk of the occurrence of trouble.

Referring to FIG. 5, where the blade is manufactured as a compound casting element, a metallurgical connection is produced between the blade part **5** contacted by the work medium and the axle journal **8** in the area of the blade neck **6**, for instance at the point **41** as shown. At this connection point, an alloy is produced along a short stretch of the two different parts so that, after completion of the cast element, the blade appears as a single workpiece that can be machined. The compound casting is arranged in such a way that the alloy site is at a point at which at least the work medium cannot supply any additional heat to the blade and, conversely, at which the blade is not yet fitted in a bearing.

Especially in the case of blades manufactured as compound castings, and also in the case of blades in which the two different materials have been interconnected mechanically by forcing or shrinking onto one another, it may be preferable to directly cool at least the bearing **10** of the axle journal **8** situated closest to the passage of the work medium. To this end, the axle journal **8** is reduced in diameter at the point **42** and a bearing tube **43** is slid over the reduced portion and welded to the axle journal **8** to form a hollow space **44** and receive the bearing sleeve **10**. This hollow space **44** is connected by bores **45** in the journal **8** to the space **46** surrounding the blade neck **6** and, in addition, by means of radial bores **47** in the journal **8** with a central bore **40** in the journal **8**. The central bore **40** leads into the open so that a partial amount of the flow of coolant determined by a dosing bore is diverted in the space **46** and guided through the hollow space **44**. As a result, the bearing tube **43** and the plastic bearing **10** fitted thereon are efficiently cooled.

What is claimed is:

1. In combination with a vane ring having a blade carrier, a plurality of blades circumferentially of said blade carrier and a plurality of axle housings secured on the outside of said blade carrier rotatably mounting a respective blade therein; a cooling system including an expansion pipe between each pair of adjacent axle housings of a group of said axle housings for conducting a flow of coolant therebetween, each said adjacent housing having a connection aperture therein in communication with said expansion pipe, said connection aperture being perpendicular to the plane of said vane ring.

2. The combination as set forth in claim **1** wherein each expansion pipe includes a connecting ring at each end secured to said axle housing thereat coaxially of said connection aperture thereat.

3. The combination as set forth in claim **1** wherein each expansion pipe includes a connecting ring at each end having a collar thereon.

4. The combination as set forth in claim **1** wherein said expansion pipe is of a relaxed length greater than the distance between said adjacent axle housings whereby said expansion pipe is preloaded between said adjacent axle housings.

5. The combination as set forth in claim **1** wherein each expansion pipe is a bellows-type hose and is preloaded between said adjacent axle housings.

6. The combination as set forth in claim **1** wherein said connection apertures of said adjacent axle housings are in parallel planes and said expansion pipe is straight.

7. The combination as set forth in claim **1** wherein at least one of said axle housings of said group has a port therein for introduction of a supply of coolant thereinto from an outside source.

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U.S. Cl. X.R.

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