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[54] ARRANGEMENT FOR SUPPLYING ROTOR OF AN ELECTRICAL MACHINE WITH A LIQUID COOLANT

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[51] **Int. Cl.** **H02k 9/00**

[58] **Field of Search** 310/54, 64, 61

[56] **References Cited**

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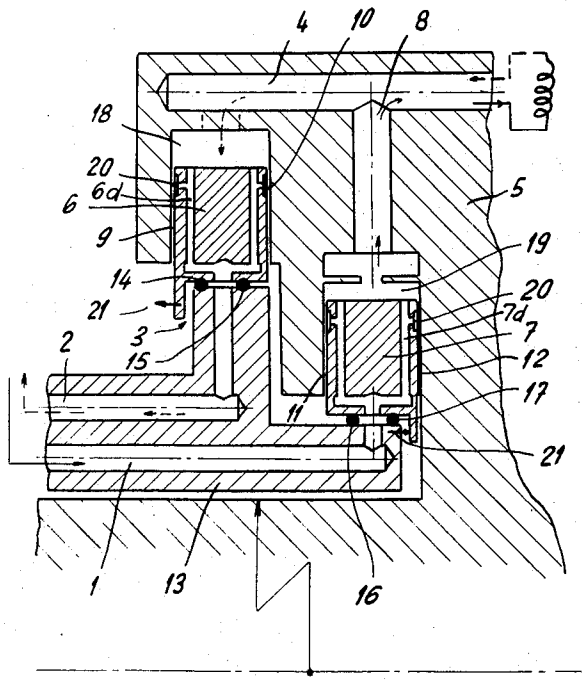
[57] **ABSTRACT**

An arrangement for circulating a liquid coolant through a tubular conductor structure on the rotor of an electrical machine includes a stationary feed part provided with feed and discharge channels leading to feed and discharge rings through which the liquid coolant is fed to and discharged from liquid guide channels at one end of the rotor which are connected to the tubular conductor structure. The liquid coolant enters the discharge ring from the rotor at a point on the rotor which is farther outside — as seen radially — than the point at which the coolant enters the feed ring to flow into the rotor.

10 Claims, 5 Drawing Figures



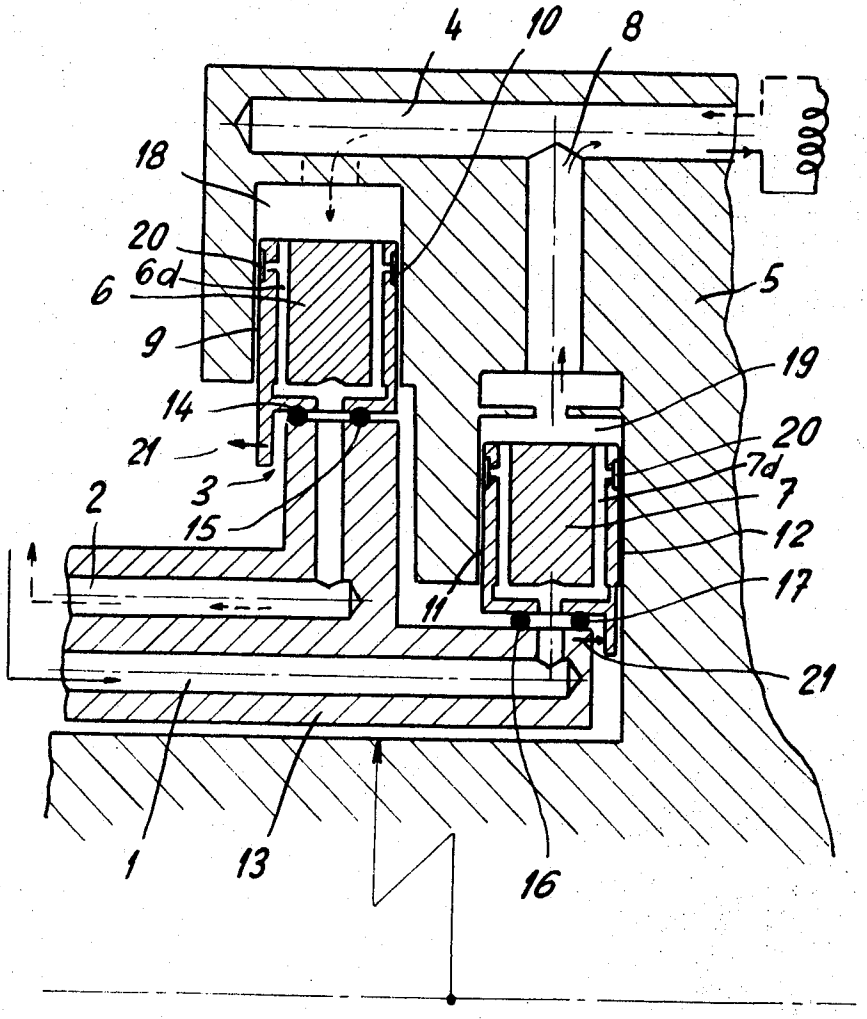


Fig. 1

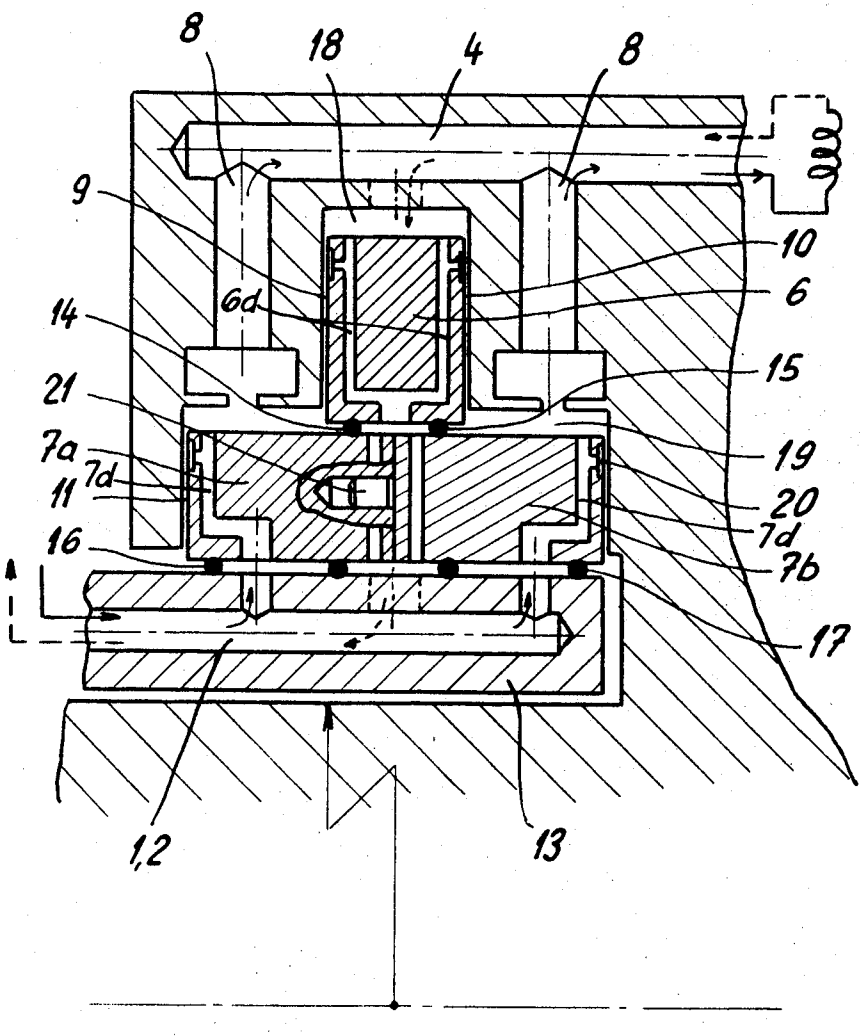


Fig. 2

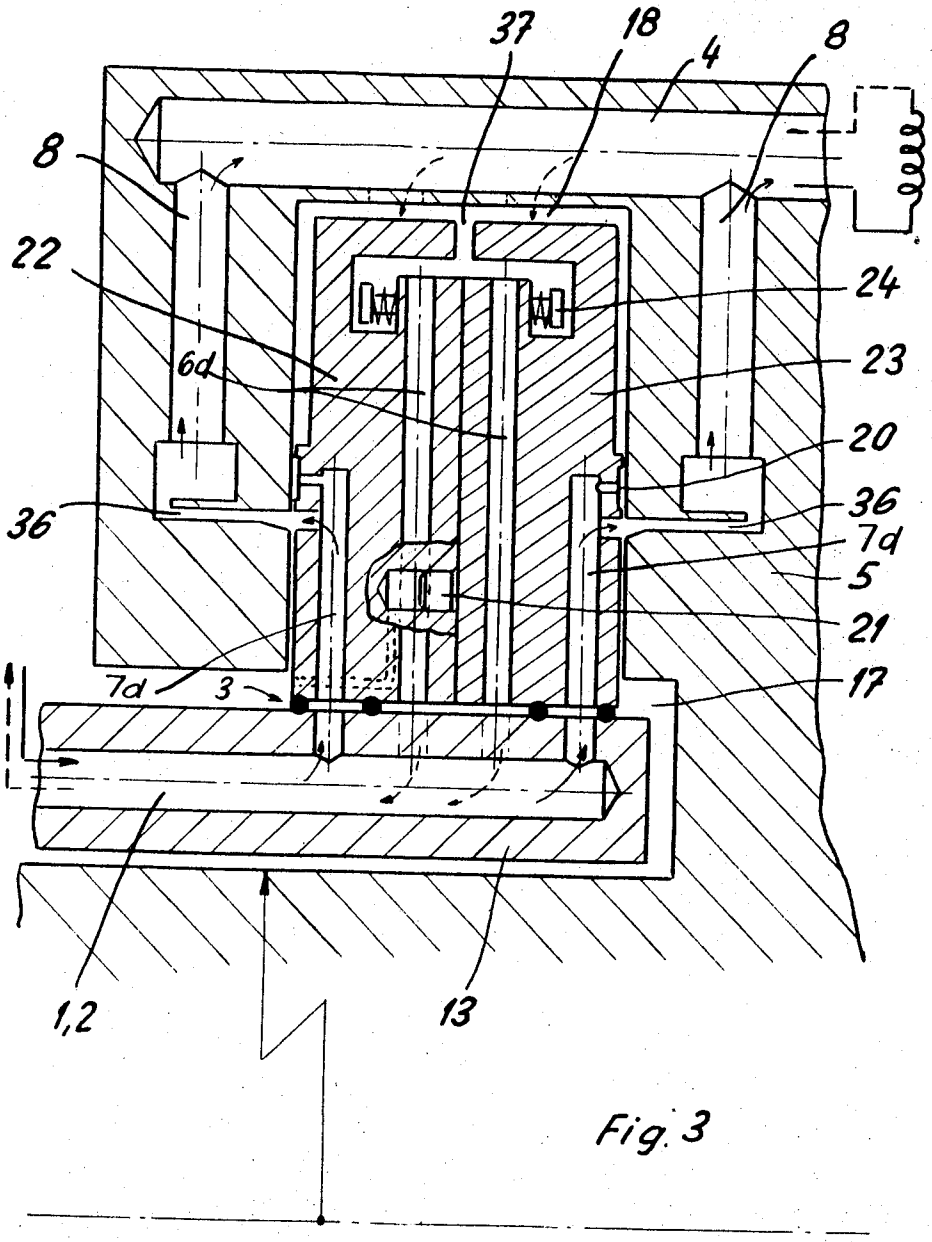


Fig. 3

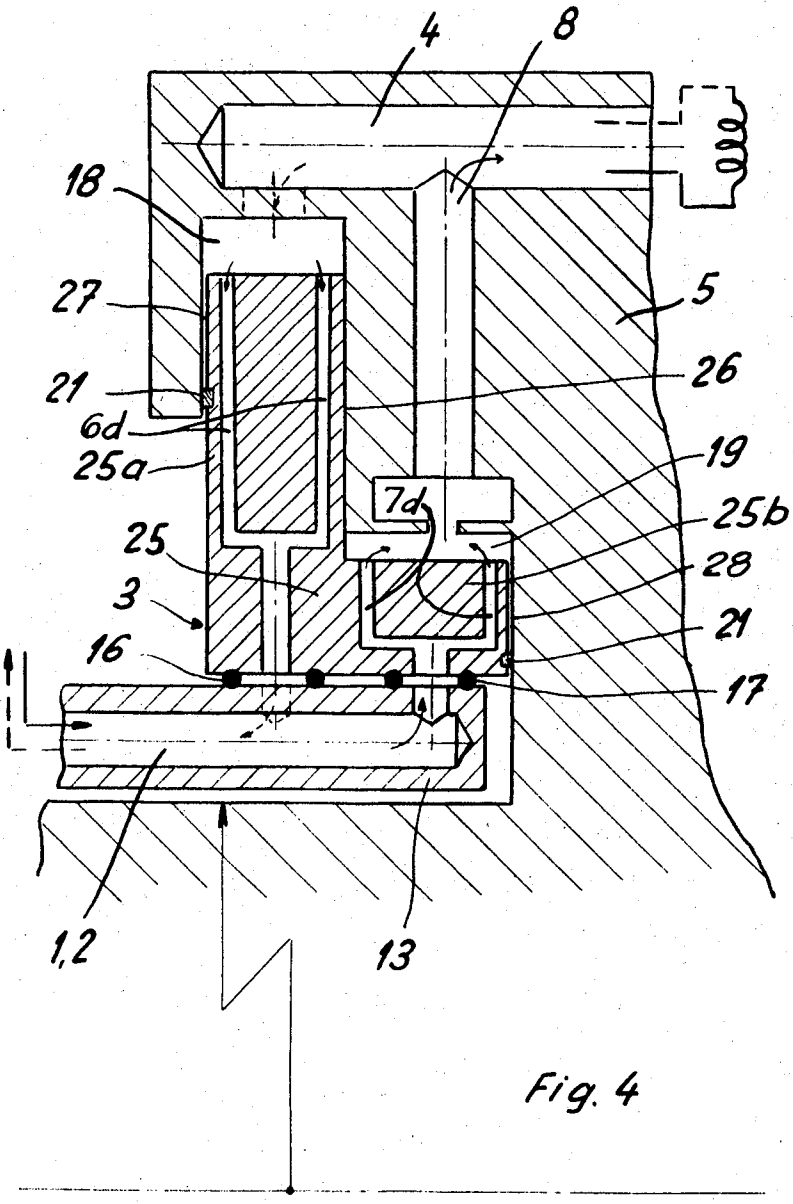


Fig. 4

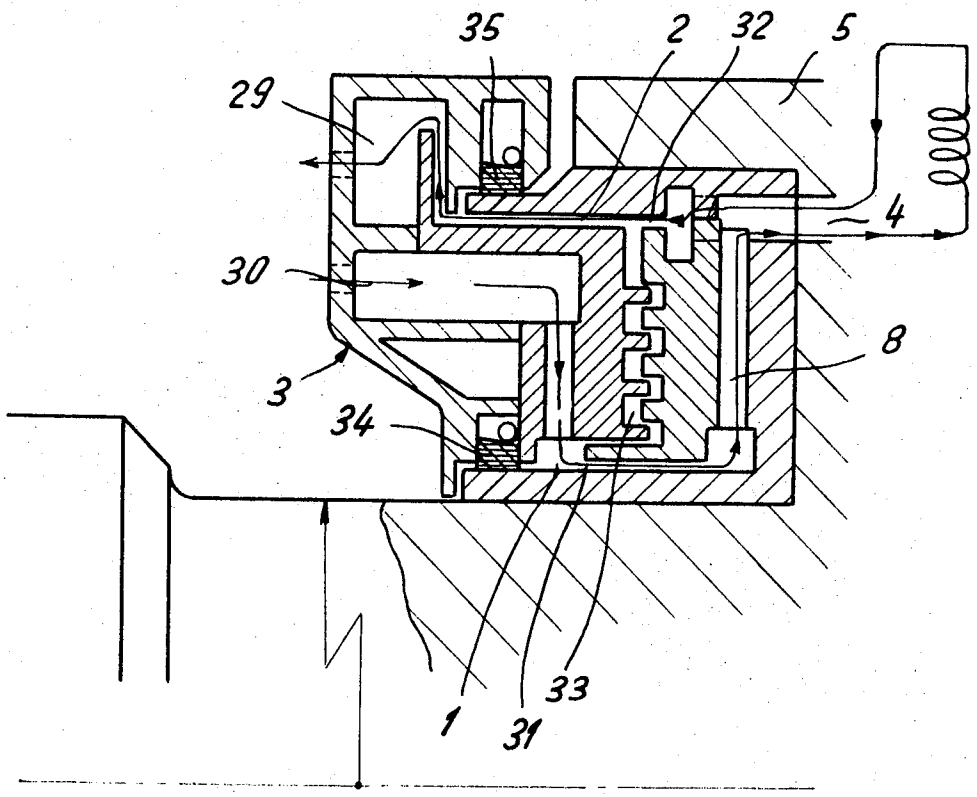


Fig. 5

ARRANGEMENT FOR SUPPLYING ROTOR OF AN ELECTRICAL MACHINE WITH A LIQUID COOLANT

The present invention relates to an improved method for feeding a liquid into at least one liquid channel connected with a rotor and rotating with the latter, a liquid feed for carrying out the method, and an application of the latter.

It is known to make the winding of the rotor in electric machines of tubular conductors and to circulate through them a liquid coolant of low electric conductivity, preferably water. The cooling water must be transmitted in a cooling water transmitter from the stationary to the rotating part of the machine and vice versa.

Various constructional solutions of such cooling water transmitters are already known. A solution is also known which works without packing elements and where the cooling water in the coil head is injected directly into the winding. The feeding- and discharge point of the water is arranged principally where the least friction- and cooling liquid losses occur, hence mostly at the shaft end, where the relatively small diameters permit the use of slip ring packings or small packing slot lengths.

The disadvantages of the known arrangements are that the packing joints are under an internal pressure which is substantially above the outside pressure, this internal pressure being composed of the delivery feed pressure of the circulation pump, the dynamic pressure, and the action of the centrifugal force on the liquid at the packing joint. This results either in an increase of the water losses (particularly in noncontract packings) or at least in an increase of the friction losses. Furthermore it is not always possible to arrange the water transmission point on a relatively small diameter on the shaft end, since both shaft ends are occupied, for example, so that the transmitter with a relatively large diameter must be placed on the shaft. With the known use of slip ring packings, this results in additional difficulties regarding wear, elimination of heat and manufacturing accuracy, particularly if the packing must consist of several parts for reasons of assembly. A design without a contact packing would result in intolerable cooling water losses, because of the above-mentioned higher pressure.

The object of this invention is to provide a method and a liquid feed which do not have these disadvantages and which are nevertheless simple to manufacture and inexpensive to operate.

The method according to the invention is characterized in that the liquid is discharged at a point which is farther outside, seen radially, than the point where it is fed, and that the course of the liquid guide channel is so selected that the liquid contained therein is conveyed through the liquid guide channel during the rotation of the rotor, due to the centrifugal force acting on it. Since the pressure necessary for circulating the liquid is produced in the rotor itself, the liquid at the transition point from the stationary to the rotating part is not additionally under the delivery pressure of a circulation pump, as in the known arrangements.

The invention also provides a novel liquid feed for carrying out the method of the invention which is characterized in that it has a stationary feed part provided with at least one feed channel and one discharge channel, which is so arranged and designed with regard to the rotor provided with at least one liquid guide channel that a liquid flowing through the liquid guide channel is discharged through the discharge channel at a point of the rotor which is farther outside as seen radially than is fed through the feed channel.

The feed part can be provided at least one radially extending ring part which protrudes packingly into at least one annular groove in the rotor for feeding and discharging the liquid conveyed through a liquid channel in the rotor. It is also expedient to provide between the ring part and the annular groove radially extending non-contact packing slots which can be closed by sealing means when the rotor stands still.

The invention furthermore provides an application of the method according to the invention for cooling a rotor winding of an electric machine consisting of tubular conductors.

The invention will be described below more fully on the basis of the attached drawings wherein:

FIG. 1 shows by way of example, a first embodiment of a liquid feed according to the invention with two ring parts arranged side-by-side in an axial direction;

FIG. 2 shows by way of example a second embodiment of a liquid feed according to the invention with two superposed ring parts arranged in radial direction;

FIG. 3 shows by way of example a third embodiment of a liquid feed according to the invention with one ring part;

FIG. 4 shows by way of example a fourth embodiment of a liquid feed according to the invention with a set-off ring part; and

FIG. 5 shows by way of example a fifth embodiment of a liquid feed according to the invention with an axially extending packing slot.

As it can be seen from FIG. 1, the cooling liquid feed represented there has a stationary feed part 3 provided with feed and discharge channels 1, 2, which is so arranged and designed with regard to rotor 5 provided with liquid guide channels 4 that the cooling liquid flowing through the liquid guide channels 4 is discharged through discharge channel 2 at a point of rotor 5 which is farther outside, seen radially, than the point at which the liquid is fed through feed channel 1.

The feed part 3 is provided with two ring parts 6 and 7 arranged side-by-side in axial direction and extending radially over a different distance, ring part 6 which extends farther outside being being provided with radical through-bores 6*d* for discharging the cooling liquid issuing from the liquid guide channels 4 into the discharge channel 2, and the other ring part 7 located further radially inward than ring 6 being provided with radial through-bores 7*d* for feeding the cooling liquid into the liquid guide channels 4 from feed channel 1. Due to this arrangement the cooling liquid issuing from ring part 7 is forced during the rotation of rotor 5 to the outside in the radially extending guide channel part 8 rotating with the latter, due to the centrifugal force acting on it, and thus into the liquid guide channel 4. The liquid guide channels 4 are extended in the tubular conductors of a rotor winding of an electric machine to be cooled.

In this manner the packing joints between the stationary ring parts 6 and 7 and the rotating rotor 5 can be laid out for a pressure which is only slightly above the atmospheric pressure, which is a hydrostatic pressure that corresponds to the height of the water tank above the packing joint. Since the pressure of the cooling liquid at the packing joints is much lower than in the known systems, due to the absence of a circulation pump, contact packings can be eliminated without experiencing excessive liquid losses.

The radially extending packing slots 9, 10, 11 and 12 have the further advantage that, due to the centrifugal force acting in the packing slots on the cooling liquid contained therein, issuance of the cooling liquid to the outside is prevented. Since there is no centrifugal force acting during the standstill of the rotor, a device can be provided which closes the packing slots mechanically under these conditions.

In order to be able to absorb variations in length of the rotor 5, the two ring parts 6, 7 can be arranged for axial displacement on a holding part 13 which is provided with the feed and discharge channels 1, 2. Between the ring parts 6, 7 and the holder 13 are arranged two O-rings 14, 15 and 16, 17 each for mutual packing. The ring parts 6, 7 are guided in axial direction in annular grooves 18, 19 of rotor 5 located transverse to and concentric with the rotor axis.

In axial direction, the position of the ring parts 6, 7 with regard to rotor 5 is not exactly defined. In order to define the position clearly, even under the action of frictional forces of the O-rings 14, 15 and 16, 17 respectively, and in order to reduce one-sided adhesion, known means can be provided by which the axial position of the rings is defined so that liquid-or at least mixed friction is ensured. Such means are already known in hydrostatic and hydrodynamic bearings and packings. The ring parts 6, 7 are pressure-equalized in axial

direction, since equal packing heights and pressure equalizing connections are provided between both sides. Pockets **20** arranged on both sides of the ring parts **6, 7** effect the centering of the latter. At the points **21** are arranged plungers which press the packing surfaces directed toward the atmosphere against each other during the standstill of rotor **5** and which effect a perfect seal of the packing slots **9** and **12**.

FIG. **2** shows by way of example a second embodiment of a liquid feed according to the invention with two ring parts **6, 7** arranged superposed in radial direction, the parts corresponding to the embodiment represented in FIG. **1** being provided with the same reference numbers.

The method of operation of this embodiment is principally the same as of the embodiment represented in FIG. **1**, with the only difference that, due to the symmetrical arrangement of the ring parts **6, 7** which are superposed in radial direction, the packing slots **11** and **12** which are in communication with the atmosphere, are only provided at the water inlet.

For sealing the packing slots **11** and **12** during the standstill of rotor **5** there are provided between the ring halves **7***a* and **7***b* a pair of plungers **21** in order to press the two ring halves apart until they bear tightly on the side walls of the annular groove **19**.

FIG. **3** shows a third embodiment of a liquid feed according to the invention with a single ring part consisting of two halves **22** and **23** provided with bores **6***d*, **7***d*, the parts corresponding to the embodiment in FIG. **1** being provided with the same reference numbers.

The method of operation of this embodiment is principally the same as of the embodiment represented in FIG. **2**, with the only difference that the entrance and exit of the water takes place through the same ring part whose two halves are pressed apart by plungers **21** during the standstill of rotor **5** to seal the packing slots, and are pressed together again by springs **24** during the rotation of rotor **5**.

FIG. **4** shows a fourth embodiment of a liquid feed according to the invention with a single ring **25** provided with one part **25***a* with through-bores **6***d*(which corresponds in function to ring **6** of FIG. **1**) accommodated in annular groove **18**, and another part **25***b* of lesser diameter than part **25***a* with through-bores **7***d* (which corresponds in function to ring **7** of FIG. **1**) accommodated in annular groove **19**-; the remaining parts corresponding to the embodiment represented in FIG. **1** being provided with the same reference numbers.

The ring part **25***a* extending farther outside i.e., in the radial direction is designed to discharge the cooling liquid issuing from the liquid guide channels **4** which enters groove **18**, and the other ring part **25***b* the periphery of which is located further inward toward the axis of the rotor than is the periphery of ring part **25***a* -; for feeding the cooling liquid from feed channel **1** into annular groove **19** and thence through guide channel **8** into-; the liquid channels **4**.

Since the ring **25** is not pressure-equalized in the axial direction, the wall surface **26** of groove **18** must be designed as a bearing surface. At the points **21** are provided sealing rings which seal the packing slots **27, 28** between the sides of the ring parts **25***a*, **25***b* and the adjacent side walls of grooves **18** and **19** during standstill of rotor **5**.

FIG. **5** shows another embodiment of a liquid feed according to the invention with axially extending packing slots.

This liquid feed has a stationary feed part **3** provided with a feed- and discharge channel **1, 2** which is so arranged and designed with regard to rotor **5** provided with cooling liquid guide channels **4** that a cooling liquid flowing through the liquid guide channels **4** (rotor winding) is discharged through discharge channel **2** and collecting chamber **29** at a point of rotor **5** that is farther outside, seen in radial direction, than is fed through collecting chamber **30** and feed channel **1**.

The inlets and outlets **31, 32** of the liquid channels **4** are separated from each other by a labyrinth packing **33** since a slight leakage between these two points is without significance. For sealing the two axially extending slots between the stationary feed part **3** and rotor **5** are provided two carbon ring packings **34, 35** which are pressed by an annular spring each in radial direction against a cylindrical packing surface of rotor **5**.

In this embodiment, the cooling liquid fed over collecting chamber **30**, feed channel **1** and inlet **31** to the rotor winding is forced radially outward during the rotation of rotor **5** in the radially extending liquid guide channel part **8** rotating with the latter, due to the action of the centrifugal force, and thus into the axially extending liquid guide channel **4**.

In this liquid feed too, the liquid pressure at the packing joints is low, since the delivery pressure for the cooling liquid is build up only in rotor **5** and reduced again partly by current losses up to outlet **32** of the cooling liquid guide channel **4**.

I claim:

1. In an arrangement for circulating a liquid coolant through a tubular structure on the rotor of an electrical machine, the combination comprising;

a stationary part adjacent the rotor provided with feed and discharge channels for the coolant,

at least one annular groove provided in said rotor transverse to and concentric with the rotor axis, and

at least one stationary ring seated in said annular groove,

said ring and annular groove serving to provide a first annular chamber into which the coolant is fed from said feed channel and thence into said tubular structure on the rotor, and a second annular chamber into which the coolant is returned from said tubular structure on the rotor and thence into said discharge channel, said second annular chamber being located further radially outward from the rotor axis than said first annular chamber thereby to effect circulation of the coolant through said tubular structure on said rotor by virtue of centrifugal forces imparted to the coolant as a result of rotor rotation.

2. An arrangement as defined in claim **1** for circulating a liquid coolant through a tubular structure on the rotor of an electrical machine wherein the inner and outer peripheral surfaces of said annular groove provided in said rotor cooperate respectively with the inner and outer peripheral surfaces of the stationary ring seated in said groove to establish said first and second annular chambers, and which further includes a labyrinth packing between said first and second annular chambers and which extends radially along a side of said stationary ring and an adjoining side of said annular groove in said rotor to prevent direct circulation of the coolant between said first and second annular chambers.

3. In arrangement for circulating a liquid coolant through a tubular structure on the rotor of an electrical machine, the combination comprising;

a stationary part adjacent the rotor provided with feed and discharge channels for the coolant,

a first annular groove provided in said rotor transverse to and concentric with the rotor axis and which communicates with the tubular structure on said rotor for feeding the coolant thereto,

a first stationary ring component seated in said first annular groove and which is provided with a bore for passing the coolant outwardly therethrough from said feed channel into said first annular groove,

a second annular groove provided in said rotor transverse to and concentric with the rotor axis and which communicates with the tubular structure on said rotor for discharging the coolant therefrom, and

a second stationary ring component seated in said second annular groove and which is provided with a bore for passing the coolant inwardly therethrough from said second annular groove into said discharge channel, said second annular groove being located further radially outward from the rotor axis than said first annular groove thereby to effect circulation of the coolant through the tubular structure on said rotor by virtue of centrifugal forces imparted to the coolant as a result of rotor rotation.

4. An arrangement as defined in claim 3 for circulating a liquid coolant through a tubular structure on the rotor of an electrical machine wherein said first and second ring components are displaceable by a predetermined amount in the axial direction of the rotor.

5. An arrangement as defined in claim 3 for circulating a liquid coolant through a tubular structure on the rotor of an electrical machine wherein said first and second ring components are constituted by separate ring structures located in axially spaced relation.

6. An arrangement as defined in claim 3 for circulating a liquid coolant through a tubular structure on the rotor of an electrical machine wherein said first and second ring components are constituted by separate ring structures located in radially spaced relation.

7. An arrangement as defined in claim 3 for circulating a liquid coolant through a tubular structure on the rotor of an electrical machine wherein said first and second ring components are integrated into a common ring structure.

8. An arrangement as defined in claim 3 for circulating a liquid coolant through a tubular structure on the rotor of an electrical machine and which further includes means operable when said rotor is at standstill for urging said ring components into contact with the walls of the annular grooves correlated therewith to prevent loss of coolant fluid from said grooves to the exterior.

9. In an arrangement for circulating a liquid coolant through a tubular structure on the rotor of an electrical machine, the combination comprising;

a stationary part adjacent the rotor provided with feed and discharge channels for the coolant,

an annular groove provided in said rotor transverse to and concentric with the rotor axis,

a ring constituted by a pair of annular ring halves seated in said annular groove in face-to-face contact,

a pair of annular slots provided in said rotor, said annular slots being concentric with the rotor axis and extending laterally from the opposite side walls of said annular groove at a radial distance from the rotor axis which is less than the radial distance from said rotor axis to the annular space established between the adjacent peripheries of said annular ring halves and the bottom wall of said annular groove,

a first bore in each ring half for passing the coolant outwardly therethrough from said feed channel into said annular slots and which flows from said annular slots through passageways communicating with the tubular structure on said rotor, and

a second bore in each ring half for returning the coolant discharged from said tubular structure on said rotor into said annular space to said discharge channel.

10. An arrangement as defined in claim 9 for circulating a liquid coolant through a tubular structure on the rotor of an electrical machine and which further includes means operable when said rotor is at standstill for urging said ring halves apart so as to contact the adjacent side walls of said annular groove to prevent loss of coolant from said groove to the exterior.

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