

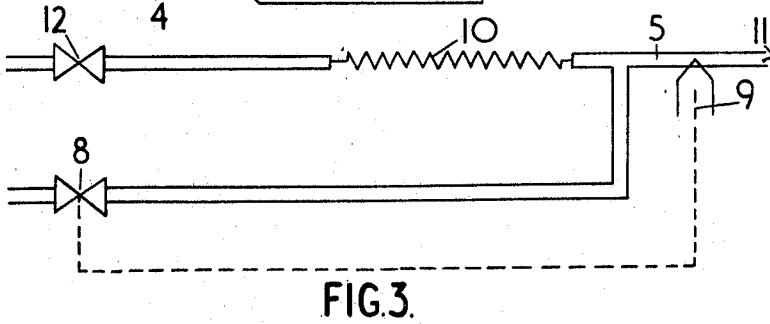
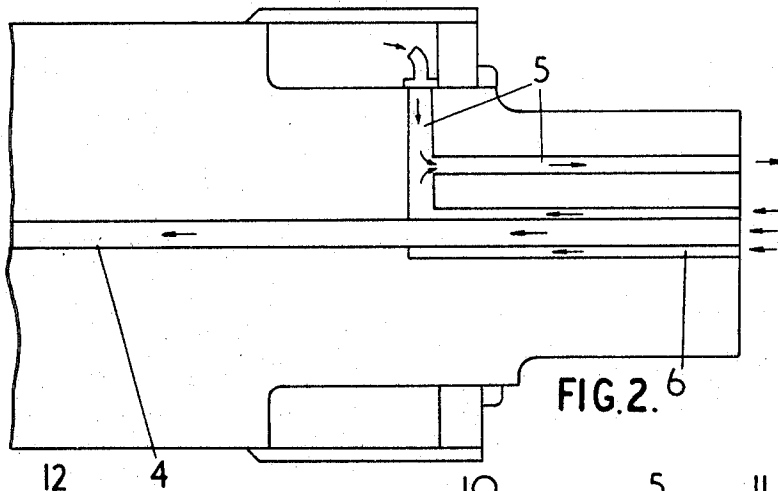
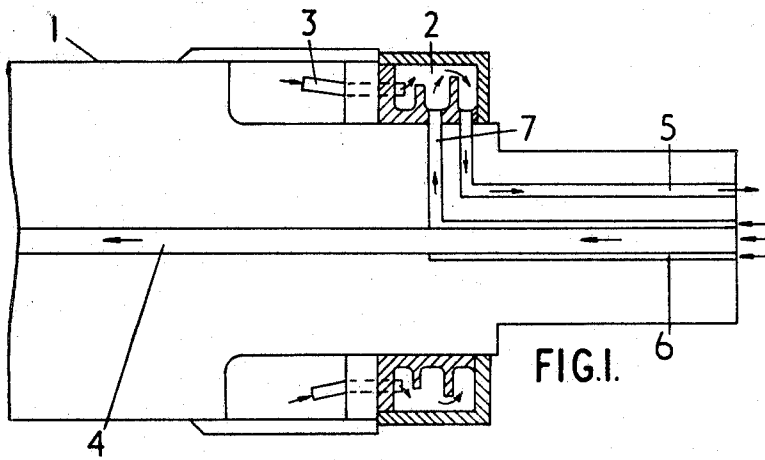
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LIQUID COOLED ROTORS FOR DYNAMO-ELECTRIC MACHINES

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LIQUID COOLED ROTORS FOR DYNAMO-ELECTRIC MACHINES

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8 Claims 10

ABSTRACT OF THE DISCLOSURE

In a liquid cooled rotor of a dynamo-electric machine, particularly a large turbo generator, boiling of the liquid coolant at low pressure regions of the liquid coolant circuit is prevented by introducing into the coolant circuit a supplementary fluid which mixes with the liquid coolant and reduces the temperature of the coolant below the boiling point. If the liquid coolant is water the supplementary fluid may also be water. The supply of the supplementary fluid can be controlled by a valve means operable in response to temperature sensitive means in the liquid coolant circuit.

This invention relates to dynamo-electric machines having a liquid cooled rotor.

It is well known that the rotors of dynamo-electric machines and in particular rotors of large turbine driven alternating current generators can be cooled by circulating a liquid coolant through passages in the rotor body and in the rotor windings, the coolant entering and leaving the rotor via passages which are usually located near the axis of rotation of the rotor.

Generally speaking, it is desirable to prevent boiling of the coolant and if the coolant used is water, the pressure of the water at the outlet from the rotor, where the coolant temperature is a maximum, would in many cases be atmospheric or near atmospheric, in which case it is necessary to keep the outlet temperature below 100° C. If the inlet temperature is 40° C. then the permissible temperature rise is 60° C., whereas in conventional gas-cooled rotors a temperature rise of the order of 90° C. is permissible on an inlet temperature of 40° C. so that the total average temperature of the rotor winding is 130° C. with hot spot temperatures of the order of 140° C. The need to avoid boiling of a liquid coolant can therefore reduce the upper temperature limit at which the rotor winding can operate compared with a gas cooled rotor and this imposes a restriction on the current carrying capacity of the rotor.

The effect of centrifugal force in the liquid coolant is to increase its pressure and in the rotor core and winding of a turbine driven alternating current generator, the coolant pressure may be several thousand pounds per square inch. At such pressures the boiling point of the coolant is much higher than at atmospheric pressure, but, as the coolant passes to its outlet near the axis of rotation of the rotor, the effect of centrifugal force is reduced and as mentioned earlier the pressure of the coolant at the outlet usually approaches atmospheric pressure.

It has been proposed to increase the pressure level of the coolant supplied to the rotor so that the outlet pressure is substantially above atmospheric, but difficulties then arise in obtaining effective seals at the higher pressure levels obtaining particularly at the inlet and outlet connections.

The object of the present invention is to provide an improved dynamo-electric machine with a liquid cooled rotor having means to avoid boiling of the aforesaid liquid.

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The invention consists in a dynamo-electric machine having a liquid cooled rotor in which machine means are provided for introducing a supplementary fluid into the coolant circuit at a selected position in said circuit to mix with and reduce the coolant temperature so as to prevent boiling of said coolant.

The invention also consists in a machine in accordance with the preceding paragraph in which the supplementary fluid is introduced into the coolant at a position in the coolant circuit between the rotor winding and an outlet from the rotor for said coolant.

The invention also consists in a machine in accordance with the preceding paragraph in which ducts for conveying liquid coolant through the rotor winding discharge into at least one header adjacent the end windings and further ducts are provided in the rotor body to convey liquid coolant from said header to a discharge outlet in the shaft of said rotor, the supplementary fluid being introduced into said liquid coolant in said header.

The invention also consists in a machine in accordance with either of the preceding two paragraphs in which the supplementary fluid is admitted to the rotor via a duct surrounding an inlet duct for liquid coolant said ducts lying along the axis of rotation of the rotor.

The invention also consists in a machine in accordance with any of the preceding four paragraphs in which the supply of supplementary fluid is controlled by valve means operable in response to temperature sensitive means in the coolant circuit.

The invention also consists in a machine in accordance with the preceding paragraph in which valve means are provided in the liquid coolant circuit and are operable by said temperature sensitive means to control the flow of liquid coolant.

The invention also consists in a machine in accordance with any of the preceding six paragraphs in which the supplementary fluid is a liquid.

The invention also consists in a machine in accordance with the preceding paragraph in which the liquid coolant and the supplementary fluid are water.

In the accompanying drawings:

FIGURE 1 is a section through part of a rotor of a turbine driven alternating current generator showing diagrammatically part of a liquid coolant circuit and means for injecting a supplementary fluid in accordance with one embodiment of the invention;

FIGURE 2 is a section similar to that shown in FIGURE 1 showing an alternative arrangement for introducing the supplementary fluid;

FIGURE 3 shows diagrammatically a control arrangement for the liquid coolant and supplementary fluid.

In carrying the invention into effect in the forms illustrated by way of example and referring first of all to FIGURE 1, one end of the rotor body of a turbine driven alternating current generator is represented in outline at 1. The windings have not been shown (for the sake of simplicity) but they may be of conventional form. As is known practice, the conductors forming the rotor winding, or ducts for coolant circulating in the winding, may terminate in one or more headers at one or both ends of the rotor and one such header is shown at 2 with a conductor or duct carrying coolant represented at 3.

Liquid coolant for the rotor winding can enter or leave the winding via headers such as header 2 but in the form shown header 2 is an outlet header.

Liquid coolant is supplied to the rotor through duct 4 which is coaxial with the axis of rotation of the rotor. In the type of rotor illustrated, the liquid coolant flows in duct 4 to the end of the rotor, not shown, or to a place intermediate the rotor ends, where it is conveyed to the rotor winding. Liquid coolant entering the header 2 leaves the rotor via duct 5.

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If, as is probable in such rotors, water is used as the liquid coolant, the water would boil as it approached the outlet from the rotor if its pressure was atmospheric and its temperature above 100° C. To prevent such boiling, a supplementary fluid preferably water is introduced into the coolant in header 2 so as to reduce its temperature and ensure that it is below the boiling point no matter what is the prevailing pressure in the fluid between the header 2 and the outlet from the duct 5. Generally speaking the temperature will be reduced below 100° C. but it may not be necessary to reduce the temperature to this level if the pressure in the coolant remains above atmospheric in duct 5.

In the form shown in FIGURE 1 the water acting as supplementary fluid is introduced to the rotor via a duct 6 which surrounds duct 4 and then is conveyed from duct 6 to header 2 via duct 7.

In the arrangement shown in FIGURE 2 the supplementary fluid is supplied to the rotor via a duct 6 as before but is introduced into the liquid coolant as it flows through duct 5.

It is not essential for the duct 6 to surround duct 4 as shown. It may lie alongside duct 4 or be spaced therefrom.

The supply of supplementary fluid can be controlled by valve means 8 (see FIGURE 3), operable by temperature sensitive device 9 which is positioned at a selected point in the liquid coolant circuit preferably between the rotor winding, indicated diagrammatically at 10, and outlet 11 for the liquid coolant from the rotor. The device 9 acts to admit a desired amount of supplementary fluid should the temperature rise above a predetermined value. The device 9, or a similar device, may also be used to control the flow through the liquid coolant circuit through valve means 12.

The introduction of supplementary fluid as described can be used in rotors where the liquid coolant circuit is initially pressurised so as to obtain an outlet pressure in excess of atmosphere; the use of supplementary fluid in the manner described serving to reduce the degree of initial pressurisation necessary to prevent boiling.

I claim:

1. In a liquid cooled rotor of a dynamo-electric machine the improvement comprising additional fluid introduction means for introducing a supplementary fluid into the low pressure region of the liquid coolant circuit to

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mix with and reduce said coolant temperature to prevent boiling thereof.

2. A machine as claimed in claim 1 in which said supplementary fluid is introduced into said coolant at a position in said coolant circuit between the rotor winding and an outlet from said rotor for said coolant.

3. A machine as claimed in claim 1, wherein ducts for conveying said liquid coolant through the rotor winding discharge into at least one header adjacent the end windings, and further ducts are provided in the body of said rotor to convey said liquid coolant from said header to a discharge outlet in a shaft of said rotor, said supplementary fluid being introduced into said liquid coolant in said header.

4. A machine as claimed in claim 1 in which said supplementary fluid is admitted to said rotor via a duct surrounding an inlet duct for said liquid coolant, said ducts lying along the axis of rotation of said rotor.

5. A machine as claimed in claim 1 in which the supply of said supplementary fluid is controlled by said additional fluid introduction means which includes a valve means operable in response to temperature sensitive means in said liquid coolant circuit.

6. A machine as claimed in claim 5 in which further valve means are provided in said liquid coolant circuit and is operable by said temperature sensitive means to also control the flow of said liquid coolant.

7. A machine as claimed in claim 1 in which said supplementary fluid is a liquid.

8. A machine as claimed in claim 7 in which both said liquid coolant and said supplementary fluid are water.

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