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(54) **DEVICE FOR COOLING ELECTRICAL EQUIPMENT IN A TURBOMACHINE**

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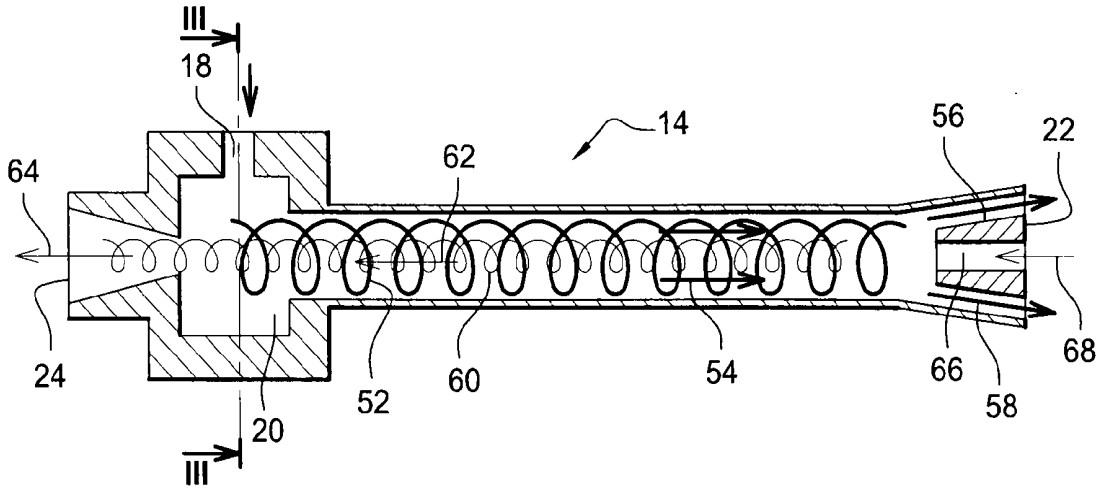
(57) **ABSTRACT**

A device for cooling electrical or electronic equipment in a turbomachine, such as a unit for controlling actuators for variable-geometry elements, the device comprising at least one vortex tube having an inlet connected to means for feeding pressurized air taken from an element of the turbomachine, and a cold air outlet connected to means for cooling the electrical equipment.



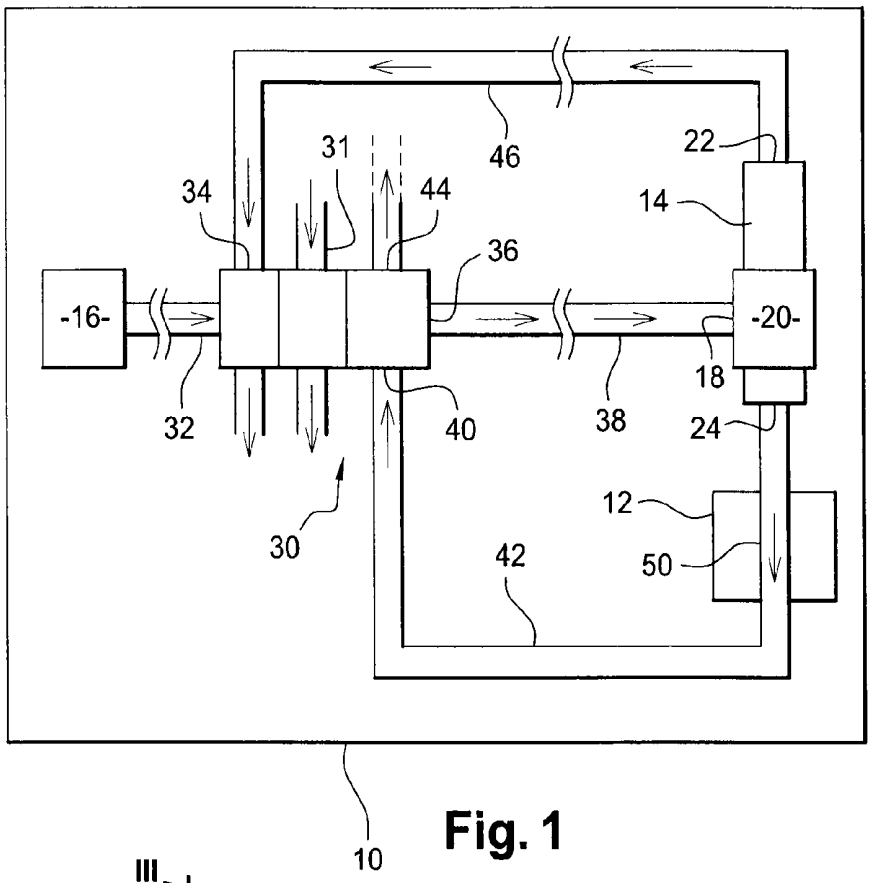


Fig. 1

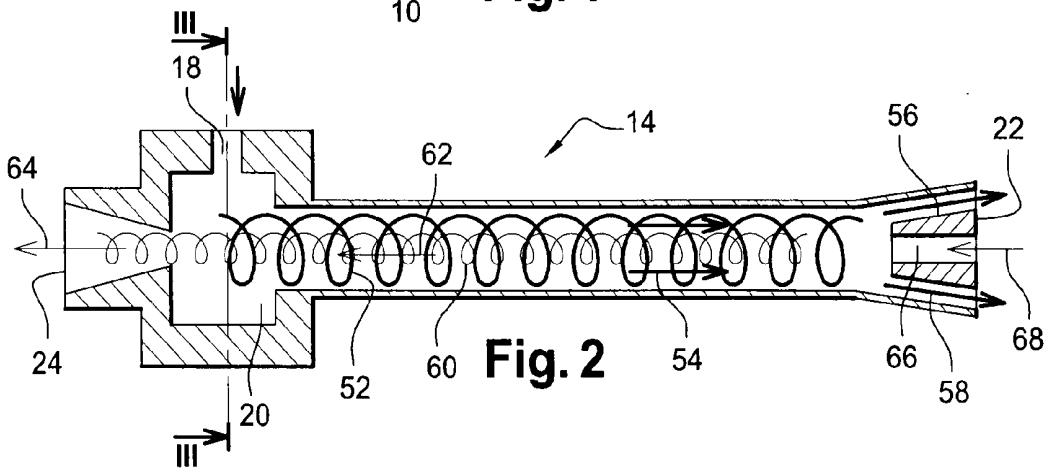


Fig. 2

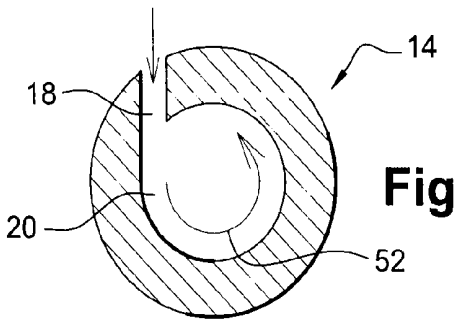


Fig. 3

DEVICE FOR COOLING ELECTRICAL EQUIPMENT IN A TURBOMACHINE

[0001] The present invention relates to a device for cooling electrical or electronic equipment in a turbomachine.

BACKGROUND OF THE INVENTION

[0002] A turbomachine includes a certain number of pieces of electrical or electronic equipment, such as units for controlling actuators of variable-geometry elements, which pieces of equipment generate a large amount of heat that needs to be removed in order to maintain acceptable temperatures for the electrical equipment and also for certain elements of the turbomachine situated in the vicinity of said equipment.

[0003] Known cooling devices generally comprise means for circulating a cooling fluid such as oil, fuel, or air, and they are often bulky and complex to implement. Furthermore, those devices present risks of leakage, and they require regular maintenance operations, which are lengthy and expensive.

OBJECTS AND SUMMARY OF THE INVENTION

[0004] A particular object of the invention is to provide a solution to those problems that is effective and inexpensive.

[0005] For this purpose, the invention provides a device for cooling electrical equipment in a turbomachine, the device comprising at least one vortex tube having an inlet connected to pressurized air feed means, and a cold air outlet connected to means for cooling the electrical equipment, wherein the vortex tube is fed with pressurized air via a heat exchanger having a secondary circuit fed with cooling fluid by the outlet of the means for cooling the electrical equipment or by the hot air outlet of the vortex tube.

[0006] In known manner, a vortex tube, also known as a Ranque tube, serves to uses the vortex effect to create a flow of cold air and a flow of hot air derived from a flow of compressed air at an intermediate temperature. The inlet air is injected tangentially into a chamber connected to the tube so as to create a rapidly swirling flow that is directed towards one end of the tube, which end is fitted with a conical outlet valve. A portion of the air leaves the tube via said valve, while another portion of the air is reflected on said valve and then progresses along the tube in the opposite direction with swirling motion inside the injected air, while yielding heat to said air, and then leaving via the opposite end of the tube.

[0007] The cooling device of the invention has one or more vortex tubes that are fed with pressurized air taken by suitable means from a compressor of the turbomachine or from an annular duct for passing a secondary air flow such as the fan duct of the turbomachine. The cold air outlet from each vortex tube is connected to a heat exchanger associated with the equipment for cooling, or to a system for injecting air into the electrical equipment for cooling.

[0008] Vortex tubes are simple to make and to implement and they enable cold air to be produced with resources that are locally available. They are fed with air at a pressure of several bars (typically lying in the range 5 bar to 10 bar) and they generate cold air at a temperature that may be about 50° C. lower than the temperature of the inlet air. Furthermore, vortex tubes are inexpensive, reliable, and have a lifetime that is relatively long without requiring special maintenance, since they do not include any moving parts.

[0009] The cooling device may include a heat exchanger having a primary circuit with an inlet connected to the outlet of the means for taking air and an outlet connected to the inlet of the vortex tube, and including at least one secondary circuit that is fed with cooling fluid.

[0010] At least some of the air that has been used for cooling the electrical equipment can be injected into a secondary circuit of the heat exchanger in order to assist in cooling the air taken from the turbomachine. Similarly, the air coming from the hot outlet of the vortex tube can be injected into a secondary circuit of the heat exchanger for assisting in cooling the air taken in, providing its temperature is lower than that of the air taken from the turbomachine. The heat exchanger may thus have two secondary circuits fed with cooling air, one by the outlet from the means for cooling the electrical equipment, the other by the hot air outlet from the vortex tube.

[0011] The vortex tube may be of the double-circuit type, in which case it includes a second inlet tube connected to the pressurized air feed means, with this disposition making it possible to double efficiency.

[0012] It is also possible to use a plurality of vortex tubes associated in series or in parallel for cooling the electrical or electronic equipment.

[0013] The invention also provides a turbomachine, including an electrical or electronic equipment cooling device as described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The invention can be better understood and other details, characteristics, and advantages of the present invention appear on reading the following description made by way of non-limiting example and with reference to the accompanying drawings, in which:

[0015] FIG. **1** is a highly diagrammatic representation of a device of the invention for cooling electrical equipment of a turbomachine;

[0016] FIG. **2** is a diagrammatic axial section view of a vortex tube of the cooling device of the invention; and

[0017] FIG. **3** is a section view on line III-III of FIG. **2**.

MORE DETAILED DESCRIPTION

[0018] FIG. **1** is a highly diagrammatic representation of the device of the invention for cooling electrical or electronic equipment **12** in a turbomachine **10**, the device comprising a vortex tube **14** or Ranque tube fed with pressurized air that is taken from an element **16** of the turbomachine, said element **16** being constituted for example by a fan duct, a low pressure or high pressure compressor, or an auxiliary compressor of smaller size driven by an accessory gearbox of the turbomachine.

[0019] The vortex tube **14** has an inlet **18** opening out into a chamber **20** formed between the ends of the tube, the tube having a hot air outlet **22** at one of its ends and a cold air outlet **24** at its other end. The well-known operation of the vortex tube is described in detail below with reference to FIGS. **2** and **3**.

[0020] In the example shown, the cooling device further comprises a heat exchanger **30** having one or more stages comprising a primary circuit with an inlet **32** connected to

means for taking air from the element **16** of the turbomachine, and an outlet **36** connected by a duct **38** to the inlet **18** of the vortex tube **14**.

[0021] The air that is taken is cooled in the heat exchanger **30** by natural convection (and also by radiation), and/or by heat exchange with a cooling fluid flowing in a secondary circuit **31** of the heat exchanger **30**.

[0022] The heat exchanger **30** may optionally include another secondary circuit for cooling fluid, with an inlet **40** connected by a duct **42** to the outlet of a heat exchanger **50** used for cooling the electrical equipment, the air rejected from the outlet **44** of the secondary circuit of the heat exchanger **30** possibly being used for cooling elements of the turbomachine.

[0023] Similarly, the hot air outlet **22** from the vortex tube **14** can be connected by a duct **46** to an inlet **34** of another secondary circuit of the heat exchanger **30**.

[0024] The cold air outlet **24** from the vortex tube is connected either to the heat exchanger **50** or to an air ejector system associated with the electrical equipment **12**, this electrical element being constituted, for example, by an electronic unit for controlling variable-geometry portions of the turbomachine.

[0025] The device may also include pressurized air filter means mounted at **32** or at **38** for limiting wear in the vortex tube and thus increasing its lifetime.

[0026] The cooling device of the invention operates as follows: pressurized air is taken from the element **16** and passes through the primary circuit of the heat exchanger **30** so as to be cooled by exchanging heat with a cooling fluid flowing in the secondary circuit **31** and possibly also with air flowing in the secondary circuit **40-44** of the heat exchanger **30**, and with hot air delivered by the outlet **22** from the vortex tube. The cooled air leaving the heat exchanger **30** is injected tangentially into the chamber **20** of the tube that is situated in the vicinity of the first end **24** of the tube (FIG. **2**). This chamber **20** is generally cylindrical in shape so as to cause the injected air to move and so as to create a rapid swirling flow **52** inside the tube, this flow going towards the second end **22** of the tube (arrow **54**). The air at the outer periphery of the swirling flow is relatively hotter while the air situated at the inner periphery of the swirling flow is relatively cooler.

[0027] A frustoconical control valve **56** is mounted in the second end **22** of the tube and co-operates with the inside surface of the tube to define an annular air outlet channel for the air situated at the outer periphery of the swirling flow, i.e. for the hot air (arrows **58**). The central portion of the swirling flow is reflected on the valve **56** and forms a second swirling flow **60** that flows in the opposite direction inside the first swirling flow **52** (arrow **62**), while yielding heat thereto, until it reaches the first end **24** of the tube (arrow **64**).

[0028] The vortex tube may be of the double-circuit type in which case it has a second air inlet at its end **22** opposite from the chamber **20** for the purpose of improving the efficiency of the tube, as is well known in the art. In the example shown, an orifice **66** on the axis of the tube is formed through the control valve **56** and can be connected to air feed means (arrow **68**), this air, for example, having the same temperature and a lower pressure than the air injected into the chamber **20**.

[0029] In a particular embodiment of the invention, the flow rate of air taken from the element **16** and passing through the heat exchanger **30** is 2833 liters per minute (L/min), this air being at a pressure of 6.3 bar and at a temperature of 200° C. The cooling fluid fed to the secondary circuit **31** of the heat exchanger **30** is air at a temperature of 90° C. and it enables the temperature of the pressurized air fed to the vortex tube **14** to be reduced to 100° C. The heat exchanger **50** is fed with cold air at a flow rate of 1840 L/min, this air having a temperature of 57° C. at the inlet to the heat exchanger **50** and a temperature of about 80° C.-90° C. at the outlet from the heat exchanger, which air can subsequently be injected into a secondary circuit of the heat exchanger via the duct **42**.

[0030] A plurality of vortex tubes **14** may be connected in series or in parallel for the purpose of cooling one or more pieces of electrical or electronic equipment. The dimensioning of the or each vortex tube depends on the flow rate and the temperature of the cold air at the outlet from the tube, which flow rate and temperature are determined as a function of the type of equipment to be cooled.

What is claimed is:

1. A device for cooling electrical equipment in a turbomachine, the device comprising at least one vortex tube having an inlet connected to pressurized air feed means, and a cold air outlet connected to means for cooling the electrical equipment, wherein the vortex tube is fed with pressurized air via a heat exchanger having a secondary circuit fed with cooling fluid by the outlet of the means for cooling the electrical equipment or by the hot air outlet of the vortex tube.

2. A device according to claim **1**, wherein the pressurized air feed means comprise means for taking air from an annular duct for passing a flow of cool air or a secondary flow of the turbomachine.

3. A device according to claim **1**, wherein the pressurized air feed means comprise means for taking air from a compressor of the turbomachine.

4. A device according to claim **1**, wherein the pressurized air feed means comprise an auxiliary compressor driven by an accessory gearbox of the turbomachine.

5. A device according to claim **1**, wherein the heat exchanger includes two secondary circuits fed with cooling air, one by the outlet from the means for cooling the electrical equipment, and the other by the hot air outlet from the vortex tube.

6. A device according to claim **1**, wherein the vortex tube is fed with air at a pressure of a few bars.

7. A device according to claim **1**, wherein the temperature of the cold air leaving the vortex tube is about 50° C. lower than the temperature of the pressurized air.

8. A device according to claim **1**, wherein the vortex tube is of the double-circuit type and includes a second inlet connected to the pressurized air feed means.

9. A device according to claim **1**, including a plurality of vortex tubes associated in series or in parallel.

10. A turbomachine, including a device according to claim **1** for cooling electrical equipment.

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