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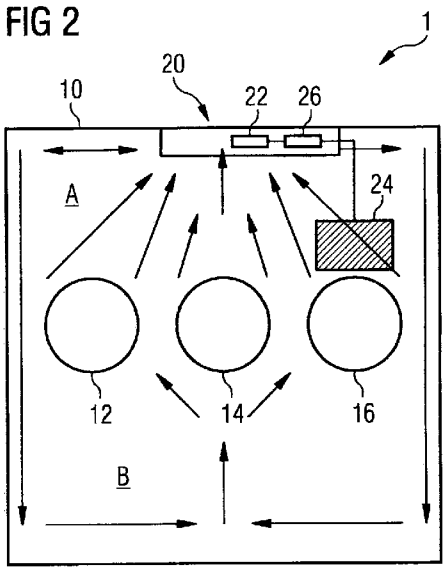
(54) Title: ELECTRICAL DEVICE



(57) Abstract: The invention describes an electrical device (1), in particular a switchgear, comprising a closed compartment (10) encasing an insulating fluid and comprising at least one electrical conductor (12, 14, 16) extending through the compartment (10) and emanating heat to the insulating fluid while a current flows through the at least one conductor (12, 14, 16). Furthermore, the switchgear comprises a heat releasing subsystem comprising a means (20) for forcing a convection of the fluid inside the insulating compartment (10) wherein an energy source for driving the means (20) for forcing the convection is located inside the compartment (10).

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ELECTRICAL DEVICE

DESCRIPTION

The invention relates to an electrical device, in particular a switchgear, comprising a closed compartment encasing an insulating fluid and comprising at least one electrical conductor extending through the compartment and emanating heat to the fluid while a current flows through the at least one conductor.

The following description is made with reference to a switchgear. However, it is to be understood, that a switchgear is only an example for an electrical device according to the invention.

A switchgear refers to a combination of electrical disconnects, fuses and/or circuit breakers, used to isolate electrical equipment. A switchgear is used both to de-energize equipment to allow work to be done and to clear faults downstream. There are several kinds of switchgears. However, as insulating fluid within the compartment often a gas is used, allowing large currents and power levels to be safely controlled by automatic equipment incorporating digital controls, protection, metering and communications. Those switchgears are referred to gas insulated switchgears (GIS) and are used for transmission-level voltages, thereby saving space compared with air-insulated switchgears. In a gas insulated switchgear the conductors and contacts are, for example, insulated by pressurized sulfur hexafluoride gas (SF_6).

The basic requirement of such switchgear is to provide a reliable operation without any service for decades of years, preferably more than 50 years. Thus, the design of switchgears has been made very simple in the past. Any complicated parts or assemblies are avoided.

An important issue of the switchgear is its thermal behavior within the closed compartment. There are many various industry standards that provide different requirements for such systems with regard to maximum allowed temperature rises of the compartment and the conductors. Since the design of such switchgears is very conservative (and thus the same design could be used for different current flows and environmental conditions) this sometimes leads to overheating.

It is therefore an object of the present invention to provide an electrical device, in particular a switchgear, in which the problem of overheating can be avoided or at least reduced.

This object is solved by an electrical device according to the features of claim 1. Preferred embodiments are set out in the dependent claims.

The invention provides an electrical device, in particular a switchgear, comprising a closed compartment encasing a fluid and at least one electrical conductor extending through the compartment and emanating heat to the fluid while a current flows through the at least one conductor. The electrical device comprises a heat releasing subsystem comprising a means for forcing a convection of the fluid inside the compartment wherein an energy source for driving the means for forcing the convection is located inside the compartment.

The invention is based on the consideration that overheating typically happens due to poor heat transfer caused by natural convection inside the compartment. By forcing the convection inside the electrical device heat transfer can be increased. As a result the temperature distribution of the fluid within the compartment can be optimized.

Forcing the convection is realized without any additional wiring coming from outside the compartment which continues avoiding complicated parts or assemblies. Therefore, the electrical device according to the invention can be used in applications with very high voltages (e.g. above 100 kV) due to the lack of insulating problems which might result from wiring coming from outside the compartment.

According to a further preferred embodiment the means for forcing the convection comprises a fan, in particular a centrifugal fan, having a fan drive being driven by the energy source. It is further preferred if the fan drive is supported by a magnetic bearing. A magnetic bearing is very reliable even at extreme conditions which is resistant to external magnetic fields. Magnetic bearings do not need any grease or oil during their lifetime and therefore need no maintenance. Magnetic bearings are widely used in aerospace industry. Therefore, they can be used advantageously in those electrical devices which shall be operated without any service for decades of years.

According to a further preferred embodiment the fan is made of a non-conducting material, in particular plastic. As a result, the fan is not influenced by any magnetic fields appearing within the closed compartment.

According to a further preferred embodiment the means for forcing the convection of the fluid is provided at a wall of the compartment which is in a direction of gravity above the at least one conductor. Providing the means for forcing the

convection, in particular the fan of the means, at the ceiling above the at least one conductor enables heat distribution of the fluid within the closed compartment. As a result the heat transfer from the fluid to the compartment can be maximized.

In a further preferred embodiment the means for forcing the convection of the fluid is provided symmetrically above the at least one conductor. This construction supports an improved heat transfer.

According to a further preferred embodiment the energy source comprises a current transformer using an electromagnetic field of the at least one conductor for providing a current to the means for forcing the convection. Using an electromagnetic field generated by the at least one conductor within the compartment provides enough energy to the fan drive without the necessity of any external energy supply. Only in case if strong electromagnetic fields are not present for driving the fan drive, small additional energy supplies provided inside the closed compartment may be used.

According to a further preferred embodiment the fluid is a gas, in particular sulfur hexafluoride (SF_6). A switchgear using gas as an insulator is called a gas insulated switchgear (GIS). Gas insulated switchgears are compared to air-insulated switchgears smaller.

The invention will be explained more detailed by reference to the figures.

Fig. 1 shows a cross-section of a conventional electrical device using natural convection for heat transfer.

Fig. 2 shows a cross-section of an electrical device according to the invention using a forced convection for better heat transfer.

Fig. 1 shows a known electrical device 1 in a cross-section. The electrical device 1 may be a switchgear, in particular a gas insulated switchgear in which a gas (preferably SF_6) is used as an insulating fluid within a closed compartment 10. As an example three electrical conductors 12, 14, 16 are extending through the compartment 10. In this example, the conductors 12, 14, 16 are located within a plane extending parallel to the bottom and the ceiling of the compartment. As already noted, the closed compartment 10 is filled with gas as insulator to provide smaller dimensions of the device compared to air-insulated devices.

During operation of the electric device 1 the conductors 12, 14, 16 emanate heat due to a current flowing through the conductor 12, 14, 16. As a result, the gas heats up.

The heat is transferred to the material of the compartment by natural convection of the gas inside the compartment 10. As a result of the natural convection of the gas, the heat distribution within the compartments is uneven. In an area indicated with A and extending in a direction of gravity above the conductors 12, 14, 16 the gas heats up stronger than in an area B between the bottom of the compartment 10 and the conductors 12, 14, 16. Arrows in area A indicate the direction of gas flow due to natural convection.

Variations of conductor geometry, surface quality and material are the only way to pass given requirements in terms of thermal behavior. It would also be possible to change the properties of the filling gas inside the compartment 10. However, these actions don't deal with the problem of pure heat transfer inside the device.

Fig. 2 shows a cross-section of an electrical device 1 according to the invention. As in the conventional electric device in the compartment 10 three conductors 12, 14, 16 are arranged. It is to be understood, that the number of conductors and the arrangement of the conductors within the compartment could be made different.

The electrical device 1, preferably a gas insulated switchgear, comprises a means 20 for forcing the convection inside the compartment 10. As a result, an increased heat transfer improves the thermal behavior of the device 1.

The forced convection increases the velocities of the fluid (gas) inside the device. It furthermore increases the recirculation zones and thus cools down the heat releasing units or subsystems, in particular the conductor 12, 14, 16. In the device according to the invention, the recirculation zone not only extends in area A but also to the area B being located under the conductors 12, 14, 16 in a direction of gravity. The circulation of the fluid is illustrated with the arrows again.

In case of a gas insulated switchgear the forced convection may decrease the temperature of the conductors 12, 14, 16 up to 10 to 15 K. Lower conductor temperatures allow to use the electrical device 1 in more extreme conditions. For example, it will be possible, to increase the current value or to use the device at sites with higher temperature of the environment.

The means 20 for forcing the convection of the fluid inside the compartment 10 consists of a fan 22 being driven by a fan drive 26 and an energy source 24. Preferably, the fan is a centrifugal fan made of a non-conducting material like plastic being

unsensitive to magnetic fields. The energy source consists of a current transformer 24 which is used as electrical power supply of the fan. The current transformer 24 transforms the energy of the magnetic field, generated by one of the conductors 12, 14, 16 during a flow of current through it, to a current for the fan drive 26. Using a current transformer 24 within the closed compartment 10 has the advantage, that there is no need for an external power source and no wiring that has to be led into the compartment 10.

Instead of using a current transformer to supply a current to the fan drive, an antenna or loop may be arranged inside the compartment that is oriented in a way to receive enough energy from the electromagnetic field of at least one of the conductors 12, 14, 16.

The fan drive 26 is supported with a magnetic bearing. The magnetic bearing is very reliable even at extreme conditions. It does not need grease or oil. Therefore, it has a very high reliability and does not need any maintenance. It is resistant to external magnetic fields and can therefore advantageously used within the the electrical device according to the invention.

The means for forcing the convection can be arranged within the closed compartment 10 with all of its components. There is no need for any additional wiring which is coming from outside. Therefore, the device according to the invention has high insulating properties and can be used in conjunction with high voltages above 100 kV.

Instead of decreasing the temperature of the conductors and the housing by decreasing the power losses of the wires, the invention suggests forcing the convection within the compartment. The latter is more effective than changing the materials of conductors or editions in conductor design as well as increasing of the conductor surface.

CLAIMS

1. An electrical device (1), in particular a switchgear, comprising

- a closed compartment (10) encasing an insulating fluid;

- at least one electrical conductor (12, 14, 16) extending through the compartment (10) and emanating heat to the fluid while a current flows through the at least one conductor (12, 14, 16);

- a heat releasing subsystem comprising a means (20) for forcing a convection of the insulating fluid inside the compartment (10) wherein an energy source for driving the means (20) for forcing the convection is located inside the compartment (10).

2. The electrical device according to claim 1, wherein the means (20) for forcing the convection comprises a fan (22), in particular a centrifugal fan, having a fan drive (26) being driven by the energy source.

3. The electrical device according to claim 2, wherein the fan drive (26) is supported by a magnetic bearing (28).

4. The electrical device according to claim 2 or 3, wherein the fan (22) is made of a non-conducting material, in particular plastic.

5. The electrical device according to one of the preceding claims, wherein the means (20) for forcing the convection of the fluid is provided at a wall of the compartment which is in a direction of gravity above the at least one conductor (12, 14, 16).

6. The electrical device according to one of the preceding claims, wherein the means (20) for forcing the convection of the fluid is provided symmetrically above the at least one conductor (12, 14, 16).

7. The electrical device according to one of the preceding claims, wherein the energy source comprises a current transformer (24) using an electromagnetic field of the at least one conductor (12, 14, 16) for providing a current to the means (20) for forcing the convection.

8. The electrical device according to one of the preceding claims, wherein the fluid is a gas, in particular SF_6.

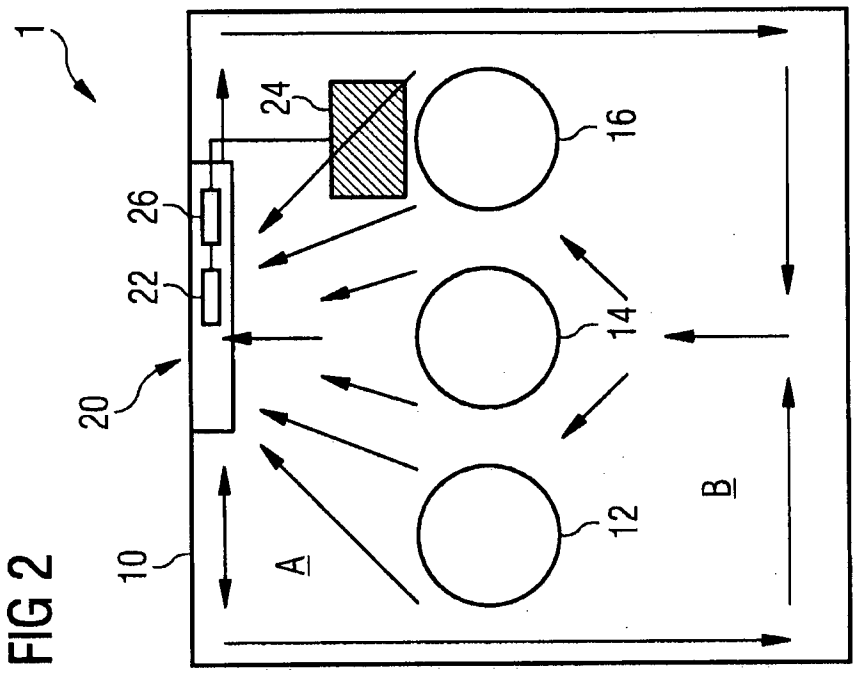

FIG 2

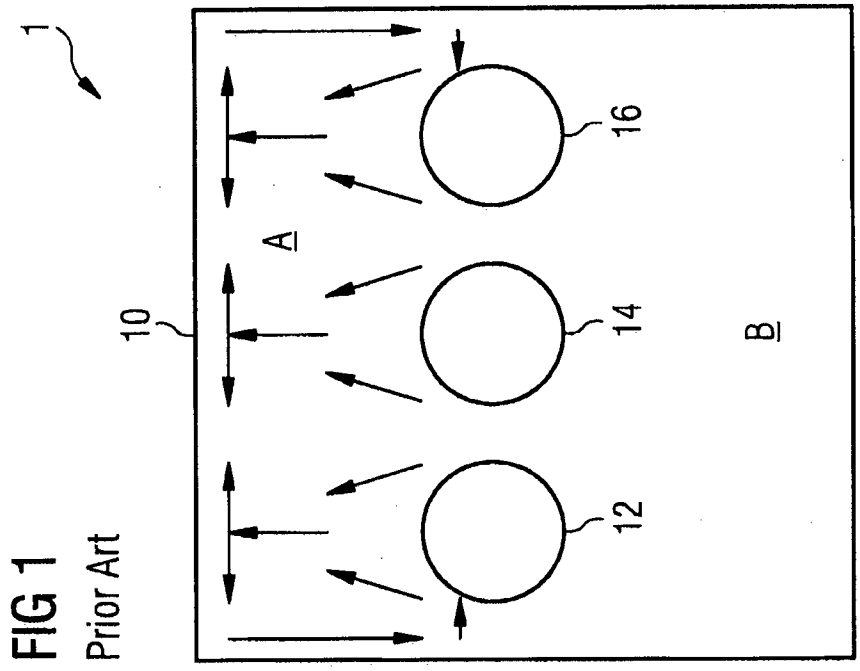

FIG 1
Prior Art

INTERNATIONAL SEARCH REPORT

International application No
PCT/RU2011/000690

A. CLASSIFICATION OF SUBJECT MATTER
INV. H02B1/56 H02B13/035 H02G5/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H02B H02G H01H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 9 163530 A (MEIDENSHA ELECTRIC MFG CO LTD) 20 June 1997 (1997-06-20) abstract; figure 1	1-8
X	EP 1 906 503 A1 (SIEMENS AG [DE]) 2 April 2008 (2008-04-02)	1-4,7,8
Y	abstract paragraph [0022] - paragraph [0028]; figure 1	1-8
Y	EP 1 022 830 A1 (ABB HOCHSPANNUNGSTECHNIK AG [CH] ABB SCHWEIZ AG [CH]) 26 July 2000 (2000-07-26) paragraphs [0014], [0017]; figure 3	1-8
X	US 3 230 293 A (TURGEON JOSEPH A) 18 January 1966 (1966-01-18) the whole document	1-4,7,8

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/RU2011/000690

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