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(54) **SWITCHGEAR**

(57) The present invention relates to a circuit breaker, comprising:
- a vacuum interrupter (2);
- an upper arm (1);
- a lower arm (4);
- a push and/or pull rod mechanism (7); and
- an outer casing (3);

wherein the upper arm comprises an upper terminal electrically connected to a fixed contact of the vacuum interrupter;
wherein the lower arm comprises a lower terminal electrically connected to a moveable contact of the vacuum interrupter;
wherein the push and/or pull rod mechanism is configured to move the moveable contact towards and/or away from the fixed contact;
wherein the outer casing surrounds at least the vacuum interrupter and the push and/or pull rod mechanism, and wherein a cavity (10) is formed at least between the push and/or pull rod mechanism and the outer casing; and
wherein the outer casing comprises at least one first opening (20) and/or at least one first conduit (20) that connects to the cavity such that air can flow between an outside of the circuit breaker and the cavity through the outer casing.

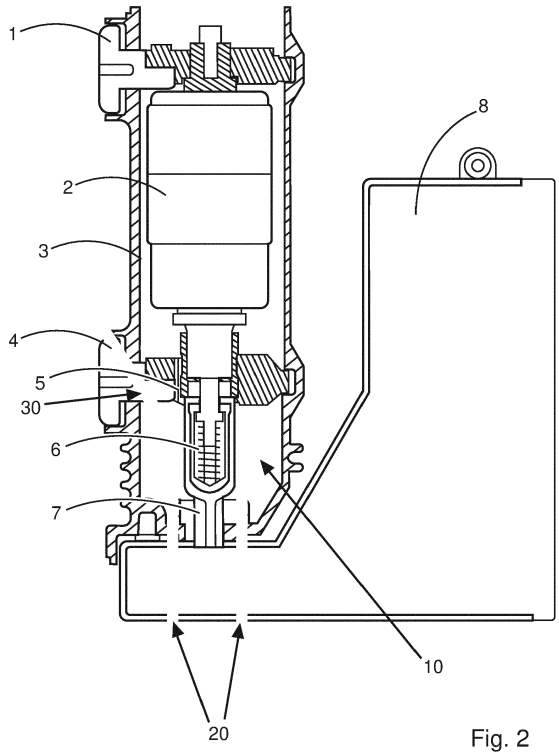

Fig. 2

EP 4 560 675 A1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a circuit breaker, a switchgear, such as for low, medium or high voltage applications, a method of cooling a circuit breaker and method of cooling a switchgear.

BACKGROUND OF THE INVENTION

[0002] In the low, medium and high voltage applications, inner parts of a circuit breaker are encapsulated in an epoxide capsule due to di-electric and electric effects. Because the epoxide is a strong heat insulator, it severely limits the amount of heat that can be dissipated into air. Fig. 1 shows a representation of a known circuit breaker.

[0003] Heat removal from inner parts of a circuit breaker often relies on heat conduction to coolers. Coolers are attached on the top of the circuit breaker or on the arms of the circuit breaker. Heat must be conducted to these coolers along a long heat conduction path that is further obstructed by heat contact resistance between components, limiting heat conduction in the whole cooling process.

[0004] These effects cause high temperatures inside a circuit breaker, that even highly optimized coolers are unable to decrease.

[0005] There is a need to address this issue.

SUMMARY OF THE INVENTION

[0006] Therefore, it would be advantageous to have an improved ability to extract thermal energy from switchgear circuit breakers.

[0007] The object of the present invention is solved with the subject matter of the independent claims, wherein further embodiments are incorporated in the dependent claims.

[0008] In a first aspect, there is provided a circuit breaker, comprising:

- a vacuum interrupter;
- an upper arm;
- a lower arm;
- a push and/or pull rod mechanism; and
- an outer casing.

The upper arm comprises an upper terminal electrically connected to a fixed contact of the vacuum interrupter. The lower arm comprises a lower terminal electrically connected to a moveable contact of the vacuum interrupter. The push and/or pull rod mechanism is configured to move the moveable contact towards and/or away from the fixed contact. The outer casing surrounds at least the vacuum interrupter and the push and/or pull rod mechanism. A cavity is formed at least between the push and/or pull rod mechanism and the outer casing. The outer casing comprises at least one first opening and/or at least one first conduit that connects to the cavity such that air can flow between an outside of the circuit breaker and the cavity through the outer casing.

[0009] Thus, an existing cavity inside the casing of a circuit breaker around the push/pull rod mechanism that enables this mechanism to move is, is utilized by a new development of opening this cavity to the outside of the circuit breaker in order that air from outside the circuit breaker, that is colder than the parts of the circuit breaker, can enter the circuit breaker and cool the circuit breaker.

[0010] In an example, the circuit breaker comprises an enclosure connected to the outer casing. The enclosure houses an operating mechanism for the push and/or pull rod. The enclosure comprises the at one first opening and/or the at least one first conduit such that the air can flow between the outside of the circuit breaker and the cavity through the enclosure.

[0011] Thus, an existing geometry of a circuit breaker can be utilized, where the cavity inside the casing of the vacuum interrupter and pull/push rod of the circuit breaker is accessed via a hole through the casing and through sheet metal parts of the enclosure housing the circuit breaker drive.

[0012] The enclosure comprising the at one first opening and/or the at least one first conduit can mean that an opening extends through the enclosure and extends through the casing, with the opening fluidly connecting the cavity with the outside of the circuit breaker. The enclosure comprising the at one first opening and/or the at least one first conduit can mean that a conduit extends through the enclosure and extends through the casing, with the conduit fluidly connecting the cavity with the outside of the circuit breaker.

[0013] In an example, the outer casing and the at least one first opening and/or the at least one first conduit are configured such that the air can flow between the outside of the circuit breaker and the cavity via natural convection.

[0014] As cooling is provided of internal parts of a circuit breaker via natural convection, not only is cooling provided of an existing design with just a hole/conduit through the casing required, no fans are required for air movement and the design is very cost effective and free from maintenance because no extra moving parts are required that could fail.

[0015] In an example, the at least one first opening and/or the at least one first conduit connects to the cavity at a bottom region of the cavity.

[0016] In an example, the outer casing and the at least one first opening and/or the at least one first conduit are configured such that the di-electric requirements of the circuit breaker are maintained.

[0017] In an example, the lower arm has at least one second opening and/or at least one second conduit that connects to the cavity such that air can flow between the outside of the circuit breaker and the cavity through the lower arm.

[0018] In this manner, air can convect through the circuit breaker, from outside to the inside and to the outside and cool the area around the pull/push rod and the bottom of the circuit breaker and also cool the lower arm/terminal of the circuit breaker.

[0019] In an example, the at least one second opening and/or the at least one second conduit connects to the cavity at a top region of the cavity.

[0020] In an example, the at least one second opening and/or the at least one second conduit passes through the outer casing.

[0021] In an example, the at least one first opening and/or the at least one first conduit connects to the cavity at a bottom region of the cavity and the at least one second opening and/or the at least one second conduit connects to the cavity at a top region of the cavity.

[0022] Thus, air inside the cavity and indeed within the lower arm can be heated and rise within the exit the circuit breaker via the at least one second opening and/or the at least one second conduit. A t the same time the reduction in air pressure within the circuit breaker due to the air exiting leads to air being drawn into the at least one first opening and/or the at least one first conduit. Thus, cooling air is drawn into the bottom of the circuit breaker and exits the circuit breaker at a higher region, and during its passage through the circuit breaker it is heated and thus heat is extracted from the circuit breaker. This is achieved with an existing design of circuit breaker, with for example a hole drilled through the bottom of the circuit breaker to the cavity and a hole drilled through the lower arm of the circuit breaker to the cavity, to provide cooling without any active air movement means, such as a fan, required.

[0023] In an example, the circuit breaker is configured such that the air can flow between the outside of the circuit breaker and the cavity through the lower arm via natural convection.

[0024] In an example, the lower arm comprises an internal hollow section in fluid connection with the at least one second opening and/or at least one second conduit.

[0025] In this manner, cooling air can cool a greater portion of the lower arm.

[0026] In an example, the circuit breaker is configured such that the air can flow between the outside of the circuit breaker and the cavity through the lower arm and the internal hollow section via natural convection.

[0027] In an example, the circuit breaker is configured such that the air can flow into the circuit breaker through the at least one first opening and/or the at least one first conduit and flow out of the circuit breaker through the at least one second opening and/or the at least one second conduit.

[0028] In an example, the outer casing and the at least one second opening and/or the at least one second conduit of the lower arm are configured such that the air can flow into the circuit breaker through the at least one first opening and/or the at least one first conduit and flow out of the circuit breaker through the at least one second opening and/or the at least one second conduit via natural convection.

[0029] In an example, the outer casing and the at least one second opening and/or the at least one second conduit of the lower arm are configured such that the di-electric requirements of the circuit breaker are maintained.

[0030] In an example, the outer casing comprises epoxy resin and/or epoxide.

[0031] In a second aspect, there is provided a low voltage, medium voltage, or high voltage switchgear comprising a circuit breaker according to the first aspect.

[0032] In a third aspect, there is provided a method of cooling a circuit breaker. The circuit breaker comprises a vacuum interrupter, an upper arm, a lower arm, a push and/or pull rod mechanism, and an outer casing. The upper arm comprises an upper terminal electrically connected to a fixed contact of the vacuum interrupter. The lower arm comprises a lower terminal electrically connected to a moveable contact of the vacuum interrupter. The push and/or pull rod mechanism is configured to move the moveable contact towards and/or away from the fixed contact. The outer casing surrounds at least the vacuum interrupter and the push and/or pull rod mechanism. A cavity is formed at least between the push and/or pull rod mechanism and the outer casing. The outer casing comprises at least one first opening and/or at least one first conduit that connects to the cavity. The method comprises:

- flowing air between an outside of the circuit breaker and the cavity through the outer casing via the at least one first opening and/or the at least one first conduit.

[0033] In an example, the circuit breaker further comprises an enclosure connected to the outer casing, the enclosure housing an operating mechanism for the push and/or pull rod, and wherein the enclosure comprises the at one first opening and/or the at least one first conduit, and wherein the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the enclosure via the at least one first opening and/or the at least one first conduit.

[0034] In an example, the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the enclosure via the at least one first opening and/or the at least one first conduit via natural convection.

[0035] In an example, the at least one first opening and/or the at least one first conduit connects to the cavity at a bottom region of the cavity.

[0036] In an example, the method comprises:

- designing the outer casing and the at least one first

opening and/or the at least one first conduit such that the di-electric requirements of the circuit breaker are maintained.

[0037] In an example, the lower arm has at least one second opening and/or at least one second conduit that connects to the cavity, and the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the lower arm via the at least one second opening and/or the at least one second conduit.

[0038] In an example, the at least one second opening and/or the at least one second conduit passes through the outer casing.

[0039] In an example, the at least one first opening and/or the at least one first conduit connects to the cavity at a bottom region of the cavity and the at least one second opening and/or the at least one second conduit connects to the cavity at a top region of the cavity.

[0040] In an example, the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the lower arm via the at least one second opening and/or the at least one second conduit via natural convection.

[0041] In an example, the lower arm comprises an internal hollow section in fluid connection with the at least one second opening and/or at least one second conduit, and the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the lower arm and the internal hollow section via natural convection.

[0042] In an example, the method comprises:

- flowing air into the circuit breaker through the at least one first opening and/or the at least one first conduit and flowing air out of the circuit breaker through the at least one second opening and/or the at least one second conduit.

[0043] In an example, the method comprises:

- flowing air into the circuit breaker through the at least one first opening and/or the at least one first conduit and flowing air out of the circuit breaker through the at least one second opening and/or the at least one second conduit via natural convection.

[0044] In an example, the method comprises:

- designing the outer casing and the at least one second opening and/or the at least one second conduit such that the di-electric requirements of the circuit breaker are maintained.

[0045] In an example, the outer casing comprises epoxy resin and/or epoxide.

[0046] In a fourth aspect, there is provided a method of cooling a low voltage, medium voltage, or high voltage switchgear. The switchgear comprises a circuit breaker. The circuit breaker comprises a vacuum interrupter, an upper arm, a lower arm, a push and/or pull rod mechanism, and an outer casing. The upper arm comprises an upper terminal electrically connected to a fixed contact of the vacuum interrupter. The lower arm comprises a lower terminal electrically connected to a moveable contact of the vacuum interrupter. The push and/or pull rod mechanism is configured to move the moveable contact towards and/or away from the fixed contact. The outer casing surrounds at least the vacuum interrupter and the push and/or pull rod mechanism. A cavity is formed at least between the push and/or pull rod mechanism and the outer casing. The outer casing comprises at least one first opening and/or at least one first conduit that connects to the cavity. The method comprises:

- flowing air between an outside of the circuit breaker and the cavity through the outer casing via the at least one first opening and/or the at least one first conduit.

[0047] In an example, the circuit breaker further comprises an enclosure connected to the outer casing, the enclosure housing an operating mechanism for the push and/or pull rod, and wherein the enclosure comprises the at one first opening and/or the at least one first conduit, and wherein the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the enclosure via the at least one first opening and/or the at least one first conduit.

[0048] In an example, the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the enclosure via the at least one first opening and/or the at least one first conduit via natural convection.

[0049] In an example, the at least one first opening and/or the at least one first conduit connects to the cavity at a bottom region of the cavity.

[0050] In an example, the method comprises:

- designing the outer casing and the at least one first opening and/or the at least one first conduit such that the di-electric requirements of the circuit breaker are maintained.

[0051] In an example, the lower arm has at least one second opening and/or at least one second conduit that

connects to the cavity, and the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the lower arm via the at least one second opening and/or the at least one second conduit.

[0052] In an example, the at least one second opening and/or the at least one second conduit passes through the outer casing.

[0053] In an example, the at least one first opening and/or the at least one first conduit connects to the cavity at a bottom region of the cavity and the at least one second opening and/or the at least one second conduit connects to the cavity at a top region of the cavity.

[0054] In an example, the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the lower arm via the at least one second opening and/or the at least one second conduit via natural convection.

[0055] In an example, the lower arm comprises an internal hollow section in fluid connection with the at least one second opening and/or at least one second conduit, and the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the lower arm and the internal hollow section via natural convection.

[0056] In an example, the method comprises:

- flowing air into the circuit breaker through the at least one first opening and/or the at least one first conduit and flowing air out of the circuit breaker through the at least one second opening and/or the at least one second conduit.

[0057] In an example, the method comprises:

- flowing air into the circuit breaker through the at least one first opening and/or the at least one first conduit and flowing air out of the circuit breaker through the at least one second opening and/or the at least one second conduit via natural convection.

[0058] In an example, the method comprises:

- designing the outer casing and the at least one second opening and/or the at least one second conduit such that the di-electric requirements of the circuit breaker are maintained.

[0059] In an example, the outer casing comprises epoxy resin and/or epoxide.

[0060] The above aspects and examples will become apparent from and be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0061] Exemplary embodiments will be described in the following with reference to the following drawings:

Fig. 1 shows a schematic representation of a known circuit breaker;

Fig. 2 shows a schematic representation of a new circuit breaker with holes/conduits from the outside to the cavity surrounding the pull/push rod mechanism; and

Fig. 3 shows a simplified representation of the new circuit breaker shown in Fig. 2.

DETAILED DESCRIPTION OF EMBODIMENTS

[0062] Figs. 2-3 relates to a new circuit breaker design with improved cooling, that applies to circuit breakers within switchgear, and also the figures relate to the method of cooling the circuit breaker and switchgear. It is to be noted that Fig. 2 especially shows parts of a circuit breaker, such as roller contact 5 and contact force spring 6, and indeed the enclosure with a drive for the circuit breaker, such as a spring operating mechanism, but these features are not essential to the new development. Indeed, the roller contact 5 and contact force spring 6 are not essential to embodiments of the new development and are not described further.

[0063] An exemplar new circuit breaker comprises:

- a vacuum interrupter 2;
- an upper arm 1;
- a lower arm 4;
- a push and/or pull rod mechanism 7; and
- an outer casing 3.

The upper arm comprises an upper terminal electrically connected to a fixed contact of the vacuum interrupter. The lower arm comprises a lower terminal electrically connected to a moveable contact of the vacuum interrupter. The push and/or pull rod mechanism is configured to move the moveable contact towards and/or away from the fixed contact. The outer casing surrounds at least the vacuum interrupter and the push and/or pull rod mechanism. A cavity 10 is formed at least between the push and/or pull rod mechanism and the outer casing. The outer casing comprises at least one first opening (20) and/or at least one first conduit 20 that connects to the cavity such that air can flow between an outside of the circuit breaker and the cavity through the outer casing.

[0064] Thus, an existing cavity inside the casing of a circuit breaker around the push/pull rod mechanism that enables this mechanism to move is, is utilized by a new development of opening this cavity to the outside of the

circuit breaker in order that air from outside the circuit breaker, that is colder than the parts of the circuit breaker, can enter the circuit breaker and cool the circuit breaker.

[0065] In an example, the circuit breaker comprises an enclosure 8 connected to the outer casing. The enclosure houses an operating mechanism for the push and/or pull rod. The enclosure comprises the at one first opening and/or the at least one first conduit such that the air can flow between the outside of the circuit breaker and the cavity through the enclosure.

[0066] Thus, an existing geometry of a circuit breaker can be utilized, where the cavity inside the casing of the vacuum interrupter and pull/push rod of the circuit breaker is accessed via a hole through the casing and through sheet metal parts of the enclosure housing the circuit breaker drive.

[0067] The enclosure comprising the at one first opening and/or the at least one first conduit can mean that an opening extends through the enclosure and extends through the casing, with the opening fluidly connecting the cavity with the outside of the circuit breaker. The enclosure comprising the at one first opening and/or the at least one first conduit can mean that a conduit extends through the enclosure and extends through the casing, with the conduit fluidly connecting the cavity with the outside of the circuit breaker.

[0068] In an example, the outer casing and the at least one first opening and/or the at least one first conduit are configured such that the air can flow between the outside of the circuit breaker and the cavity via natural convection.

[0069] As cooling is provided of internal parts of a circuit breaker via natural convection, not only is cooling provided of an existing design with just a hole/conduit through the casing required, no fans are required for air movement and the design is very cost effective and free from maintenance because no extra moving parts are required that could fail.

[0070] In an example, the at least one first opening and/or the at least one first conduit connects to the cavity at a bottom region of the cavity.

[0071] In an example, the outer casing and the at least one first opening and/or the at least one first conduit are configured such that the di-electric requirements of the circuit breaker are maintained.

[0072] In an example, the lower arm has at least one second opening and/or at least one second conduit 30 that connects to the cavity such that air can flow between the outside of the circuit breaker and the cavity through the lower arm.

[0073] In this manner, air can convect through the circuit breaker, from outside to the inside and to the outside and cool the area around the pull/push rod and the bottom of the circuit breaker and also cool the lower arm/terminal of the circuit breaker.

[0074] In an example, the at least one second opening and/or the at least one second conduit passes through the outer casing.

[0075] In an example, the at least one second opening and/or the at least one second conduit connects to the cavity at a top region of the cavity.

[0076] In an example, the at least one first opening and/or the at least one first conduit connects to the cavity at a bottom region of the cavity and the at least one second opening and/or the at least one second conduit connects to the cavity at a top region of the cavity.

[0077] Thus, air inside the cavity and indeed within the lower arm can be heated and rise within the exit the circuit breaker via the at least one second opening and/or the at least one second conduit. A t the same time the reduction in air pressure within the circuit breaker due to the air exiting leads to air being drawn into the at least one first opening and/or the at least one first conduit. Thus, cooling air is drawn into the bottom of the circuit breaker and exits the circuit breaker at a higher region, and during its passage through the circuit breaker it is heated and thus heat is extracted from the circuit breaker. This is achieved with an existing design of circuit breaker, with for example a hole drilled through the bottom of the circuit breaker to the cavity and a hole drilled through the lower arm of the circuit breaker to the cavity, to provide cooling without any active air movement means, such as a fan, required.

[0078] In an example, the circuit breaker is configured such that the air can flow between the outside of the circuit breaker and the cavity through the lower arm via natural convection.

[0079] In an example, the lower arm comprises an internal hollow section in fluid connection with the at least one second opening and/or at least one second conduit.

[0080] In this manner, cooling air can cool a greater portion of the lower arm.

[0081] In an example, the circuit breaker is configured such that the air can flow between the outside of the circuit breaker and the cavity through the lower arm and the internal hollow section via natural convection.

[0082] In an example, the circuit breaker is configured such that the air can flow into the circuit breaker through the at least one first opening and/or the at least one first conduit and flow out of the circuit breaker through the at least one second opening and/or the at least one second conduit.

[0083] In an example, the outer casing and the at least one second opening and/or the at least one second conduit of the lower arm are configured such that the air can flow into the circuit breaker through the at least one first opening and/or the at least one first conduit and flow out of the circuit breaker through the at least one second opening and/or the at least one second conduit via natural convection.

[0084] In an example, the outer casing and the at least one second opening and/or the at least one second conduit of the lower arm are configured such that the di-electric requirements of the circuit breaker are maintained.

[0085] In an example, the outer casing comprises epoxy resin and/or epoxide.

[0086] A low voltage, medium voltage, or high voltage switchgear can then comprise a new circuit breaker as described above.

[0087] An exemplar new method of cooling a circuit breaker is now described. The circuit breaker comprises a vacuum interrupter 2, an upper arm 1, a lower arm 4, a push and/or pull rod mechanism 7, and an outer casing 3. The upper arm comprises an upper terminal electrically connected to a fixed contact of the vacuum interrupter. The lower arm comprises a lower terminal electrically connected to a moveable contact of the vacuum interrupter. The push and/or pull rod mechanism is configured to move the moveable contact towards and/or away from the fixed contact. The outer casing surrounds at least the vacuum interrupter and the push and/or pull rod mechanism. A cavity 10 is formed at least between the push and/or pull rod mechanism and the outer casing. The outer casing comprises at least one first opening 20 and/or at least one first conduit 20 that connects to the cavity. The method comprises:

- flowing air between an outside of the circuit breaker and the cavity through the outer casing via the at least one first opening and/or the at least one first conduit.

[0088] In an example, the circuit breaker further comprises an enclosure 8 connected to the outer casing, the enclosure housing an operating mechanism for the push and/or pull rod, and wherein the enclosure comprises the at one first opening and/or the at least one first conduit, and wherein the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the enclosure via the at least one first opening and/or the at least one first conduit.

[0089] In an example, the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the enclosure via the at least one first opening and/or the at least one first conduit via natural convection.

[0090] In an example, the at least one first opening and/or the at least one first conduit connects to the cavity at a bottom region of the cavity.

[0091] In an example, the method comprises:

- designing the outer casing and the at least one first opening and/or the at least one first conduit such that the di-electric requirements of the circuit breaker are maintained.

[0092] In an example, the lower arm has at least one second opening and/or at least one second conduit 30 that connects to the cavity, and the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the lower arm via the at least one second opening and/or the at least one second conduit.

[0093] In an example, the at least one second opening and/or the at least one second conduit passes through the outer casing.

[0094] In an example, the at least one first opening and/or the at least one first conduit connects to the cavity at a bottom region of the cavity and the at least one second opening and/or the at least one second conduit connects to the cavity at a top region of the cavity.

[0095] In an example, the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the lower arm via the at least one second opening and/or the at least one second conduit via natural convection.

[0096] In an example, the lower arm comprises an internal hollow section in fluid connection with the at least one second opening and/or at least one second conduit, and the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the lower arm and the internal hollow section via natural convection.

[0097] In an example, the method comprises:

- flowing air into the circuit breaker through the at least one first opening and/or the at least one first conduit and flowing air out of the circuit breaker through the at least one second opening and/or the at least one second conduit.

[0098] In an example, the method comprises:

- flowing air into the circuit breaker through the at least one first opening and/or the at least one first conduit and flowing air out of the circuit breaker through the at least one second opening and/or the at least one second conduit via natural convection.

[0099] In an example, the method comprises:

- designing the outer casing and the at least one second opening and/or the at least one second conduit such that the di-electric requirements of the circuit breaker are maintained.

[0100] In an example, the outer casing comprises epoxy resin and/or epoxide.

[0101] An exemplar new method of cooling a low voltage, medium voltage, or high voltage switchgear is now described. The switchgear comprises a circuit breaker. The circuit breaker comprises a vacuum interrupter 2, an

upper arm 1, a lower arm 4, a push and/or pull rod mechanism 7, and an outer casing 3. The upper arm comprises an upper terminal electrically connected to a fixed contact of the vacuum interrupter. The lower arm comprises a lower terminal electrically connected to a moveable contact of the vacuum interrupter. The push and/or pull rod mechanism is configured to move the moveable contact towards and/or away from the fixed contact. The outer casing surrounds at least the vacuum interrupter and the push and/or pull rod mechanism. A cavity 10 is formed at least between the push and/or pull rod mechanism and the outer casing. The outer casing comprises at least one first opening 20 and/or at least one first conduit 20 that connects to the cavity. The method comprises:

- flowing air between an outside of the circuit breaker and the cavity through the outer casing via the at least one first opening and/or the at least one first conduit.

[0102] In an example, the circuit breaker further comprises an enclosure 8 connected to the outer casing, the enclosure housing an operating mechanism for the push and/or pull rod, and wherein the enclosure comprises the at one first opening and/or the at least one first conduit, and wherein the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the enclosure via the at least one first opening and/or the at least one first conduit.

[0103] In an example, the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the enclosure via the at least one first opening and/or the at least one first conduit via natural convection.

[0104] In an example, the at least one first opening and/or the at least one first conduit connects to the cavity at a bottom region of the cavity.

[0105] In an example, the method comprises:

- designing the outer casing and the at least one first opening and/or the at least one first conduit such that the di-electric requirements of the circuit breaker are maintained.

[0106] In an example, the lower arm has at least one second opening and/or at least one second conduit 30 that connects to the cavity, and the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the lower arm via the at least one second opening and/or the at least one second conduit.

[0107] In an example, the at least one second opening and/or the at least one second conduit passes through the outer casing.

[0108] In an example, the at least one first opening and/or the at least one first conduit connects to the cavity at a bottom region of the cavity and the at least one second opening and/or the at least one second conduit connects to the cavity at a top region of the cavity.

[0109] In an example, the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the lower arm via the at least one second opening and/or the at least one second conduit via natural convection.

[0110] In an example, the lower arm comprises an internal hollow section in fluid connection with the at least one second opening and/or at least one second conduit, and the method comprises:

- flowing air between the outside of the circuit breaker and the cavity through the lower arm and the internal hollow section via natural convection.

[0111] In an example, the method comprises:

- flowing air into the circuit breaker through the at least one first opening and/or the at least one first conduit and flowing air out of the circuit breaker through the at least one second opening and/or the at least one second conduit.

[0112] In an example, the method comprises:

- flowing air into the circuit breaker through the at least one first opening and/or the at least one first conduit and flowing air out of the circuit breaker through the at least one second opening and/or the at least one second conduit via natural convection.

[0113] In an example, the method comprises:

- designing the outer casing and the at least one second opening and/or the at least one second conduit such that the di-electric requirements of the circuit breaker are maintained.

[0114] In an example, the outer casing comprises epoxy resin and/or epoxide.

[0115] Thus, the new development centred around the inventors realizing that currently there is cavity inside the lower part of a circuit breaker because a pull/push rod operating the circuit breaker requires space to move, and this space could be utilized for cooling the circuit breaker by venting air out of the cavity and/or sucking air into the cavity.

[0116] Thus, at a simple level the new development relates to the creation of a system of ventilation openings

in a lower part of circuit breaker assembly, where there can be just one opening.

[0117] In a detailed embodiment a first opening 20 allows for the passage of air through switch sheet metal parts of an enclosure of the drive of the circuit breaker and through the epoxide outer casing. The airflow is then guided into the cavity 10 that already exists in lower part of circuit breaker around the push/pull rod mechanism, cooling the components inside the cavity in the process. Air will than pass through a hollowed lower circuit breaker arm via a further opening 30, cooling the arm in the process. Hot air will be than ventilated into the switchgear compartment.

[0118] Thus, creating an opening in the switch sheet metal parts allows air at ambient temperature to enter the assembly. This system allows cooling of the bottom part of the circuit breaker by utilizing the already existing cavity around the pull/push rod.

[0119] Also, by creating a hole in circuit breaker arm allows hot air to leave the cavity while also cooling the circuit breaker arm from the inside. Cooling will be performed on bare metal parts, greatly increasing effectivity.

[0120] The circuit breaker remains encapsulated in epoxide, negating any di-electric issues.

[0121] Thus in summary the new development uses an already existing cavity inside the lower part of circuit breaker. From the bottom air is fed into this cavity via a hole in a sheet metal part. Cold air will cool parts inside the cavity and then proceed onto cooling the inside of the lower arm of the circuit breaker through a hole drilled into the arm. The whole system can rely on natural convection and utilizes an already existing geometry of the circuit breaker.

[0122] Thus, natural cooling is provided without fans enabling higher currents to be utilized.

[0123] By providing improved cooling, operation at higher currents can be performed, but operation at the same current can be performed, but conductors used for current flow can use less copper, that would otherwise be heated to much due to increased resistance, but now less copper can be utilized to safe costs because increased cooling capability is provided meaning that temperature rises can be kept within required limits.

[0124] The new development is achieved without a major change in the existing design, with only the provision of air holes being required.

Reference Numerals

[0125]

1 Upper arm / terminal connected to a fixed terminal of the vacuum interrupter

2 Vacuum interrupter

3 Outer casing, epoxy resin and/or epoxide

4 Lower arm / terminal electrically connected to a moveable contact of the vacuum interrupter

5 Roller contact

6 Contact force spring

7 Push and/or pull rod mechanism to move a moveable

8 Enclosure that houses an operating mechanism for the push and/or pull rod

10 Cavity between the outer casing and the push and/or pull rod mechanism

20 At least one first opening and/or at least one first conduit that connects the outside of the circuit breaker to the cavity and passes through the outer casing and optionally the lower arm

30 At least one second opening and/or at least one second conduit that connects the outside of the circuit breaker to the cavity and passes through the lower arm and through the casing.

[0126] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. The invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing a claimed invention, from a study of the drawings, the disclosure, and the dependent claims.

Claims

1. A circuit breaker, comprising:

- a vacuum interrupter (2);
- an upper arm (1);
- a lower arm (4);
- a push and/or pull rod mechanism (7); and
- an outer casing (3);

wherein the upper arm comprises an upper terminal electrically connected to a fixed contact of the vacuum interrupter;
wherein the lower arm comprises a lower terminal electrically connected to a moveable contact of the vacuum interrupter;
wherein the push and/or pull rod mechanism is configured to move the moveable contact towards and/or away from the fixed contact;
wherein the outer casing surrounds at least

the vacuum interrupter and the push and/or pull rod mechanism, and wherein a cavity (10) is formed at least between the push and/or pull rod mechanism and the outer casing; and
wherein the outer casing comprises at least one first opening (20) and/or at least one first conduit (20) that connects to the cavity such that air can flow between an outside of the circuit breaker and the cavity through the outer casing.

2. Circuit breaker according to claim 1, further comprising an enclosure (8) connected to the outer casing, the enclosure housing an operating mechanism for the push and/or pull rod, and wherein the enclosure comprises the at one first opening and/or the at least one first conduit such that the air can flow between the outside of the circuit breaker and the cavity through the enclosure.

3. Circuit breaker according to any of claims 1-2, wherein the outer casing and the at least one first opening and/or the at least one first conduit are configured such that the air can flow between the outside of the circuit breaker and the cavity via natural convection.

4. Circuit breaker according to any of claims 1-3, wherein the outer casing and the at least one first opening and/or the at least one first conduit are configured such that the di-electric requirements of the circuit breaker are maintained.

5. Circuit breaker according to any of claims 1-4, wherein the lower arm has at least one second opening and/or at least one second conduit (30) that connects to the cavity such that air can flow between the outside of the circuit breaker and the cavity through the lower arm.

6. Circuit breaker according to claim 5, wherein the circuit breaker is configured such that the air can flow between the outside of the circuit breaker and the cavity through the lower arm via natural convection.

7. Circuit breaker according to any of claims 5-6, wherein the lower arm comprises an internal hollow section in fluid connection with the at least one second opening and/or at least one second conduit.

8. Circuit breaker according to claim 7, wherein the circuit breaker is configured such that the air can flow between the outside of the circuit breaker and the cavity through the lower arm and the internal hollow section via natural convection.

9. Circuit breaker according to any of claims 5-8, wherein the circuit breaker is configured such that the air can flow into the circuit breaker through the at least one first opening and/or the at least one first conduit and flow out of the circuit breaker through the at least one second opening and/or the at least one second conduit.

10. Circuit breaker according to any of claims 5-9, wherein the outer casing and the at least one second opening and/or the at least one second conduit of the lower arm are configured such that the air can flow into the circuit breaker through the at least one first opening and/or the at least one first conduit and flow out of the circuit breaker through the at least one second opening and/or the at least one second conduit via natural convection.

11. Circuit breaker according to any of claims 5-10, wherein the outer casing and the at least one second opening and/or the at least one second conduit of the lower arm are configured such that the di-electric requirements of the circuit breaker are maintained.

12. Circuit breaker according to any of claims 1-11, wherein the outer casing comprises epoxy resin and/or epoxide.

13. A low voltage, medium voltage, or high voltage switchgear comprising a circuit breaker according to any of claims 1-12.

14. A method of cooling a circuit breaker, the circuit breaker comprising a vacuum interrupter (2), an upper arm (1), a lower arm (4), a push and/or pull rod mechanism (7), and an outer casing (3), wherein the upper arm comprises an upper terminal electrically connected to a fixed contact of the vacuum interrupter, wherein the lower arm comprises a lower terminal electrically connected to a moveable contact of the vacuum interrupter, wherein the push and/or pull rod mechanism is configured to move the moveable contact towards and/or away from the fixed contact, wherein the outer casing surrounds at least the vacuum interrupter and the push and/or pull rod mechanism, and wherein a cavity (10) is formed at least between the push and/or pull rod mechanism and the outer casing; and wherein the outer casing comprises at least one first opening (20) and/or at least one first conduit (20) that connects to the cavity; and wherein the method comprises:

- flowing air between an outside of the circuit breaker and the cavity through the outer casing via the at least one first opening and/or the at least one first conduit.

15. A method of cooling a low voltage, medium voltage,

or high voltage switchgear, the switchgear comprising a circuit breaker, the circuit breaker comprising a vacuum interrupter (2), an upper arm (1), a lower arm (4), a push and/or pull rod mechanism (7), and an outer casing (3), wherein the upper arm comprises an upper terminal electrically connected to a fixed contact of the vacuum interrupter, wherein the lower arm comprises a lower terminal electrically connected to a moveable contact of the vacuum interrupter, wherein the push and/or pull rod mechanism is configured to move the moveable contact towards and/or away from the fixed contact, wherein the outer casing surrounds at least the vacuum interrupter and the push and/or pull rod mechanism, and wherein a cavity (10) is formed at least between the push and/or pull rod mechanism and the outer casing; and wherein the outer casing comprises at least one first opening (20) and/or at least one first conduit (20) that connects to the cavity; and wherein the method comprises:

- flowing air between an outside of the circuit breaker and the cavity through the outer casing via the at least one first opening and/or the at least one first conduit.

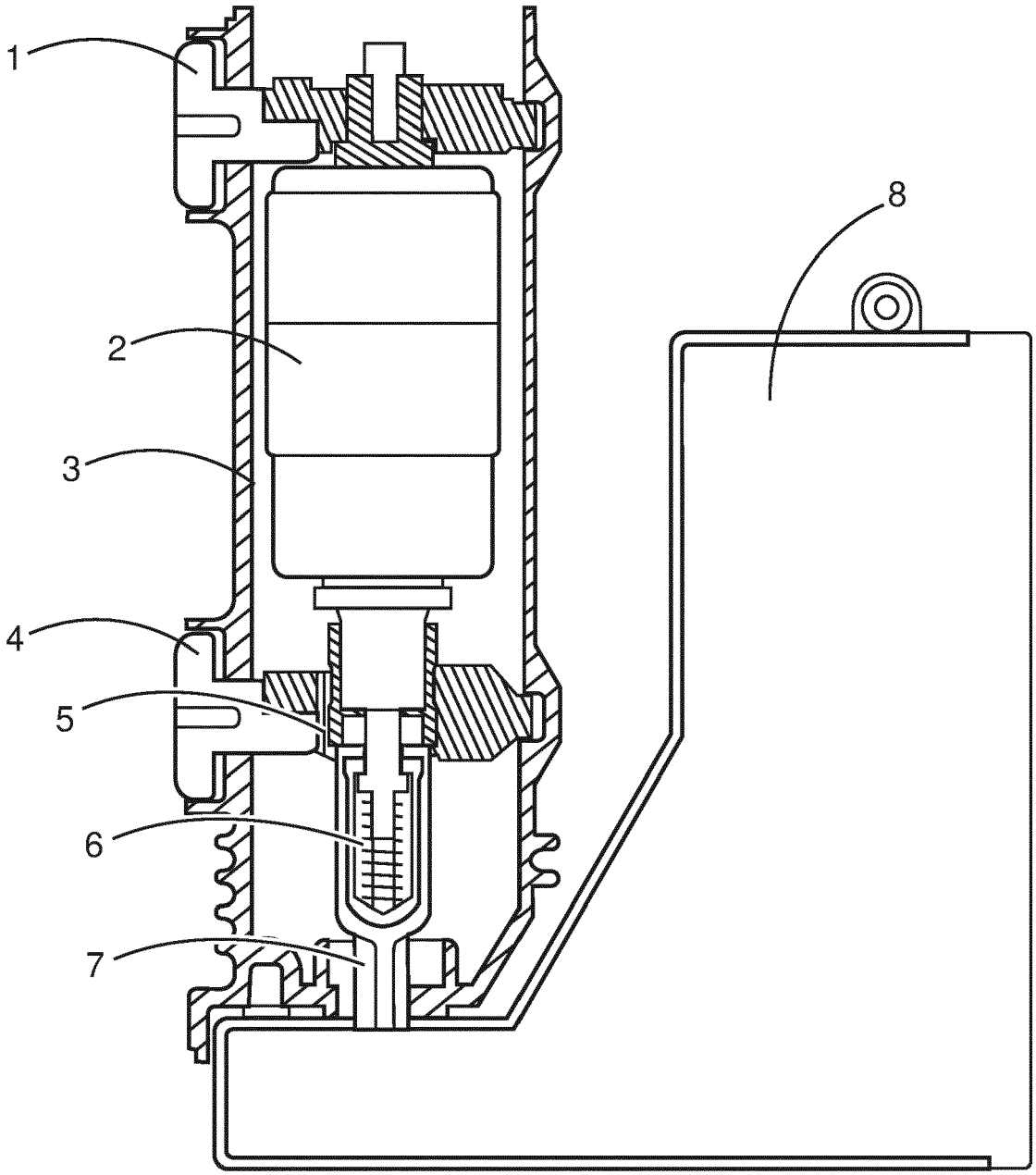

Fig. 1

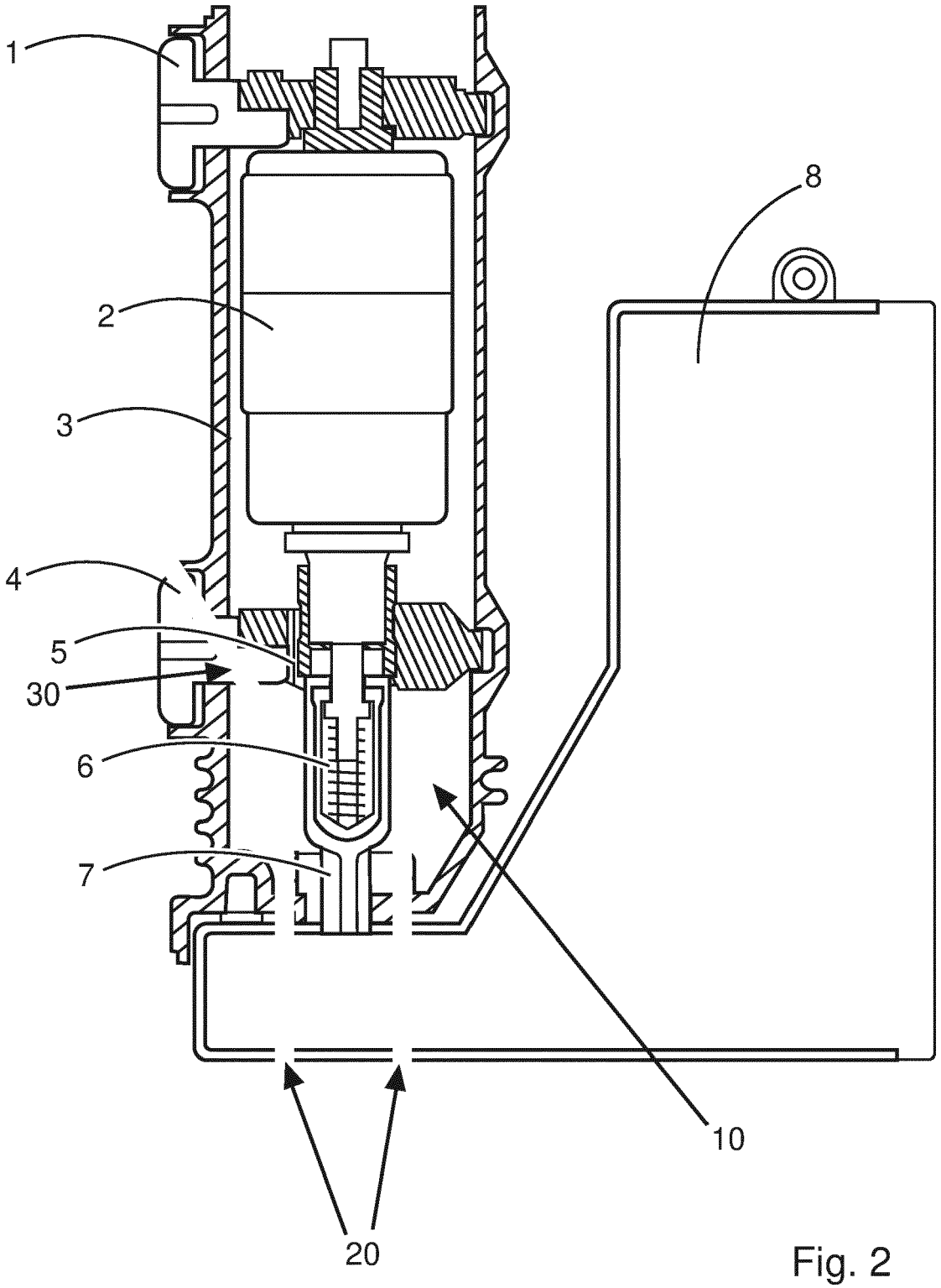

Fig. 2

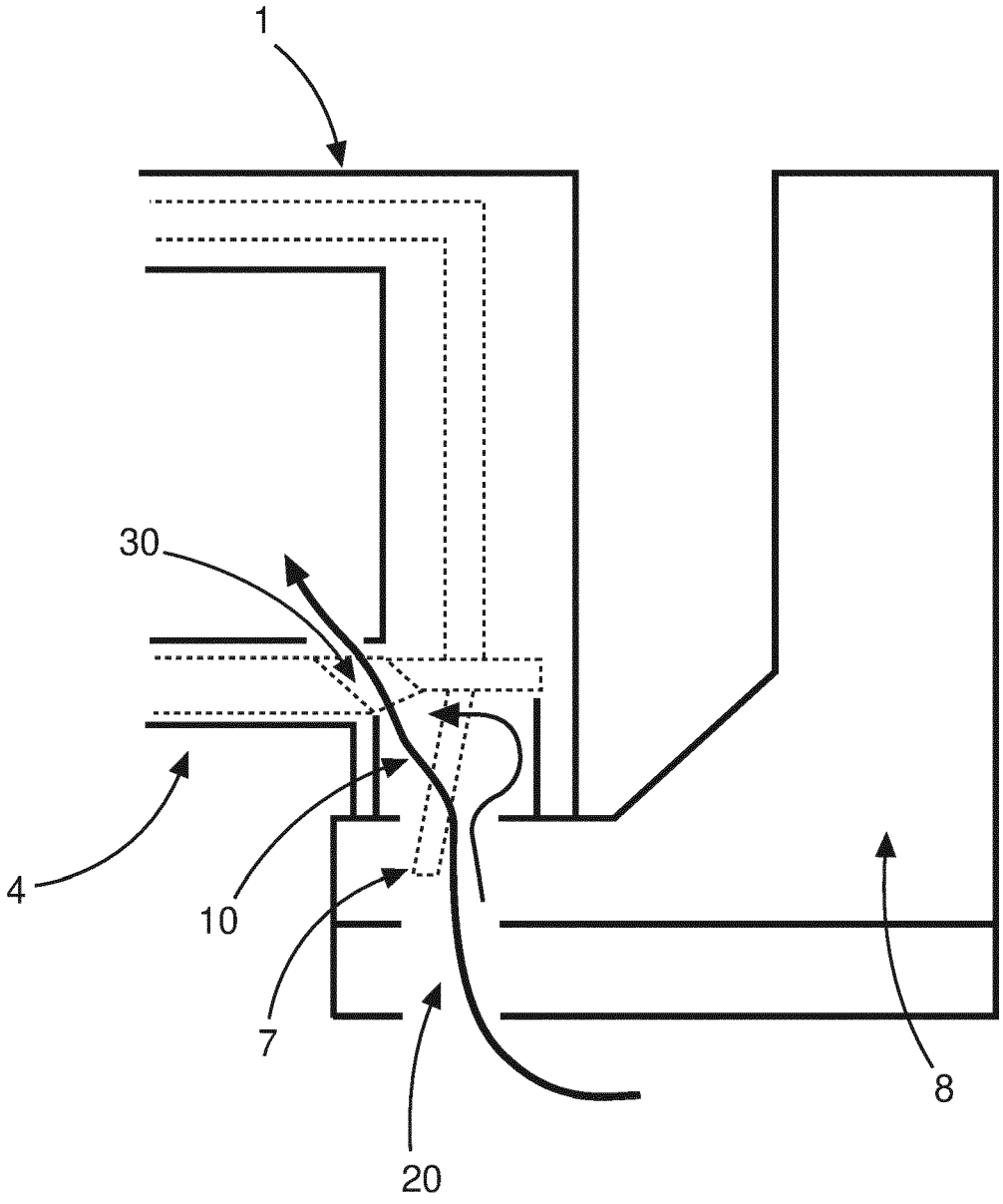

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 23 21 1148

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	CN 203 118 850 U (JIANGSU VOLT ELECTRIC CO LTD) 7 August 2013 (2013-08-07) * paragraph [0004] * * paragraph [0006] - paragraph [0007] * * paragraph [0010] - paragraph [0011] *	1,3,6-8, 10,11	INV. H01H9/52 ADD. H01H33/66
X	CN 100 397 737 C (MITSUBISHI ELECTRIC CORP [JP]) 25 June 2008 (2008-06-25) * paragraph [0037] - paragraph [0039] * * paragraph [0042] * * paragraph [0045] - paragraph [0046] * * paragraph [0052] *	1,2,4,5, 9,13-15	
X	CN 205 828 208 U (CHANGSHA HONGRUI ELECTRIC EQUIPMENT CO LTD) 21 December 2016 (2016-12-21) * paragraph [0014] *	1,12	
A	CN 112 117 160 A (MURGE ELECTRIC CO LTD) 22 December 2020 (2020-12-22) * paragraph [0001] *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)
H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	4 April 2024	Abdelmoula, Amine

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04-04-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 203118850 U	07-08-2013	NONE	
CN 100397737 C	25-06-2008	CN 1667895 A	14-09-2005
		JP 4360234 B2	11-11-2009
		JP 2005259562 A	22-09-2005
CN 205828208 U	21-12-2016	NONE	
CN 112117160 A	22-12-2020	NONE	

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