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(54) **HIGH VOLTAGE CIRCUIT BREAKER**

(57) The invention relates to a high voltage circuit breaker (1) comprising two contact elements (2) arranged opposite and movable relative to one another along a centre axis (3) of the high-voltage circuit breaker (1), and forming, during a breaking operation, in an arcing region (4) between the two contact elements (2) an arc extinguishable by an arc extinguishing gas; a heating vol-

ume (8) and a heating channel (7) connected to the arcing region (4) and configured for dissipating arc extinguishing gas (14) heated by the arc into the heating volume (8); and a cooling structure (11) embedded in the heating volume (8) and configured for cooling the heated arc extinguishing gas (14) flowing into the heating volume (8).

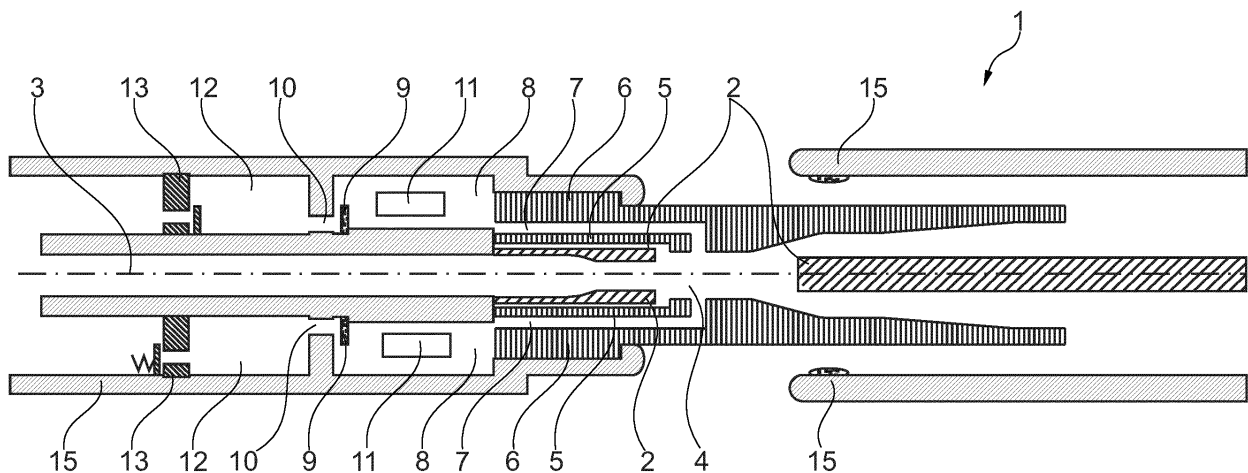


Fig. 1

Description

Technical Field

[0001] The invention relates to a high voltage circuit breaker comprising two contact elements arranged opposite and movable relative to one another along a centre axis of the high-voltage circuit breaker, and forming, during a breaking operation, in an arcing region between the two contact elements an arc extinguishable by an arc extinguishing gas; and a heating volume and a heating channel connected to the arcing region and configured for dissipating arc extinguishing gas heated by the arc into the heating volume. The invention further relates to a respective use.

Background Art

[0002] Circuit breakers are well known in the field of high voltage switching applications and are predominantly used for interrupting a current, when an electrical fault occurs. As an example, circuit breakers have the task of opening contact elements and keeping them apart from one another in order to avoid a current flow even in case of high electrical potential originating from the electrical fault itself. Such high voltage circuit breakers typically break high currents at voltages of 72 kV and up to 1200 kV and are arranged in the respective electrical circuits which are intended to be interrupted based on some pre-defined event occurring in the electrical circuit.

[0003] Beside switching of normal load currents, operation of such circuit breakers are responsive to detection of a fault condition or fault current. On detection of such a fault condition or fault current, a mechanism may operate the circuit breaker to interrupt the current flowing through the circuit breaker, thereby interrupting the current flowing in the electrical circuit protected by the circuit breaker. Once a fault is detected, contact elements within the circuit breaker separate in order to interrupt the electrical circuit. Often spring arrangements, pneumatic drives or some other means utilizing mechanically stored energy are employed to separate the contacts. Some of the energy required for separating the contact elements may be obtained from the fault current itself. When interrupting the current flowing in the electrical circuit, an arc is generated. This arc must be cooled so that it becomes quenched or extinguished, such that a gap between the contact elements can repeatedly withstand the voltage in the electrical circuit. It is known to use, air, oil, vacuum or insulating gas as medium in which the arc forms. Insulating gas comprises for example Sulphur hexafluoride (SF₆) or CO₂. Current interruption performance in SF₆ alternative circuit breakers are, however, limited due to lower thermal and dielectric interruption capability.

Summary of invention

[0004] It is therefore an object of the invention to pro-

vide a high voltage circuit breaker characterized by an improved interruption performance for SF₆ alternative gases.

[0005] The object of the invention is solved by the features of the independent claims. Preferred implementations are detailed in the dependent claims.

[0006] Thus, the object is solved by a high voltage circuit breaker comprising

two contact elements arranged opposite and movable relative to one another along a centre axis of the high-voltage circuit breaker, and forming, during a breaking operation, in an arcing region between the two contact elements an arc extinguishable by an arc extinguishing gas;
a heating volume and a heating channel connected to the arcing region and configured for dissipating arc extinguishing gas heated by the arc into the heating volume; and
a cooling structure embedded in the heating volume and configured for cooling the heated arc extinguishing gas flowing into the heating volume.

[0007] A key point of the invention lies in the proposed cooling structure embedded in the heating volume. The cooling elements can lower a temperature of the heated respectively hot arc extinguishing gas in the heating volume and by this the temperature of the arc extinguishing gas at current zero. Additional benefit is that a PTFE, polytetrafluoroethylene, content in the heating volume can be increased, which is beneficial when using SF₆ alternative gases. Both measures increase an interruption performance of the circuit breaker. The proposed cooling structure as cooler is thus an advantageous possibility for improving interruption performance for SF₆ alternative gases.

[0008] Prior art interruption performance of SF₆ alternative circuit breakers is limited due to lower thermal and dielectric interruption capabilities of the SF₆ alternative gases. For closing said gap to SF₆, investigations showed that the temperature of the arc extinguishing gas affects the interruption performance. Thus, it is desired to keep the temperature of arc extinguishing gas as low as possible. However, since temperature is linked to pressure build up, a high pressure and low temperature cannot be realized together in prior art circuit breaker designs. Additionally, the composition of the arc extinguishing gas is defined by the pressure build up.

[0009] In other words, it is known that high temperatures in the extinguishing gas might deteriorate the interruption performance of the circuit breaker. Thus, it is desirable to keep the temperature in the heating volume low, which for a given pressure also corresponds to a higher density. Additionally, it can be expected that a higher PTFE vapor content at large short circuit currents increases not only the dielectric strength, but also the thermal interruption performance. For example, it is known that CF₄ as blow gas shows similar thermal inter-

ruption performance as SF₆. CF₄ is formed from PTFE vapor, assuming chemical equilibrium. Thus, it can be expected that with larger PTFE content in the heating volume a higher CF₄ content at the arc can be obtained.

[0010] The solution proposes to change a relation between pressure build up, temperature and arc extinguishing gas composition in the heating volume, which is achieved by introducing the cooling structure into the heating volume. Said cooling structure can absorb energy from the arc extinguishing gas and by this lower the temperature of the arc extinguishing gas in the heating volume. Additionally, more PTFE mass can be injected from the arcing region into the heating volume, since the pressure is determined by the arcing region. Lower temperature and higher PTFE content significantly improves thermal and dielectric interruption. Due to the different dynamic back-heating behaviour at lower and higher short circuit currents before described typical relations will be altered, which allows an improved interruption performance for SF₆ alternative gases. With the proposed design of the cooling structure the before described relation between pressure, temperature and PTFE concentration can be adjusted according to specific needs.

[0011] The term high voltage preferably relates to voltages ranging from above 72,5 kV to 1200 kV, like 145 kV, 245 kV or 420 kV. Nominal currents of the circuit breaker can be preferably in the range from 10 kA to 500 kA. The circuit breaker can be provided as a gas-insulated circuit breaker, for example including an encapsulating housing which defines a volume for the gas. The circuit breaker can include a gas blowing system configured to extinguish the arc during a stage of the current interruption operation.

[0012] The arc-extinguishing gas can be any suitable gas that enables to adequately extinguish the electric arc formed between the arcing contacts during a current interruption operation, such as, but not limited, to an inert gas as, for example, sulphur hexafluoride SF₆. Thereby, the arc between the contact element develops in the arcing region. Specifically, the arc-extinguishing gas used in the circuit breaker can be SF₆ gas or any other dielectric insulation medium, may it be gaseous and/or liquid, and in particular can be a dielectric insulation gas or arc quenching gas. Such dielectric insulation medium can for example encompass media comprising an organofluorine compound, such organofluorine compound being selected from the group consisting of: a fluoroether, an oxirane, a fluoroamine, a fluoroketone, a fluoroolefin, a fluoronitrile, and mixtures and/or decomposition products thereof. Herein, the terms "fluoroether", "oxirane", "fluoroamine", "fluoroketone", "fluoroolefin" and "fluoronitrile" refer to at least partially fluorinated compounds. In particular, the term "fluoroether" encompasses both hydrofluoroethers and perfluoroethers, the term "oxirane" encompasses both hydrofluorooxiranes and perfluorooxiranes, the term "fluoroamine" encompasses both hydrofluoroamines and perfluoroamines, the term "fluoroketone" encompasses both hydrofluoroketones

and perfluoroketones, the term "fluoroolefin" encompasses both hydrofluoroolefins and perfluoroolefins, and the term "fluoronitrile" encompasses both hydrofluoronitriles and perfluoronitriles. It can thereby be preferred that the fluoroether, the oxirane, the fluoroamine and the fluoroketone are fully fluorinated, i.e. perfluorinated.

[0013] The dielectric insulation medium can be selected from the group consisting of: a hydrofluoroether, a perfluoroketone, a hydrofluoroolefin, a perfluoronitrile, and mixtures thereof. In particular, the term "fluoroketone" as used in the context of the present invention shall be interpreted broadly and shall encompass both fluoromonoketones and fluorodiketones or generally fluoropolyketones. Explicitly, more than a single carbonyl group flanked by carbon atoms may be present in the molecule. The term shall also encompass both saturated compounds and unsaturated compounds including double and/or triple bonds between carbon atoms. The at least partially fluorinated alkyl chain of the fluoroketones can be linear or branched and can optionally form a ring. The dielectric insulation medium may comprise at least one compound being a fluoromonoketone and/or comprising also heteroatoms incorporated into the carbon backbone of the molecules, such as at least one of: a nitrogen atom, oxygen atom and sulphur atom, replacing one or more carbon atoms. More preferably, the fluoromonoketone, in particular perfluoroketone, can have from 3 to 15 or from 4 to 12 carbon atoms and particularly from 5 to 9 carbon atoms. Most preferably, it may comprise exactly 5 carbon atoms and/or exactly 6 carbon atoms and/or exactly 7 carbon atoms and/or exactly 8 carbon atoms.

[0014] Further, the dielectric insulation medium may comprise at least one compound being a fluoroolefin selected from the group consisting of: hydrofluoroolefins (HFO) comprising at least three carbon atoms, hydrofluoroolefins (HFO) comprising exactly three carbon atoms, trans-1,3,3,3-tetrafluoro-1-propene (HFO-1234ze), 2,3,3,3-tetrafluoro-1-propene (HFO-1234yf), and mixtures thereof. The organofluorine compound can also be a fluoronitrile, in particular a perfluoronitrile. In particular, the organofluorine compound can be a fluoronitrile, specifically a perfluoronitrile, containing two carbon atoms, and/or three carbon atoms, and/or four carbon atoms. More particularly, the fluoronitrile can be a perfluoroalkylnitrile, specifically perfluoroacetonitrile, perfluoropropionitrile (C₂F₅CN) and/or perfluorobutyronitrile (C₃F₇CN). Most particularly, the fluoronitrile can be perfluoroisobutyronitrile (according to the formula (CF₃)₂CF₂CN) and/or perfluoro-2-methoxypropanenitrile (according to formula CF₃CF(OCF₃)CN). Of these, perfluoroisobutyronitrile (i.e. 2,3,3,3-tetrafluoro-2-trifluoromethyl propanenitrile alias i-C₃F₇CN) is particularly preferred due to its low toxicity. The dielectric insulation medium can further comprise a background gas or carrier gas different from the organofluorine compound (in particular different from the fluoroether, the oxirane, the fluoroamine, the fluoroketone and the fluoroolefin) and

can be selected from the group consisting of: air, N₂, O₂, CO₂, a noble gas, H₂; NO₂, NO, N₂O; fluorocarbons and in particular perfluorocarbons, such as CF₄; CF₃I, SF₆; and mixtures thereof. For example, the dielectric insulating gas can be CO₂.

[0015] According to a preferred implementation, the cooling structure is provided as labyrinth, as mesh, lattice, bar, grating and/or as grid structure. The labyrinth, mesh, lattice, bar, grating and/or grid structure preferably comprises a thickness, radius and/or diameter of $\geq 0,5$, 1, 2, 4, 5 or 7,5 mm for an individual element thereof, such as for example a single grid. Such shape of the cooling structure advantageously influences mixing of the heated arc extinguishing gas in the heating volume in case of a so-called "self-blast" circuit breaker, SB CB, or a single puffer volume in case of a "puffer" circuit breaker, for a respectively cooling the heated arc extinguishing gas. Preferably, the solution applies to SB CB since in this type of circuit breaker a volume for placing the cooling structure is unchanged over an operation of the CB and temperatures of the arc extinguishing gas in the heating volume becomes higher. In case of a puffer CB the volume to which the arc extinguishing gas is flowing is diminishing in course of the opening operation, which limits the possible volume for placing the cooling structure. The following description can be understood to be limited to an SB CB, therefore.

[0016] For example, gas flow might be directed by the respectively shaped cooling structure to avoid mixing and pushing of cold arc extinguishing gas out of the heating volume at flow reversal. Flow may thus be directed by the cooling structure to pass the cooling structure at in- and out-flow or only at inflow. Another possibility is to just cool outflowing arc extinguishing gas by a respectively shaped cooling structure. A further possible design with two heating channels could take advantage of the flow cooling structure.

[0017] In a further preferred implementation, the cooling structure extends in the heating volume in one, two or three dimensions. The cooling structure is preferably shaped, thereby for example comprising multiple different shaped and/or oriented elements, before described labyrinth, as mesh and/or as grid structure, such that heated arc extinguishing gas flowing from the heating channel into the heating volume first flows through the cooling structure, is then deflected by an end of the heating volume opposite to the heating channel for such wise again flowing through the cooling structure in opposite direction and finally again deflected by an opposite end of the heating volume associated to a side of the heating volume where the heating channels enters into the heating volume, so that such wise a turbulence is created by the cooling structure within the heating volume. As the heated arc extinguishing gas thereby impinges various different surfaces of the cooling structure, the heated arc extinguishing gas is effectively cooled by the cooling structure.

[0018] According to another preferred implementation,

the cooling structure comprises stainless steel, steel, titanium, carbon, in particular carbon steel, and/or ceramic. Thus, the cooling structure is preferably made of materials with high a evaporation temperature, high heat resistance and/or good heat conduction, such as for example stainless steel or carbon steel comprising a higher heat conduction. Also, ceramics with high heat conduction properties are preferred for the cooling structure. The term embedded means that the cooling structure is arranged within the heating volume.

[0019] The cooling structure is preferably provided as guiding element configured for guiding the arc extinguishing gas being such wise cooled by the cooling structure. Heat conduction calculations for CO₂ have shown that a significant amount of arcing energy can be removed from the arc extinguishing gas by the cooling structure if a sufficient surface area can be reached..

[0020] In a further preferred implementation, the cooling structure comprises an additively manufactured structure and/or is an additively manufactured. With such additively manufactured cooling structure larger surface area of the cooling structure can be obtained, thus resulting in more effective cooling capabilities of the cooling structure. Flow resistance of such cooling structure can be minimized for a given heat transfer capacity and arrangement of elements within the cooling structure can be flexibly designed by using 3D printing design and manufacturing techniques.

[0021] According to another preferred implementation, the cooling structure comprises a first part associated to the heating channel and a second part arranged within the heating volume. Due to such first part and second part, for example each provided as grid or mesh, before described turbulences can be easily created for such wise effectively cooling the heated arc extinguishing gas. Thereby, the first part can be arranged to be flown through by the heated arc extinguishing gas entering the heating volume and the second part can be arranged, for example horizontally extending within the heating volume, for separating gas flow of the opposite directions.

[0022] In a further preferred implementation, the high voltage circuit breaker comprises a valve configured for closing an opening of the heating volume towards a so called compression volume. The valve, which is preferably provided as a check-valve, can be operated by a pressure difference in the heating volume and compression volume, respectively. Hence, the heating volume is preferably closed so that cooled arc extinguishing gas can only exit the heating volume through the heating channel or the valve. The valve is preferably arranged opposite to the heating channel i.e. the opening is preferably arranged opposite to an entrance of the heating channel into the heating volume.

[0023] According to another preferred implementation, the valve is provided as a pressure operated valve configured for closing the opening upon pressure generated by the arc. Thus, heated arc extinguishing gas flowing into the heating volume due to the arc generates said

pressure which in turn closes the valve. Preferably, the arc extinguishing gas flowing out of the heating volume occurs through the heating channel, which is preferably part of a nozzle system composed by the main nozzle and/or auxiliary nozzle, while being controlled by a position of the contact elements and/or a pressure difference of the heating volume and the arcing zone. opening

[0024] In a further preferred implementation, the high voltage circuit breaker comprises the compression volume connected to the heating volume via the valve, whereby the compression volume is limited by a piston arranged opposite to the valve. Said piston may be provided with a further pressure or spring-operated valve.

[0025] According to another preferred implementation, the high voltage circuit breaker comprises an auxiliary nozzle, which at least partially surrounds one of the contact elements, and a main nozzle, which at least partially surrounds the auxiliary nozzle, whereby the heating channel extends between the auxiliary nozzle and the main nozzle from the arcing region into the heating volume. The main nozzle is preferably provided as insulating nozzle. Said auxiliary nozzle and/or main nozzle can be provided as nozzles known from prior art.

[0026] In a further preferred implementation, the high voltage circuit breaker comprises a nominal current contact system, which at least partially surrounds the two contact elements, the heating volume, the heating channel and the cooling structure. The nominal current contact system can be provided as contact tulip and corresponding contact pin. In a similar manner, the contact elements can be as well provided as contact tulip and corresponding contact pin.

[0027] According to another preferred implementation, the high voltage circuit breaker is provided as high voltage self-blast circuit breaker. In such self-blast circuit breaker arc control is typically provided by internal means i.e. the arc itself is employed for its own extinction efficiently. Alternatively, the circuit breaker may include one or more components such as a puffer-type cylinder, a self-blast chamber, a pressure collecting space, a compression space, or puffer volume, and an expansion space. The circuit breaker may effectuate interruption of the electrical circuit by means of one or more of such components, thereby discontinuing flow of electrical current in the electrical circuit, and/or extinction of the arc produced when the electrical circuit is interrupted. The circuit breaker can include also other parts such as a drive, a controller, and the like, which have been omitted in the description. These parts are provided in analogy to a conventional high voltage gas-insulated circuit breaker.

[0028] The object is further solved by a use of a cooling structure for cooling heated arc extinguishing gas flowing into a heating volume of a high voltage circuit breaker, the high voltage circuit breaker, comprising

two contact elements arranged opposite and movable relative to one another along a centre axis of the

high-voltage circuit breaker and forming, during a breaking operation, in an arcing region between the two contact elements an arc extinguishable by an arc extinguishing gas;

the heating volume and a heating channel connected to the arcing region and configured for dissipating arc extinguishing gas heated by the arc into the heating volume; and

the cooling structure embedded in the heating volume.

[0029] Further implementations and advantages of the use of the cooling structure are directly and unambiguously derived by the person skilled in the art from the high voltage circuit breaker as described before.

Brief description of drawings

[0030] These and other aspects of the invention will be apparent from and elucidated with reference to the implementations described hereinafter.

[0031] In the drawings:

Fig. 1 shows a high voltage circuit breaker comprising a cooling structure embedded in a heating volume of the circuit breaker in a schematic sectional view according to a preferred implementation,

Fig. 2 shows the cooling structure embedded in the heating volume of Fig. 1 in a schematic sectional view according to the preferred implementation,

Fig. 3 shows the cooling structure embedded in the heating volume of Fig. 1 in a schematic sectional view according to another preferred implementation,

Fig. 4 shows the cooling structure embedded in the heating volume of Fig. 1 in a schematic sectional view according to another preferred implementation,

Fig. 5 shows the cooling structure embedded in the heating volume of Fig. 1 in a schematic sectional view according to another preferred implementation,

Fig. 6 shows the cooling structure embedded in the heating volume of Fig. 1 in a schematic sectional view according to another preferred implementation,

Fig. 7 shows the cooling structure embedded in the heating volume of Fig. 1 in a schematic sectional view according to another preferred implementation, and

Fig. 8 shows the cooling structure of Fig. 1 in a perspective view according to another preferred implementation.

Description of implementations

[0032] Fig. 1 shows a high voltage circuit breaker 1 provided as high voltage self-blast circuit breaker and comprising a cooling structure 11 embedded in a heating volume 8 of the circuit breaker 1 in a schematic sectional view according to a preferred implementation.

[0033] The high voltage circuit breaker 1 comprises two contact elements 2 arranged opposite and movable relative to one another along a centre axis 3 of the high-voltage circuit breaker 1. The two contact elements 2 forming an arcing contact system are provided as contact tulip, left, and respective contact pin respectively plug, right. The two contact elements 2 form, during a breaking operation, in an arcing region 4 between the two contact elements 2 an arc 14 extinguishable by an arc extinguishing gas such as CO₂.

[0034] The left contact element 2 is at least partially surrounded by an auxiliary nozzle 5, while the auxiliary nozzle 5 and the right contact element 2 are at least partially surrounded by main nozzle 6. A heating channel 7 extends between the auxiliary nozzle 5 and the main nozzle 6 from the arcing region 4 into a heating volume 8. Said heating channel 7 is configured for dissipating arc extinguishing gas heated by the arc 14 into the heating volume 8.

[0035] The heating volume 8, shown in more detail in Figs. 2 to 7, comprises a basically closed volume axially extending around the auxiliary nozzle 5 and radially outward limited by a nominal contact system 15. The heating channel 7 exists at one axial end into the heating volume 8, while the other axial opposite end comprises a valve 9 configured for closing an opening 10 of the heating volume 8. The valve 9 is provided as a pressure operated valve 9 which closes the opening 10 upon pressure generated by the arc. In axial extension away from the heating channel 7 a compression volume 12 is foreseen, which is connected to the heating volume 8 via the valve 9. The compression volume 12 is limited by a piston 13 arranged opposite to the valve 9.

[0036] Arranged with the heating volume 8 is a cooling structure for cooling the heated arc extinguishing gas 14 flowing into the heating volume 8. Now referring to Figs. 2 to 3, as can be seen from the figures, the arc extinguishing gas heated by the arc 14 initially flows in axial direction through the heating channel 7. At an entrance of the heating volume 8 a first, radially extending part of the cooling structure 11 is arranged, which is passed by the heated arc extinguishing gas 14 thereby cooling the arc extinguishing gas 14. Pressure generated by the heated arc extinguishing gas 14 entering the heating volume 8 leads the operated valve 9 to close the opening 10, not shown in Figs. 2 to 3.

[0037] Having passed the first part of the cooling structure 11, the arc extinguishing gas 14 continues to travel in axial direction within the heating volume 8 and is reflected by the closed valve 9 arranged opposite to the entrance of the heating channel 7. The so radially up-

wards reflected arc extinguishing gas 14 passes a second, approximately axially extending part of the cooling structure 11, thereby being further cooling the arc extinguishing gas 14. Following this, the radially upwards reflected arc extinguishing gas 14 basically flows axially back and is reflected again by an axial outer end of the heating volume 8 above the heating channel 7 such that a turbulence of the so flowing arc extinguishing gas 14 is created. In such way the so reflected arc extinguishing gas 14 is cooled down by the cooling structure 11.

[0038] The implementation shown in Fig. 3 differs from the implementation shown in Fig. 2 that the first part of the cooling structure 11 is placed further away from the entrance. Thus, as can be seen, the reflected arc extinguishing gas 14 flows again through the first part of cooling structure 11, thereby mixing with heated arc extinguishing gas 14 inflowing from the arcing region 4.

[0039] Fig. 4 to 7 show further implementations with the cooling structure 11 provided as labyrinth, as mesh and/or as grid structure. Thereby, the cooling structure 11 extends in the heating volume 8 in one, two or three dimensions. Said cooling structure 11 can comprise stainless steel and/or ceramic, and can be additively manufactured.

[0040] Larger surface areas of the cooling structure 11 improve said cooling effect. Fig. 9 shows an additively manufactured cooling structure 11 in a perspective view according to another preferred implementation. The cooling structure 11 shown in Fig. 9 assuming a volume of about 1.5 litre, reaches about 0.2 m² total surface area. A flow resistance of such cooling structure 11 can be minimized for a given heat transfer capacity and an arrangement of elements in the cooling structure 11 can be flexibly designed by using 3D printing design and manufacturing.

[0041] With such cooling structure 11 as shown in Fig. 8, even large surface areas, e.g. of the order of 0.1 m², can be realized resulting in a cooling energy, over 5 ms, of about 24 kJ. In this case twice of the energy could flow into the heating volume 8, or even more, to reach the same pressure, increasing an amount of PTFE vapor significantly and possibly reducing a temperature of the arc extinguishing gas 14 in the heating volume 8 at the same time.

[0042] Normally, only a small fraction, very roughly about 10 %, of an arc energy in a short-circuit current interruption that leads to strong back-heating is directed to the heating volume 8. The remainder of the arc energy is exhausted as evaporated PTFE. The proposed solution allows a larger fraction of the arc energy to be used for effectively cooling the arc.

[0043] Doubling of the PTFE content from about 10% typically to more than 20%, on average, thus improves thermal interruption performance capability of the circuit breaker 1. At the same time the temperature of the arc extinguishing gas 14 is reduced, which improves thermal and dielectric interruption performance further

[0044] While the invention has been illustrated and de-

scribed 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 implementations. Other variations to be disclosed implementations can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting scope.

Reference signs list

[0045]

- 1 high voltage circuit breaker
- 2 contact element
- 3 centre axis
- 4 arcing region
- 5 auxiliary nozzle
- 6 main nozzle
- 7 heating channel
- 8 heating volume
- 9 valve
- 10 opening
- 11 cooling structure
- 12 compression volume
- 13 piston
- 14 arc extinguishing gas
- 15 nominal contact system

Claims

1. High voltage circuit breaker (1) comprising

two contact elements (2) arranged opposite and movable relative to one another along a centre axis (3) of the high-voltage circuit breaker (1), and forming, during a breaking operation, in an arcing region (4) between the two contact elements (2) an arc extinguishable by an arc extinguishing gas (14);
a heating volume (8) and a heating channel (7) connected to the arcing region (4) and configured for dissipating arc extinguishing gas (14) heated by the arc into the heating volume (8); and
a cooling structure (11) embedded in the heating volume (8) and configured for cooling the heated arc extinguishing gas (14) flowing into the heating volume (8).

- 2. High voltage circuit breaker (1) according to the previous claim, whereby the cooling structure (11) is provided as labyrinth, as mesh and/or as grid structure.
- 3. High voltage circuit breaker (1) according to any of the previous claims, whereby the cooling structure (11) extends in the heating volume (8) in one, two or three dimensions.
- 4. High voltage circuit breaker (1) according to any of the previous claims, whereby the cooling structure (11) comprises stainless steel, carbon steel, steel, titanium and/or ceramic.
- 5. High voltage circuit breaker (1) according to any of the previous claims, whereby the cooling structure (11) comprises an additively manufactured structure.
- 6. High voltage circuit breaker (1) according to any of the previous claims, whereby the cooling structure (11) comprises a first part associated to the heating channel (7) and a second part arranged within the heating volume (8).
- 7. High voltage circuit breaker (1) according to any of the previous claims, comprising a valve (9) configured for closing an opening (10) of the heating volume (8).
- 8. High voltage circuit breaker (1) according to the previous claim, whereby the valve (9) is provided as a pressure operated valve (9) configured for closing the opening (10) upon pressure generated by the arc.
- 9. High voltage circuit breaker (1) according to any of the two previous claims, comprising a compression volume (12) connected to the heating volume (8) via the valve (9), whereby the compression volume (12) is limited by a piston (13) arranged opposite to the valve (9).
- 10. High voltage circuit breaker (1) according to any of the previous claims, comprising an auxiliary nozzle (5), which at least partially surrounds one of the contact elements (2), and a main nozzle (6), which at least partially surrounds the auxiliary nozzle (4), whereby the heating channel (7) extends between the auxiliary nozzle (5) and the main nozzle (6) from the arcing region (4) into the heating volume (8).
- 11. High voltage circuit breaker (1) according to any of the previous claims, comprising a nominal current contact system (15), which at least partially surrounds the two contact elements (2), the heating volume (8), the heating channel (7) and the cooling

structure (11).

12. High voltage circuit breaker (1) according to any of the previous claims, whereby the high voltage circuit breaker (1) is provided as high voltage self-blast circuit breaker. 5
13. Use of a cooling structure (11) for cooling heated arc extinguishing gas (14) flowing into a heating volume (8) of a high voltage circuit breaker (1), the high voltage circuit breaker (1), comprising 10
- two contact elements (2) arranged opposite and movable relative to one another along a centre axis (3) of the high-voltage circuit breaker (1) and forming, during a breaking operation, in an arcing region (4) between the two contact elements (2) an arc extinguishable by an arc extinguishing gas; 15
- the heating volume (8) and a heating channel (7) connected to the arcing region (4) and configured for dissipating arc extinguishing gas (14) heated by the arc into the heating volume (8); 20
- and
- the cooling structure (11) embedded in the heating volume (8). 25

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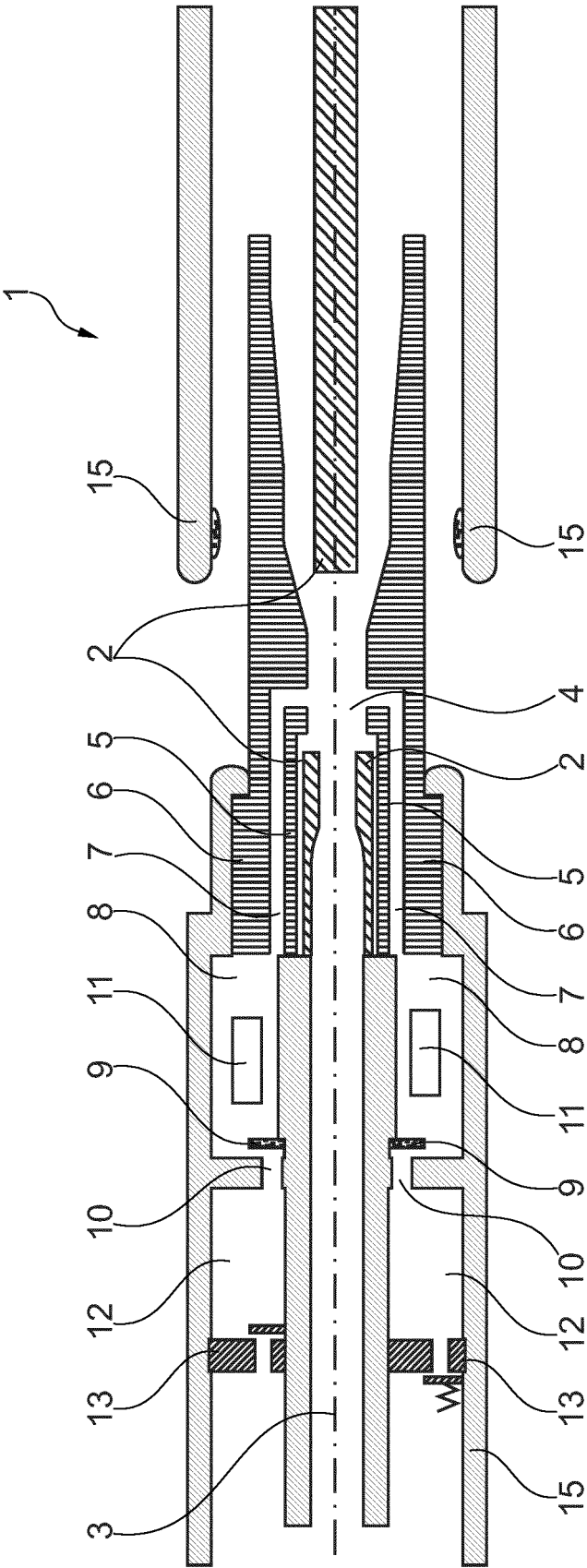
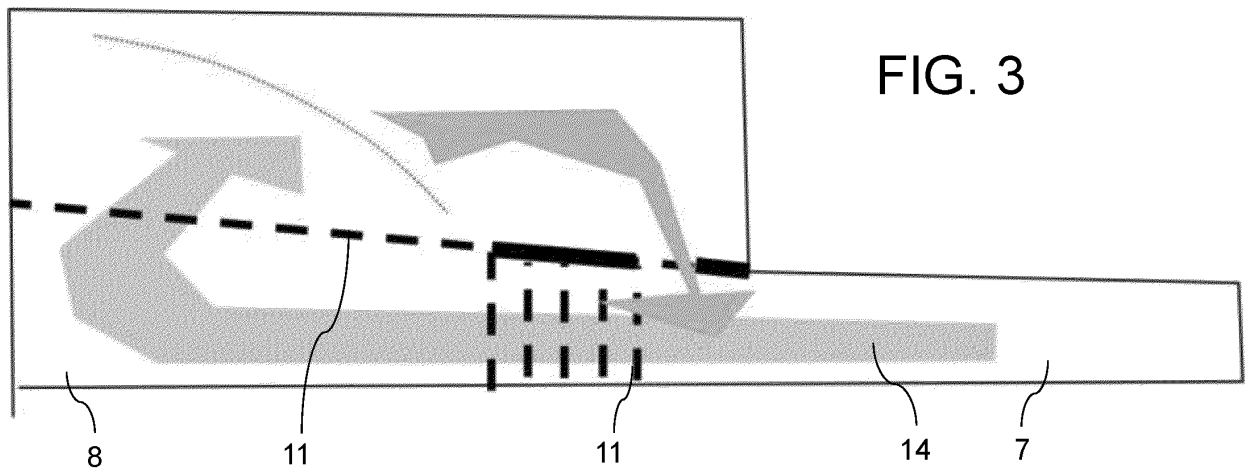
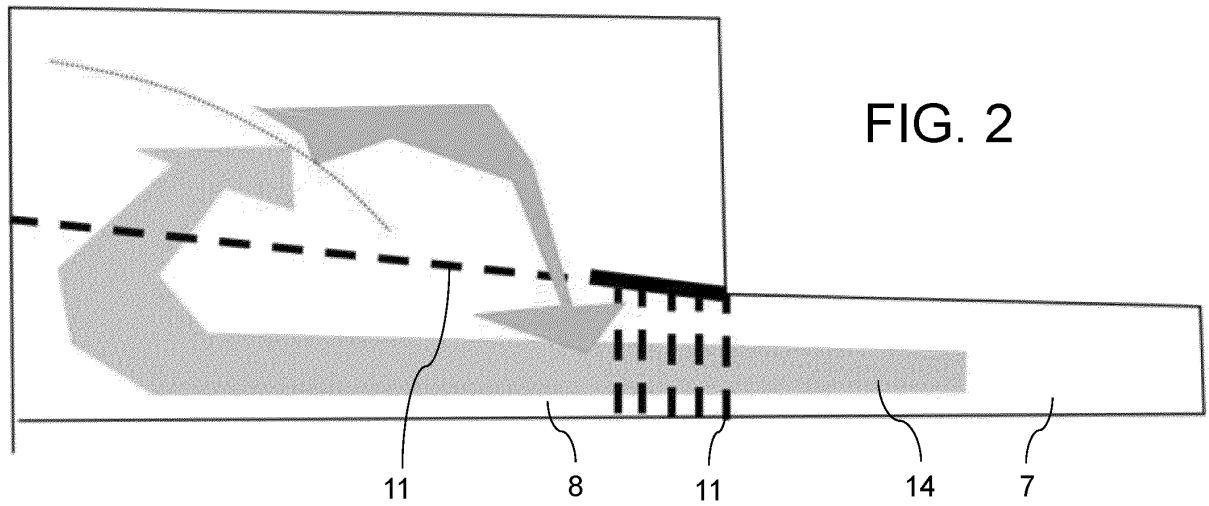
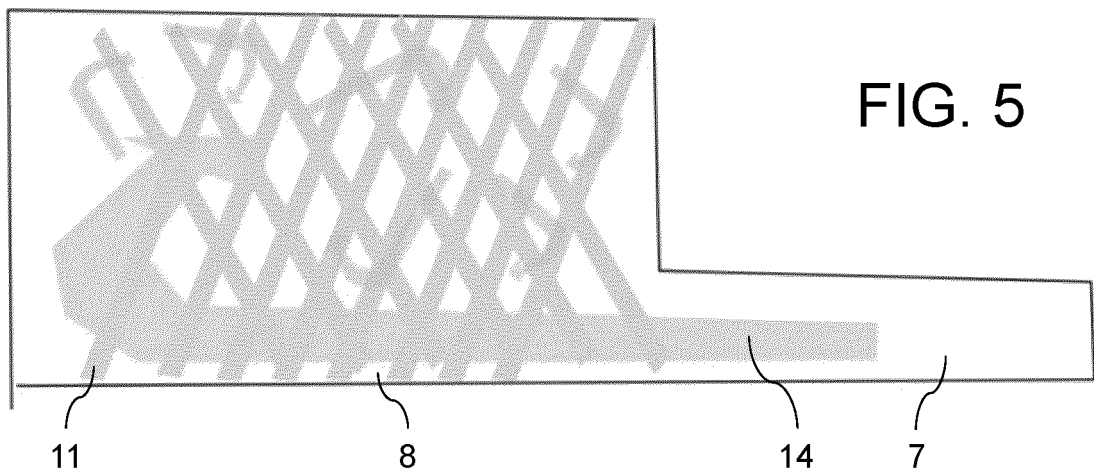
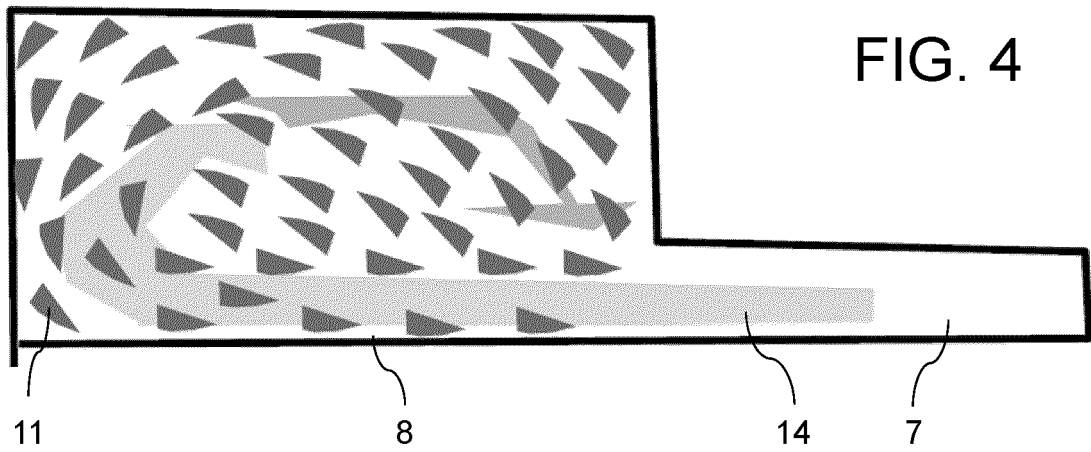
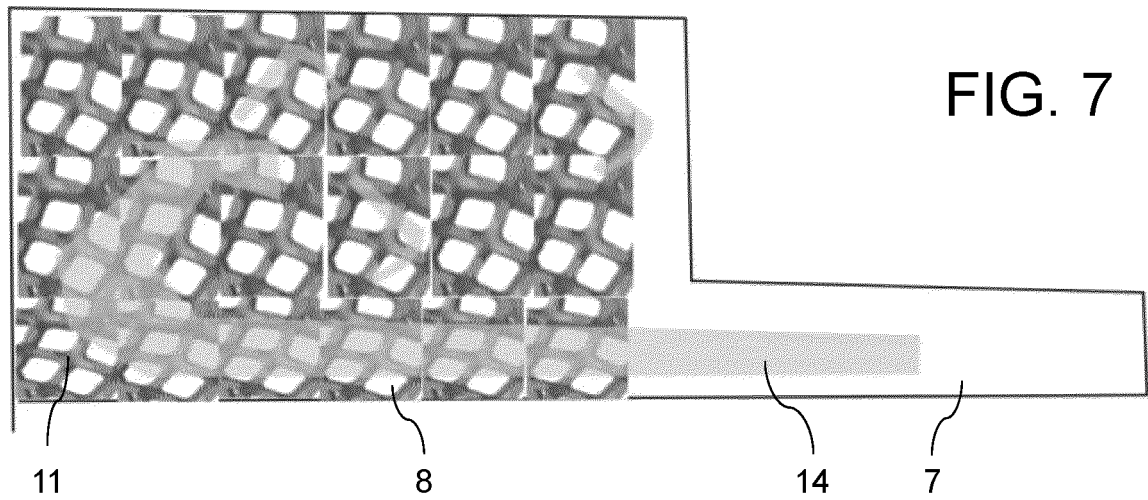
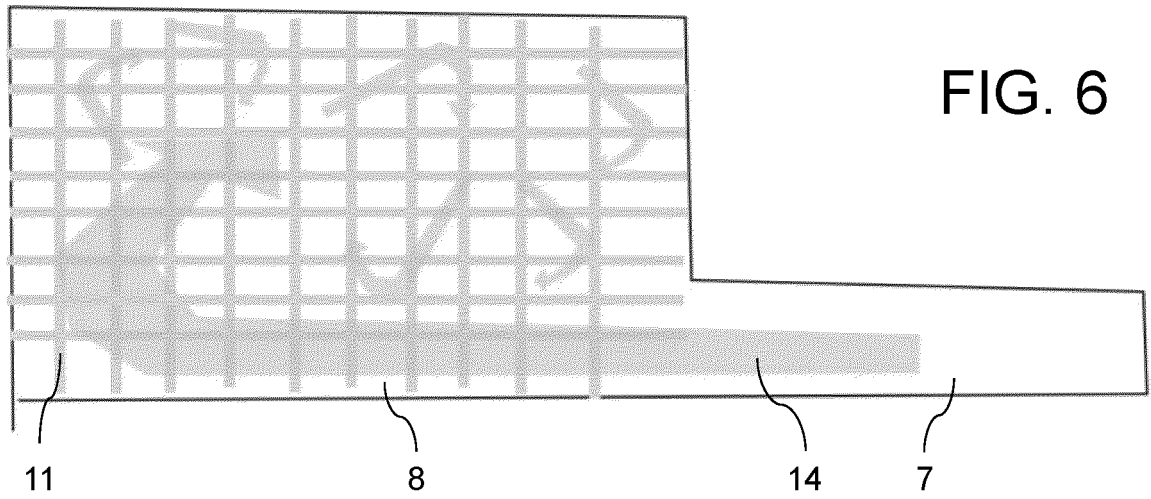


Fig. 1







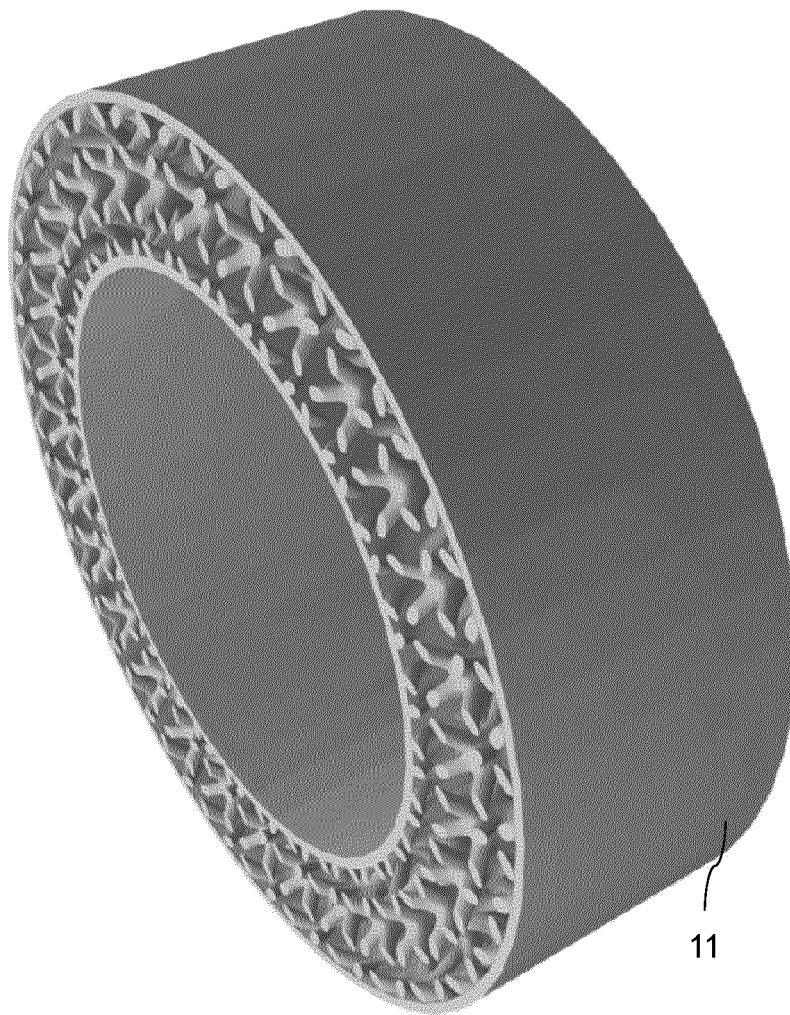


FIG. 8



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