

(19)



(11)

EP 4 553 878 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
14.05.2025 Bulletin 2025/20

(51) International Patent Classification (IPC):
H01H 33/662 ^(2006.01)

(21) Application number: **23208483.0**

(52) Cooperative Patent Classification (CPC):
H01H 33/66261; H01H 2033/66269

(22) Date of filing: **08.11.2023**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(72) Inventors:
• **GENTSCH, Dietmar**
40882 Ratingen (DE)
• **JAVORA, Radek**
664 62 Hrusovany u Brna (CZ)

(74) Representative: **Maiwald GmbH**
Engineering
Elisenhof
Elisenstrasse 3
80335 München (DE)

(71) Applicant: **ABB SCHWEIZ AG**
5400 Baden (CH)

(54) **VACUUM INTERRUPTER WITH COATED PARTS**

(57) The present invention relates to a vacuum interrupter or vacuum device (10), comprising:

- a movable contact (8a);
- a fixed contact (8b); and
- an arc shield (7);

wherein the arc shield surrounds at least the fixed contact and/or the movable contact; and

wherein at least a portion of an inner and/or surface of the arc shield and/or an outer surface of at least a portion of at least one contact stem comprises an arc resistant surface coating. In addition, the coating will be placed inside the vacuum or on the outside of the device in a gas atmosphere, in liquid or even in a solid insulation material. The coating has conductive, semi conductive or insulation material properties.

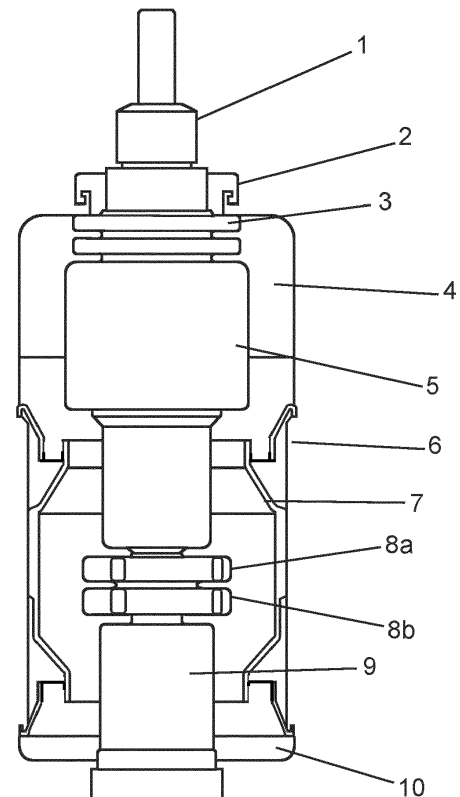


Fig. 1

EP 4 553 878 A1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a vacuum interrupter in a low, or medium, or high voltage switchgear, and a method of manufacturing a vacuum interrupter.

BACKGROUND OF THE INVENTION

[0002] The environment inside a vacuum interrupter (VI) is exposed to an electric arc while interruption. The effects of such an arc may have negative impact on components used within the VI and thus negatively impact the performance of the VI over the time.

[0003] Usually, the VI contacts are properly designed for such arc phenomena, but electrodes used for electric field distribution within or around the VI are negatively impacted as well by the arc. Such electrodes are also termed arc shields and E-field steering components.

[0004] The deterioration of the surface of such electrodes due to the needed electrical conditioning to achieve the needed dielectric strength or while the arc events can cause impurities, further generated microtips, vapors in the vacuum environment within the VI and thus lead to a worsening of the dielectric withstand strength inside of the VI.

[0005] The inner components of the VI and here especially the metal parts, the metal stems (mainly made from copper), contacts, ceramics, and sheet metal shielding are, during the needed dielectric conditioning, exposed to high impact during the breakdown of voltage. In such a case, deterioration of the surface will occur and will limit the dielectric performance. A similar situation happens in the case that the metal vapor damp condensates on the insulation part in unfavorable cases.

[0006] Furthermore, during the breakdown, further micro-tips can be generated thus a subsequent increase of the voltage withstand cannot be achieved, and the device's limit will be reached or even a deconditioning will take place.

[0007] A general structure of a VI is now described. A moveable stem 1 is connected to a moveable contact 8a. The moveable stem 1 passes through twist protection 2. An interrupter lid 4 connects to the twist protection 2 and to a ceramic body 6 that connects to another interrupter lid 10 that forms an outer body of the VI. A metal bellows 3 connects at one end to the interrupter lid 4 and to a shield 5 that connects to the moveable stem 1 and enables the moveable contact to move with respect to a fixed contact 8a that is connected to a fixed stem.

[0008] An arc / E-field shield or so-called metal-vapor shield 7 surrounds at least one of the contacts and prevents melted contact material from impacting and depositing and collecting on the ceramic body. This arc / E-field shield 7 ensures that a conductive surface does not develop over a time into a conductive path over the interior of ceramic body. Nevertheless, the arc and the

conditioning breakdown also causes metal evaporation / particles from the shielding electrode that leads to a deterioration of the metal surface and generating micro-tips on its surfaces and thus reducing dielectric withstand of the VI and consequently limiting the remaining lifetime of the whole circuit breaker. Thus, during the VI conditioning and breakdown together result in small amounts of metal vapor damp that unavoidably occur even at the surface area of the shielding and some metal vapor damp will condensate even on the inner ceramic insulation surface of the VI, leading to an irreversible degradation of the inner dielectric withstand voltage and limitation of the dielectric performance as well. In addition, and during the conditioning of the VI's components, the breakdown can result in generating microtips at the same time with the consequence in limiting the further conditioning effect.

[0009] These issues need to be addressed.

[0010] There is a need to address these issues.

SUMMARY OF THE INVENTION

[0011] Therefore, it would be advantageous to have an improved Vacuum Interrupter.

[0012] 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.

[0013] In a first aspect, there is provided a vacuum interrupter or a vacuum device, comprising:

- a movable contact;
- a fixed contact; and
- an arc shield.

[0014] The arc shield surrounds at least the fixed contact and/or the movable contact. At least a portion of an inner and/or outer surface of the arc shield and/or an outer surface of at least a portion of at least one contact stem comprises an arc resistant surface coating.

[0015] In an example, the vacuum interrupter or the vacuum device comprises an electrically conductive lid. An outer housing of the vacuum interrupter or the vacuum device is at least partially formed from the electrically conductive lid. At least a portion of an inner surface of the electrically conductive lid comprises the arc resistant surface coating.

[0016] In an example, the vacuum interrupter or the vacuum device comprises a moveable stem connected to the moveable contact. The vacuum interrupter or the vacuum device also comprises a first electrically conductive lid. The first conductive lid at least partially surrounds the moveable stem. The outer housing of the vacuum interrupter or the vacuum device is at least partially formed from the first electrically conductive lid. At least a portion of an inner surface of the first electrically conductive lid comprises the arc resistant surface coating.

[0017] In an example, at least a portion of an outer surface of the moveable stem comprises the arc resistant surface coating.

[0018] In an example, the vacuum interrupter or the vacuum device also comprises a metal shield surrounding at least a portion of the moveable stem, and the first electrically conductive lid surrounds at least a portion of the metal shield. At least a portion of an outer surface of the metal shield comprises the arc resistant surface coating.

[0019] In an example, the vacuum interrupter or the vacuum device comprises a fixed stem connected to the fixed contact. The vacuum interrupter or the vacuum device also comprises a second electrically conductive lid. The outer housing of the vacuum interrupter or the vacuum device is at least partially formed from the second electrically conductive lid. At least a portion of an inner surface of the second electrically conductive lid comprises the arc resistant surface coating.

[0020] In an example, at least a portion of an outer surface of the fixed stem comprises the arc resistant surface coating.

[0021] In an example, the arc resistant surface coating is applied by spraying, brushing, painting, sprinkling or the bulk material is basically made out of arc resistive material.

[0022] In an example, the coating or the arc resistant surface coating is applied by plasma coating, or sputtering, or chemical vapour deposition, or physical vapour deposition, or laser deposition.

[0023] In an example, an outer surface of the arc resistant surface coating has a surface roughness less than surface roughness of the material upon which it is coated, or similar or even partly higher after coating.

[0024] In an example, the arc resistant coating comprises one or more of: TiN, TiCN, TiAlN, TiAlN-HT, CrN, Diamond Like Carbon, Tungsten disulphide, one or more carbides, one or more nitrides, one or more oxides or their combinations. In addition, the coating can be pure metal like Nickel, Chromium, Tungsten, Cobalt, Vanadium, Zirconium, Tin, Aluminium, or their combinations and oxides.

[0025] In an example, the arc resistant coating comprises one or more of: In addition, the coating can be pure metal like Nickel, Chromium, Tungsten, Cobalt, Vanadium, Zirconium, Tin, Aluminium, or their combinations and oxides.

[0026] In an example, the arc resistant coating comprises a multilayer coating of components.

[0027] In an example, the arc resistant coating comprises a coating with conductivity, semiconductive behaviour or fully insulation condition.

[0028] In an example, the arc resistant coating comprises a coating which has high work-function.

[0029] In an example, the arc resistant coating will be applied to the outer side of the device in gas, liquid or a solid insulation material.

[0030] In a second aspect, there is provided a low

voltage switchgear or medium voltage switchgear or high voltage switchgear comprising a vacuum interrupter or a vacuum device according to the first aspect.

[0031] In a third aspect, there is provided a method of manufacturing a vacuum interrupter or a vacuum device, comprising:

- providing a movable contact;
- providing a fixed contact;
- providing an arc or E-field steering shield that surrounds at least the fixed contact and/or the movable contact; and
- coating at least a portion of an inner and/or outer surface of the arc shield and/or an outer surface of at least a portion of at least one contact stem with an arc resistant surface coating.

[0032] In an example, the method comprises applying the arc resistant surface coating by spraying, brushing, painting, or sprinkling, plasma coating, or sputtering, or chemical vapour deposition, or physical vapor deposition, or laser deposition, or a galvanic process.

[0033] In an example, the arc resistant coating comprises one or more of: TiN, TiCN, TiAlN, TiAlN-HT, CrN, Diamond Like Carbon, Tungsten disulphide, one or more carbides, one or more nitrides, one or more oxides or their combinations. In addition, the coating can be pure metal like Nickel, Chromium, Tungsten, Cobalt, Vanadium, Zirconium, Tin, Aluminium, or their combinations.

[0034] The above aspect and examples will become apparent from and be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] Exemplary embodiments will be described in the following with reference to the following drawing: Fig. 1 shows a schematic representation of a vacuum interrupter, or another vacuum device under voltage application.

DETAILED DESCRIPTION OF EMBODIMENTS

[0036] Fig. 1 shows a schematic representation of an example of vacuum interrupter, a high voltage vacuum interrupter or another vacuum device under voltage application. The new development described here is that one or more surfaces within the vacuum interrupter or a vacuum device have been coated by an arc resistant coating.

[0037] In an example, vacuum interrupter or the vacuum device, comprises:

- a movable contact 8a;
- a fixed contact 8b; and
- an arc shield 7.

[0038] The arc shield surrounds at least the fixed con-

tact and/or the movable contact. At least a portion of an inner and/or outer surface of the arc shield and/or an outer surface of at least a portion of at least one contact stem comprises an arc resistant surface coating.

[0039] According to an example, the vacuum interrupter or the vacuum device comprises an electrically conductive lid 4, and an outer housing of the vacuum interrupter or the vacuum device is at least partially formed from the conductive lid. At least a portion of an inner surface of the conductive lid comprises the arc resistant surface coating.

[0040] According to an example, the vacuum interrupter or the vacuum device comprises a moveable stem 1 connected to the moveable contact. The vacuum interrupter or the vacuum device comprises a first electrically conductive lid 4, and the first electrically conductive lid at least partially surrounds the moveable stem. The outer housing of the vacuum interrupter or the vacuum device is at least partially formed from the first electrically conductive lid. At least a portion of an inner surface of the first electrically conductive lid comprises the arc resistant surface coating.

[0041] The electrically conductive lid 4 and the first electrically conductive lid 4 can be the same.

[0042] In an example, the moveable stem is configured to move with respect to the first electrically conductive lid.

[0043] According to an example, at least a portion of an outer surface of the moveable stem comprises the arc resistant surface coating.

[0044] According to an example, the vacuum interrupter or the vacuum device comprises a metal shield 5 surrounding at least a portion of the moveable stem. The first electrically conductive lid surrounds at least a portion of the metal shield. At least a portion of an outer surface of the metal shield comprises the arc resistant surface coating.

[0045] According to an example, the vacuum interrupter or the vacuum device comprises a fixed stem 9 connected to the fixed contact. The vacuum interrupter or the vacuum device also comprises a second electrically conductive lid 10. The outer housing of the vacuum interrupter or the vacuum device is at least partially formed from the second electrically conductive lid. At least a portion of an inner surface of the second electrically conductive lid comprises the arc resistant surface coating.

[0046] According to an example, at least a portion of an outer surface of the fixed stem comprises the arc resistant surface coating.

[0047] According to an example, the arc resistant surface coating is applied by spraying, brushing, painting, sprinkling or another coating method.

[0048] According to an example, the arc resistant surface coating is applied by plasma coating, or sputtering, or chemical vapour deposition, or physical vapour deposition, or laser deposition or a galvanic process.

[0049] According to an example, an outer surface of the arc resistant surface coating has a surface roughness

less than surface roughness of the material upon which it is coated.

[0050] According to an example, the arc resistant coating comprises one or more of: TiN, TiCN, TiAlN, TiAlN-HT, CrN, Diamond Like Carbon, Tungsten disulphide, one or more carbides, one or more nitrides, one or more oxides or their combinations. In addition, the coating can be pure metal like Nickel, Chromium, Tungsten, Cobalt, Vanadium, Zirconium, Tin, Aluminium, or their combinations and oxides.

[0051] In an example, the arc resistant coating comprises one or more of: In addition, the coating can be pure metal like Nickel, Chromium, Tungsten, Cobalt, Vanadium, Zirconium, Tin, Aluminium, or their combinations and oxides.

[0052] In an example, the arc resistant coating comprises a multilayer coating of components.

[0053] In an example, the arc resistant coating comprises a coating with conductivity, semiconductive behaviour or fully insulation condition.

[0054] In an example, the arc resistant coating comprises a coating which has high work-function.

[0055] In an example, the arc resistant coating will be applied to the outer side of the device in gas, liquid or a solid insulation material.

[0056] It is to be noted that when more than one part of the VI is coated with an arc resistant coating the same arc resistant can be used, or different arc resistant coatings can coat one or more parts.

[0057] A low voltage switchgear or medium voltage switchgear or high voltage switchgear can then have one or more vacuum interrupters / devices as described above.

[0058] In an example, a method of manufacturing a vacuum interrupter or a vacuum device, comprises:

- providing a movable contact 8a;
- providing a fixed contact 8b;
- providing an arc shield 7 that surrounds at least the fixed contact and/or the movable contact; and
- coating at least a portion of an inner and/or outer surface of the arc shield and/or an outer surface of at least a portion of at least one contact stem with an arc resistant surface coating.

[0059] In an example, the method comprises providing a conductive lid 4, forming an outer housing of the vacuum interrupter or the vacuum device at least partially from the electrically conductive lid, and coating at least a portion of an inner surface of the electrically conductive lid with the arc resistant surface coating.

[0060] In an example, the method comprises connecting a moveable stem 1 to the moveable contact, providing a first conductive lid 4 that at least partially surrounds the moveable stem, forming the outer housing of the vacuum interrupter or the vacuum device at least partially formed from the first electrically conductive lid, and coating at least a portion of an inner surface of the first electrically

conductive lid with the arc resistant surface coating.

[0061] In an example, the method comprises coating at least a portion of an outer surface of the moveable stem with the arc resistant surface coating.

[0062] In an example, the method comprises providing a metal shield 5 surrounding at least a portion of the moveable stem, surrounding at least a portion of the metal shield with the first electrically conductive lid, and coating at least a portion of an outer surface of the metal shield with the arc resistant surface coating. In addition, the shielding will be at the inner surface of the metal shielding but even the outer surface and outside of the vacuum atmosphere the coating can be placed / present.

[0063] In an example, the method comprises connecting a fixed stem 9 to the fixed contact, forming the outer housing of the vacuum interrupter or the vacuum device at least partially from the second electrically conductive lid, and coating at least a portion of an inner surface of the second electrically conductive lid with the arc resistant surface coating.

[0064] In an example, the method comprises coating at least a portion of an outer surface of the fixed stem with the arc resistant surface coating.

[0065] According to an example, the method comprises applying the arc resistant surface coating by spraying, brushing, painting or sprinkling, plasma coating, or sputtering, or chemical vapour deposition, or physical vapour deposition, or laser deposition, or galvanic process.

[0066] In an example the method comprises providing a surface roughness of an outer surface of the arc resistant surface coating less, similar, or even higher than a surface roughness of the material upon which it is coated.

[0067] According to an example, the arc resistant coating comprises one or more of: TiN, TiCN, TiAlN, TiAlN-HT, CrN, Diamond Like Carbon, Tungsten disulphide, one or more carbides, one or more nitrides, one or more oxides or their combinations. In addition, the coating can be pure metal like Nickel, Chromium, Tungsten, Cobalt, Vanadium, Zirconium, Tin, Aluminium, or their combinations.

[0068] In an example, the arc resistant coating comprises one or more of: In addition, the coating can be pure metal like Nickel, Chromium, Tungsten, Cobalt, Vanadium, Zirconium, Tin, Aluminium, or their combinations and oxides.

[0069] In an example, the arc resistant coating comprises a multilayer coating of components.

[0070] In an example, the arc resistant coating comprises a coating with conductivity, semiconductive behaviour or fully insulation condition.

[0071] In an example, the arc resistant coating comprises a coating which has high work-function.

[0072] In an example, the arc resistant coating will be applied to the outer side of the device in gas, liquid or a solid insulation material.

[0073] It is to be noted that when more than one part of

the VI / vacuum device is coated with an arc resistant coating the same arc resistant can be used, or different arc resistant coatings can coat one or more parts.

[0074] Thus, the inventors realized that a new design of vacuum interrupter / vacuum device (VD) could be provided, where electric field distribution electrodes or arc shields can use a material with a high resistance towards the electric arc and the high voltage breakdown "current". The material is provided on a surface facing the arc, or facing where high field strength breakdown can occur. Also, a number of surfaces within the VI can be coated if necessary.

[0075] The new design can be used in general at any high-power or high voltage enclosed environment experiencing an electric breakdown or an arc. Due to the proximity of an electric breakdown and small amount of enclosed gas area, it is especially beneficial for application in VIs. Such improved durability of shielding electrode will not deteriorate the gas purity within the VI / VD and will thus maintain the same dielectric withstand of the VI / VD over a longer time, even after multiple breakdowns or / and arc events due to conditioning, testing or current interruption (switching) on the VI and in field application for the entire service lifetime.

[0076] The above discussion has focused on vacuum interrupters and vacuum devices, but the new development may be generally applied to all applications, which are sensitive to purity of gas and the surface deterioration during and at voltage breakdown events within certain enclosed environments and where the breakdown current or an arc may impact surrounding parts or devices. Such devices can be vacuum interrupters, HV circuit breakers, load-break switches, vacuum devices, but also gas insulated switchgears and for sure sphere spark gap.

[0077] Thus, as discussed above the new development provides the dielectrically highly stressed components / areas / sub-areas with an appropriate surface coating, which is coated using the spray, chemical vapor deposition (CVD), Vapor Deposition (PVD) process or other processes which allow such coating. The surface of the coated components (these should already have a low basic roughness or even having balancing performances by the coating) have an even lower, similar, or higher roughness after coating. In addition, these layers have a less sensitive surface, especially when the selected layer has mainly a higher basic hardness than the base/bulk material. Furthermore, the coating can be improved by post-treatment in case that will be needed, like polishing. In VI / VD and after brazing, the subsequent unavoidable micro-tips of the component surface can be dielectrically conditioned - removed. In the event of a dielectric breakdown within the VI, no or neglectable base material is vaporized (compared to untreated stainless steel or copper from the shielding or stem), that could condense at points on the ceramic within the VI / VD and thus reduce the dielectric strength of the unit.

[0078] Furthermore, the surfaces can be conditioned with the advantage that no further (or only a few) new

micro-emitters (tips) are formed on the surface during / after a breakdown. In addition, there is no or only little "tracing" of cathode base point erosion that occurs, i.e. on components.

[0079] The arc resistant coating can one or more of: TiN, TiCN, TiAlN, TiAlN-HT, CrN, Diamond Like Carbon, Tungsten disulphide, one or more carbides, one or more nitrides, one or more oxides or their combinations. In addition, the coating can be pure metal like Nickel, Chromium, Tungsten, Cobalt, Vanadium, Zirconium, Tin, Aluminium, or their combinations.

[0080] In a specific example, the arc resistant coating can be a multi-layer structure - duplex or other layers in the composite. Such a multilayer high-performance coating can consist of for example titanium aluminium nitride (TiAlN) and/or titanium carbonitride (TiCN), which ensure very high hardness with good toughness. The top layer can be for example TiCN. In addition, the coating can be pure metal like Nickel, Chromium, Tungsten, Cobalt, Vanadium, Zirconium, Tin, Aluminium, or their combinations and oxides.

[0081] A low work function can be provided through the choice of the coating or modification of the surface with the coating permanently chemically bound.

[0082] Reduced roughness (micro-tips) can be provided after heat treatment in the manufacturing process - after brazing of the vacuum interrupter or the vacuum device.

[0083] A low basic roughness or even having balancing performances can be achieved through an appropriate coating process.

[0084] Sheet metal components can have a higher dimensional stability (stiffness of part), so that later deformation "relaxation" of the components occurs/stays on a small scale, resulting in a "bimetal material" effect with the well-known advantages (no shape-dimensional deviations from the specification).

[0085] Very "smooth" and "inert" layers can be achieved on the components, which also will be available "after" the heat treatment (brazing process), including the associated sheet metal component dimensional stability.

[0086] The surface quality, the number of technically unavoidable micro-tips is reduced via the arc resistant coating or by post-treatment of coating, the number of particles on a surface and the number of defects in the material and the surface is also reduced.

[0087] Appropriate devices can be vacuum interrupters, vacuum devices, HV circuit breakers, load-break switches, but also gas insulated switchgears and for sure sphere spark gap in vacuum or in gas atmosphere.

Reference numerals

[0088]

- 1 = moveable stem/terminal
- 2 = twist protection
- 3 = metal bellows

- 4 = interrupter lid
- 5 = shield
- 6 = ceramic body
- 7 = arc shield
- 8a = moveable contact
- 8b = fixed contact
- 9 = fixed stem
- 10 = interrupter lid

Claims

1. A vacuum interrupter or a vacuum device, comprising:

- a movable contact (8a);
- a fixed contact (8b); and
- an arc shield (7);

wherein the arc shield surrounds at least the fixed contact and/or the movable contact; and wherein at least a portion of an inner and/or outer surface of the arc shield and/or an outer surface of at least a portion of at least one contact stem comprises an arc resistant surface coating.

2. Vacuum interrupter or vacuum device according to claim 1, wherein the vacuum interrupter or the vacuum device comprises a conductive lid (4), wherein an outer housing of the vacuum interrupter or the vacuum device is at least partially formed from the electrically conductive lid, and wherein at least a portion of an inner surface of the electrically conductive lid comprises the arc resistant surface coating.

3. Vacuum interrupter or vacuum device according to any of claims 1-2, wherein the vacuum interrupter or the vacuum device comprises a moveable stem (1) connected to the moveable contact, wherein the vacuum interrupter or the vacuum device comprises a first electrically conductive lid (4), wherein the first electrically conductive lid at least partially surrounds the moveable stem, wherein the outer housing of the vacuum interrupter or the vacuum device is at least partially formed from the first electrically conductive lid, and wherein at least a portion of an inner surface of the first electrically conductive lid comprises the arc resistant surface coating.

4. Vacuum interrupter or vacuum device according to claim 3, wherein at least a portion of an outer surface of the moveable stem comprises the arc resistant surface coating.

5. Vacuum interrupter or vacuum device according to any of claims 3-4, wherein the vacuum interrupter or the vacuum device comprises a metal shield (5) surrounding at least a portion of the moveable stem,

wherein the first electrically conductive lid surrounds at least a portion of the metal shield, and wherein at least a portion of an outer surface of the metal shield comprises the arc resistant surface coating.

6. Vacuum interrupter or vacuum device according to any of claims 1-5, wherein the vacuum interrupter or the vacuum device comprises a fixed stem (9) connected to the fixed contact, wherein the vacuum interrupter or the vacuum device comprises a second electrically conductive lid (10), wherein the outer housing of the vacuum interrupter or the vacuum device is at least partially formed from the second electrically conductive lid, and wherein at least a portion of an inner surface of the second electrically conductive lid comprises the arc resistant surface coating.
7. Vacuum interrupter or the vacuum device according to claim 6, wherein at least a portion of an outer surface of the fixed stem comprises the arc resistant surface coating.
8. Vacuum interrupter or vacuum device according to any of claims 1-7, wherein the arc resistant surface coating is applied by spraying, brushing, painting, sprinkling or a galvanic process.
9. Vacuum interrupter or vacuum device according to any of claims 1-7, wherein the arc resistant surface coating is applied by plasma coating, or sputtering, or chemical vapour deposition, or physical vapour deposition, or laser deposition.
10. Vacuum interrupter or vacuum device according to any of claims 1-9, wherein an outer surface of the arc resistant surface coating has a surface roughness less, similar or even higher than surface roughness of the material upon which it is coated.
11. Vacuum interrupter or vacuum device according to any of claims 1-10, wherein the arc resistant coating comprises one or more of: TiN, TiCN, TiAlN, TiAlN-HT, CrN, Diamond Like Carbon, Tungsten disulphide, Nickel, Chromium, Tungsten, Cobalt, Vanadium, Zirconium, Tin, Aluminium, or their combinations and oxides, one or more carbides, one or more nitrides, one or more oxides or their combinations.
12. A low voltage switchgear or medium voltage switchgear or high voltage switchgear comprising a vacuum interrupter or a vacuum device according to any of claims 1-11.
13. A method of manufacturing a vacuum interrupter, or a vacuum device comprising:

- providing a movable contact (8a);

- providing a fixed contact (8b);
 - providing an arc shield (7) that surrounds at least the fixed contact and/or the movable contact; and
 - coating at least a portion of an inner and/or outer surface of the arc shield and/or an outer surface of at least a portion of at least one contact stem with an arc resistant surface coating.

14. Method according to claim 13, wherein the method comprises applying the arc resistant surface coating by spraying, brushing, painting or sprinkling, plasma coating, or sputtering, or chemical vapour deposition, or physical vapour deposition, or laser deposition, or galvanic coating.
15. Method according to any of claims 13-14, wherein the arc resistant coating comprises one or more of: TiN, TiCN, TiAlN, TiAlN-HT, CrN, Diamond Like Carbon, Tungsten disulphide, Nickel, Chromium, Tungsten, Cobalt, Vanadium, Zirconium, Tin, Aluminium, or their combinations and oxides, one or more carbides, one or more nitrides, one or more oxides or their combinations.

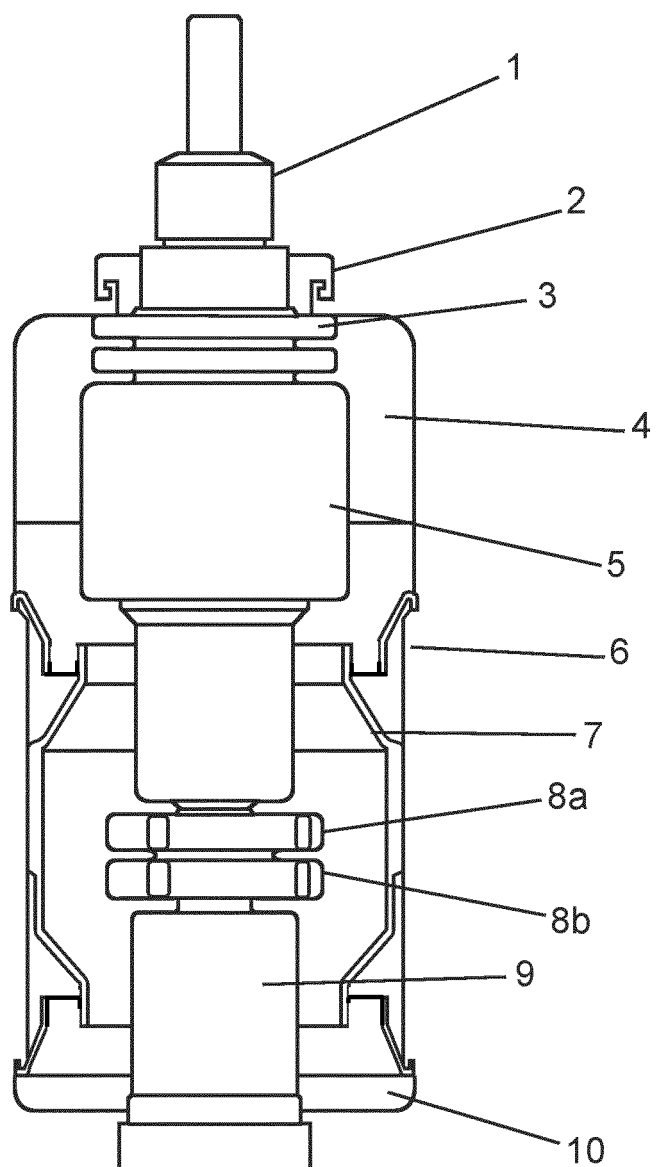


Fig. 1



EUROPEAN SEARCH REPORT

Application Number

EP 23 20 8483

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	US 2016/104590 A1 (CAMPBELL LOUIS GRANT [US] ET AL) 14 April 2016 (2016-04-14)	1, 5, 12, 13	INV. H01H33/662
Y	* paragraph [0026] - paragraph [0092]; figures 1, 2 *	2-4, 6-11, 14, 15	
X	EP 2 407 991 A1 (TOSHIBA KK [JP]) 18 January 2012 (2012-01-18)	1	
Y	* paragraph [0015] - paragraph [0019]; figure 2 *	4, 7, 10, 11, 15	
Y	US 4 361 742 A (KASHIWAGI YOSHIYUKI ET AL) 30 November 1982 (1982-11-30)	2, 3, 6, 11, 15	TECHNICAL FIELDS SEARCHED (IPC) H01H
	* page 1, column 1 - page 2, column 4; figure 1 *		
Y	US 7 939 777 B2 (ABB TECHNOLOGY AG [CH]) 10 May 2011 (2011-05-10)	8, 9, 11, 14, 15	
	* column 2 - column 3; figure 1 *		
Y	EP 3 134 912 B1 (SIEMENS AG [DE]) 22 July 2020 (2020-07-22)	10	
	* paragraph [0017] - paragraph [0018] *		
Y	US 2007/196570 A1 (GENTSCH DIETMAR [DE] ET AL) 23 August 2007 (2007-08-23)	11, 15	
	* paragraph [0019] - paragraph [0020] *		
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 14 March 2024	Examiner Abdelmoula, Amine
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 23 20 8483

14-03-2024

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2016104590 A1	14-04-2016	CN 105513882 A	20-04-2016
		CN 113257613 A	13-08-2021
		EP 3018684 A1	11-05-2016
		ES 2667484 T3	11-05-2018
		JP 6806430 B2	06-01-2021
		JP 7019015 B2	14-02-2022
		JP 2016081910 A	16-05-2016
		JP 2021036548 A	04-03-2021
		KR 20160043513 A	21-04-2016
		US 2016104590 A1	14-04-2016
EP 2407991 A1	18-01-2012	US 2018075991 A1	15-03-2018
		CN 102332364 A	25-01-2012
		EP 2407991 A1	18-01-2012
		JP 5537303 B2	02-07-2014
		JP 2012022812 A	02-02-2012
US 4361742 A	30-11-1982	KR 20120006447 A	18-01-2012
		DE 3027948 A1	29-01-1981
		GB 2055250 A	25-02-1981
		JP S5618324 A	21-02-1981
		JP S5855609 B2	10-12-1983
US 7939777 B2	10-05-2011	US 4361742 A	30-11-1982
		CN 101263571 A	10-09-2008
		DE 102005043484 A1	19-04-2007
		EP 1927123 A1	04-06-2008
		US 2008203063 A1	28-08-2008
EP 3134912 B1	22-07-2020	WO 2007031202 A1	22-03-2007
		DE 102014211855 A1	24-12-2015
		EP 3134912 A1	01-03-2017
US 2007196570 A1	23-08-2007	WO 2015193065 A1	23-12-2015
		CN 101052746 A	10-10-2007
		EP 1794350 A1	13-06-2007
		US 2007196570 A1	23-08-2007
		WO 2006032522 A1	30-03-2006