(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 971 930 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
23.03.2022 Bulletin 2022/12

(21) Application number: **20197216.3**

(22) Date of filing: **21.09.2020**

(51) International Patent Classification (IPC):
H01H 1/38 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
H01H 1/385; H01H 33/02

(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 MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) **FEMALE CONTACT MEMBER FOR A SWITCHGEAR CONTACT ASSEMBLY**

(57) The invention relates to a female contact member (1) for a switchgear contact assembly, the female contact member (1) comprising a contact member body to receive a male contact member, wherein the contact member body comprises at least two strip-shaped contact parts (2), extending along a longitudinal axis of the contact member (1), the contact parts (2) being contactable with the male contact member, wherein the contact parts (2) are separated from each other by at least one slit (3) extending from a junction of the contact parts (2) to a slit opening; and a support member (4) to support the contact parts (2) at the at least one slit (3) and to make bending stress at the contact parts (2), caused by receiving the male contact member (10), occur at a distance from the junction of the contact parts (2).

The invention also relates to a switchgear contact assembly, comprising the female contact member (1) and a male contact member. The invention also relates to a switchgear device, comprising the switchgear assembly.

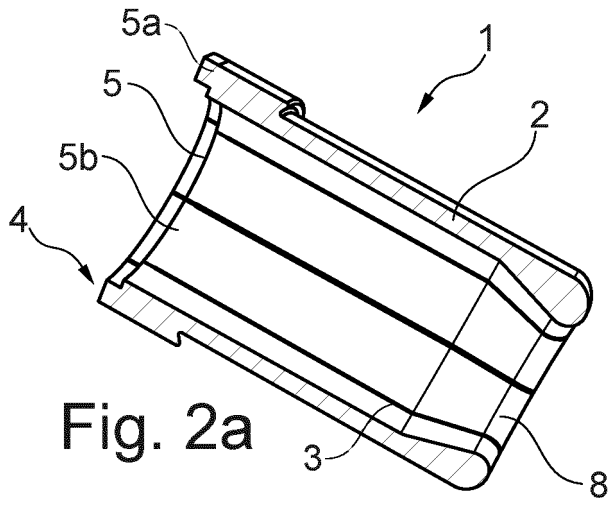

Fig. 2a

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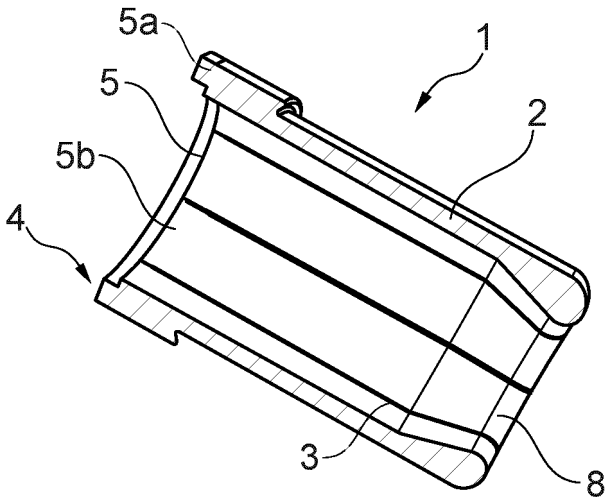

Fig. 2b

Description

Technical Field

[0001] The invention relates to a female contact member for a switchgear contact assembly.

[0002] The present invention also relates to a switchgear contact assembly, comprising the female contact member and a male contact member.

[0003] The present invention also relates to a switchgear device, comprising the switchgear assembly.

Background Art

[0004] Switchgear devices are essential for the protection of technical equipment, especially in the high voltage range. For example, they protect cables or other equipment from damage due to excessive heating. The contact members of a switchgear device are critical components for the functionality of a switchgear device.

Summary of invention

[0005] It is an object of the invention to provide an improved female contact member for a switchgear contact assembly. For example, it is an object of the present invention to ensure an improved functionality of the contact members even more reliably and even for increasing closing speeds, while maintaining a compactness of the contact members.

[0006] The object of the invention is solved by the features of the independent claims. Modified embodiments are detailed in the dependent claims.

[0007] Thus, the object is solved by a female contact member for a switchgear contact assembly, the female contact member comprising a contact member body to receive a male contact member, wherein the contact member body comprises at least two strip-shaped contact parts, extending along a longitudinal axis of the contact member, the contact parts being contactable with the male contact member, wherein the contact parts are separated from each other by at least one slit extending from a junction of the contact parts to a slit opening; and a support member to support the contact parts at the at least one slit and to make bending stress at the contact parts, caused by receiving the male contact member, occur at a distance from the junction of the contact parts.

[0008] The object is also solved by a switchgear contact assembly, comprising the female contact member and a male contact member. The female contact member may be modified according to any of the modified embodiments.

[0009] The object is also solved by a switchgear device, comprising the switchgear contact assembly, which comprises the female contact member and the male contact member. The female contact member may be modified according to any of the modified embodiments.

[0010] For example, the contact parts can, for example, extend between a junction and its ends in a cuboid shape along a receiving space for receiving the male contact member. The contact parts are then connected to each other at an end opposite the free end at which the receiving space has an opening to accommodate the male contact member contact parts. For example, bending stress may occur in a middle area between the free and connected end of the respective contact part. Such a middle area is then distanced from the junction of the contact parts.

[0011] The contact parts of the contact member body can be two or more. Together with the support member, the contact parts need to be designed to form a receiving space to receive a male contact member and to contact the male contact member. The connection between the female contact member and the male contact member must be repeatable.

[0012] The female contact member should above all meet the requirements for switchgear devices: For example, high voltage switchgears have the task to interrupt the current when an electrical fault occurs. The function of the device is to open the contacts with a speed proving an appropriate switchgear reaction time and keep them far away from each other to avoid the current flow, even in case of high electrical potential coming from the fault itself. The opening and closing operations must be done with a determined speed according to the specifications of the device. During the closing of the device the arcing contacts suffer an impact which severity depends on the closing speed and arcing contact features. The impact produces contact part deflections as a function of different parameters: stiffness, mass, contact area features, plug shape of the male contact member and plug axial speed of the male contact member. The equilibrium among stiffness, mass and speed influences the contact part deflection and the stress in the contact part, which cannot be allowed to produce too high permanent deformation, otherwise the contact will be eventually lost.

[0013] In case that the contact member body is a cylindrical element on which slits are created, the weakest part of the contact parts are the beginnings of the slits at the junction, which are also defined as roots. In case of sharp edges at the roots, these edges provide stress concentration factors, thus limiting the loads that the contact member body can withstand.

[0014] It is, inter alia, an aspect of the invention to use contact parts having the same shape as fingers in a tulip as a mean to increase the closing speed, and increase the fatigue life without recurring to special materials and without increasing the contact part dimensions, which could influence the weight of the contact parts. This is, inter alia, reached by longer slits than in prior art designs, thereby avoiding that bending stress is at the same location as the end of the slits, and by using a proper fixation for the contact parts to support the longer contact parts.

[0015] Thereby, there is provided means to improve the performance of switchgear devices, such as circuit breakers. The performance is improved by allowing high-

er closing speeds and endurance lives together with the possibility to upgrade existing interrupters without changing a receiving chamber design, that means an accommodation space, in which the female contact member receives the male contact member. Furthermore, standard materials can be maintained while improving the mechanical quality and reliability of the arcing contacts. Thereby, mechanical and electrical failures in expensive tests can be avoided.

[0016] According to a modified embodiment, the contact parts are connected by a contact member section, wherein the contact member section is integrally formed to the contact parts and wherein the junction is part of the contact member section. For example, the contact member section is designed as one piece and extends the receiving space provided by the contact parts. The contact member section may have a cylindrical shape. The contact member section can be integrally formed on the contact parts at an end opposite bulks of the contact parts. The design according to the modified embodiment simplifies assembly and mounting with advantage. With such an embodiment, the support member can also be made in one piece with the contact member body, which would simplify assembly further. Furthermore, a good distribution of the bending stress in the contact member body is achieved.

[0017] According to a modified embodiment, the contact parts separately from each other extend over the complete longitudinal axis of the contact member, wherein the contact parts are connected via a connecting member provided as a separate piece to the contact member body and wherein the connecting member comprises the junction. For example, the connecting member can enclose the contact parts at an end of the contact parts remote from the bulks. There can be a frictional and/or form-fit connection between the connecting member and the contact parts. The use of individual contact parts minimizes the deburring effort compared to a slit version of the contact member body, where the contact parts are connected at one end. Other manufacturing processes can also be used for the contact parts.

[0018] According to a modified embodiment, the junction is part of a contact member section integrally formed to the contact parts and wherein the at least one slit extends through the contact member such that the contact parts are inelastically deformable when receiving the male contact member without the support member. In other words, this version of the contact member body requires an additional part to the contact member body, the additional part being the support member. Only with the additional part an elastic deformation of the contact parts is guaranteed within the scope of the usual function of the contact assembly, i.e. a contact between the female contact part and the male contact part can be established repeatedly. Generally, the slits can extend along the whole length of the contact parts. It may also be possible that the slits extend only until a step at a root of the female member. The design according to the modified embodiment, including the previously described modifications, simplifies assembly and mounting with advantage. With this type of embodiment, the support member can also be made in one piece with the contact member body, which would simplify assembly further.

[0019] According to a modified embodiment, the connecting member is part of the support member. Such a design simplifies assembly and mounting with advantage. Furthermore, part of the support member not comprising the connecting member can be used for other functionalities, such as electrical insulation.

[0020] According to a modified embodiment, the connecting member is the support member. Such a design simplifies assembly and mounting with advantage.

[0021] According to a modified embodiment, the support member comprises at least two parts: One part is provided as a separate piece to the contact member body and another part of the support member is integrally formed to the contact parts. This makes it possible, for example, to select different materials for connecting member and support member, if required.

[0022] According to a modified embodiment, the support member comprises at least two parts: One part is provided as a separate piece to the contact member body and another part of the support member is integrally formed to the contact parts and the support member comprises the contact member section. This makes it possible, for example, to select different materials for connecting member and support member, if required.

[0023] According to a modified embodiment, the support member comprises at least two parts: One part is provided as a separate piece to the contact member body and another part of the support member is integrally formed to the contact parts and the support member is the contact member section. This makes it possible, for example, to select different materials for connecting member and support member, if required.

[0024] According to a modified embodiment, the support member is provided as a separate piece to the contact member body. A separate design of the support member has the advantage that the contact member body can be created more easily if a part of the support member body is not formed on it. In such a case, no arrangements would have to be made to make the contact member body resistant to bending stress. The contact parts could be supported by the support member alone in such a case.

[0025] According to a modified embodiment, the support member is integrally formed to the contact parts. In other words, both functions, i.e. those of the support member and those of the contact parts, are combined in a single component. Such a design simplifies assembly and mounting with advantage.

[0026] According to a modified embodiment, the support member is integrally formed to the contact parts and the support member comprises the contact member section. For example, the support member can have other functions besides connecting the contact parts. Such a

design simplifies assembly and mounting with advantage.

[0027] According to a modified embodiment, the support member is integrally formed to the contact parts and the support member is the contact member section. Such a design simplifies assembly and mounting with advantage.

[0028] According to a modified embodiment, the support member comprises a radial thickening. This embodiment can be applied in case of a one-piece design of the support member with the contact member body. A radial thickening is an easy to execute option to shift bending stress of the contact parts away from the junction. Regardless of whether the support member is formed in one piece with the contact member body or separately from the contact member body, radial thickening is a material reinforcement that can be produced easily and cost-effectively in order to place mechanical loads specifically on a component.

[0029] According to a modified embodiment, the contact member section comprises a radial thickening. A radial thickening is an easy to execute option to shift bending stress of the contact parts away from the junction. Here the thickening can interact with the support member or a part of the support member. For example, the thickening can form a contact edge for locking the contact member body with the support member.

[0030] According to a modified embodiment, the radial thickening extends towards the slit opening beyond the junction. This is a simple and cost-effective solution to shift bending stress away from the junction towards the slit opening(s).

[0031] According to a modified embodiment, the contact parts are connected at a part radially shifted with respect to their longitudinal axis. The connection can, for example, be realized by a ring formed onto the contact member body, which encloses an outer circumference of the contact member body or vice versa, i. e. the contact member body encloses the ring. The ring can also axially protrude beyond the contact member body. Preferably, the connection between the contact parts is realized at an end of the contact member body, namely at the end of the contact member body opposite the slit opening(s). It turned out that a slit design of the contact parts of the contact member body combined with the radially shifted connection of the contact parts can more effectively shift bending stress away from the beginning of the slits and thus from the junction.

[0032] According to a modified embodiment, the contact parts are connected at a part radially outwards shifted from their longitudinal axis. In other words, the arcing contact comprises the fixation or clamping point which is far in front of roots of the contact parts, i.e. the beginnings of the slits at the junction, so that stress cannot reach (sharp) edges at the contact part roots and they cannot act as stress concentrators.

[0033] According to a modified embodiment, the support member is arranged to enclose at least one of the contact parts. In the present context it can for example be a partial enclosure of the contact part by the support member. In such a constellation it is also possible that the support member takes over additional support functions, for example because it can be made of a different material than the contact parts. For example, it would be conceivable that the support member is also electrically insulating.

[0034] According to a modified embodiment, the support member is arranged to support at least one of the contact parts against forces perpendicular to the longitudinal axis of the contact member. In the present context it can for example be a partial enclosure of the contact part by the support member. It is also possible that the support member provides additional support functions, for example because it can be made of a different material than the contact parts. For example, it would be conceivable that the support member is also electrically insulating.

[0035] According to a modified embodiment, the support member is arranged to enclose at least one of the contact parts, and the support member is arranged to support at least one of the contact parts against forces perpendicular to the longitudinal axis of the contact member. Here, the effects of the two above mentioned modified embodiments can be provided.

[0036] According to a modified embodiment, the support member is arranged to fix the contact parts in a force-locking and/or form-locking way against radially outwardly directed bending at least in an area of the longitudinal axis of the contact member, where the support member and the contact parts radially overlap. Since the support member has the fixing functions and thus ensures that contact between the female contact member and the male contact member can be re-established, the contact member body can be made even in a more flexible way, for example with a larger receiving space to receive the male contact member.

[0037] According to a modified embodiment, the support member is arranged to fix the contact parts in a force-locking and/or form-locking way against radially outwardly directed bending at least in an area of the longitudinal axis of the contact member, where the support member radially encloses the contact parts. Here it is advantageous to choose the type of fixation, so that bending stress occurs on the contact parts in a certain region of the contact parts.

[0038] According to a modified embodiment, the support member extends along a longitudinal axis of the contact parts over a length in a range from 1/8 to 1/2 of a total length of the contact parts along the longitudinal axis of the contact member. The advantage of this is that the suspension of the contact parts can be specifically adjusted, which in turn allows more flexibility in the choice of material for the contact member body.

[0039] According to a modified embodiment, the support member extends along the longitudinal axis of the contact parts over a length in a range from 1/4 to 1/3 of

a total length of the contact parts along the longitudinal axis of the contact member. The advantage of this is that the suspension of the contact parts can be specifically adjusted, which in turn allows more flexibility in the choice of material for the contact member body.

[0040] According to a modified embodiment, the support member extends along the longitudinal axis of the contact parts over a length in a range from 1/6 to 1/5 of a total length of the contact parts along the longitudinal axis of the contact member. The advantage of this is that the suspension of the contact parts can be specifically adjusted, which in turn allows more flexibility in the choice of material for the contact member body.

[0041] According to a modified embodiment, the support member extends along the longitudinal axis of the contact member beyond the contact member section and/or beyond the contact parts. For example, by extending out over the contact member body, the support member can take on additional functions to its supporting function, such as forming part of a connecting means with a remaining arrangement of a switchgear device or being electrically insulating.

[0042] According to a modified embodiment, the support member is constructed in three parts, wherein a first part is formed by the radial thickening of the contact member section, a second part is formed by an outer ring radially enclosing at least the thickening, and a third part is formed by an inner ring axially adjoining the first part, wherein the third part axially rests on the first part and rests radially inwards on the second part. This has the advantage that both axial support of the contact member body and radial support of the contact member body can be ensured. In this way, the contact member body can be optimally supported mechanically when the male contact member is inserted, which can, for example, extend the lifetime of the female contact member.

[0043] Further embodiments and advantages of the method are directly and unambiguously derived by the person skilled in the art from the system as described before.

Brief description of drawings

[0044] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

[0045] In the drawings:

Fig. 1 schematically shows a cross-sectional view of a part of a switchgear assembly according to an embodiment;

Fig. 2a schematically shows a three-dimensional view of a part of a female contact member according to an embodiment;

Fig. 2b schematically shows a three-dimensional view of a part of a female contact member according to another embodiment;

Fig. 3 schematically shows another three-dimensional view of the part of the female contact member according to the embodiment according to Fig. 2a with further components;

Fig. 4 schematically shows another three-dimensional view of the part of the female contact member according to the embodiment according to Fig. 2a with further components; and

Fig. 5 schematically shows, in a three-dimensional view, a bending stress distribution of a contact part according to the embodiment of Figures 2a, 3 and 4.

Description of embodiments

[0046] Fig. 1 schematically shows a cross-sectional view of a part of a switchgear assembly according to an embodiment. The male contact member 10 is designed as a pin. The female contact member 1 is designed as a socket. The female contact member 1 has a receiving space 9, in which the male contact member 10 can be inserted.

[0047] Fig. 2a schematically shows a three-dimensional view of a part of a female contact member 1 according to an embodiment and Fig. 2b schematically shows a three-dimensional view of a part of a female contact member 1 according to another embodiment. The female contact member 1 comprises a contact member body to receive the male contact member 10 (not shown in the Figures 2a, 2b, 3 to 5, see Figure 1 for an exemplary embodiment of the contact member 10).

[0048] The contact member body comprises multiple strip-shaped contact parts 2. In the present embodiment, the contact member body comprises ten strip-shaped contact parts 2. The strip-shaped contact parts 2 extend along a longitudinal axis of the contact member 1 and these strip-shaped parts 2 are contactable with the male contact member 10 when the male contact member 10 is inserted into the female contact member 1. The strip-shaped contact parts 2 are formed as one piece with a contact member section 5, which connects the contact parts 2 with each other. The contact member section 5 comprises several areas of the contact member body: It is partially provided as a first ring-formed part 5a which partially encloses the contact parts 2. Furthermore, it is partially provided as another, second ring-formed part 5b adjoining the contact parts and being enclosed by the first ring-formed part 5a.

[0049] The contact parts 2 are separated from each other by slits 3, which extend from a junction of the contact parts 2 to a slit opening and which interrupt the first ring 5a of the contact member section 5. Each of the strip-shaped contact parts 2 is connected in a junction, comprised by the contact member section 5, with two adjacent strip-shaped contact parts 2. At the end opposite the junction, i.e. in an area of the slit openings, each of the strip-shaped contact parts 2 has a bulge 8. The bulge 8 is directed towards the receiving space 9 (see Figure 1), in which the male contact member 10 can be inserted.

[0050] The female contact member 1 further compris-

es a support member 4 to support the contact parts 2 at the slits 3 and to make bending stress at the contact parts 2, caused by receiving the male contact member 10, occur at a distance from the junction of the contact parts 2.

[0051] In the embodiment of Figure 2b the support member 4 is one piece with the contact member body. As also elucidated by the first and second ring-formed parts 5a, 5b of the connecting part, the support member 4 is formed by a contact member section 5, which is axially connected along the longitudinal axis of the contact member 1 to the contact parts 2. Furthermore, the support member 4 is also formed on the contact parts 2. The support member 4 has a radial thickening, which partially corresponds to the ring 5a and which further extends towards the slit openings from the first ring-formed part 5a. The radial thickening faces away from the receiving space 9, i.e. it is formed on an outer circumference of the contact member body.

[0052] Fig. 2a and Fig. 3 schematically show a three-dimensional view of a part of a female contact member 1 according to the other embodiment. According to this embodiment, the support member 4 is constructed in three parts: A first part is formed by the radial thickening of the contact member section 5. A second part is formed by an outer ring 6 radially enclosing the thickening. A third part is formed by an inner ring 7 axially adjoining the first part, wherein the third part axially rests on the first part and rests radially inwards on the second part.

[0053] Fig. 4 schematically shows another three-dimensional view of a part of a female contact member 1 according to the embodiment of Figures 2a and 3. Here, the female contact member 1 is shown without the inner ring 7 and in a different perspective than in Fig. 3.

[0054] Fig. 5 schematically shows, in a three-dimensional view, a bending stress distribution of a contact part 2 according to the embodiment of Figures 2a, 3 and 4. To understand the bending stress distribution it should be noted that the radial thickening extends beyond a beginning(s) of the slit(s) 3. The dashed lines in Fig. 5 indicate the region of the contact part 2 where the bending stress occurs. As can be seen, the bending stress does not occur at the beginning(s) of the slit(s) 3. The stress occurs in a region between the bulge 8 and a root of the slit 3, which is the beginning of the slit 3.

[0055] 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 be disclosed embodiments 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

[0056]

1	female contact member
2	contact part
3	slit
4	support member
5	contact member section
5a	first ring-formed part
5b	second ring-formed part
6	outer ring
7	inner ring
8	bulge
9	receiving space
10	male contact member

Claims

1. A female contact member (1) for a switchgear contact assembly, the female contact member (1) comprising
a contact member body to receive a male contact member (10),

wherein the contact member body comprises at least two strip-shaped contact parts (2), extending along a longitudinal axis of the contact member (1), the contact parts (2) being contactable with the male contact member (10),
wherein the contact parts (2) are separated from each other by at least one slit (3) extending from a junction of the contact parts (2) to a slit opening; and
a support member (4) to support the contact parts (2) at the at least one slit (3) and to make bending stress at the contact parts (2), caused by receiving the male contact member (10), occur at a distance from the junction of the contact parts (2).

2. The female contact member (1) according to the preceding claim,
wherein the contact parts (2) are connected by a contact member section (5), wherein the contact member section (5) is integrally formed to the contact parts (2) and wherein the junction is part of the contact member section (5); or
wherein the contact parts (2) separately from each other extend over the complete longitudinal axis of the contact member (1), wherein the contact parts (2) are connected via a connecting member provided as a separate piece to the contact member body and

wherein the connecting member comprises the junction; or
wherein the junction is part of a contact member section (5) integrally formed to the contact parts (2) and wherein the at least one slit (3) extends through the contact member (1) such that the contact parts (2) are inelastically deformable when receiving the male contact member (10) without the support member (4).

3. The female contact member (1) according to the preceding claim,
wherein the connecting member is part of the support member (4); or
wherein the connecting member is the support member (4).

4. The female contact member (1) according to any of the preceding claims,
wherein the support member (4) is provided as a separate piece to the contact member body; and/or
wherein the support member (4) is integrally formed to the contact parts (2); or
wherein the support member (4) is integrally formed to the contact parts (2) and wherein the support member (4) comprises the contact member section (5); or
wherein the support member (4) is integrally formed to the contact parts (2) and wherein the support member (4) is the contact member section (5).

5. The female contact member (1) according to any of the preceding claims, wherein the support member (4) comprises a radial thickening; or wherein the contact member section (5) comprises a radial thickening.

6. The female contact member (1) according to the preceding claim,
wherein the radial thickening extends towards the slit opening beyond the junction.

7. The female contact member (1) according to any of the preceding claims,
wherein the contact parts (2) are connected at a part radially shifted with respect to their longitudinal axis; or
wherein the contact parts (2) are connected at a part radially outwards shifted from their longitudinal axis.

8. The female contact member (1) according to any of the preceding claims,
wherein the support member (4) is arranged to enclose at least one of the contact parts (2) and/or
wherein the support member (4) is arranged to support at least one of the contact parts (2) against forces perpendicular to the longitudinal axis of the contact member (1).

9. The female contact member (1) according to any of the preceding claims,
wherein the support member (2) is arranged to fix the contact parts (2) in a force-locking and/or form-locking way against radially outwardly directed bending at least in an area of the longitudinal axis of the contact member (1), where the support member (4) and the contact parts (2) radially overlap; or
wherein the support member (2) is arranged to fix the contact parts (2) in a force-locking and/or form-locking way against radially outwardly directed bending at least in an area of the longitudinal axis of the contact member (1), where the support member (4) radially encloses the contact parts (2).

10. The female contact member (1) according to any of the preceding claims,
wherein the support member (4) extends along a longitudinal axis of the contact parts (2) over a length in a range from 1/8 to 1/2 of a total length of the contact parts (2) along the longitudinal axis of the contact member (1); or
wherein the support member (4) extends along the longitudinal axis of the contact parts (2) over a length in a range from 1/4 to 1/3 of a total length of the contact parts (2) along the longitudinal axis of the contact member (1); or
wherein the support member (4) extends along the longitudinal axis of the contact parts (2) over a length in a range from 1/6 to 1/5 of a total length of the contact parts (2) along the longitudinal axis of the contact member (1).

11. The female contact member (1) according to any of the preceding claims,
wherein the support member (4) extends along the longitudinal axis of the contact member (1) beyond the contact member section (5) and/or beyond the contact parts (2).

12. The female contact member (1) according to any of the preceding claims 5 to 11,
wherein the support member (4) is constructed in three parts,
wherein a first part is formed by the radial thickening of the contact member section (5), a second part is formed by an outer ring (6) radially enclosing at least the thickening, and a third part is formed by an inner ring (7) axially adjoining the first part,
wherein the third part axially rests on the first part and rests radially inwards on the second part.

13. A switchgear contact assembly, comprising the female contact member (1) according to any of the preceding claims and a male contact member (10).

14. A switchgear device, comprising the switchgear contact assembly according to the preceding claim.

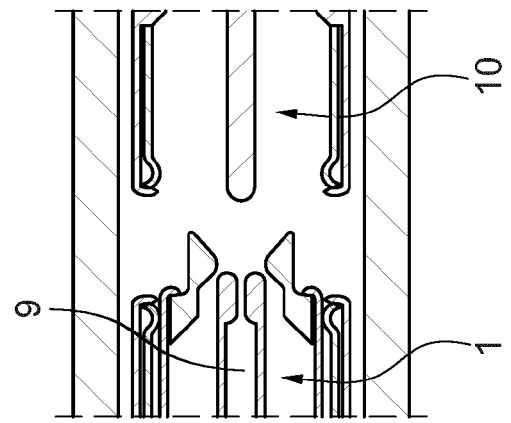

Fig. 1

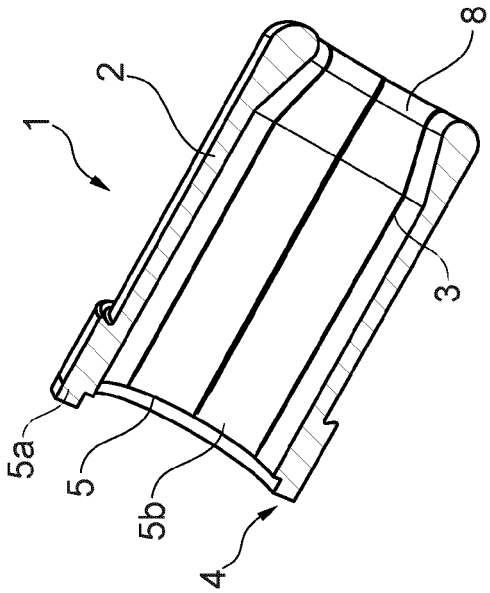

Fig. 2b

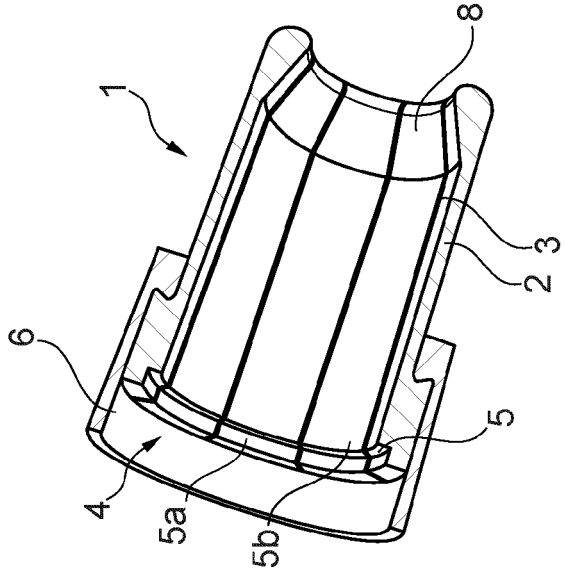

Fig. 4

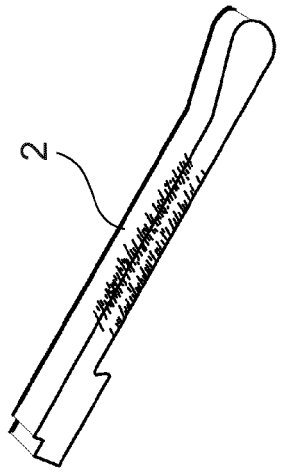

Fig. 5

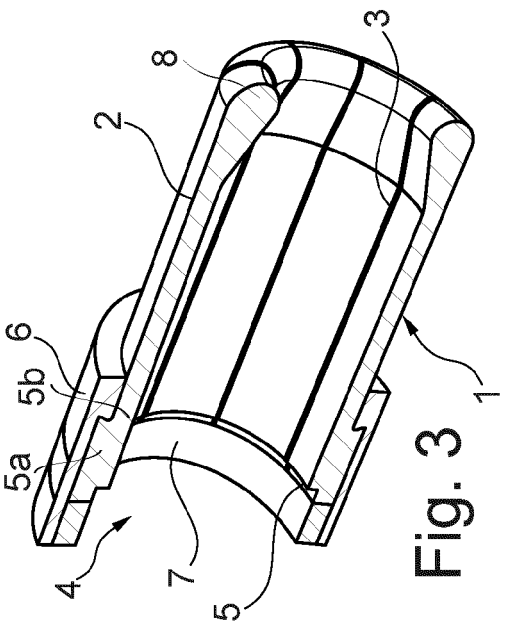

Fig. 3

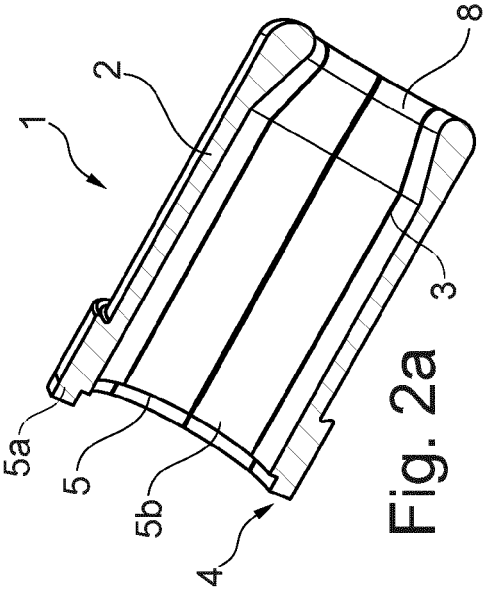

Fig. 2a

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EUROPEAN SEARCH REPORT

Application Number
EP 20 19 7216

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	22 February 2021	Socher, Günther

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