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

(72) Inventors:
- **GENTSCH, Dietmar**
  40882 Ratingen (DE)
- **REUBER, Christian**
  47877 Willich (DE)

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

(54) **VACUUM INTERRUPTER**

(57) The present invention relates to vacuum interrupter (1), comprising:
- a fixed terminal (40);
- a fixed contact piece (50);
- a movable terminal (70); and
- a movable contact piece (60).

The fixed contact piece is connected to the fixed terminal. The movable contact piece is connected to the movable terminal. The fixed contact piece comprises a first layer or region (52) and a second layer or region (54). The movable contact piece comprises a first layer or region (62) and a second layer or region (64). In a deactivated state the vacuum interrupter is configured to hold the fixed contact piece spaced from the movable contact piece. In an activated state the vacuum interrupter is configured to move the movable terminal to bring the first layer or region of the movable contact piece into contact with the first layer or region of the fixed contact piece.

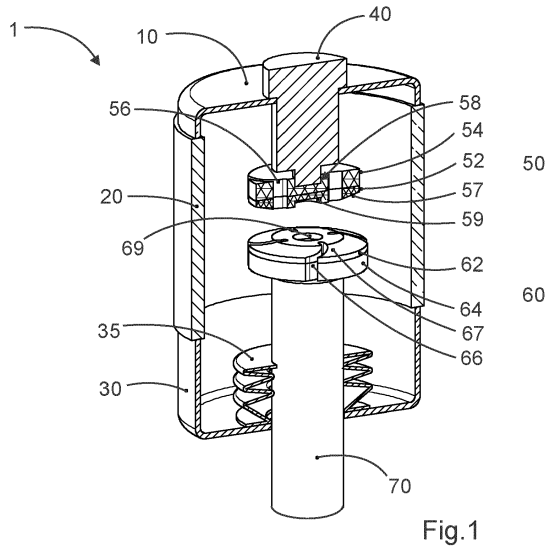

Fig.1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a vacuum interrupter and a method of manufacturing a contact piece for a vacuum interrupter.

BACKGROUND OF THE INVENTION

[0002] Vacuum interrupters (VI) have contact terminals, usually made of copper, that carry contact pieces that are in the inside of the vacuum chamber. The contact pieces have the task of closing and opening electrical circuits; they have to withstand the energy of the vacuum arc, they have to limit contact welding, they have to provide a low ohmic resistance and they have to be economic in production.

[0003] To fulfil these requirements, contact pieces usually consist of a mixture of two main materials, one main material is a refractory material with a high melting temperature, like Cr, Mo, W or WC, for obtaining a high durability regarding melting and welding, and the second main material for obtaining a low ohmic resistance, like Cu or Ag. Further, VI contact pieces may contain certain additives for improving the durability.

[0004] For mechanical reasons, for steering the direction of current flow and magnetic field generation, and for a certain thermal capacity, VI contact pieces have a certain thickness, that is in the range of about 10 mm, while the area that is really exposed to the vacuum arc and where reinforcement against melting and welding is required, is only a few mm thick.

[0005] The material of the contact pieces is relatively expensive for its durability against melting and welding. The mentioned mixtures of for example Cu, Cr and additives can comprise complex, energy intensive and costly manufacturing processes, compared to for example a contact piece made of pure copper. Pure copper however cannot withstand the vacuum arc to the required degree.

[0006] There is a need to address these issues.

SUMMARY OF THE INVENTION

[0007] Therefore, it would be advantageous to have an improved technique to make contact pieces for a vacuum interrupter and to provide a vacuum interrupter having such contact pieces.

[0008] The object of the present invention is solved with the subject matter of the independent claim, wherein further embodiments are incorporated in the dependent claims.

[0009] In a first aspect, there is provided a vacuum interrupter, comprising:

- a fixed terminal;
- a fixed contact piece;
- a movable terminal; and
- a movable contact piece.

[0010] The fixed contact piece is connected to the fixed terminal. The movable contact piece is connected to the movable terminal. The fixed contact piece comprises a first layer or region and a second layer or region. The movable contact piece comprises a first layer or region and a second layer or region. In a deactivated state the vacuum interrupter is configured to hold the fixed contact piece spaced from the movable contact piece. In an activated state the vacuum interrupter is configured to move the movable terminal to bring the first layer or region of the movable contact piece into contact with the first layer or region of the fixed contact piece.

[0011] In an example, the first layer or region of the fixed contact piece is configured to be arc resistant.

[0012] In an example, the first layer or region of the movable contact piece is configured to be arc resistant.

[0013] In an example, the first layer or region of the fixed contact piece comprises at least two materials. A first material of the at least two materials of the fixed contact piece has a low ohmic resistance and a second material of the at least two materials of the fixed contact piece has a high durability against melting and welding.

[0014] In an example, the first layer or region of the movable contact piece comprises at least two materials. A first material of the at least two materials of the movable contact piece has a low ohmic resistance and a second material of the at least two materials of the movable contact piece has a high durability against melting and welding.

[0015] In an example, the first layer or region of the fixed contact piece comprises: CuCr, MoCu, WCu, or WCAg.

[0016] In an example, the first layer or region of the movable contact piece comprises: CuCr, MoCu, WCu, or WCAg.

[0017] In an example, the second layer or region of the fixed contact piece is configured to support the first layer or region of the fixed contact piece.

[0018] In an example, the second layer or region of the movable contact piece is configured to support the first layer or region of the movable contact piece.

[0019] In an example, the second layer or region of the fixed contact piece comprises Cu and/or Ag and/or Stainless steel and/or steel.

[0020] In an example, the second layer or region of the movable contact piece comprises Cu and/or Ag and/or Stainless steel and/or steel.

[0021] In a second aspect, there is provided a method of manufacturing a contact piece for a vacuum interrupter. The contact piece comprises a first layer or region and a second layer or region. The first layer or region of the contact piece is configured to be arc resistant, and the second layer or region of the contact piece is configured to support the first layer or region of the contact piece. The method comprises:

- filling a void above a movable base of a part of a mould with a first powdered material such that a surface of the first powdered material is at a first set level of the mould, and wherein the movable base is configured to move with respect to the first set level of the mould;
- moving the movable base away from the first set level of the mould to create a void above the first powdered material in the part of the mould;
- filling the void above the first powdered material in the part of the mould with a second powdered material such that a surface of the second powdered material is at a second set level of the mould;
- pressing the first powdered material and the second powdered material with a stamp;
- sintering the pressed first powdered material and second powdered material.

[0022] In an example, after filling the void above the movable base of the part of the mould with the first powdered material and before filling the void above the first powdered material in the part of the mould with the second powdered material the method comprises pressing the first powdered material with a stamp.

[0023] In an example, the stamp used to press the first powdered material is different to the stamp used to press the first powdered material and the second powdered material.

[0024] In an example, filling the void above the movable base of the part of the mould with the first powdered material comprises sliding a slider over the part of the mould, and a base portion of the slider slides at the first set level.

[0025] In an example, filling the void above the movable base of the part of the mould with the first powdered material comprises transferring the first powdered material from the slider to the part of the mould.

[0026] In an example, filling the void above the first powdered material in the part of the mould with the second powdered material comprises sliding a slider over the part of the mould, and a base portion of the slider slides at the second set level.

[0027] In an example, filling the void above the first powdered material in the part of the mould with the second powdered material comprises transferring the second powdered material material from the slider to the part of the mould.

[0028] In an example, before sintering the pressed first powdered material and second powdered material the method comprises removing the pressed first powdered material and second powdered material from the mould.

[0029] In an example, removing the pressed first powdered material and second powdered material from the mould comprises moving the movable base toward the first set level of the mould.

[0030] The above aspect and examples will become apparent from and be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] Exemplary embodiments will be described in the following with reference to the following drawings:

Fig. 1 shows a sectional view of a vacuum interrupter with two-layer contact pieces;

Figs. 2-11 show diagrammatically certain steps of a method of manufacturing a contact piece for a vacuum interrupter; and

Fig. 12 shows a detailed workflow of a method of manufacturing a contact piece for a vacuum interrupter.

DETAILED DESCRIPTION OF EMBODIMENTS

[0032] Figs 1-12 relate to a vacuum interrupter having new types of contact piece and a method of manufacturing a new type of contact piece for a vacuum interrupter.

[0033] The vacuum interrupter 1 comprises a fixed terminal 40, a fixed contact piece 50, a movable terminal 70, and a movable contact piece 60. The fixed contact piece is connected to the fixed terminal. The movable contact piece is connected to the movable terminal. The fixed contact piece comprises a first layer or region 52 and a second layer or region 54. The movable contact piece comprises a first layer or region 62 and a second layer or region 64. In a deactivated state the vacuum interrupter is configured to hold the fixed contact piece spaced from the movable contact piece. In an activated state the vacuum interrupter is configured to move the movable terminal to bring the first layer or region of the movable contact piece into contact with the first layer or region of the fixed contact piece.

[0034] According to an example, the first layer or region of the fixed contact piece is configured to be arc resistant.

[0035] According to an example, the first layer or region of the movable contact piece is configured to be arc resistant.

[0036] According to an example, the first layer or region of the fixed contact piece comprises at least two materials. A first material of the at least two materials of the fixed contact piece has a low ohmic resistance and a second material of the at least two materials of the fixed contact piece has a high durability against melting and welding.

[0037] According to an example, the first layer or region of the movable contact piece comprises at least two materials. A first material of the at least two materials of the movable contact piece has a low ohmic resistance and a second material of the at least two materials of the movable contact piece has a high durability against melting and welding.

[0038] In an example, the first layer or region of the fixed contact piece comprises one or more of: Cr, Mo, W, WC.

[0039] In an example, the first layer or region of the movable contact piece comprises one or more of: Cr, Mo, W, WC.

[0040] According to an example, the first layer or region of the fixed contact piece comprises: CuCr, MoCu, WCu, WCCu or WCAg.

[0041] According to an example, the first layer or region of the movable contact piece comprises: CuCr, MoCu, WCu, WCCu or WCAg.

[0042] In an example, the first layer or region of the fixed contact piece comprises endowed CuCr. Thus this is "Pure" CuCr with a few % of an additive.

[0043] In an example the first layer or region of the fixed contact piece comprises endowed MoCu. Thus this is "Pure" MoCu with a few % of an additive.

[0044] In an example the first layer or region of the fixed contact piece comprises endowed WCu. Thus this is "pure" WCu with a few % of an additive.

[0045] In an example the first layer or region of the fixed contact piece comprises endowed WCCu. Thus this is "pure" WCCu with a few % of an additive.

[0046] In an example the first layer or region of the fixed contact piece comprises endowed WCAg. Thus this is "pure" WCAg with a few % of an additive.

[0047] In an example the first layer or region of the fixed contact piece comprises CuCr with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0048] In an example the first layer or region of the fixed contact piece comprises MoCu with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0049] In an example the first layer or region of the fixed contact piece comprises WCu with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0050] In an example the first layer or region of the fixed contact piece comprises WCCu with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0051] In an example the first layer or region of the fixed contact piece comprises WCAg with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0052] In an example, the at least one material comprises an oxide, nitride or boride of Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0053] Thus, the first layer or region of the fixed contact piece comprises a relatively pure material or a composition of two relatively pure main components, alloyed with additives like oxides, nitrides or borides of Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si with a relative content of about 0.1% to 5% acting as dispersoids for increasing the hardness and the welding resistance.

[0054] In an example, the first layer or region of the movable contact piece comprises endowed CuCr. Thus this is "Pure" CuCr with a few % of an additive.

[0055] In an example the first layer or region of the movable contact piece comprises endowed MoCu. Thus this is "Pure" MoCu with a few % of an additive.

[0056] In an example the first layer or region of the movable contact piece comprises endowed WCu. Thus this is "pure" WCu with a few % of an additive.

[0057] In an example the first layer or region of the movable contact piece comprises endowed WCCu. Thus this is "pure" WCCu with a few % of an additive.

[0058] In an example the first layer or region of the movable contact piece comprises endowed WCAg. Thus this is "pure" WCAg with a few % of an additive.

[0059] In an example the first layer or region of the movable contact piece comprises CuCr with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0060] In an example the first layer or region of the movable contact piece comprises MoCu with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0061] In an example the first layer or region of the movable contact piece comprises WCu with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0062] In an example the first layer or region of the movable contact piece comprises WCCu with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0063] In an example the first layer or region of the movable contact piece comprises WCAg with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0064] In an example, the at least one material comprises an oxide, nitride or boride of Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0065] Thus, the first layer or region of the movable contact piece comprises a relatively pure material alloyed with additives like oxides, nitrides or borides of Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si with a relative content of about 0.1% to 5% acting as dispersoids for increasing the hardness and the welding resistance.

[0066] According to an example, the second layer or region of the fixed contact piece is configured to support the first layer or region of the fixed contact piece.

[0067] According to an example, the second layer or region of the movable contact piece is configured to support the first layer or region of the movable contact piece.

[0068] According to an example, the second layer or region of the fixed contact piece comprises Cu and/or Ag and/or Stainless steel and/or steel.

[0069] According to an example, the second layer or region of the movable contact piece comprises Cu and/or Ag and/or Stainless steel and/or steel.

[0070] In an example the second layer or region of the fixed contact piece comprises endowed Cu. Thus this is "Pure" Cu with a few % of an additive.

[0071] In an example the second layer or region of the fixed contact piece comprises endowed Ag. Thus this is "Pure" Ag with a few % of an additive.

[0072] In an example the second layer or region of the fixed contact piece comprises endowed steel. Thus this is Steel with a few % of an additive.

[0073] In an example the second layer or region of the fixed contact piece comprises endowed stainless steel. Thus this is stainless steel with a few % of an additive.

[0074] In an example the second layer or region of the fixed contact piece comprises Cu with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0075] In an example the second layer or region of the fixed contact piece comprises Ag with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0076] In an example the second layer or region of the fixed contact piece comprises steel with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0077] In an example the second layer or region of the fixed contact piece comprises Stainless steel with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0078] In an example, the at least one material comprises an oxide, nitride or boride of Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0079] Thus, the second layer or region of the fixed contact piece comprises a relatively pure material alloyed with additives like oxides, nitrides or borides of Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si with a relative content of about 0.1% to 5% acting as dispersoids for increasing the hardness and the welding resistance.

[0080] In an example the second layer or region of the movable contact piece comprises endowed Cu. Thus this is "Pure" Cu with a few % of an additive.

[0081] In an example the second layer or region of the movable contact piece comprises endowed Ag. Thus this is "Pure" Ag with a few % of an additive.

[0082] In an example the second layer or region of the movable contact piece comprises endowed steel. Thus this is Steel with a few % of an additive.

[0083] In an example the second layer or region of the movable contact piece comprises endowed stainless steel. Thus this is stainless steel with a few % of an additive.

[0084] In an example the second layer or region of the movable contact piece comprises Cu with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0085] In an example the second layer or region of the movable contact piece comprises Ag with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0086] In an example the second layer or region of the movable contact piece comprises steel with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0087] In an example the second layer or region of the movable contact piece comprises Stainless steel with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0088] In an example, the at least one material comprises an oxide, nitride or boride of Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0089] Thus, the second layer or region of the movable contact piece comprises a relatively pure material alloyed with additives like oxides, nitrides or borides of Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si with a relative content of about 0.1% to 5% acting as dispersoids for increasing the hardness and the welding resistance.

[0090] The method of manufacturing a contact piece 50, 60 for a vacuum interrupter is now described. The contact piece comprises a first layer or region 52, 62 and a second layer or region 54, 64. The first layer or region of the contact piece is configured to be arc resistant. The second layer or region of the contact piece is configured to support the first layer or region of the contact piece. The method comprises:

- filling a void above a movable base 120 of a part of a mould 110 with a first powdered material such that a surface of the first powdered material is at a first set level of the mould. The movable base 120 is configured to move with respect to the first set level of the mould;
- moving the movable base away from the first set level of the mould to create a void above the first powdered material in the part of the mould;
- filling the void above the first powdered material in the part of the mould 110 with a second powdered material such that a surface of the second powdered material is at a second set level of the mould;
- pressing the first powdered material and the second powdered material with a stamp 150; and
- sintering the pressed first powdered material and second powdered material.

[0091] According to an example, after filling the void above the movable base of the part of the mould with the first powdered material and before filling the void above the first powdered material in the part of the mould with the second powdered material the method comprises pressing the first powdered material with a stamp.

[0092] In an example, the stamp used to press the first powdered material is the same as the stamp used to press the first powdered material and the second powdered material.

[0093] According to an example the stamp used to press the first powdered material is different to the stamp used to press the first powdered material and the second powdered material.

[0094] According to an example filling the void above the movable base of the part of the mould with the first powdered material comprises sliding a slider 130 over the part of the mould. A base portion of the slider slides at the first set level.

[0095] According to an example, filling the void above

the movable base of the part of the mould with the first powdered material comprises transferring the first powdered material material from the slider to the part of the mould.

[0096] According to an example, filling the void above the first powdered material in the part of the mould with the second powdered material comprises sliding a slider 140 over the part of the mould. A base portion of the slider slides at the second set level.

[0097] According to an example, filling the void above the first powdered material in the part of the mould with the second powdered material comprises transferring the second powdered material material from the slider to the part of the mould.

[0098] In an example, the first set level is defined by an upper surface of the mould.

[0099] In an example, the first set level defined by the upper surface of the mould is an upper surface of the mould upon which the slider used in filling the part of the mould with the first powdered material slides.

[0100] In an example, the second set level is defined by an upper surface of the mould.

[0101] In an example, the second set level defined by the upper surface of the mould is an upper surface of the mould upon which the slider used in filling the part of the mould with the second powdered material slides.

[0102] In an example, the first set level is the same as the second set level.

[0103] In an example, the slider used in filling the part of the mould with the first powdered material is different to the slider used in filling the part of the mould with the second powdered material.

[0104] In an example, the slider used in filling the part of the mould with the first powdered material is the same as the slider used in filling the part of the mould with the second powdered material.

[0105] According to an example, before sintering the pressed first powdered material and second powdered material the method comprises removing the pressed first powdered material and second powdered material from the mould.

[0106] According to an example, removing the pressed first powdered material and second powdered material from the mould comprises moving the movable base toward the first set level of the mould.

[0107] In an example, the pressed and sintered first powdered material forms the first layer or region of the contact piece, and the pressed and sintered second powdered material forms the second layer or region of the contact piece.

[0108] In an example, the pressed and sintered first powdered material forms the second layer or region of the contact piece, and the pressed and sintered second powdered material forms the first layer or region of the contact piece.

[0109] In an example, the first layer or region of the contact piece comprises at least two materials, wherein a first material of the at least two materials of the contact piece has a low ohmic resistance and a second material of the at least two materials of the contact piece has a high durability against melting and welding.

[0110] In an example, the first layer or region of the contact piece comprises one or more of: Cr, Mo, W, WC.

[0111] In an example, the first layer or region of the contact piece comprises: CuCr, MoCu, WCu, WCCu or WCAg.

[0112] In an example the first layer or region of the contact piece comprises endowed CuCr. Thus this is "Pure" CuCr with a few % of an additive.

[0113] In an example the first layer or region of the contact piece comprises endowed MoCu. Thus this is "Pure" MoCu with a few % of an additive.

[0114] In an example the first layer or region of the contact piece comprises endowed WCu. Thus this is "Pure" WCu with a few % of an additive.

[0115] In an example the first layer or region of the contact piece comprises endowed WCCu. Thus this is "Pure" WCCu with a few % of an additive.

[0116] In an example the first layer or region of the contact piece comprises endowed WCAg. Thus this is "Pure" WCAg with a few % of an additive.

[0117] In an example the first layer or region of the contact piece comprises CuCr with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0118] In an example the first layer or region of the contact piece comprises MoCu with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0119] In an example the first layer or region of the contact piece comprises WCu with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0120] In an example the first layer or region of the contact piece comprises WCCu with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0121] In an example the first layer or region of the contact piece comprises WCAg with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0122] In an example, the at least one material comprises an oxide, nitride or boride of Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0123] In an example, the second layer or region of the contact piece comprises Cu and/or Ag and/or Stainless steel and/or steel.

[0124] In an example the second layer or region of the contact piece comprises endowed Cu. Thus this is "Pure" Cu with a few % of an additive.

[0125] In an example the second layer or region of the contact piece comprises endowed Ag. Thus this is "Pure" Ag with a few % of an additive.

[0126] In an example the second layer or region of the contact piece comprises endowed steel. Thus this is Steel with a few % of an additive.

[0127] In an example the second layer or region of the contact piece comprises endowed stainless steel. Thus this is stainless steel with a few % of an additive.

[0128] In an example the second layer or region of the contact piece comprises Cu with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0129] In an example the second layer or region of the contact piece comprises Ag with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0130] In an example the second layer or region of the contact piece comprises steel with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0131] In an example the second layer or region of the contact piece comprises Stainless steel with a content of 0.1% to 5% of at least one material comprising Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0132] In an example, the at least one material comprises an oxide, nitride or boride of Fe, Al, Cr, V, Nb, Ta, Hf, Sn, Zr or Si.

[0133] The vacuum interrupter having the new types of contact piece and the method of manufacturing the new type of contact piece for a vacuum interrupter are now described in further detail with respect to specific detailed embodiments.

[0134] Fig. 1 shows a sectional view of a vacuum interrupter with two-layer contact pieces; some details of the vacuum interrupter, like shields, have been omitted for clarity.

[0135] The manufacturing or production sequence of a two layer contact piece is now described.

Step 1.

[0136] Filling the mould with the first material.

[0137] The movable base 120 of the mould was positioned in a way that the sliding movement forth and back of the first slider 130 with the first powder 132 will fill the void between the vertically movable base 120 and the table 110, as shown in Figs. 2-4. The table 110 can be considered to be a mould. The movable base 120 is located at a part of the mould. The powder 132 that is contained in the slider 130 will fall into the void by gravity. A contact piece with a cylindrical shape can be prepared in the mould, and one or more features of the completed contact piece, like slits 56, chamfers 57, cylindrical cut-outs 58, 59 or the like can directly be realised in the pressing process if they are required. The pressed contact piece can be a basic shape, a net shape or near net shape. The first slider 130 has a base portion that sits on and slides on a surface of the mould 110 and as it is moved back and forth it creates a flat top to the powder 132 that fills what was a void above the movable base 120. The surface of the mould upon which the first slider slides defines a first set level.

Step 2.

[0138] Pre-Pressing of the first material.

[0139] Stamp 150 is pressed into the powder (see Fig. 5 and Fig. 6) for a first solidification of the first material, forming the first layer of the contact piece. The pressure of the stamp can be reduced compared to the full pressure that would be applied in step 5 for the final preparation of the sintering process, as the bond between the two layers after the sintering process can be reduced when the first material is already fully pressed before the second material was added. For the same reason, this step 2 can be optionally omitted.

[0140] Step 3. Lowering the base of the mould.

[0141] This step provides the space for the second powder 142 (see Fig. 7). The lowering of the base 120 of the mould can as well be supported by the stamp 150 to ensure that the fist layer of the contact piece is completely following the base 120, so that the correct void for the second material is created.

Step 4.

Filling the mould with the second material

[0142] A sliding movement forth and back of the second slider 140 with the second powder 142 will fill the void between the first powder 132 and the table 110, as shown in Figs. 8-9. The second slider 140 has a base portion that sits on and slides on a surface of the mould 110 and as it is moved back and forth it creates a flat top to the powder 142 that fills what was a void above first powder 132 on the movable base 120. The surface of the mould upon which the second slider slides defines a second set level.

[0143] It is to be noted that the first and second sliders do not need to contain the first and second powders, but can be used just to form the flat top of the first powder and second powder respectively, with the powders being transferred into the voids by some other means. Indeed, there can be only one slider.

Step 5.

Pressing the powder into the mould

[0144] In this step, all the powder in the mould will be compressed with the stamp 150 (See Fig. 10). The stamp can now have a different shape compared to the stamp for the first pressing (step 2) to enable the features that are required for the corresponding side of the contact piece, e.g. the cylindrical cut-out 58 for assembly to the corresponding terminal. When the stamp 150 is withdrawn (See Fig. 11), the contact piece can be removed from the mould. This removal can be supported by an upward motion of the base 120. The contact piece is now a solid block having the desired shape and the desired two-layer structure.

Step 6.

Sintering

[0145] The sintering of the pressed contact piece is carried out in a state of the art process, for example at a temperature below the melting temperature of copper, or a little bit above this temperature to obtain infiltration, and under an inert gas or in vacuum.

[0146] The following provides further details regarding the new contact pieces.

[0147] The first material is a dedicated vacuum interrupter contact piece material, for example CuCr, MoCu, WCAg, WCu or the like, with various material shares for example CuCr10, CuCr25, CuCr35, and CuCr50. It may further contain additives or dispersoids to increase the durability against melting and welding. These materials can require a relatively complex, energy intensive and costly manufacturing processes. However, in the new contact piece design and manufacturing process they are being used only where they are required, i.e. in that first region of the contact piece that is directly exposed to the vacuum arc. The remaining second region of the contact piece can be filled with a relatively inexpensive material, for example pure Cu or even Ag, which has the main tasks to transfer the current with low losses, to steer the direction of the current inside the contact pieces for the generation of the desired magnetic field, like TMF or AMF, to mechanically support the first region, and to transfer excessive heat from the first region of the contact piece to the terminals of the vacuum interrupter.

[0148] An additional advantage of using pure Cu or Ag for this second region is that this pure material has a better electrical and thermal conductivity compared to the dedicated vacuum interrupter contact piece material of the first region of the contact piece, so that also the overall losses of a contact piece are reduced compared to the state of the art, i.e. a contact piece entirely made of the material used in the first region.

[0149] As cost is often a strong driver, it is another option to use a combination of Cu or Ag with a low-cost filling material for the second material. This filling material can for example be steel or stainless steel. Certainly, the ohmic resistance of such a mixture will be higher than of e.g. pure Cu, but using pure Cu for the second material would already be an improvement compared to the state of the art, where e.g. CuCr would be used for the entire contact piece. Further, the current path in the region of the second material is not long when the entire vacuum interrupter is considered, so this aspect can be omitted for many applications. The other main tasks of the second material, i.e. the mechanical support and the thermal capacity, are not affected by using this filling material. The advantages of using a combination of powders of Cu or Ag with a filling material like powders of steel of stainless steel as the second material are the material costs and the fact that the coefficients of thermal expansion of the second material and the first material, for example CuCr, are much closer compared to for example pure Cu as the second material. This improves the bond between the two layers of the contact piece after the entire production process.

[0150] It is to be noted that the second material can be filled first into the mould, followed by the first material so that the direction of the contact in the press can be chosen.

[0151] Also, a vacuum interrupter is described having both a fixed contact piece and a movable contact piece of the new two layer design. However, a vacuum interrupter can have one contact piece of the new design and one standard contact piece.

[0152] Also, the new fixed contact piece and the new movable contact piece in a vacuum interrupter, of a vacuum interrupter, can be of different diameter and/or thickness.

[0153] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. The invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing a claimed invention, from a study of the drawings, the disclosure, and the dependent claims.

Reference Numerals

[0154]

1 VI
10 Upper lid
20 Insulator
30 Lower lid
35 Bellows
40 Fixed terminal
50 Fixed contact piece
52 First layer of 50 - arc resistance
54 Second layer of 50 - support
56 Slits of 50
57 Chamfer of 50
58 Cylindrical cut-out in 50 for connection to 40
59 Cylindrical cut-out in 50 for steering the current flow from 50 to 60 and vice versa
60 Movable contact piece
62 First layer of 60 - arc resistance
64 Second layer of 60 - support
66 Slits of 60
67 Chamfer of 60
69 Cylindrical cut-out in 60 for steering the current flow from 50 to 60 and vice versa
70 Movable terminal 100 Mould filling and pressing machine
110 Table
120 Vertically movable base
130 First slider, containing 132
132 First powder

140 Second slider, containing 142
142 Second powder
150 Stamp

Claims

1. A vacuum interrupter (1), comprising:

- a fixed terminal (40);
- a fixed contact piece (50);
- a movable terminal (70); and
- a movable contact piece (60);

wherein the fixed contact piece is connected to the fixed terminal;
wherein the movable contact piece is connected to the movable terminal;
wherein the fixed contact piece comprises a first layer or region (52) and a second layer or region (54);
wherein the movable contact piece comprises a first layer or region (62) and a second layer or region (64);
wherein in a deactivated state the vacuum interrupter is configured to hold the fixed contact piece spaced from the movable contact piece; and
wherein in an activated state the vacuum interrupter is configured to move the movable terminal to bring the first layer or region of the movable contact piece into contact with the first layer or region of the fixed contact piece.

2. Vacuum interrupter according to claim 1, wherein the first layer or region of the fixed contact piece is configured to be arc resistant, and wherein the first layer or region of the movable contact piece is configured to be arc resistant.

3. Vacuum interrupter according to any of claims 1-2, wherein the first layer or region of the fixed contact piece comprises at least two materials, wherein a first material of the at least two materials of the fixed contact piece has a low ohmic resistance and a second material of the at least two materials of the fixed contact piece has a high durability against melting and welding; and wherein the first layer or region of the movable contact piece comprises at least two materials, wherein a first material of the at least two materials of the movable contact piece has a low ohmic resistance and a second material of the at least two materials of the movable contact piece has a high durability against melting and welding.

4. Vacuum interrupter according to any of claims 1-4, wherein the first layer or region of the fixed contact piece comprises: CuCr, MoCu, WCu, or WCAg; and wherein the first layer or region of the movable contact piece comprises: CuCr, MoCu, WCu, or WCAg.

5. Vacuum interrupter according to any of claims 1-4, wherein the second layer or region of the fixed contact piece is configured to support the first layer or region of the fixed contact piece; and wherein the second layer or region of the movable contact piece is configured to support the first layer or region of the movable contact piece.

6. Vacuum interrupter according to any of claims 1-5, wherein the second layer or region of the fixed contact piece comprises Cu and/or Ag and/or Stainless steel and/or steel; and wherein the second layer or region of the movable contact piece comprises Cu and/or Ag and/or Stainless steel and/or steel.

7. A method of manufacturing a contact piece (50, 60) for a vacuum interrupter, wherein the contact piece comprises a first layer or region (52, 62) and a second layer or region (54, 64), wherein the first layer or region of the contact piece is configured to be arc resistant, and wherein the second layer or region of the contact piece is configured to support the first layer or region of the contact piece, and wherein the method comprises:

- filling a void above a movable base (120) of a part of a mould (110) with a first powdered material such that a surface of the first powdered material is at a first set level of the mould, and wherein the movable base (120) is configured to move with respect to the first set level of the mould;
- moving the movable base away from the first set level of the mould to create a void above the first powdered material in the part of the mould;
- filling the void above the first powdered material in the part of the mould (110) with a second powdered material such that a surface of the second powdered material is at a second set level of the mould;
pressing the first powdered material and the second powdered material with a stamp (150); and
- sintering the pressed first powdered material and second powdered material.

8. Method according to claim 7, wherein after filling the void above the movable base of the part of the mould with the first powdered material and before filling the void above the first powdered material in the part of the mould with the second powdered material the method comprises pressing the first powdered material with a stamp.

9. Method according to claim 8, wherein the stamp

used to press the first powdered material is different to the stamp used to press the first powdered material and the second powdered material.

10. Method according to any of claims 7-9, wherein filling the void above the movable base of the part of the mould with the first powdered material comprises sliding a slider (130) over the part of the mould, and wherein a base portion of the slider slides at the first set level.

11. Method according to claim 10, wherein filling the void above the movable base of the part of the mould with the first powdered material comprises transferring the first powdered material from the slider to the part of the mould.

12. Method according to any of claims 7-11, wherein filling the void above the first powdered material in the part of the mould with the second powdered material comprises sliding a slider (140) over the part of the mould, and wherein a base portion of the slider slides at the second set level.

13. Method according to claim 12, wherein filling the void above the first powdered material in the part of the mould with the second powdered material comprises transferring the second powdered material from the slider to the part of the mould.

14. Method according to any of claims 1-13, wherein before sintering the pressed first powdered material and second powdered material the method comprises removing the pressed first powdered material and second powdered material from the mould.

15. Method according to claim 14, wherein removing the pressed first powdered material and second powdered material from the mould comprises moving the movable base toward the first set level of the mould.

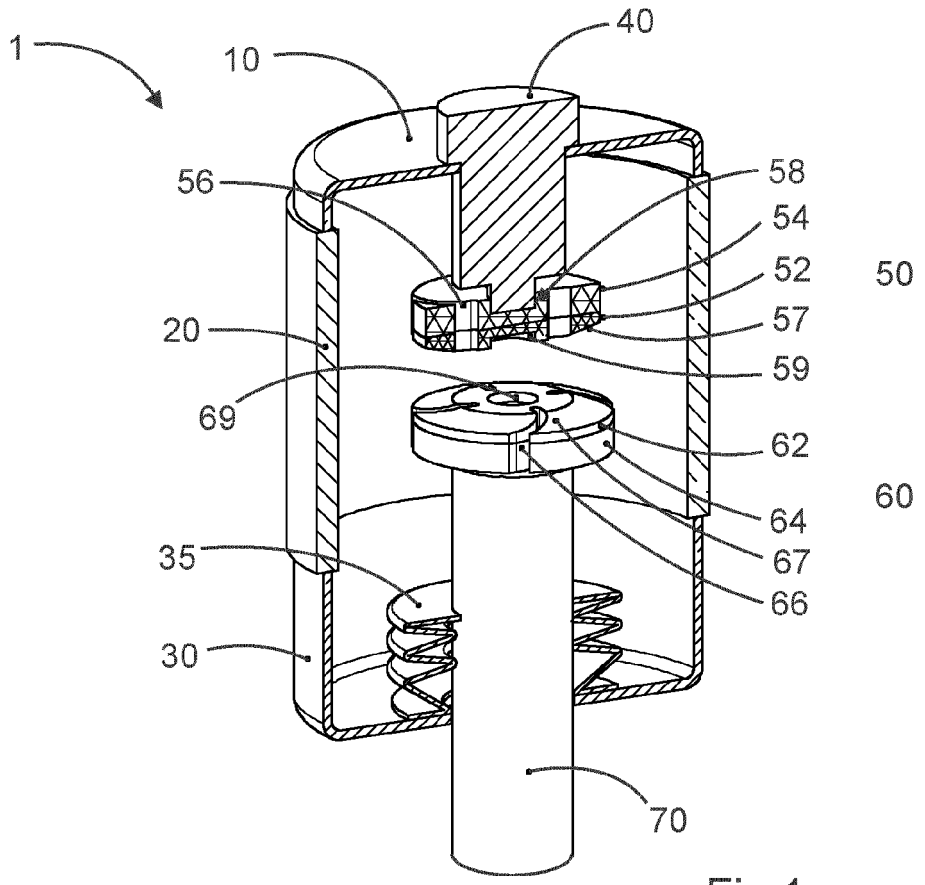
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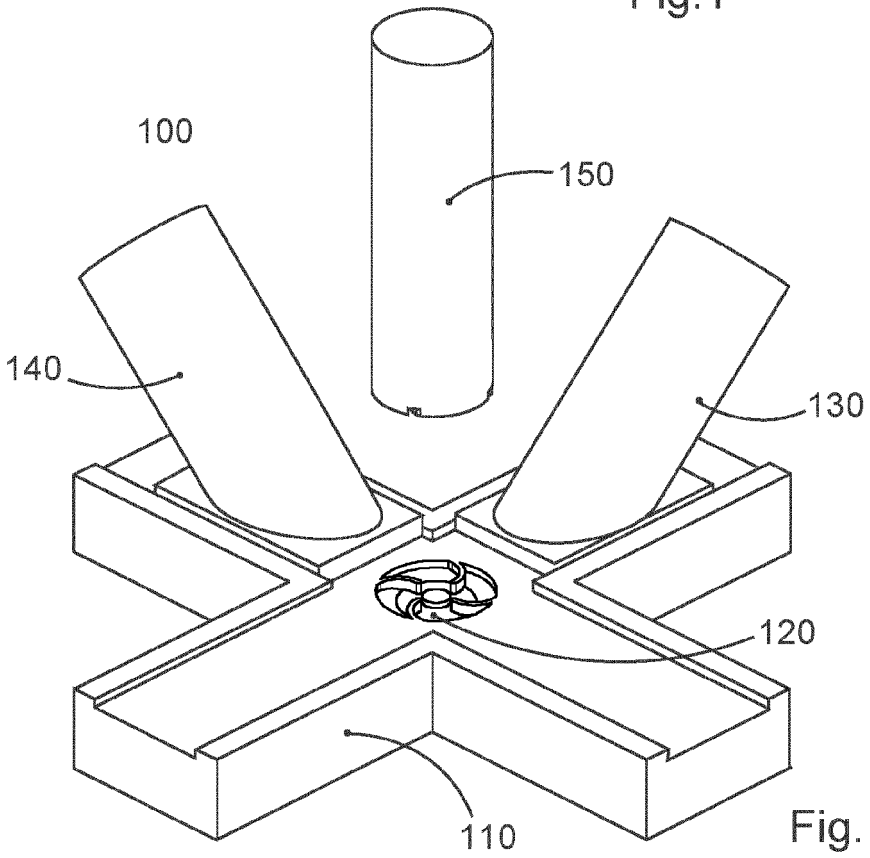
Fig.1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130
120
110

Fig. 2

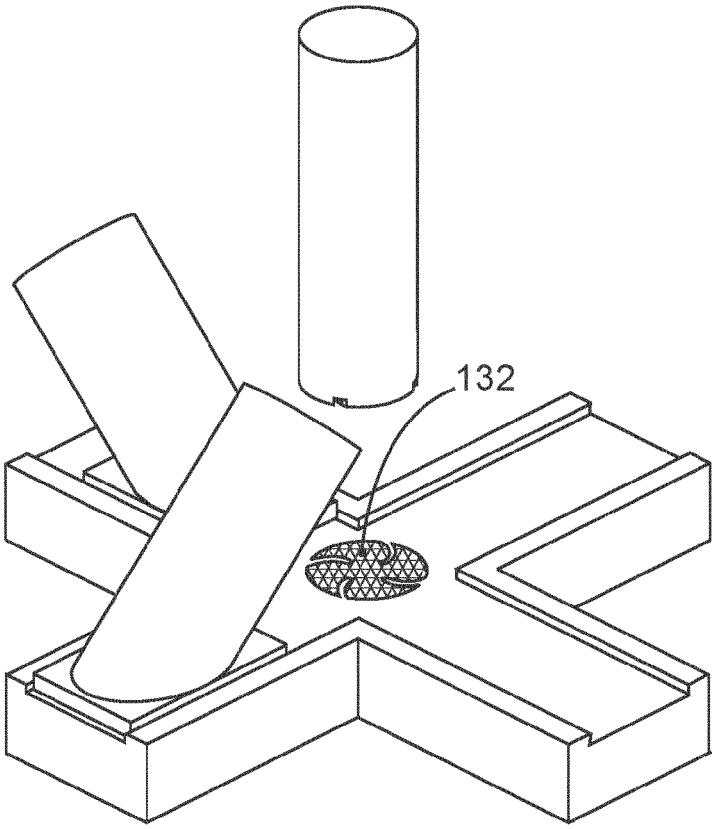

Fig. 3

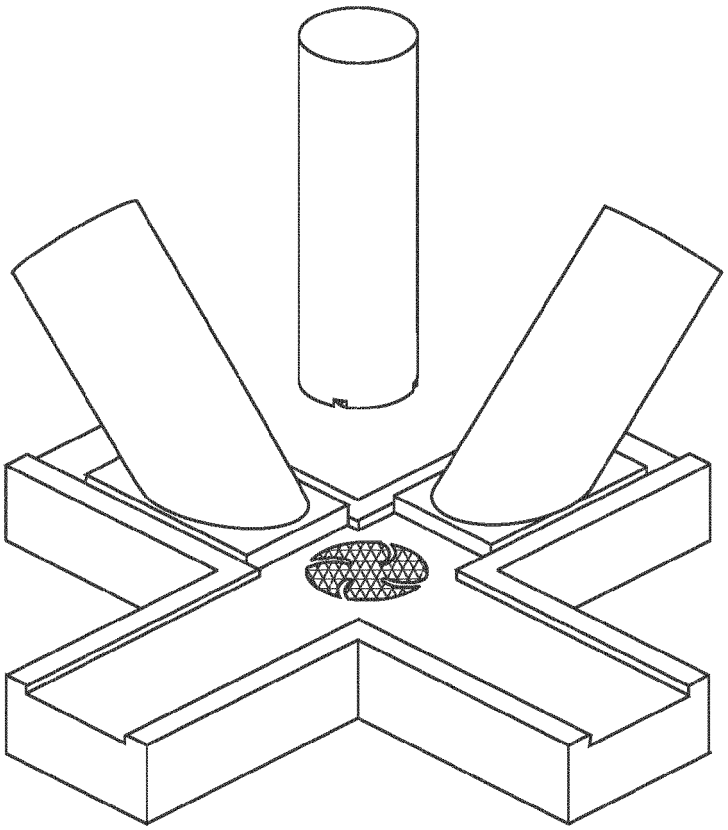

Fig. 4

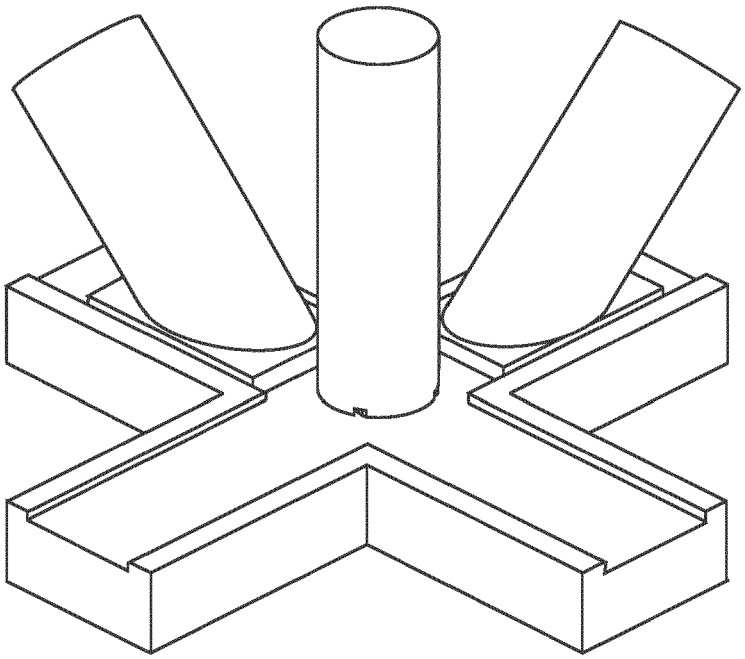

Fig. 5

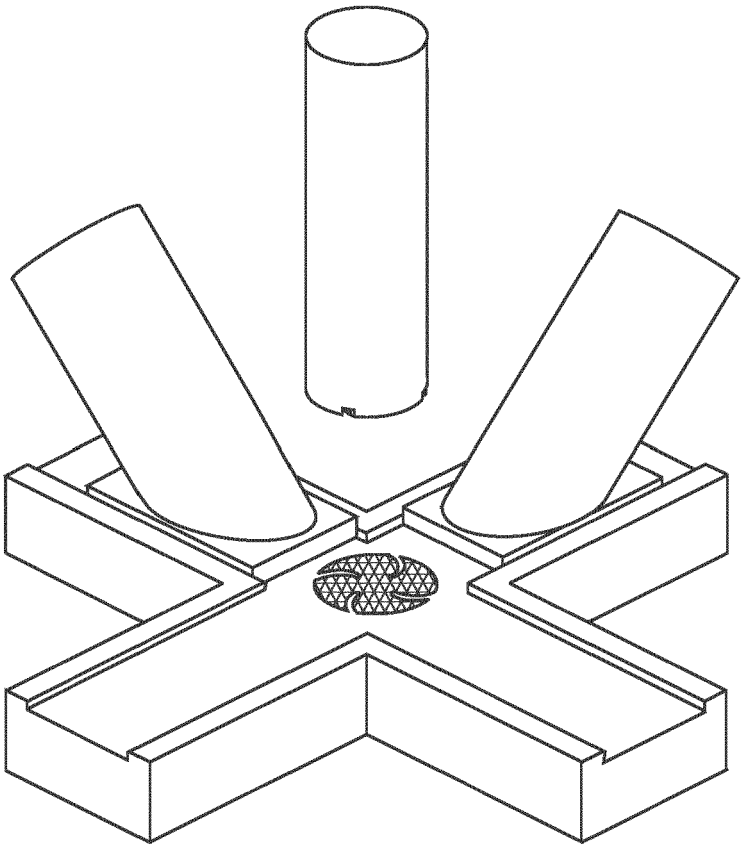

Fig. 6

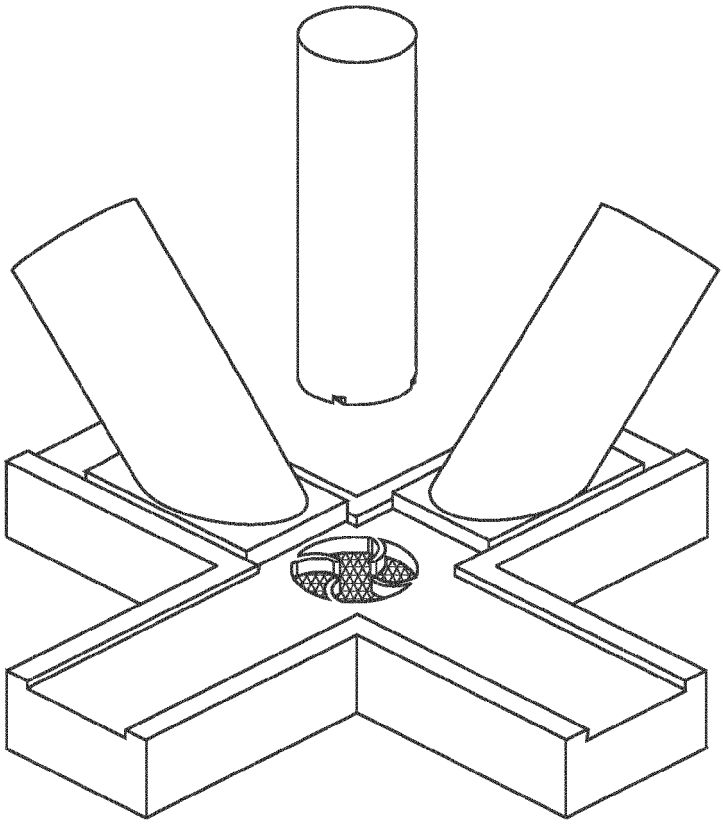

Fig. 7

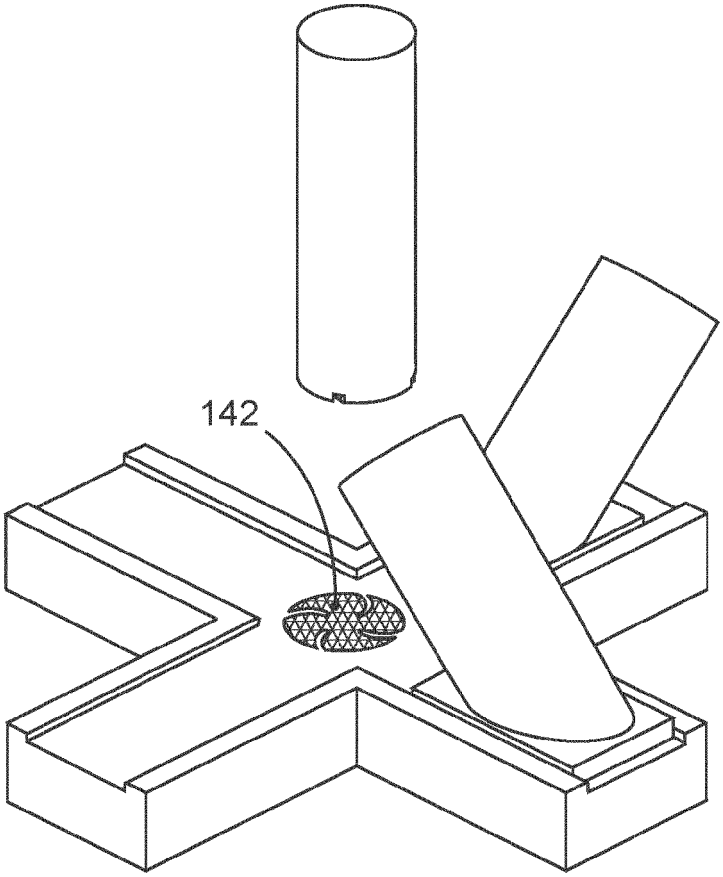

Fig. 8

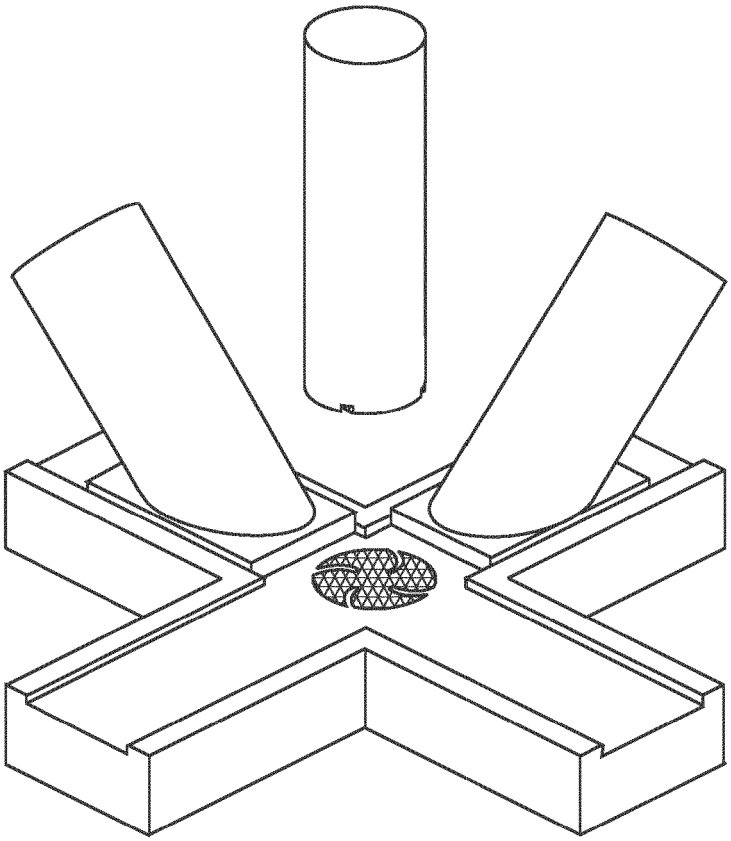

Fig. 9

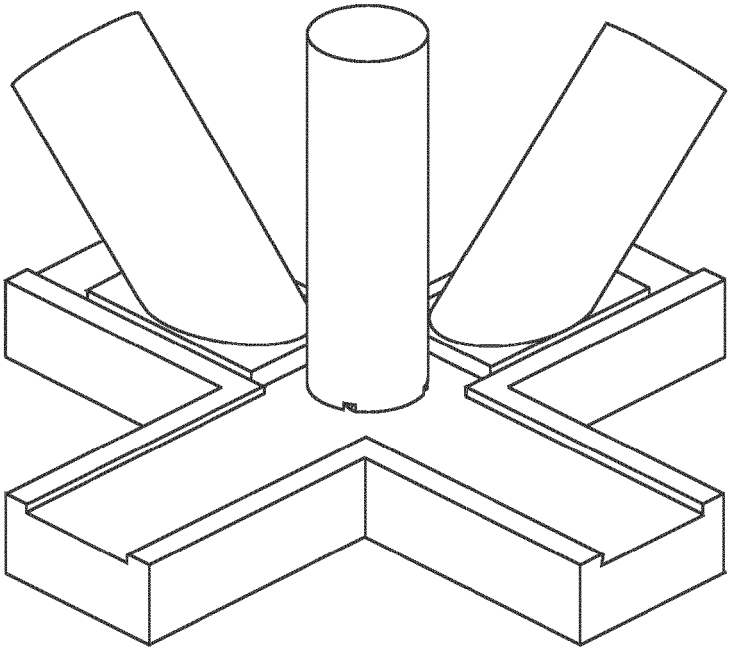

Fig. 10

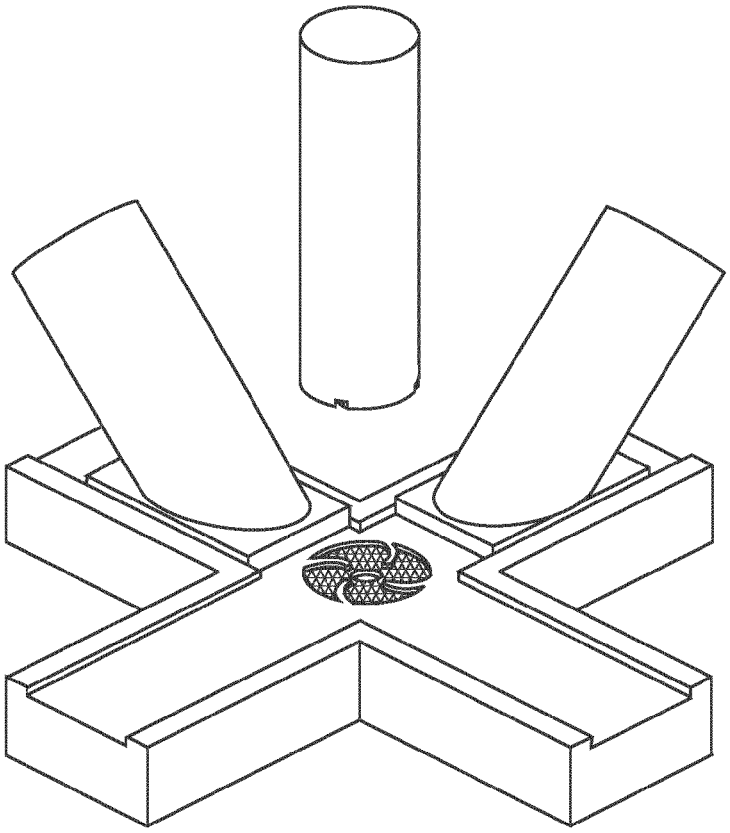

Fig. 11

1 - Filling the mould with the first material

2 - Pre-pressing of the first material

3 - Lowering the base of the mould

4 - Filling the mould with the second material

5 - Presing the powder into the mould

6 - Sintering

Fig. 12

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EUROPEAN SEARCH REPORT

Application Number
EP 22 16 5701

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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	18 August 2022	Ernst, Uwe

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