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(71) Applicant: **Aptiv Technologies Limited**
St. Michael (BB)

(72) Inventors:
- **WOESTE, Guido**
  58332 Schwelm (DE)
- **RAMAEKERS, Udo**
  58332 Schwelm (DE)

(74) Representative: **Bardehle Pagenberg Partnerschaft mbB**
Patentanwälte Rechtsanwälte
Prinzregentenplatz 7
81675 München (DE)

(54) **BUSBAR CONNECTION SYSTEM**

(57) The present invention relates to a busbar system, a busbar assembly 1a, a busbar connection system 1 and a method for electrically connecting busbars of different potentials P1, P2, particularly for electrically connecting a first busbar portion 10 with a second busbar portion 12 and a third busbar portion 20 with a fourth busbar portion 22. The system 1 comprising a first electrically conductive bushing 30, including a through hole for providing a passage 35 through the third and fourth busbar portions 20, 22 and being configured for electrically connecting the first busbar portion 10 with the second busbar portion 12. The system further comprising a first insulator bushing 40, being configured for receiving the first electrically conductive bushing 30 at least partially and for electrically insulating busbar portions 10,12 configured for the first potential form busbar portions 20, 22 configured for the second potential P2, and a pressing means 50, comprising a shaft 52 that is configured for being received in the first electrically conductive bushing 30 so as to extend through the passage 35, wherein the pressing means 50 is configured for pressing first, second, third and fourth busbar portions 10, 12, 20, 22 in a shaft direction to electrically connect the first busbar portion 10 with the second busbar portion 12 and the third busbar portion 20 with the fourth busbar portion 22.

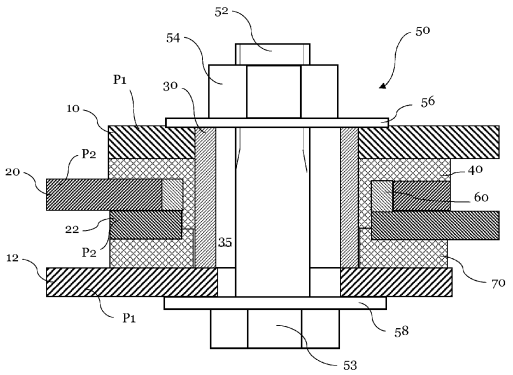

Fig. 2

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Description

Field of the invention

[0001] The present invention relates to a busbar system, a busbar assembly, a busbar connection system and a method for electrically connecting busbar portions of different potentials Pi, P2 jointly. Particularly, the present invention relates to electrically connecting a first busbar portion with a second busbar portion and a third busbar portion with a fourth busbar portion, wherein the first and second busbar portions are configured for a first electrical potential and the third and fourth busbar portions are configured for a second, different electrical potential.

Background

[0002] Busbars are well known in the art of electrical power conduction, particularly for conducting high electrical current and/or voltages. With the emerging numbers of electric vehicles, such as electric cars, busbar are increasingly used in the automotive field. For example, busbars are used to provide an electrical connection between a vehicle's drive, a vehicle's battery and/or a charging unit. Typically busbars of two different potentials (e.g. "+" and "-") are required.

[0003] During assembly of the vehicle, busbars have to be connected to further busbar portions, such as a further busbar section and/or a terminal of the vehicle's drive, battery and/or charging unit.

[0004] In this field, specific requirements arise. Among these are highly reliable connections, even under changing environmental influences, such as temperature, moisture, dust, vibrations and shock. Those connections must not only ensure a proper electrical connection but also a mechanical connection. Further, particularly in the automotive field, assembly time and costs play an important role.

[0005] Known busbars are typically connected by screwing. To ensure a proper electrical and mechanical connection, each busbar is separately screwed to its respective counterpart, typically using multiple screws in parallel. These connections are separately necessary for all busbars of different potential. For example, a "+" busbar has to be screwed to a corresponding "+" counterpart and a "-" busbar has to be screwed to a corresponding "-" counterpart. Hence, multiple screw connections are required, leading to high assembly times and costs. In those screw connections, torque has to be carefully controlled, leading to further financial and temporal efforts.

[0006] Further, welding of busbars is known. However, welded connections are impossible to disconnect, hindering maintenance and repair of electric vehicles.

[0007] Hence, there is a need in the art for an improved connection of busbars, particularly for busbars of different potentials. A particular object of the present invention is to provide a separable electrical connection between busbars/busbar portions of different potentials. Further the connection shall be connectable fast and reliable and shall include a minimum number of parts, while providing low thermal and electrical resistances.

Summary

[0008] The objects are at least partially achieved by a busbar system, a busbar assembly, a busbar connection system and a method for electrically connecting busbars of different potentials as defined in the independent claims. Further aspects of the present invention are given in the dependent claims as well as in the following description.

[0009] According to a first aspect, there is provided a busbar connection system, for electrically connecting a first busbar portion with a second busbar portion and a third busbar portion with a fourth busbar portion. The first and second busbar portions are configured for a first electrical potential, P1 (e.g. "+"), and the third and fourth busbar portions are configured for a second electrical potential, P2 (e.g. "-").

[0010] The busbar/busbar portions may be configured for guiding DC-current and/or AC-current. The busbar portions may be part of a vehicle's busbar, drive, battery, charging unit and/or any other part of a vehicles power supply system.

[0011] Particularly, the first and third busbar portions may form a busbar of different potentials, wherein the first and third busbar portions sandwich an electrical insulator, so that the first and third busbar portions are electrically insulated from each other. Particularly, the first and third busbar portion may form the following stack, wherein further layers may be included (even though not explicitly named):
first busbar portions / electrical insulator / third busbar portion.

[0012] The same applies for the second and fourth busbar portions. Accordingly, the second and fourth busbar portions may form a busbar of different potentials, wherein the second and fourth busbar portions sandwich an electrical insulator, so that the second and fourth busbar portions are electrically insulated from each other. Particularly, the second and fourth busbar portion may form the following stack, wherein further layers may be included (even though not explicitly named):
second busbar portions / electrical insulator / fourth busbar portion.

[0013] The busbar portions include an electrically conductive material, such as aluminum and/or copper or respective alloys thereof. Particularly, the busbar portions may include sections of different materials. A first section (pressing section) may be made of a different material than a second (remaining) section of the respective busbar portion. For example, the pressing section may be made of a copper-based material, such as copper or a copper alloy and the second section may be made of an aluminum-based material, such as aluminum or an alu-

minum alloy. Further the busbar portions may be at least partially plated, so as to enhance electrical conductivity, thermal conductivity and resistance against environmental influences (corrosion, ...). For example, the first section may be plated, while the second section is not (or vice versa). Possible plating materials are gold, tin, silver and/or the like. Still further the busbar portions may at least partially surrounded by an electrical insulator.

[0014] Providing busbar portion(s) having sections of different materials allows to safe costs and/or weight. For example, providing a first section that is e.g. copper-based may provide a good electrical connection between the respective busbar portion and an electrically conductive bushing. Providing a second section that is aluminum-based may still allow for sufficient electrical conductivity and reduced weight. This second section may provide a connection between the busbar connection system and further components of a vehicle, such as a battery, drive, charging unit, and/or the like.

[0015] Generally, the pressing section of a busbar portion may be made of the same or substantially the same material (e.g. a copper alloy) as an electrically conductive bushing being associated with the respective busbar portion.

[0016] The busbar connection system comprises a first electrically conductive bushing. Said bushing includes a through hole for providing a passage through the third and fourth busbar portions and is configured for electrically connecting the first busbar portion with the second busbar portion, i.e. the busbar portions of the first potential P1. Further, the bushing may be configured to provide a passage through the first and/or second busbar portions. Said passage may be a through hole, having a substantially circular cross section.

[0017] The first electrically conductive bushing may include a first contact section for electrically contacting the first busbar portion and a second contact section for electrically contacting the second busbar portion. For example, the first contact section may be arranged on a lateral outer surface of the first electrically conductive bushing and the second contact section on an end face of the first electrically conductive bushing.

[0018] The first electrically conductive bushing may be a copper (or copper alloy) bushing. Further, the first electrically conductive bushing may be an aluminum (or aluminum alloy) bushing. Further, the first electrically conductive bushing may be at least partially plated with a suitable material, such as gold, silver, tin, and/or the like to provide a reliable connection.

[0019] Further, the first electrically conductive bushing may have at least one collar. Said collar may increase a contact surface between the first electrically conductive bushing and any one of the first and/or second busbar portions.

[0020] The busbar connection system comprises further a first insulator bushing being configured for receiving the first electrically conductive bushing at least partially and for electrically insulating busbar portions configured for the first potential from busbar portions configured for the second potential. Hence, when being assembled, the first insulator bushing at least partially encircles the first electrically conductive bushing, thereby preventing the third and/or fourth busbar portion to electrically contact the first electrically conductive bushing. The first insulator bushing may be a polymer-based bushing, a ceramic bushing or a bushing of any other suitable electric insulator.

[0021] Further, the first insulator bushing may include a collar, that is sandwiched between the first and third busbar portion, thereby electrically insulating those portions.

[0022] Still further, the busbar connection system comprises a pressing means comprising a shaft that is configured for being received in the first electrically conductive bushing so as to extend through the passage provided by the first electrically conductive bushing. As the shaft extends through the passage of the first electrically conductive bushing, and as the passage goes through the third and fourth busbar portions, the third and fourth busbar portions (potential P2) can be held in place.

[0023] Said pressing means is further configured for pressing first, second, third and fourth busbar portions in a shaft axial direction to electrically connect the first busbar portion with the second busbar portion and the third busbar portion with the fourth busbar portion. Thus, with tightening the pressing means, an electric connection can be established for busbar portions of the first and second potential, jointly. There is no need for multiple screws or connecting means, as in the prior art discussed above. Particularly, the busbar connection system may include only a single pressing means.

[0024] Said busbar connection system allows for high-cost efficiency and a reduced number of process steps for connecting busbars, compared to formerly known screw-connections.

[0025] Providing a busbar portion having a first section (pressing section) of a different material than a second section, allows optimizing the material of the section of the busbar portion that is pressed by the pressing means. For example, this first section may be copper based, as copper provides for a reduced ease of flow, compared to aluminum. Hence, higher pressing forces can be applied, leading to a more reliable connection.

[0026] The busbar connection system may further comprise a second electrically conductive bushing, which is configured for receiving the first electrically conductive bushing and optionally the first insulator bushing. Particularly, the first electrically conductive bushing and the second electrically conductive bushing may be separated by the first insulator bushing. The second electrically conductive bushing is configured for electrically connecting the third busbar portion with the fourth busbar portion. Hence, a reliable electric connection can be achieved.

[0027] The second electrically conductive bushing may include a third contact section for electrically con-

tacting the third busbar portion and a fourth contact section for electrically contacting the fourth busbar portion. For example, the third contact section may be arranged on a lateral outer surface of the second electrically conductive bushing and the fourth contact section on an end face of the second electrically conductive bushing.

[0028] The second electrically conductive bushing may be a copper (or copper alloy) bushing. Further, the second electrically conductive bushing may be an aluminum (or aluminum alloy) bushing. Further, the second electrically conductive bushing may be at least partially plated with a suitable material, such as gold, silver, tin, and/or the like to provide a reliable connection.

[0029] Further, the second electrically conductive bushing may have at least one collar. Said collar may increase a contact surface between the second electrically conductive bushing and any one of the third and/or fourth busbar portions.

[0030] The busbar connection system may further comprise a second insulator bushing, the second insulator bushing being configured for receiving the first electrically conductive bushing at least partially. Further, the second insulator bushing serves for electrically insulating busbar portions configured for the first potential from busbar portions configured for the second potential. Hence, when being assembled, the second insulator bushing at least partially encircles the first electrically conductive bushing, thereby preventing the third and/or fourth busbar portion to electrically contact the first electrically conductive bushing. Particularly the second insulator bushing may serve for separating the second and fourth busbar portions as well as the first conductive bushing and the fourth busbar portion.

[0031] The second insulator bushing may be a polymer-based bushing, a ceramic bushing or a bushing of any other suitable electric insulator. When being assembled, particularly, when first, second, third and fourth busbar portions are pressed by the pressing means, first and second insulator bushings may contact each other. This allows encircling the first conductive bushing, so as to provide a proper insulation of first and second potentials. Further, the first insulator bushing may include a collar, that is sandwiched between the second and fourth busbar portion, thereby electrically insulating those portions.

[0032] The pressing means may include a threaded shaft, a nut and optionally at least one spring washer. Particularly, the pressing means may provide for a screwing connection. For example, the threaded shaft may be inserted into the first electrically conductive bushing so as to extend through the passage and hence through the third and fourth busbar portions. Further, the threaded shaft may be inserted into a respective recess or through hole of the first and second busbar portions. By screwing the nut on the threaded shaft, first, second, third and fourth busbar portions may be pressed in a shaft axial direction, thereby electrically connecting the first busbar portion with the second busbar portion (via the first electrically conductive bushing) and the third busbar portion with the fourth busbar portion (optionally via the second electrically conductive bushing). Further, said screwing may provide for a rigid mechanical connection.

[0033] Further, a spring washer may be sandwiched between the first busbar portion and the nut and/or between the second busbar portion and a collar or head of the threaded shaft. Said spring washer provides for a constant pressing force over lifetime of the assembled busbar connection system.

[0034] In a further embodiment, the pressing means may include an eccentric clamp mechanism, and optionally at least one spring washer, wherein the eccentric clamp mechanism includes at least one rotatable eccentric element that is arranged rotatably relative to the shaft from an initial position to a press position. The rotatable eccentric element may be configured for applying a press force for pressing first, second, third and fourth busbar portions when being in the press position. Providing a rotatable eccentric element allows for a constant and defined press force and hence, overwinding of a thread and/or providing excessive press forces can be prevented.

[0035] The eccentric clamp mechanism may be shaped so as to fit through the passage provided in the first electrically conductive bushing. Hence, the shaft and/or the eccentric clamp mechanism may be sticked through the first, second, third and/or fourth busbar portions.

[0036] Further at least one spring washer may be associated with the eccentric clamp mechanism, and particularly with the at least one rotatable eccentric element. According to this embodiment, said spring washer may have a through opening, that is adapted to the shape of the eccentric clamp mechanism. For example, the through opening may be keyhole shaped. Particularly, the through opening may be shaped, so that the spring washer may be arrangeable relative to the eccentric clamp mechanism in at least two positions. In a first position the through opening allows the eccentric clamp mechanism to pass through the spring washer. In a second position, which is different from the first position, the eccentric clamp mechanism is hindered from passing through the spring washer. The first position may serve for assembling/disassembling the pressing means including the eccentric clamp mechanism. In the second position, a pressing force provided by the pressing means can be transferred via the spring washer to at least one of the busbar portions. For moving the spring washer from the first to the second position, the spring washer may be slidable relative to the pressing means, particularly in a direction perpendicular to an axis of the shaft.

[0037] Particularly, the eccentric clamp mechanism may comprise a stop lug and a corresponding stop lug. The stop lug maybe arranged e.g. on the rotatable eccentric element so as to be moveable relative to the shaft. The corresponding stop lug may be arranged fixedly adhered relative to the shaft. The stop lug and correspond-

ing stop lug may be configured to engage with each other, when the rotatable eccentric element is in the press position. Thus, over rotating the rotatable eccentric element can be effectively prevented. Further, stop lug and corresponding stop lug may engage with each other, so that an unintentional loosening of the eccentric clamp mechanism can be prevented. For example, stop lug and corresponding stop lug may be configured to be locked to each other when the rotatable eccentric element is in the press position, e.g. by a snap fitting.

[0038] Particularly, a screw bit receptacle (e.g. a torx, a cross slot, a hexagonal recess or the like) may be associated with the rotatable eccentric element. Hence, the rotatable eccentric element can be actuated with standardized tools.

[0039] Further, a spring washer may be sandwiched between the first busbar portion and the rotatable eccentric element and/or between the second busbar portion and a collar or head of the shaft. Said spring washer provides for a constant pressing force over lifetime of the assembled busbar connection system.

[0040] Additionally, the busbar connection system may comprise a cover, that is adapted to cover the pressing means at least partially. Said cover may be fitted to the eccentric clamp mechanism, so as to cover the rotatable eccentric element. Hence, the rotatable eccentric element can be prevented form unintentional loosening and the pressing means is protected from environmental influences (e.g. dirt, dust, moisture, and the like).

[0041] Further, the shaft, the first electrically conductive bushing and the first insulator bushing and optionally also the second electrically conductive bushing and/or the second insulator bushing are arranged coaxially. This allows a facilitated assembly of the system. Further, the coaxial arrangement allows to adapt the angular orientation of the busbar portions, as those busbar portions may be individually rotatable around the respective bushings. Hence, the system allows for a flexible assembly that can be adapted to outer spacial requirements.

[0042] In particular, the busbar connection system maybe configured to allow adjusting an angular offset of at least one of the first, second, third and/or fourth busbar portions, prior to pressing. After pressing, the first, second, third and/or fourth busbar portions can be securely fixed to each other.

[0043] The objects may be further achieved by a busbar assembly. The busbar assembly comprises a first busbar portion configured for a first electrical potential, P1 and a third busbar portion configured for a second electrical potential P2. The first and third busbar portions sandwich an electrical insulator, which may be a collar of a first insulator bushing. The first and third busbar portions as well as the electrical insulator may be fixedly attached to each other.

[0044] Further the first and third busbar portions include a receptacle. Said receptacle may be a through hole extending through the first and third busbar portions as well as through the electrical insulator. Said through hole may vary in shape and diameter. For example, the through hole may have a first diameter in the first busbar portion, a second diameter in the insulator and a third diameter in the third busbar portion.

[0045] Further, the busbar assembly comprises a first electrically conductive bushing. Said first electrically conductive bushing may be configured as described above and particularly includes a through hole for providing a passage. Further, the first electrically conductive bushing is configured for electrically connecting the first busbar portion with a second busbar portion. Additionally, the busbar assembly includes a first insulator bushing, being configured for receiving the first electrically conductive bushing at least partially and for electrically insulating busbar portions configured for the first potential P1 from busbar portions configured for the second potential P2. The first insulator bushing and/or the first electrically conductive bushing are configured for being inserted at least partially in the receptacle.

[0046] Hence, a passage may be formed through the first and third busbar portions by means of the first electrically conductive bushing, for receiving a pressing means, which may be configured as described above.

[0047] The busbar assembly may further comprise a second electrically conductive bushing which is configured for receiving the first electrically conductive bushing and optionally the first insulator bushing. The second electrically conductive bushing is configured for electrically connecting the third busbar portion with a fourth busbar portion. Further, the second electrically conductive bushing may be received at least partially in the receptacle formed in the first and third busbar portions.

[0048] The busbar assembly may further comprise a second insulator bushing. The second insulator bushing may be configured for receiving the first electrically conductive bushing at least partially and for electrically insulating busbar portions configured for the first potential from busbar portions configured for the and second potentials. The first and second insulator bushings may contact each other particularly when the first, second, third and fourth busbar portions are pressed by the pressing means.

[0049] Further, at least one pressing means may be preinstalled with the busbar assembly. In particular, the at least one pressing means maybe preinstalled, so that at least the shaft of the pressing means extends through the passage formed through the first and third busbar portions. This allows a facilitated assembly of further components of the system, such as second and fourth busbar portions and/or additional bushings such as insulator bushings and/or electrically conductive bushings. The preinstalled pressing means may be securely fixed to the busbar assembly to prevent the pressing means from getting lost during storage and/or delivery.

[0050] The objects may be further achieved by a busbar system, comprising the busbar assembly as described above, and a second busbar portion configured for the first electrical potential and a fourth busbar portion

configured for the second electrical potential.

[0051] The second and fourth busbar portions sandwich an electrical insulator, which may be a collar of the second insulator bushing. Said second insulator bushing may be configured as described above. Further, the second and fourth busbar portions as well as the electrical insulator may be fixedly attached to each other. Still further the second and fourth busbar portions may include a second receptacle. Said second receptacle may be a through hole extending through the second and fourth busbar portions as well as through the electrical insulator. Said through hole may vary in shape and diameter. For example, the through hole may have a first diameter in the second busbar portion, a second diameter in the insulator and a third diameter in the fourth busbar portion. Said receptacle may be configured for receiving a pressing means of the busbar system. Said pressing means may be preinstalled with the busbar assembly.

[0052] Said pressing means comprises a shaft that is configured for being received in the first electrically conductive bushing so as to extend through the passage, wherein the pressing means is configured for pressing first, second, third and fourth busbar portions in a shaft axial direction to electrically connect the first busbar portion with the second busbar portion (via the first electrically conductive bushing) and the third busbar portion with the fourth busbar portion (optionally via a second electrically conductive bushing). Particularly, the pressing means may be configured as described above.

[0053] It is to be understood that the busbar system is not limited to two different potentials Pi, P2 but may further comprise at least two additional busbar portions, configured for a third electrical potential, P_3. The system may be configured for electrically insulating busbar portions configured for the third potential from any of the busbar portions configured for the first and second potentials Pi, P2, and further to electrically connect the at least two additional busbar portions by means of the pressing means (e.g. via a third electrically conductive bushing). Said third electrically conductive bushing may be aligned concentrically with any of the first and/or second third electrically conductive bushings and/or first and/or second insulator bushings. Further, the system may include a third insulator bushing, for providing a proper electrical insulation of the third potential, P_3. Hence, the system is scalable to multiple potentials and may also be used to carry signals. Further, the system is scalable to different sizes.

[0054] The assemblies and systems described above, provide for an improved connection of busbar portions of different potentials, using a (single) clamping means. Further, thermal and electrical conductivity can be improved. Further, it had shown, that the assemblies and systems described above led to a reduced EMC emission.

[0055] Further, the object is achieved by a method for electrically connecting busbar portions of different potentials jointly. The method comprises the steps of providing a busbar assembly, which is configured as described above, and providing a second busbar portion configured for the first electrical potential and a fourth busbar portion configured for the second electrical potential, the second and fourth busbar portions sandwiching an electrical insulator. In a further step, an electrical connection is established by pressing first, second, third and fourth busbar portions in a shaft axial direction using the pressing means of the busbar system, as described above.

Brief description of the figures

[0056] In the following, the accompanying figures are briefly described.

Fig. 1A shows a busbar assembly in a first condition;

Fig. 1B shows the busbar assembly of Fig. 1A in a second condition;

Fig. 2 shows a busbar connection system 1, according to a first embodiment;

Fig. 3A shows a busbar connection system 1, according to a second embodiment, in a first condition;

Fig. 3B shows the busbar connection system 1 of Fig. 1B, according to a second embodiment, in a second condition;

Fig. 4 is a detailed view of a spring washer, and

Fig. 5 gives a flow diagram of the inventive method.

Detailed description of the figures

[0057] In the following the embodiments shown in the accompanying figures are described in more detail.

[0058] Fig. 1A shows a busbar assembly 1a being part of a busbar connection system 1 in a first condition. The pressing means of the busbar connection system is not shown in Fig. 1A, but in Fig. 2. The busbar assembly 1a comprises a first busbar portion 10 configured for a first electrical potential P1 and a third busbar portion 20 configured for a second electrical potential P2. The first and third busbar portions 10, 20 sandwich an electrical insulator, which is part (particularly a collar) of a first insulator bushing 40.

[0059] Further, the first and third busbar portions 10, 20 include a first receptacle 13. A first electrically conductive bushing 30 includes a trough hole for providing a passage 35 and is configured for electrically connecting the first busbar portion 10 with a second busbar portion 12, as shown in Fig. 1B. Here, the first electrically conductive bushing 30 is inserted at least partially in the receptacle being formed in the first and third busbar portions 10, 20. Particularly, the first electrically conductive

bushing 30 extends through the first and third busbar portions 10, 20 as well as through the insulator 40. The first and third busbar portions 10, 20 as well as the electrical insulator 40 may be fixedly attached to each other.

[0060] Further, the first insulator bushing 40 receives the first electrically conductive bushing 30 at least partially and electrically insulates the first and second potentials Pi, P2, respectively the third busbar portion 20 from the first busbar portion 10 and the first electrically conductive bushing 30.

[0061] In the configuration shown, the first electrically conductive bushing 30 extends axially over the first insulator bushing 40. This allows electrically contacting a second busbar portion 12, as shown in Fig. 1B.

[0062] In an embodiment, e.g. the second busbar portion 12 may have a first section (pressing section) of a different material than a second section. This allows optimizing the material of the section of the second busbar portion 12 that is pressed by the pressing means 50, 500. For example, the first section may be copper based, as copper provides for a reduced ease of flow, compared to aluminum. Hence, higher pressing forces can be applied, leading to a more reliable connection. It is to be understood, that likewise first, third and fourth busbar portions 10, 20, 22 may include a respective pressing section, having a different material than e.g. the remaining busbar portion.

[0063] Further, a second electrically conductive bushing 60 is provided. Said second electrically conductive bushing 60 is arranged concentrically around the first insulator bushing 40 and the first electrically conductive bushing 30, wherein the first insulator bushing 40 separates the first and second electrically conductive bushings 30, 60. The second electrically conductive bushing 60 is configured for electrically connecting the third busbar portion 20 with the fourth busbar portion 22, as shown in Fig. 1B and 2.

[0064] Further, second and fourth busbar portions 12, 22 are provided, which sandwich an electrical insulator 70, which may be a collar of the second insulator bushing 70. Further, the second and fourth busbar portions 12, 22 as well as the electrical insulator may be fixedly attached to each other. Still further the second and fourth busbar portions 12, 22 may include a second receptacle 23.

[0065] Fig. 1B shows the busbar assembly of Fig. 1A in a second, preassembled condition. Here, the first electrically conductive bushing 30 is at least partially received in the second receptacle formed in the second and fourth busbar portions 12, 22, respectively. In this second condition, there may be an electrical connection between the first busbar portion 10 and the second busbar portion 12 (via the first electrically conductive bushing 30) and between the third busbar portion 12 and the fourth busbar portion 22 (via the second electrically conductive bushing 60). However, a reliable mechanical connection is not (yet) provided.

[0066] This mechanical connection can be achieved by a pressing means 50 (cf. Fig. 2) or a pressing means 500 (cf. Figs. 3A and 3B).

[0067] Fig. 2 shows a busbar connection system 1, according to a first embodiment. For connecting the first, second, third and fourth busbar portions, 10, 12, 20, 22 those portions are aligned and first and second insulator bushings 40, 70, as well as first and second electrically conductive bushing are provided, as described with respect to Figs. 1A and 1B. Particularly, those parts are arranged as shown in Fig. 1B, i.e. coaxially aligned.

[0068] For providing an electrical and mechanical connection, a threaded shaft 52 of the pressing means 50 is inserted in the passage 35 of the first electrically conductive bushing 30, so as to extend at least through the first, second, third and fourth busbar portions, 10, 12, 20, 22. The threaded shaft 52 may include a screw head 53, which may be screwed to the threaded shaft 52 or integrally formed with the threaded shaft 52. On the opposite end of the threaded shaft 52, a nut 54 may be provided. By screwing the nut on the threaded shaft, first, second, third and fourth busbar portions may be pressed in a shaft axial direction, thereby electrically and mechanically connecting the first busbar portion 10 with the second busbar portion 12 (via the first electrically conductive bushing 30) and the third busbar portion 20 with the fourth busbar portion 22 (via the second electrically conductive bushing 60).

[0069] Further, spring washers 56, 58 are sandwiched between the first busbar portion 10 and the nut 54 and between the second busbar portion 23 and the screw head 53 Said spring washers 56, 58 provide for a constant pressing force over lifetime of the assembled busbar connection system 1.

[0070] Figs. 3A and 3B show a busbar connection system 1, according to a second embodiment. In this embodiment, the pressing means 50 is exchanged by pressing means 500. In this second embodiment, for connecting the first, second, third and fourth busbar portions, 10, 12, 20, 22 those portions are aligned and first and second insulator bushings 40, 70, as well as first and second electrically conductive bushing are provided, as described with respect to Figs. 1A and 1B. Particularly, those parts are arranged as shown in Fig. 1B, i.e. coaxially aligned.

[0071] The pressing means 500 of the second embodiment includes an eccentric clamp mechanism, and optionally at least one spring washer 560, 580. Particularly, the eccentric clamp mechanism includes at least one rotatable eccentric element 542 that is arranged rotatably relative to a shaft 520 from an initial position (shown in Fig. 3A) to a press position (shown in Fig. 3A). The shaft 520 of the pressing means 500 is inserted in the passage 35 of the first electrically conductive bushing 30, so as to extend at least through the first, second, third and fourth busbar portions, 10, 12, 20, 22. The shaft 520 includes a collar 530 which may be attached to the shaft 520 or integrally formed with the shaft 520. Said collar is adapted to engage with a spring washer 580 or with the

second busbar portion 12.

[0072] On the opposite side of the shaft 520, a base member 540 is provided that supports a bolt 544, which is associated to the at least one rotatable eccentric element 542. The rotatable eccentric element 542 is configured for applying a press force for pressing first, second, third and fourth busbar portions 10, 12, 20, 22 when being in the press position (cf. Fig. 3B).

[0073] The eccentric clamp mechanism further comprises a stop lug 546 and a corresponding stop lug 548. The stop lug 546 is arranged on the rotatable eccentric element 542 so as to be moveable relative to the shaft 520. The corresponding stop lug 548 is fixedly adhered relative to the shaft 520, here on the base member 540.

[0074] As shown in Fig. 3B, the stop lug 546 and corresponding stop lug 548 engage with each other, when the rotatable eccentric element 542 is rotated in the press position. Further, the stop lug 546 and corresponding stop lug 548 are locked to each other when the rotatable eccentric element 542 is in the press position, e.g. by a snap fitting to prevent an unintentional loosening of the established connection. Further, a screw bit receptacle 545, is associated with the rotatable eccentric element 542. Hence, the rotatable eccentric element can be actuated with standardized tools.

[0075] As shown in Figs. 3A and 3B, spring washers 560, 580 are sandwiched between the first busbar portion 10 and the rotatable eccentric element542 and between the second busbar portion 12 and a collar 530 of the shaft 520. Said spring washers provide for a constant pressing force over lifetime of the assembled busbar connection system 1.

[0076] Additionally, the busbar connection system comprises a cover 540, that is adapted to cover the pressing means 500 at least partially. Said cover 540 is fitted to the eccentric clamp mechanism, so as to cover the rotatable eccentric element 542, when being installed.

[0077] Fig. 4 is a detailed view of a spring washer 560, which is associated with an eccentric clamp mechanism including at least one rotatable eccentric element 542, as shown in Figs. 3A and 3B. Said spring washer 560 may have a through opening 566, that is adapted to the shape of the eccentric clamp mechanism, particularly the rotatable eccentric element 542. In the embodiment shown, the through opening 566 is keyhole shaped. Said keyhole-shaped opening has a first section 568 and a narrower second section 567. Said through opening 566 allows to arrange the spring washer 560 relative to the rotatable eccentric element 542 in at least two positions. In a first position the through opening allows the eccentric clamp mechanism, particularly the rotatable eccentric element 542, to pass through the spring washer 560, as shown in Fig. 3A. In a second position (as shown in Fig. 3B), which is different from the first position, the rotatable eccentric element 542 is hindered from passing through the spring washer 560. For moving the spring washer 560 from the first to the second position, the spring washer 560 is slidable relative to the pressing means 500 a direction C perpendicular to an axis of the shaft 520.

[0078] The first position serves for assembling/disassembling the pressing means 500 including the eccentric clamp mechanism. In the second position, a pressing force provided by the pressing means 500 can be transferred via the spring washer 560 to at least one of the busbar portions 10, 12, 20, 22.

[0079] Fig. 5 gives a flow diagram of the inventive method 1000 for electrically connecting busbar portions 10, 12, 20, 22 of different potentials Pi, P2 jointly. The method 1000 comprises the steps of providing 1100 a busbar assembly, which is configured as described above, and providing 1200 a second busbar portion 12 configured for the first electrical potential P1 and a fourth busbar portion 22 configured for the second electrical potential P2, the second and fourth busbar portions sandwiching an electrical insulator 70. In a further step 1300, an electrical connection is established by pressing the first, second, third and fourth busbar portions 10, 12, 20, 22 in a shaft axial direction using the pressing means 50; 500 of the busbar system 1, as described above.

List of reference signs

[0080]

1	busbar connection system
1a	busbar assembly
10	first busbar portion, potential P1
12	second busbar portion, potential P1
13	first receptacle
20	third busbar portion, potential P2
22	fourth busbar portion, potential P2
23	second receptacle
30	electrically conductive bushing
35	passage
40	first insulator bushing
50, 500	pressing means
52, 520	shaft
530	collar
53	screw head
54	nut
540	base member
542	rotatable eccentric element
544	bolt
545	screw bit receptacle
546	stop lug
548	corresponding stop lug
56, 560	spring washer
58, 580	spring washer
566	through opening, keyhole shaped
567	first section
568	second section
60	second electrically conductive bushing

70 second insulator bushing
80 cover

1000 method
1100 providing a busbar assembly
1200 providing second and fourth busbar portions
1300 establishing an electrical connection

P1 first potential, e.g. (+)
P2 first potential, e.g. (-)

Claims

1. A busbar connection system (1), for electrically connecting a first busbar portion (10) with a second busbar portion (12) and a third busbar portion (20) with a fourth busbar portion (22), the first and second busbar portions (10, 12) configured for a first electrical potential (Pi) and the third and fourth busbar portions (20, 22) configured for a second electrical potential (P2), the system (1) comprising

a first electrically conductive bushing (30), including a through hole for providing a passage (35) through the third and fourth busbar portions (20, 22) and being configured for electrically connecting the first busbar portion (10) with the second busbar portion (12);
a first insulator bushing (40), being configured for receiving the first electrically conductive bushing (30) at least partially and for electrically insulating busbar portions (10,12) configured for the first potential (Pi) from busbar portions (20, 22) configured for the second potential (P2), and
a pressing means (50; 500), comprising a shaft (52; 520) that is configured for being received in the first electrically conductive bushing (30) so as to extend through the passage (35), wherein the pressing means (50) is configured for pressing the first, second, third and fourth busbar portions (10, 12, 20, 22) in a shaft axial direction to electrically connect the first busbar portion (10) with the second busbar portion (12) and the third busbar portion (20) with the fourth busbar portion (22).

2. The busbar connection system (1) according to claim 1, further comprising a second electrically conductive bushing (60) being configured for receiving the first electrically conductive bushing (30) and optionally the first insulator bushing (40), wherein the second electrically conductive bushing (60) is configured for electrically connecting the third busbar portion (20) with the fourth busbar portion (22).

3. The busbar connection system (1) according to any preceding claim, further comprising a second insulator bushing (70), the second insulator bushing (70) being configured for receiving the first electrically conductive bushing (30) at least partially and for electrically insulating busbar portions (12) configured for the first potential (Pi) from busbar portions (22) configured for the second potential (P2), wherein the first and second insulator bushings (40, 70) may contact each other when the first, second, third and fourth busbar portions (10, 12, 20, 22) are pressed by the pressing means (50; 500).

4. The busbar connection system (1) according to any preceding claim, wherein the pressing means (50) includes a threaded shaft (52), a nut (54) and optionally at least one spring washer (56, 58).

5. The busbar connection system (1) according to any one of claims 1 to 3, wherein the pressing means (500) includes an eccentric clamp mechanism, and optionally at least one spring washer (560, 580), wherein the eccentric clamp mechanism includes at least one rotatable eccentric element (542) that is arranged rotatably relative to the shaft (520) from an initial position to a press position, and wherein the rotatable eccentric element (542) applies a press force for pressing the first, second, third and fourth busbar portions (10, 12, 20, 22), when being in the press position.

6. The busbar connection system (1) according to claim 5, wherein the eccentric clamp mechanism comprises a stop lug (546) and a corresponding stop lug (548) that are configured to engage with each other, when the rotatable eccentric element (542) is in the press position.

7. The busbar connection system (1) according to claim 5 or 6, further comprising a cover, being adapted to cover the pressing means (500) at least partially.

8. The busbar connection system (1) according to any preceding claim, wherein the shaft (52, 520), the first electrically conductive bushing (30) and the first insulator bushing (40) and optionally also the second electrically conductive bushing (60) and/or the second insulator bushing (70) are arranged coaxially.

9. The busbar connection system (1) according to any preceding claim, wherein the busbar connection system is configured to allow adjusting an angular offset of at least one of the first, second, third and/or fourth busbar portions (10, 12, 20, 22), prior to pressing.

10. A busbar assembly (1a), comprising

a first busbar portion (10) configured for a first electrical potential (Pi);
a third busbar portion (20) configured for a sec-

ond electrical potential (P2), the first and third busbar portions (10, 20) sandwiching an electrical insulator (40), wherein the first and third busbar portions (10, 20) include a receptacle (13);
a first electrically conductive bushing (30), providing a passage (35) and being configured for electrically connecting the first busbar portion (10) with a second busbar portion (12), and
a first insulator bushing (40), being configured for receiving the first electrically conductive bushing (30) at least partially and for electrically insulating busbar portions (10,12) configured for the first potential (Pi) from busbar portions (20, 22) configured for the second potential (P1), wherein
the first insulator bushing (40) and/or the first electrically conductive bushing (30) are configured for being inserted at least partially in the receptacle (13).

11. The busbar assembly (1a) according to claim 10, further comprising a second electrically conductive bushing (60) being configured for receiving the first electrically conductive bushing (30) and optionally the first insulator bushing (40), wherein the second electrically conductive bushing (60) is configured for electrically connecting the third busbar portion (20) with a fourth busbar portion (22).

12. A busbar system, comprising

the busbar assembly (1a) according to claim 10 or 11, and
a second busbar portion (12) configured for the first electrical potential (Pi) and a fourth busbar portion (22) configured for the second electrical potential (P2), the second and fourth busbar portions (12, 22) sandwiching an electrical insulator (70), the busbar system further comprising
a pressing means (50; 500), comprising a shaft (52; 520) that is configured for being received in the first electrically conductive bushing (30) so as to extend through the passage (35), wherein the pressing means (50) is configured for pressing first, second, third and fourth busbar portions (10, 12, 20, 22) in a shaft axial direction to electrically connect the first busbar portion (10) with the second busbar portion (12) and the third busbar portion (20) with the fourth busbar portion (22).

13. The busbar system according to claim 12, wherein the pressing means is configured according to any one of claims 4 to 7.

14. The busbar system according to claim 12 or 13, further comprising at least two additional busbar portions, configured for a third electrical potential, wherein the system is configured for electrically insulating busbar portions configured for the third potential from any of the busbar portions configured for the first and second potentials (Pi, P2), and further to electrically connect the at least two additional busbar portions by means of the pressing means (50; 500).

15. A method (1000) for electrically connecting first, second, third and fourth busbar portions (10, 12, 20, 22) of different potentials (Pi, P2) jointly, the method comprising

providing (1100) a busbar assembly (1a) according to claim 10 or 11,
providing (1200) a second busbar portion (12) configured for the first electrical potential (Pi) and a fourth busbar portion (22) configured for the second electrical potential (P2), the second and fourth busbar portions (12, 22) sandwiching an electrical insulator (70),
establishing (1300) an electrical connection by pressing the first, second, third and fourth busbar portions (10, 12, 20, 22) in a shaft axial direction using the pressing means (50; 500).

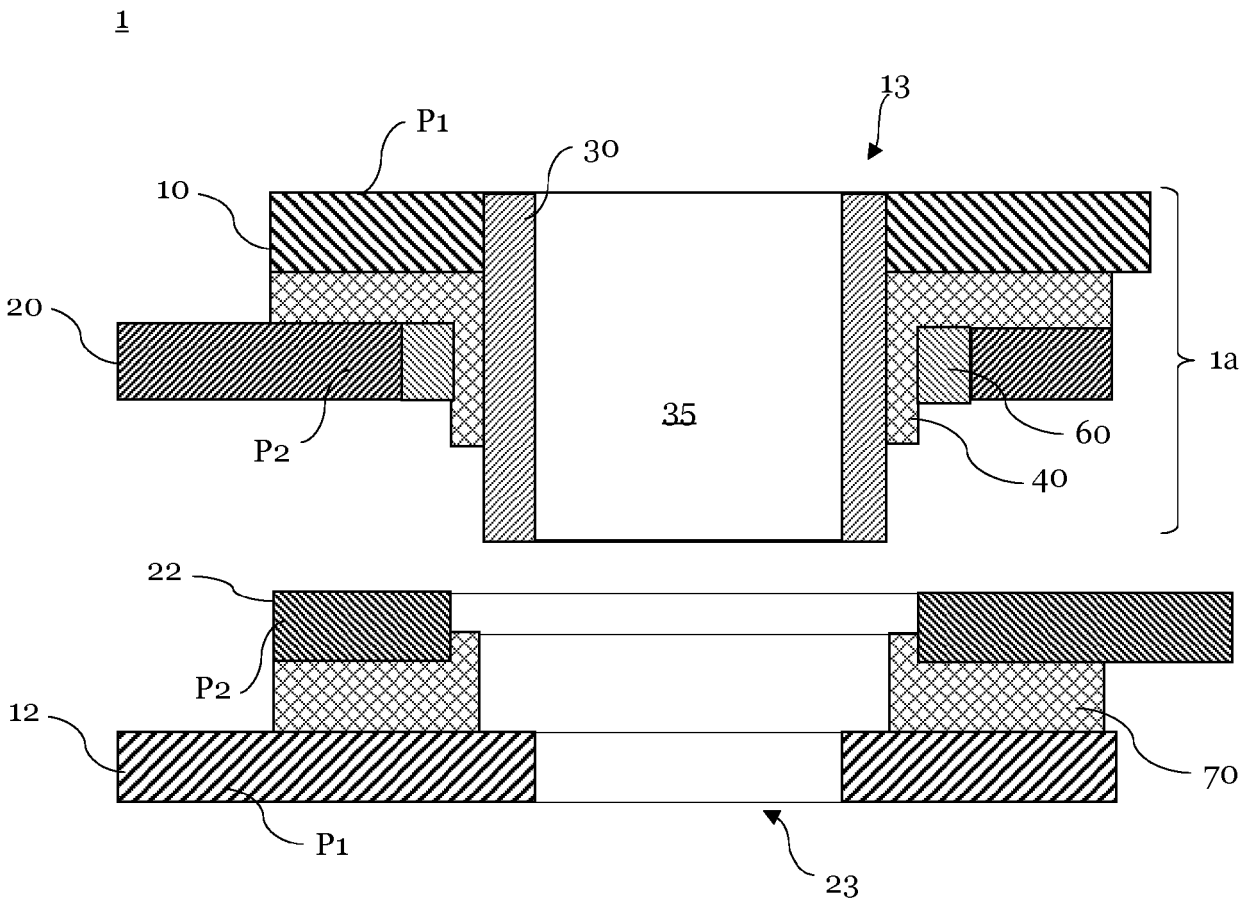

Fig. 1A

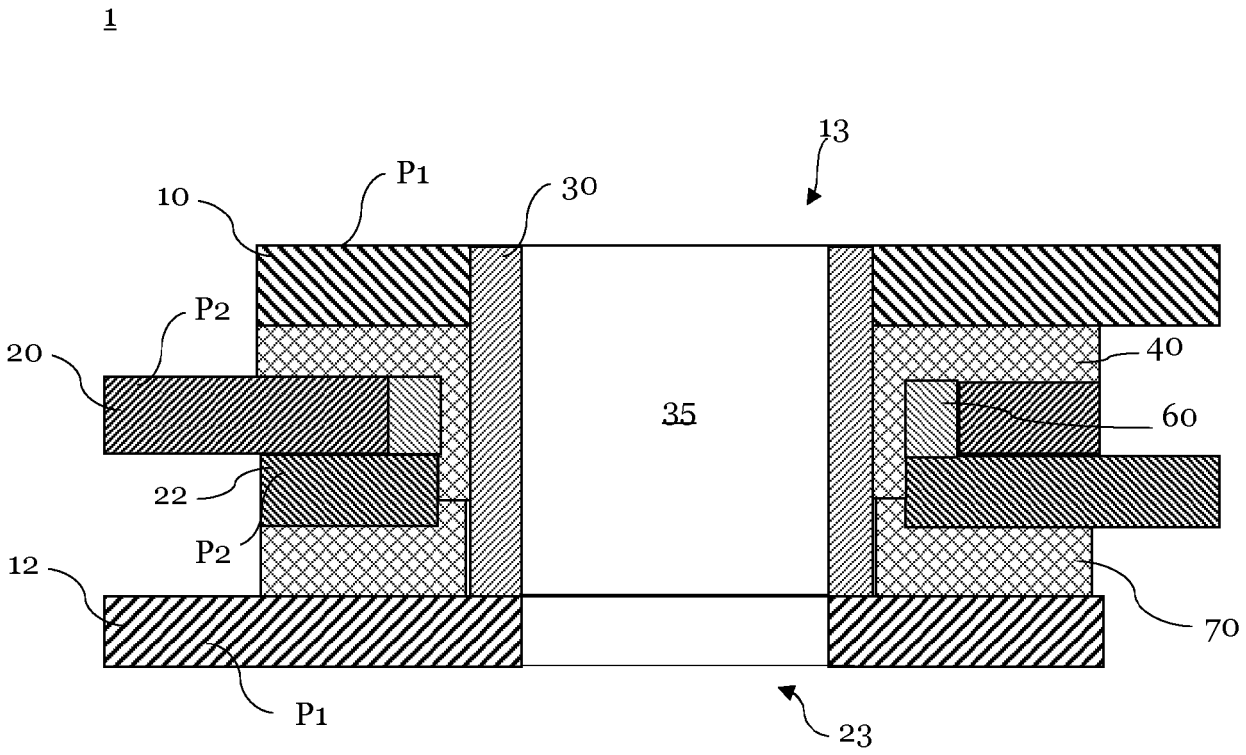

Fig. 1B

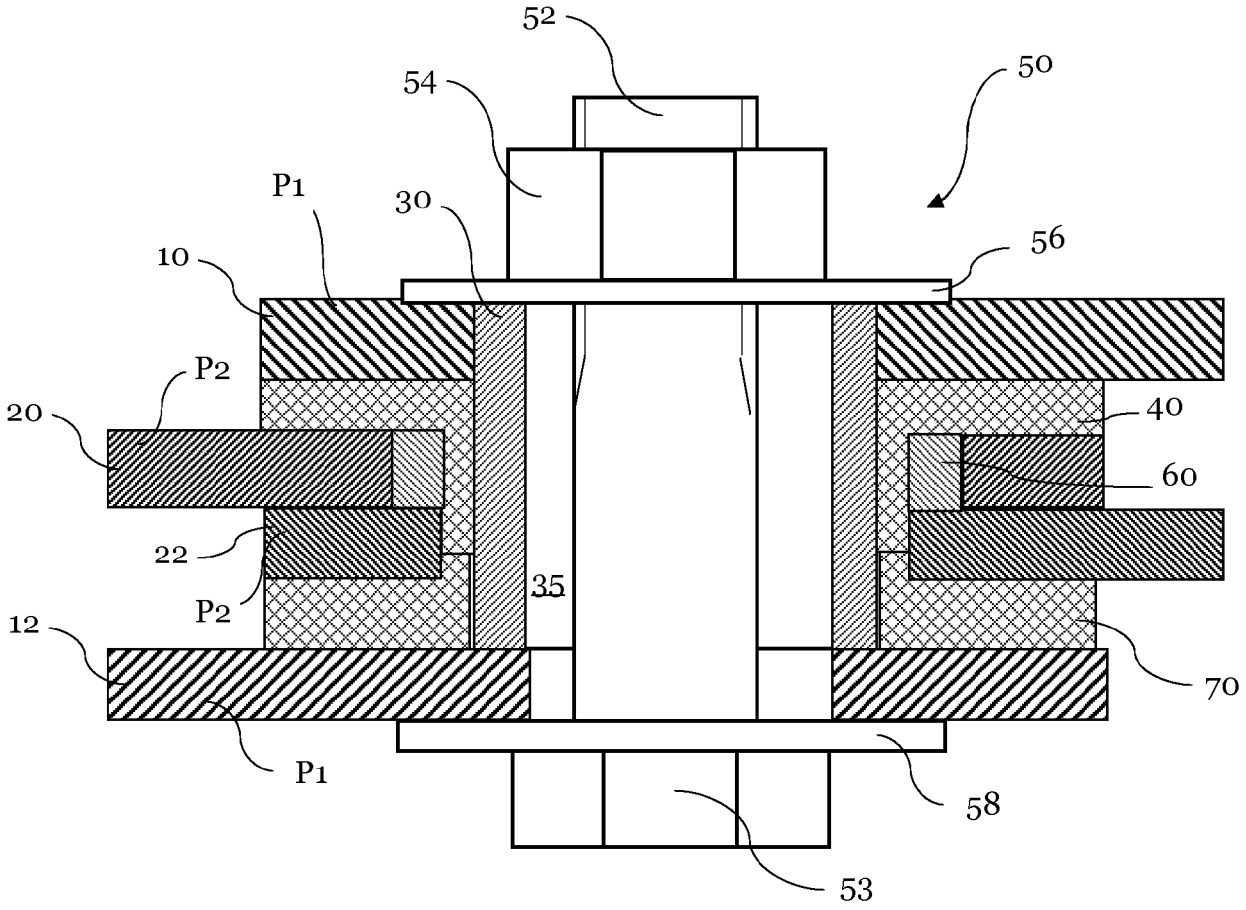

Fig. 2

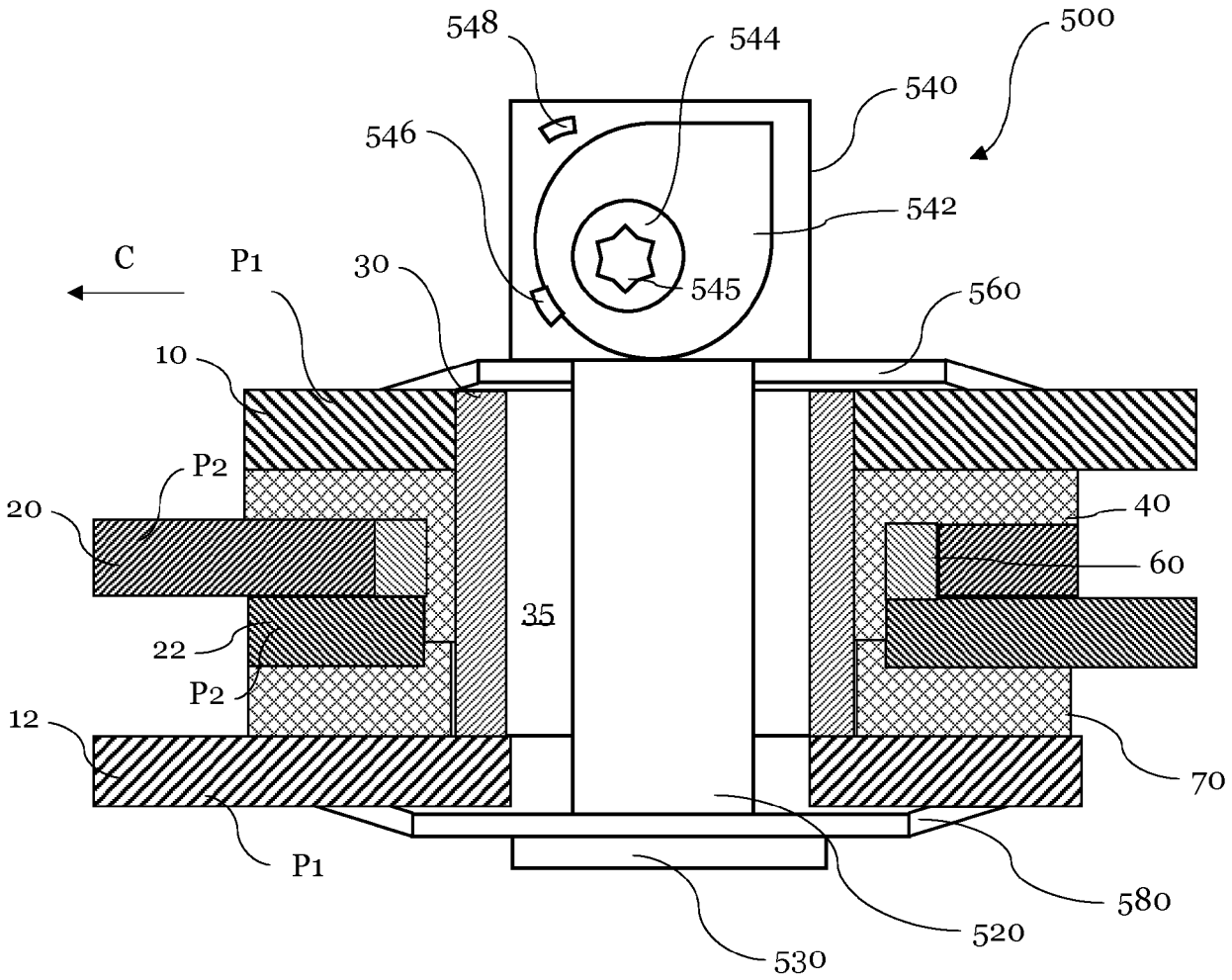
548
544
500
540
546
542
C
P1
30
545
560
10
P2
20
40
60
35
22
P2
12
70
P1
580
520
530

Fig. 3A

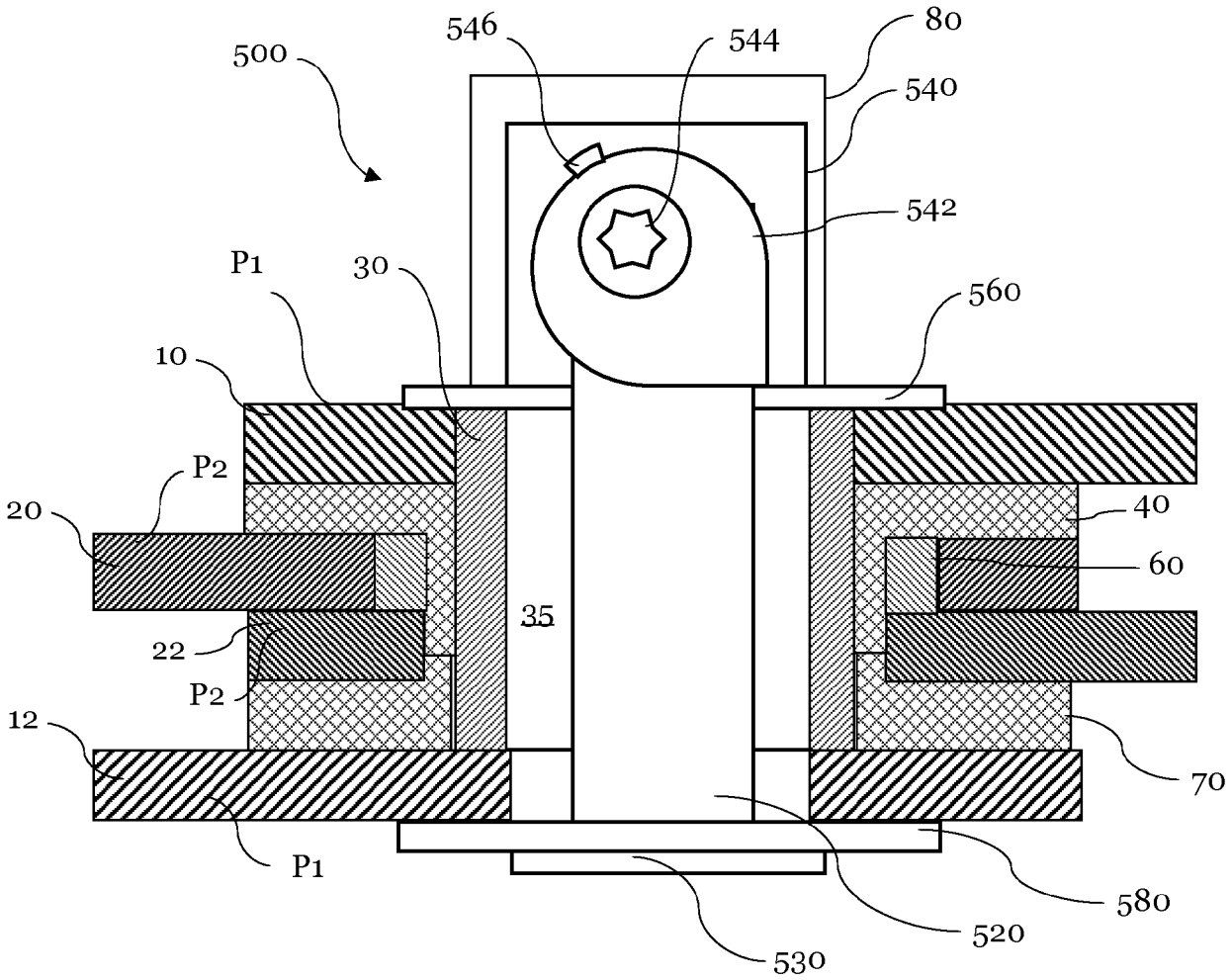
500
546
544
80
540
542
P1
30
560
10
P2
20
40
60
35
22
P2
12
70
P1
580
520
530

Fig. 3B

560

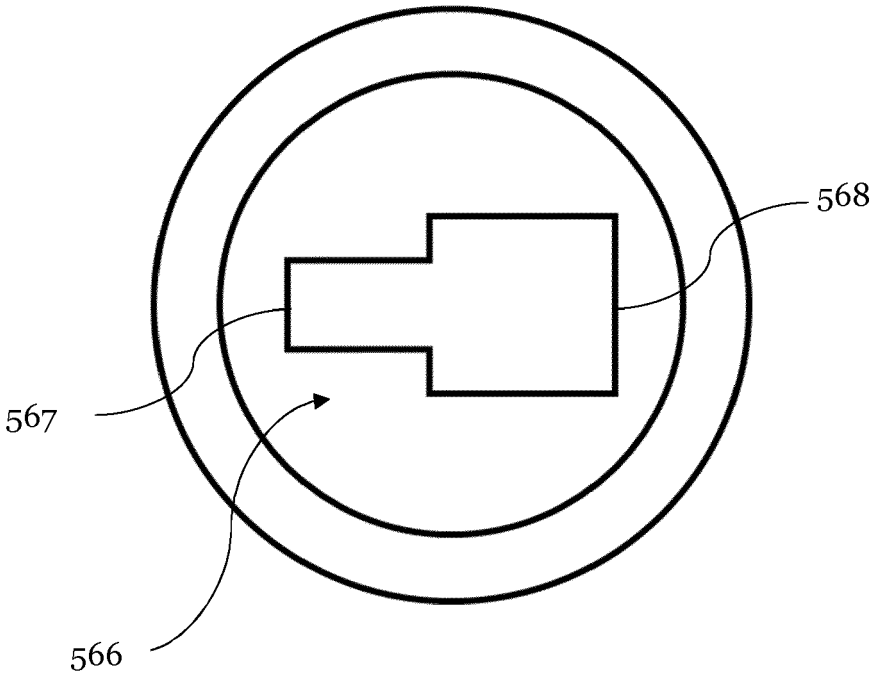

Fig. 4

1000

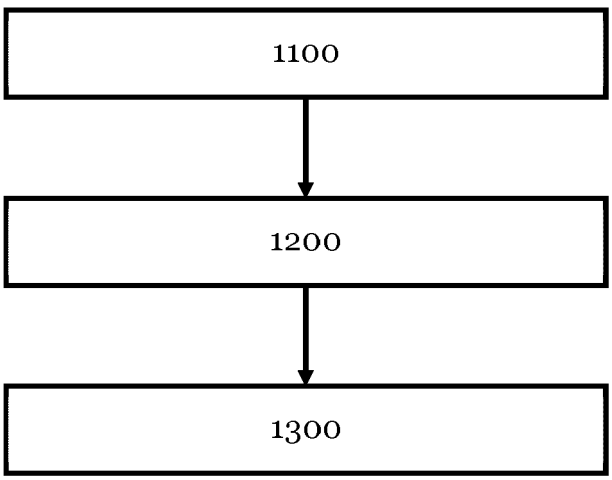

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 21 21 7080

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	"LAMINAR AND SEPARABLE ELECTRICAL CONNECTIONS WITH MULTIPLE CONTACTS", RESEARCH DISCLOSURE, KENNETH MASON PUBLICATIONS, HAMPSHIRE, UK, GB, no. 334, 1 February 1992 (1992-02-01), page 143, XP000291248, ISSN: 0374-4353 * page 1 *	1-15	
A	GB 717 640 A (HIGH DUTY ALLOYS LTD) 27 October 1954 (1954-10-27) * figures 1-4 * * pages 1,2 *	1-15	
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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
The Hague	1 June 2022	Kandyla, Maria

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01-06-2022

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