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(54) COUPLING DEVICE FOR COUPLING A LOAD TO A POWER LINE

(57) The invention relates to a coupling device and a method for inductively coupling a load to a power line, wherein the coupling device comprises a first coupling member and a second coupling member which are arranged to be mated in a coupling position, wherein the coupling members comprise transformer parts that form a transformer core for surrounding the power line, wherein the coupling device comprises first magnetic elements and second magnetic elements which are connected to the first coupling member and the second coupling member, respectively, for retaining the second coupling member to the first coupling member with a retaining force in a retaining direction, wherein the first coupling member is released from the second coupling member in a release direction opposite to the retaining direction when a release force, exceeding the retaining force, is exerted on the first coupling member in said release direction.

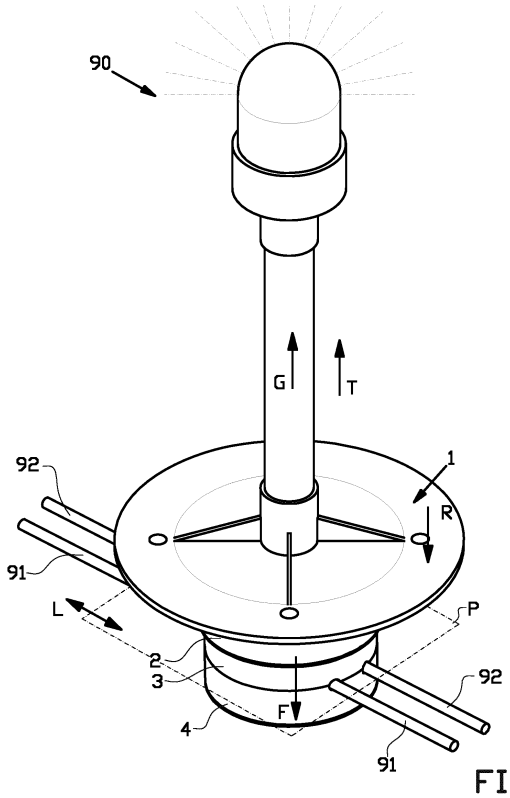

FIG. 1A

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Description

BACKGROUND

[0001] The invention relates to a coupling device for coupling a load to a power line.

[0002] Infrastructure, such as airfields, tunnels and/or offshore facilities, comprise a wide array of lighting features. The lighting features typically branch off from a main power line. Occasionally, said lighting features become detached unintentionally, for example due to a collision of a vehicle with said lighting features. EP 2 712 810 A1 discloses a taxi way light that is mounted in the ground and connected to a power source via a connector. The connector can disconnect the taxi way light from the power source when the taxi way light becomes dislocated. It is also known to provide lighting armatures which are provided with mechanical breaking zones to control the breaking behavior of the lighting feature with respect to the main power line.

[0003] A drawback of the known lighting features is that the breaking and/or disconnecting behavior is unpredictable and may, in some cases, still result in damage to or even exposure of the main power line. Furthermore, the lighting feature may be damaged beyond repair.

[0004] It is an object of the present invention to provide a coupling device for coupling a load to a power line, wherein the coupling device is arranged to release easily to prevent damage to the coupling device and/or the power line.

SUMMARY OF THE INVENTION

[0005] According to a first aspect, the invention provides a coupling device for coupling a load to a power line and for inductively transferring electrical power between the power line and the load, wherein the coupling device comprises a first coupling member and a second coupling member which are arranged to be mated in a coupling position at opposite sides of a mating plane, wherein the first coupling member and the second coupling member are provided with a first transformer part and a second transformer part, respectively, which in the coupling position form a transformer core for surrounding the power line, wherein the coupling device comprises one or more first magnetic elements and one or more second magnetic elements which are connected to the first coupling member and the second coupling member, respectively, wherein each of the one or more first magnetic elements in the coupling position is located opposite to a respective one of the one or more second magnetic elements in a retaining direction transverse to the mating plane, wherein the one or more first magnetic elements and the one or more second magnetic elements are arranged to be magnetically attracted to each other with a magnetic force, wherein the first coupling member is arranged to be retained in the retaining direction to the second coupling member with a retaining force comprising said magnetic force, wherein the first coupling member is arranged to be released from the second coupling member in a release direction opposite to the retaining direction when a release force, exceeding the retaining force, is exerted on the first coupling member in said release direction.

[0006] The first coupling member can be connected directly to the load. When the load is unintentionally dislocated, e.g. due to a collision with a vehicle, the release of the first coupling member from the second coupling member can prevent damage to the coupling device and/or the power line.

[0007] In an embodiment the first coupling member is arranged to be entirely spaced apart from the second coupling member in the released state. In other words, the first coupling member is arranged to be fully separated from the second coupling member in the release direction in the released state. The first coupling member can thus remain connected to the load without the dislocation of the load causing damage to the second coupling member and/or the power line.

[0008] In an exemplary embodiment the first coupling member is arranged to be retained to the second coupling member solely at the one or more first magnetic elements and the one or more second magnetic elements. In other words, the first coupling member is arranged to be retained to the second coupling member in the coupling position solely by the magnetic force between the one or more first magnetic elements and the one or more second magnetic elements. More specifically, the retaining force is the magnetic force. Hence, the retaining of the first coupling member to the second coupling member can be effectuated without mechanical connecting means. With no physical or mechanical connection between the first coupling member and the second coupling member, it can be prevented that the release of the first coupling member damages the second coupling member. The release can thus be more reliable and/or predictable.

[0009] In an alternative embodiment the coupling device comprises a hinge member that rotatably couples the second coupling member to the first coupling member about a hinge axis, wherein the hinge member is arranged for retaining the first coupling member to the second coupling member with a mechanical force, wherein the retaining force comprises the magnetic force and the mechanical force, wherein the hinge member is arranged for decoupling the first coupling member from the second coupling member in the release direction when the release force, exceeding the retaining force, is exerted on the first coupling member in said release direction. The hinging can facilitate and/or guide the manual opening of the coupling device, e.g. for maintenance purposes. Meanwhile the decoupling still allows for the release of the first coupling member from the second coupling member.

[0010] In an embodiment thereof the mechanical force is equal to or smaller than the magnetic force. Thus, the hinge member can be decoupled at the same moment

or prior to the release at the magnetic elements. The physical or mechanical connection of first coupling member to the second coupling member at the hinge member can thus be terminated at the same moment or prior to the actual release to prevent said connection from damaging the power line.

[0011] In a further embodiment thereof the hinge member comprises a first hinge part that is connected to the first coupling member and a second hinge part that is connected to the second coupling member, wherein the hinge parts are arranged to be interlocked in the retaining direction via a torsional snap fit connection that is arranged to detach when the release force is exerted on first hinge part in the release direction. The torsional snap fit connection can thus be terminated under the influence of the release force.

[0012] In a preferred embodiment the coupling device is arranged for receiving the power line in a longitudinal direction, wherein the hinge axis extends parallel to said longitudinal direction. The second coupling member can thus be rotated into the open position in a direction transverse or perpendicular to the longitudinal direction.

[0013] In an embodiment thereof the coupling device comprises a housing with a chamber for receiving the first coupling member, wherein the second coupling member is rotatable with respect to the first coupling member about the hinge axis into an open position, wherein the first coupling member, in the open position of the second coupling member, is slidable into and out of said chamber in a sliding direction parallel to the mating plane. The first coupling member can thus be easily extracted from and inserted back into the housing, e.g. for maintenance purposes.

[0014] In a further embodiment thereof the sliding direction is transverse or perpendicular to the longitudinal direction. The first coupling member can thus be removed in a direction transverse to the power line, making it accessible for manual removal.

[0015] In an embodiment the coupling device further comprises a biasing member that biases one of the first transformer part and the second transformer part against the other of the first transformer part and the second transformer part with a biasing force, wherein the biasing force partially counteracts the magnetic force. The clamping of the transformer parts around the power line can be improved, resulting in a more secure and/or effective inductive coupling between the load and the power line.

[0016] In an embodiment the retaining force is at least thirty newton and preferably at least forty newton. This can prevent the first coupling member from being released under the influence of minor forces.

[0017] In an embodiment the retaining force is less than one-hundred newton and preferably less than fifty newton. The first coupling member can thus be released from the second coupling member prior to the release force reaching levels that could potentially damage the coupling device and/or the power line.

[0018] In an embodiment the one or more first magnetic elements and the one or more second magnetic elements are spaced apart from the first transformer part and the second transformer part, respectively, in a spacing direction parallel to the mating plane. The spacing may prevent interference of the magnetic fields generated by the magnetic elements and the transformer core.

[0019] In an embodiment thereof the coupling device comprises at least one magnetic shielding member that is arranged to extend between the magnetic elements and the transformer core in the spacing direction to shield the transformer core from the magnetic elements. In this manner, interference can be prevented. This can be useful to prevent unintentional saturation of the transformer core, in particular when the power line also carries data which is to be reliably transferred between the load and the power line via the coupling device.

[0020] In a further embodiment thereof the coupling device comprises a plurality of the magnetic shielding members, wherein each shielding member extends circumferentially around one of the one or more first magnetic elements and a respective one of the second magnetic elements. Each set or pair of a first magnetic element and an opposite second magnetic element can thus be individually shielded.

[0021] In a further embodiment thereof the at least one shielding member comprises or consists of a material with a high magnetic permeability, preferably a mu-metal. Such materials can be very effective in shielding and/or deflecting magnetic fields.

[0022] In an embodiment each of the one or more first magnetic elements and the one or more second magnetic elements are displaceable with respect to each other in an unlocking direction perpendicular to the retaining direction. In said unlocking direction, the force required to displace the magnetic elements can be considerably lower than the magnetic force between the magnetic elements in the retaining direction.

[0023] In an embodiment thereof the one or more first magnetic elements and the one or more second magnetic elements are manually displaceable with respect to each other in the unlocking direction. Hence, the magnetic elements can be manually displaced in the unlocking direction without tools.

[0024] In a further embodiment thereof the second coupling member is displaceable with respect to the first coupling member in the unlocking direction. Preferably, the second coupling member is slidable with respect to the first coupling member in the unlocking direction. The second coupling member can be displaced together with the second magnetic elements thereof in the unlocking direction to intentionally release the second coupling member from the first coupling member, e.g. for maintenance purposes. This can be done manually, e.g. by simply sliding the second coupling member with respect to the first coupling member in the unlocking direction.

[0025] In a preferred embodiment the one or more first magnetic element and the one or more second magnetic

element are ferromagnetic elements, in particular permanent magnets. The permanent magnets can automatically retain the second coupling member to the first coupling member when their respective magnetic elements are within each other's magnetic fields.

[0026] In an embodiment the first transformer part and the second transformer part comprise or consist of ferrite. Ferrite can be quite brittle. A smooth release of the first coupling member with respect to the second coupling member can prevent damage to the transformer parts, such that they may be reusable after the release.

[0027] In an embodiment the retaining direction is normal to or substantially normal to the mating plane. In this way, the retaining force can act normal to mating plane, thereby securely and/or reliably retaining the first coupling member to the second coupling member.

[0028] In a preferred embodiment the power line comprises two or more conductive wires, wherein the ferrite core comprises an equal number of channels for receiving each of said two or more conductive wires.

[0029] According to a second aspect, the invention provides a method for coupling a load to a power line and for inductively transferring electrical power between the power line and the load with the use of the aforementioned coupling device, wherein the method comprises the steps of; mating the first coupling member and the second coupling member in the coupling position for forming a transformer core with the first transformer part and the second transformer part around the power line, releasing the first coupling member from the second coupling member in a release direction opposite to the retaining direction when a release force, exceeding the retaining force, is exerted on the first coupling member in said release direction.

[0030] The method and its embodiments have the same advantages as the coupling device and its corresponding features. These advantages will not be repeated hereafter for reasons of conciseness.

[0031] In an embodiment of the method the first coupling member is fully separated from the second coupling member in the release direction after the release.

[0032] In a further embodiment of the method the first coupling member is retained to the second coupling member solely by the magnetic force between the one or more first magnetic elements and the one or more second magnetic elements.

[0033] The various aspects and features described and shown in the specification can be applied, individually, wherever possible. These individual aspects, in particular the aspects and features described in the attached dependent claims, can be made subject of divisional patent applications.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] The invention will be elucidated on the basis of an exemplary embodiment shown in the attached schematic drawings, in which:

figure 1A shows an isometric top view of a coupling device according to a first embodiment of the invention, together with an exemplary lighting feature;
figure 1B shows the coupling device without the lighting feature;
figure 2 shows the coupling device according to figure 1 in a partially exploded view;
figure 3 shows the coupling device according to figure 2 from a lower perspective;
figure 4 shows the coupling device in cross section according to the line IV-IV in figure 1;
figure 5 shows a the coupling device in cross section according to the line V-V in figure 4;
figure 6 shows a cross section of an alternative coupling device according to a second embodiment of the invention;
figures 7A and 7B show the alternative coupling device in cross section according to the line VII-VII in figure 6 during subsequent steps of manual release of the alternative coupling device;
figure 8 shows an isometric view of a further alternative coupling device according to a third embodiment of the invention;
figures 9-11 shows the further alternative coupling device according to figure 8 in subsequent stages of disassembly; and
figure 12 shows the further alternative coupling device in cross section according to the line XII-XII in figure 8.

DETAILED DESCRIPTION OF THE INVENTION

[0035] Figure 1A, 1B and 2-5 shows a coupling device 1 according to a first embodiment of the invention. The coupling device 1 is used for coupling a load to a power line and for inductively transferring power between the power line and the load.

[0036] In this exemplary embodiment, the load is formed by a lighting feature 90 and the power line is formed by two insulated, electrically conductive wires 91, 92. The lighting feature 90 can be a light for a taxiway or runway of an airfield, a tunnel, an offshore installation or any other infrastructure. The wires 91, 92 are electrically connected to a source of alternating current. The coupling device 1 is arranged for inductively transferring the electrical power of the alternating current from the wires 91, 92 to the lighting feature 90. The wires 91, 92 may additionally carry data signals, which can be transferred inductively to the lighting feature 90, e.g. for controlling the lighting feature 90.

[0037] The coupling device 1 comprises a housing 2 that holds the electronics, e.g. a circuit board and/or transformer components, for electrically connecting the coupling device 1 to the lighting feature 90. The coupling device 1 further comprises a first coupling member 3 and a second coupling member 4. The housing 2 can be rigidly connected to the first coupling member 3 or can be an integral part of the first coupling member 3. In figure

1A, the first coupling member 3 and the second coupling member 4 are shown in a coupling position underneath the lighting feature 90. In said coupling position the first coupling member 3 and the second coupling member 4 are closely fitted and/or mated to each other at opposite sides of a mating plane P. In this exemplary embodiment, the wires 91, 92 are received at and/or extend through the coupling device 1 at or in the mating plane P. In particular, the wires 91, 92 extend through the coupling device 1 between the first coupling member 3 and the second coupling member 4. The longitudinal direction of the wires 91, 92 through the coupling device 1 is schematically indicated with arrow L.

[0038] The first coupling member 3 is arranged to be positioned on and/or mounted to the bottom of the lighting feature 90. As such, the first coupling member 3 can be considered as a upper member of the coupling device 1. The first coupling member 3 is arranged to be retained to the second coupling member 4 in a retaining direction R extending transverse, normal or perpendicular to the mating plane P. In this example, the first coupling member 3 and the second coupling member 4 are mated with respect to a horizontal or substantially horizontal mating plane P. Hence, the second coupling member 4 is arranged to be placed vertically opposite to the first coupling member 3. As such, the second coupling member 4 can be considered as an lower member, a cover or a lid of the coupling device 1 at a side of the first coupling member 3 that faces away from the lighting feature 90. Alternatively, the mating plane P can extend at any angle, e.g. vertically or at an oblique angle.

[0039] The first coupling member 3 can be rigidly connected to the lighting feature 90 with mechanical fasteners, such as screws or bolts. Alternatively, the first coupling member 3 can be connected to the lighting feature 90 via an electrical connection cable (not shown) that conducts the electrical power between the coupling device 1 and the lighting feature 90. In case of an electrical connection cable, the coupling device 1 can be spaced apart from the lighting feature 90, e.g. in a pit in the ground below the lighting feature 90.

[0040] As shown in figure 2, the housing 2 is arranged for receiving, housing and/or holding a transformer core 5. The transformer core 5 forms part of a transformer (not shown) that transfers the electrical power between the wires 91, 92 and the lighting feature 90. In particular, the transformer core 5 is at least partially within the secondary winding of a transformer (not shown). The transformer core 5 comprises a first transformer part 51 and a second transformer part 52. The transformer parts 51, 52 preferably comprise or consist of a magnetic material such as ferrite. In this exemplary embodiment, the first transformer part 51 is provided with channels 53 for receiving and guiding the wires 91, 92 into and out of the transformer core 5 in the longitudinal direction L. The second transformer part 52 is arranged to cover or close the channels 53 of the first transformer part 51.

[0041] As best seen in figure 2, the first coupling member 3 comprises a main body 30 and a recess 31 in said main body 30 for receiving the first transformer part 51. As best seen in figure 3, the second coupling member 4 comprises a main body 40 and a recess 41 in said main body 40 for receiving the second transformer part 52. As shown in cross section in figure 4, when the first coupling member 3 and the second coupling member 4 are mated in the coupling position, the first transformer part 51 and the second transformer part 52 are in abutment and form a continuous or substantially continues transformer body 50 extending circumferentially around the wires 91, 92 in a plane normal to the longitudinal direction L of said wires 91, 92. Both coupling members 3, 4 are provided with respective channels 32, 42 in their main bodies 30, 40 extending in the longitudinal direction L of the wires 91, 92 and guiding said wires 91, 92 into and out of the transformer core 5. By forming the transformer core 5 circumferentially around the wires 91, 92, the electrical power can be non-intrusively transferred by induction from the wires 91, 92 to the lighting feature 90.

[0042] Optionally, as shown in figure 4, the coupling device 1 is provided with one or more biasing members 6, e.g. springs, for biasing the first transformer part 51 with a biasing force B1 against the second transformer part 52. The biasing force B1 ensures that the transformer parts 51, 52 are securely clamped together. In this example, the biasing members 6 are placed in a space H between the first transformer part 51 and the recess 31 in the first coupling member 3. Hence, the first transformer part 51 is pushed off from the first coupling member 3 towards the second transformer part 52 in the second coupling member 4 with a biasing force B. Alternatively, the second transformer part 52 can be pushed off from the second coupling member 4 towards the first transformer part 51 by alternative biasing means (not shown).

[0043] As shown in figures 2, 3, and 4, the coupling device 1 is provided with a plurality of magnetic elements 7, preferably in the form of magnets or permanent magnets, for retaining the first coupling member 3 to the second coupling member 4 in the retaining direction R. In this exemplary embodiment, the plurality of magnetic elements 7 comprises a plurality of first magnetic elements 71 which are connected to the first coupling member 3 and an equal number of second magnetic elements 72 which are connected to the second coupling member 4. In the coupling position of the coupling members 3, 4, each of the first magnetic elements 71 is located opposite or directly opposite to a respective one of the second magnetic elements 72 in the retaining direction R. In particular, each pair of a first magnetic element 71 and a second magnetic element 72 has two mutually facing, opposite magnetic poles that are arranged to be magnetically attracted to each other when the coupling members 3, 4 are at or near the coupling position. As a result, the first coupling member 3 is pulled and/or retained onto the second coupling member 4. The total or combined magnetic force that is generated and/or exerted between the first magnetic elements 71 and the second magnetic

elements 72 in the retaining direction R is schematically indicated in figures 2, 3 and 4 with arrow M.

[0044] Preferably, the magnetic elements 71, 72 are ferromagnetic elements. In this exemplary embodiment, the magnetic elements 71, 72 are permanent magnets.

[0045] As best seen in cross section in figure 5, the first magnetic elements 71, and thus also the second magnetic elements 72, are spaced apart from the transformer core 5 in a spacing direction S parallel to the mating plane P. In particular, the first magnetic elements 71 are located outside the recess 31 that houses the first transformer part 51, while the second magnetic elements 72 are located outside the recess 41 that houses the second transformer part 52.

[0046] As shown in figures 2 and 3, the first coupling member 3 and the second coupling member 4 are provided with mutually facing mating surfaces 33, 43 which are arranged to be in abutment on opposite sides of the mating surface M when the coupling members 3, 4 are in the coupling position. As best seen in figure 2, the first magnetic elements 71 are recessed with respect to the mating surface 33 of the first coupling member 3. In particular, the first coupling member 3 is provided with a plurality of cavities, sockets or receptacles 34 that hold the first magnetic elements 71 in their respective recessed positions. As best seen in figure 3, the second magnetic elements 72 are protruding from the mating surface 43 of the second coupling member 4 towards the first coupling member 3. In particular, the second coupling member 4 is provided with a plurality of protrusions or lugs 44 that hold the second magnetic elements 72 in their respective protruding positions. In this exemplary embodiment, as shown in figures 2 and 3, the receptacles 34 have a cylindrical shape and the lugs 44 have a complimentary shape that fits into the shape of the receptacles 34. Hence, the second coupling member 4 is arranged to be placed with its lugs 44 in the corresponding receptacles 34 of the first coupling member 3.

[0047] As best seen in cross section in figure 4, the first magnetic elements 71 are positioned at the inside of the housing 2 facing away from the second coupling member 4. In other words, the first magnetic elements 71 are shielded from the second coupling member 4 by the housing 2 at the receptacles 34 to prevent direct contact with the second coupling member 4. In particular, the first magnetic elements 71 are partially encapsulated by the housing 2. Similarly, the second magnetic elements 72 are placed inside the lugs 44 and are shielded from the first coupling member 3 by the housing 2 at the lugs 44 to prevent direct contact with the first coupling member 3. When the coupling members 3, 4 are in the coupling position, as shown in figure 4, the first magnetic elements 71 and the second magnetic elements 72 are spaced apart over a small pole distance of less than five millimeters, and preferably less than three millimeters. Most preferably, the pole distance is as small as possible to reduce the dispersion or smearing of field lines, in particular the so-called 'H-field', from the magnetic field between the opposing magnetic poles of the first magnetic elements 71 and the second magnetic elements 72.

[0048] The magnetic fields from the various magnetic elements 71, 72 can potentially influence the magnetic behavior of the transformer core 5. In particular, the magnetic field may increase the saturation of the transformer core 5 which can ultimately distort the transfer of electrical power and/or data between the wires 91, 92 and the lighting feature 90. The invention aims to reduce or prevent said influence. To this end, the coupling device 1 comprises a plurality of shielding members 8 extending between the first magnetic elements 71 and the transformer core 5 in the spacing direction S to magnetically shield the transformer core 5 from the magnetic fields of the magnetic elements 71, 72 in said spacing direction S. As shown in cross section in figure 5, each shielding member 8 is formed like a bushing 80, having a circumferential wall 81 that is arranged to extend circumferentially around and/or surround one of the first magnetic elements 71 in the spacing direction S.

[0049] In this exemplary embodiment, the shielding members 8 are retained inside the housing 2 at the locations of the respective first magnetic elements 71. In particular, the shielding members 8 surround the receptacles 34 at the inside of the housing 2. The shielding members 8 may, as shown in figure 4, extend up to the mating surface 33 of the first coupling member 3 to additionally extend circumferentially around or surround the second magnetic element 72 when the latter is received in the respective receptacle 34. Thus, the shielding members 8 can provide a single and/or continuous shielding for both the first magnetic elements 71 and the second magnetic elements 72 when the coupling members 3, 4 are in the coupling position.

[0050] Alternatively, the additional shielding members (not shown) may be provided in or at the plugs 44 of the second coupling member 4 to shield the second magnetic elements 72, in which case the shielding members 8 as shown in figure 4 solely extend at the first magnetic elements 71. The shielding members 8 preferably comprise or consist of a material with a high magnetic permeability, e.g. a Mu-metal.

[0051] The aforementioned coupling device 1 is arranged to be clamped and/or coupled around the wires 91, 92 in the coupling position as shown in figures 1A, 1B and 4. The coupling can be achieved in-situ by placing one of the first coupling member 3 and the second coupling member 4 at one side of the mating plane P with the respective channels 32, 42 aligned with the longitudinal direction of the wires 91, 92, as shown in figure 2. Subsequently, the other of the first coupling member 3 and the second coupling member 4 is aligned with and placed against coupling member 3, 4 that is already in position at the wires 91, 92, as shown in figure 3. As the first coupling member 3 and the second coupling member 4 approach each other the first magnetic elements 71 and the second magnetic elements 72 are attracted to each other by the magnetic force M. The magnetic force

M retains the first coupling member 3 to the second coupling member 4.

[0052] As discussed before, the first transformer part 51 can optionally be biased with a biasing force B1 to move towards the second transformer part 52 thereby increasing the clamping of said transformer parts 51, 52 around the wires 91, 92. The biasing force B1 or its reaction force B2 is opposite to and thus partially counteracts the magnetic force M. As a result, the first coupling member 3 is retained to the second coupling member 4 by a retaining force F or a net retaining force F that is less than the magnetic force M. The biasing force B1 and the magnetic force M are chosen such that the retaining force F equals a release force G at which the first coupling member 3 should release form the second coupling member 3. The release force G is exerted on the first coupling member 3 in a release direction T, opposite to the retaining direction R, when the lighting device 90 connected to the first coupling member 3 is removed without disconnecting it from the first coupling member 3, e.g. in case of unintentional dislocation of the lighting device 90.

[0053] The retaining force R is at least thirty newton and preferably at least forty newton. The retaining force R is preferably less than one-hundred newton and most preferably less than fifty newton. In this exemplary embodiment, the biasing force B1 is approximately forty newton and the magnetic force M is approximately eighty newton. Hence, the retaining force R and the release force G are approximately forty newton.

[0054] In the absence of the biasing force B, the magnetic force M is equal or substantially equal to the retaining force R and/or the release force G.

[0055] In both cases, the first coupling member 3 is retained to the second coupling member 4 in the retaining direction R solely by magnetic forces. There are no mechanical means that further retain, resist or hinder the release. Hence, the release of the first coupling member 3 from the second coupling member 4 in the release direction T occurs automatically when the release force G exceeds the retaining force R. The first coupling member 3 is simply lifted from the second coupling member 4. Hence, the release itself does normally not cause any significant damage to the coupling device 1 or the wires 91, 92. The coupling device 1 remains fully functional and may even be reused immediately after the first coupling member 3 is returned to the coupling position. If the lighting feature 90 is undamaged and its connection to the first coupling member 3 has remained intact, the lighting feature 90, together with the first coupling member 3, can simply be returned to their previous positions to restore operation.

[0056] After the release, the first coupling member 3 is in a released state, e.g. as shown in figures 2 and 3, in which the first coupling member 3 is released or fully released from the second coupling member 4. In other words, the first coupling member 3 is spaced apart, fully spaced apart, separated, fully separated, detached and/or disconnected from the second coupling member 4. In the release state, the first coupling member 3 is a fully independent part of the coupling device 1 that can be returned to the coupling position or replaced if damaged.

[0057] Figures 6, 7A and 7B show an alternative coupling device 101 according to a second embodiment of the invention. As shown in figure 6, the alternative coupling device 101 differs from the coupling device 1 according to the first embodiment in that its first magnetic element 171 is provided at the bottom of an enlarged receptacle 134. In particular, the receptacle 134 has an elongate shape that forms a slot 135 extending in an unlocking direction U. In this exemplary embodiment, the unlocking direction U is parallel to or substantially parallel to the longitudinal direction L of the wires 91, 92. The slot 135 is arranged to receive the protrusion 144 with the corresponding second magnetic element 172. The slot 135 is dimensioned to allow the protrusion 144 to be displaced in the unlocking direction U within the boundaries of the slot 135. A similar slot 135 is provided for each set of a first magnetic element 171 and a second magnetic element 172, each slot 135 extending in the same unlocking direction U. Hence, all of the second ferromagnetic elements 172 can be simultaneously displaced in the unlocking direction U within the boundaries of the slots 135.

[0058] By providing all the slots 135 in the unlocking direction U, the second coupling member 104 can be displaced and/or slid with respect to the first coupling member 103 in the said unlocking direction U. When the unlocking direction U is parallel to the longitudinal direction L of the wires 91, 92, the channels 142 in the second coupling member 104 remain aligned with and can simply slide over the wires 91, 92 in the channels 132 of the first coupling member 103 in the longitudinal direction L. There is little or less magnetic resistance to said displacement as it occurs perpendicular to the retaining direction R and laterally with respect to the opposing magnetic poles of the magnetic elements 171, 172. Friction between the opposing magnetic elements 171, 172 can be reduced by providing smooth surfaces. The sliding can be performed manually. Once the second magnetic elements 172 are sufficiently displaced with respect to the first magnetic elements 171, their mutual magnetic attraction is reduced and the second coupling member 104 can be easily removed from the first coupling member 103 in the release direction T. The first coupling member 103 can remain attached to the lighting feature 90. The sliding in the unlocking direction U thus facilitates an easy way of intentionally releasing the first coupling member 103 and the second coupling member 104 with respect to each other, e.g. for maintenance purposes.

[0059] As shown in figure 6, the alternative coupling device 101 according to the second embodiment of the invention only comprises two first magnetic elements 171 and two second magnetic elements 172. However, it will be clear to one skilled in the art that these numbers can be varied, as demonstrated by the other embodiments

of the invention.

[0060] Figures 8-12 show a further alternative coupling device 201 according to a third embodiment of the invention. This alternative coupling device 201 is again provided with a first coupling member 203 and a second coupling member 204. The alternative coupling device 201 further comprises a housing 202 that is connectable to the lighting feature 90 in substantially the same manner as in the previous embodiments. The first coupling member 203 and the second coupling member 204 house a transformer core 205 having a first transformer part 251 in the first coupling member 203 and a second transformer part 252 in the second coupling member 204, similar in function to the coupling devices 1, 101 in the previously discussed embodiments. The alternative coupling device 201 differs from the previously discussed embodiments in that the further alternative coupling device 201 comprises a hinge member 210 that rotatably couples the second coupling member 204 to the first coupling member 203 about a hinge axis A. The second coupling member 204 thus acts as a rotatable cover or lid that can be intentionally manually opened, e.g. for maintenance purposes. A grip 245 is provided to ergonomically open and close the second coupling member 204. In this exemplary embodiment, the hinge axis A is parallel or substantially parallel to the longitudinal direction L of the wires 91, 92.

[0061] The further alternative coupling device 201 comprises a single first magnetic element 271 and a single second magnetic element 272 that are connected to the first coupling member 203 and the second coupling member 204, respectively, at a side of the wires 91, 92 opposite to the hinge member 210. The magnetic force M between the first magnetic element 271 and the second magnetic element 271 retains the second coupling member 204 in the coupling position as shown in figure 8 when it is rotated about the hinge axis A onto the first coupling member 203. Again, it will be apparent to one skilled in the art that the further alternative coupling device 201 can also be provided with a different number of magnetic elements 271, 272, as also demonstrated by the previously discussed embodiments.

[0062] As schematically shown in figure 12, the hinge member 210 is arranged for retaining the first coupling member 203 to the second coupling member 204 with a mechanical force N. The mechanical force N retains the first coupling member 203 to the second coupling member 204 together with the magnetic force M between the first magnetic element 271 and the second magnetic element 272. The retaining force R is thus equal to the sum of the magnetic force M and the mechanical force N. The hinge member 210 is arranged for decoupling the first coupling member 203 from the second coupling member 204 in the release direction T when a release force G that exceeds the retaining force R is exerted on the first coupling member 203 in said release direction T. Preferably, the mechanical force N is equal to or smaller than the magnetic force M, so that the hinge member 210 decouples prior to the release at the magnetic elements 271, 272.

[0063] To facilitate the decoupling of the first coupling member 203 from the second coupling member 204 at the hinge member 210, the first hinge part 211 and the second hinge part 212 are arranged to be interlocked in the retaining direction R via a torsional snap fit connection that is arranged to detach when the release force G is exerted on second hinge part 212 in the release direction T. In particular, as best seen in figure 12, one or both of the hinge parts 211, 212 are provided with flexible deflection parts 213, preferably from a resilient material such as plastic, that allow for the coupling and decoupling of the other hinge part 211, 212 under the influence of a force acting in the retaining direction R and the release direction T, respectively.

[0064] As shown in figures 10 and 11, the further alternative coupling device 201 further differs from the previously discussed embodiments in that the housing 202 comprises a main body 220 and a chamber 221 in said main body 220 for receiving the first coupling member 203. The chamber 221 is open in a sliding direction Y to allow for the insertion and/or extraction of the first coupling member 203 into and out of the housing 202, e.g. for maintenance purposes. In this exemplary embodiment, the sliding direction Y extends parallel to the mating plane P and transverse or perpendicular to the longitudinal direction L of the wires 91, 92. Before the first coupling member 203 can be extracted from the housing 202, the second coupling member 204 has to be rotated about the hinge axis A into the open position as shown in figure 10 and the second transformer part 252 has to be removed to not hinder the sliding movement of the first coupling member 203 in the sliding direction Y. As long as the second coupling member 204 remains coupled to the first coupling member 204 at the hinge member 210, it will move together with the first coupling member 201 in the sliding direction Y.

[0065] In this exemplary embodiment, the housing 202 is provided with two supports 222, 223 extending in the longitudinal direction L underneath the respective wires 91, 92 to support said wires 91, 92 with respect to the housing 202 rather than the first coupling member 203. Hence the first coupling member 203 can be removed from underneath the wires 91, 92 without affecting the positioning of the wires 91, 92 on the housing 202. The second coupling member 204 is provided with channels 242 for guiding the wires 91, 92 into and out of the channels 253 in the second transformer part 253. The housing 202 further comprises an opening 224 that aligns with the first magnetic element 271 in the retaining direction R when the first coupling member 203 is slid into place in the housing 202. The opening 224 additionally acts as a receptacle for the protrusion 244 that holds the opposing second magnetic element 272.

[0066] It is to be understood that the above description is included to illustrate the operation of the preferred embodiments and is not meant to limit the scope of the invention. From the above discussion, many variations will

be apparent to one skilled in the art that would yet be encompassed by the scope of the present invention.

[0067] For example, it is noted that the features of the first coupling member 3 and the second coupling member 4 can be interchanged. The protrusions 44 can be provided at the first coupling member 3 while the receptacles 34 can be provided at the second coupling member 4. In the same manner, the first transformer part 51 may be housed in the second coupling member 4 while the second transformer part 52 may be housed in the first coupling member 3.

[0068] In summary, the invention relates to a coupling device 1, 101, 201 and a method for inductively coupling a load 90 to a power line 91, 92, wherein the coupling device 1, 101, 201 comprises a first coupling member 3, 103, 203 and a second coupling member 4, 104, 204 which are arranged to be mated in a coupling position, wherein the coupling members comprise transformer parts 51, 52, 251, 252 that form a transformer core 5, 205 for surrounding the power line 91, 92, wherein the coupling device 1, 101, 201 comprises first magnetic elements 71, 171, 271 and second magnetic elements 72, 172, 272 which are connected to the first coupling member and the second coupling member, respectively, for retaining the first coupling member to the second coupling member with a retaining force R in a retaining direction R, wherein the first coupling member 3, 103, 203 is released from the second coupling member 4, 104, 204 in a release direction T opposite to the retaining direction R when a release force G, exceeding the retaining force F, is exerted on the first coupling member 3, 103, 203 in said release direction T.

Claims

1. Coupling device for coupling a load to a power line and for inductively transferring electrical power between the power line and the load, wherein the coupling device comprises a first coupling member and a second coupling member which are arranged to be mated in a coupling position at opposite sides of a mating plane, wherein the first coupling member and the second coupling member are provided with a first transformer part and a second transformer part, respectively, which in the coupling position form a transformer core for surrounding the power line, wherein the coupling device comprises one or more first magnetic elements and one or more second magnetic elements which are connected to the first coupling member and the second coupling member, respectively, wherein each of the one or more first magnetic elements in the coupling position is located opposite to a respective one of the one or more second magnetic elements in a retaining direction transverse to the mating plane, wherein the one or more first magnetic elements and the one or more second magnetic elements are arranged to be magnetically attracted to each other with a magnetic force, wherein the first coupling member is arranged to be retained in the retaining direction to the second coupling member with a retaining force comprising said magnetic force, wherein the first coupling member is arranged to be released from the second coupling member in a release direction opposite to the retaining direction when a release force, exceeding the retaining force, is exerted on the first coupling member in said release direction.

2. Coupling device according to claim 1, wherein the first coupling member is arranged to be entirely spaced apart and/or fully separated from the second coupling member in the released state.

3. Coupling device according to claim 1 or 2, wherein the first coupling member is arranged to be retained to the second coupling member solely at and/or by the magnetic force between the one or more first magnetic elements and the one or more second magnetic elements.

4. Coupling device according to any one of the preceding claims, wherein the retaining force is the magnetic force.

5. Coupling device according to claim 1 or 2, wherein the coupling device comprises a hinge member that rotatably couples the second coupling member to the first coupling member about a hinge axis, wherein the hinge member is arranged for retaining the first coupling member to the second coupling member with a mechanical force, wherein the retaining force comprises the magnetic force and the mechanical force, wherein the hinge member is arranged for decoupling the first coupling member from the second coupling member in the release direction when the release force, exceeding the retaining force, is exerted on the first coupling member in said release direction, preferably wherein the mechanical force is equal to or smaller than the magnetic force, preferably wherein the hinge member comprises a first hinge part that is connected to the first coupling member and a second hinge part that is connected to the second coupling member, wherein the hinge parts are arranged to be interlocked in the retaining direction via a torsional snap fit connection that is arranged to detach when the release force is exerted on first hinge part in the release direction.

6. Coupling device according to claim 5, wherein the coupling device is arranged for receiving the power line in a longitudinal direction, wherein the hinge axis extends parallel to said longitudinal direction, preferably wherein the coupling device comprises a housing with a chamber for receiving the first coupling member, wherein the second coupling member

is rotatable with respect to the first coupling member about the hinge axis into an open position, wherein the first coupling member, in the open position of the second coupling member, is slidable into and out of said chamber in a sliding direction parallel to the mating plane, preferably wherein the sliding direction is transverse or perpendicular to the longitudinal direction.

7. Coupling device according to any one of the preceding claims, wherein the coupling device further comprises a biasing member that biases one of the first transformer part and the second transformer part against the other of the first transformer part and the second transformer part with a biasing force, wherein the biasing force partially counteracts the magnetic force.

8. Coupling device according to any one of the preceding claims, wherein the retaining force is at least thirty newton and preferably at least forty newton and/or wherein the retaining force is less than one-hundred newton and preferably less than fifty newton.

9. Coupling device according to any one of the preceding claims, wherein the one or more first magnetic elements and the one or more second magnetic elements are spaced apart from the first transformer part and the second transformer part, respectively, in a spacing direction parallel to the mating plane.

10. Coupling device according to claim 9, wherein the coupling device comprises at least one magnetic shielding member that is arranged to extend between the magnetic elements and the transformer core in the spacing direction to shield the transformer core from the magnetic elements, preferably wherein the coupling device comprises a plurality of the magnetic shielding members, wherein each shielding member extends circumferentially around one of the one or more first magnetic elements and a respective one of the second magnetic elements, preferably wherein the at least one shielding member comprises or consists of a material with a high magnetic permeability, preferably a mu-metal.

11. Coupling device according to any one of the preceding claims, wherein each of the one or more first magnetic elements and the one or more second magnetic elements are displaceable with respect to each other in an unlocking direction perpendicular to the retaining direction, preferably wherein the one or more first magnetic elements and the one or more second magnetic elements are manually displaceable with respect to each other in the unlocking direction.

12. Coupling device according to claim 11, wherein the second coupling member is displaceable with respect to the first coupling member in the unlocking direction, preferably wherein the second coupling member is slidable with respect to the first coupling member in the unlocking direction.

13. Coupling device according to any one of the preceding claims, wherein the one or more first magnetic element and the one or more second magnetic element are ferromagnetic elements, in particular permanent magnets.

14. Coupling device according to any one of the preceding claims, wherein the first transformer part and the second transformer part comprise or consist of ferrite.

15. Coupling device according to any one of the preceding claims, wherein the retaining direction is normal to or substantially normal to the mating plane.

16. Coupling device according to any one of the preceding claims, wherein the power line comprises two or more conductive wires, wherein the ferrite core comprises an equal number of channels for receiving each of said two or more conductive wires.

17. Method for coupling a load to a power line and for inductively transferring electrical power between the power line and the load with the use of the coupling device according to any one of the preceding claims, wherein the method comprises the steps of; mating the first coupling member and the second coupling member in the coupling position for forming a transformer core with the first transformer part and the second transformer part around the power line, releasing the first coupling member from the second coupling member in a release direction opposite to the retaining direction when a release force, exceeding the retaining force, is exerted on the first coupling member in said release direction.

18. Method according to claim 17, wherein the first coupling member is fully separated from the second coupling member in the release direction after the release and/or wherein the first coupling member is retained to the second coupling member solely by the magnetic force between the one or more first magnetic elements and the one or more second magnetic elements.

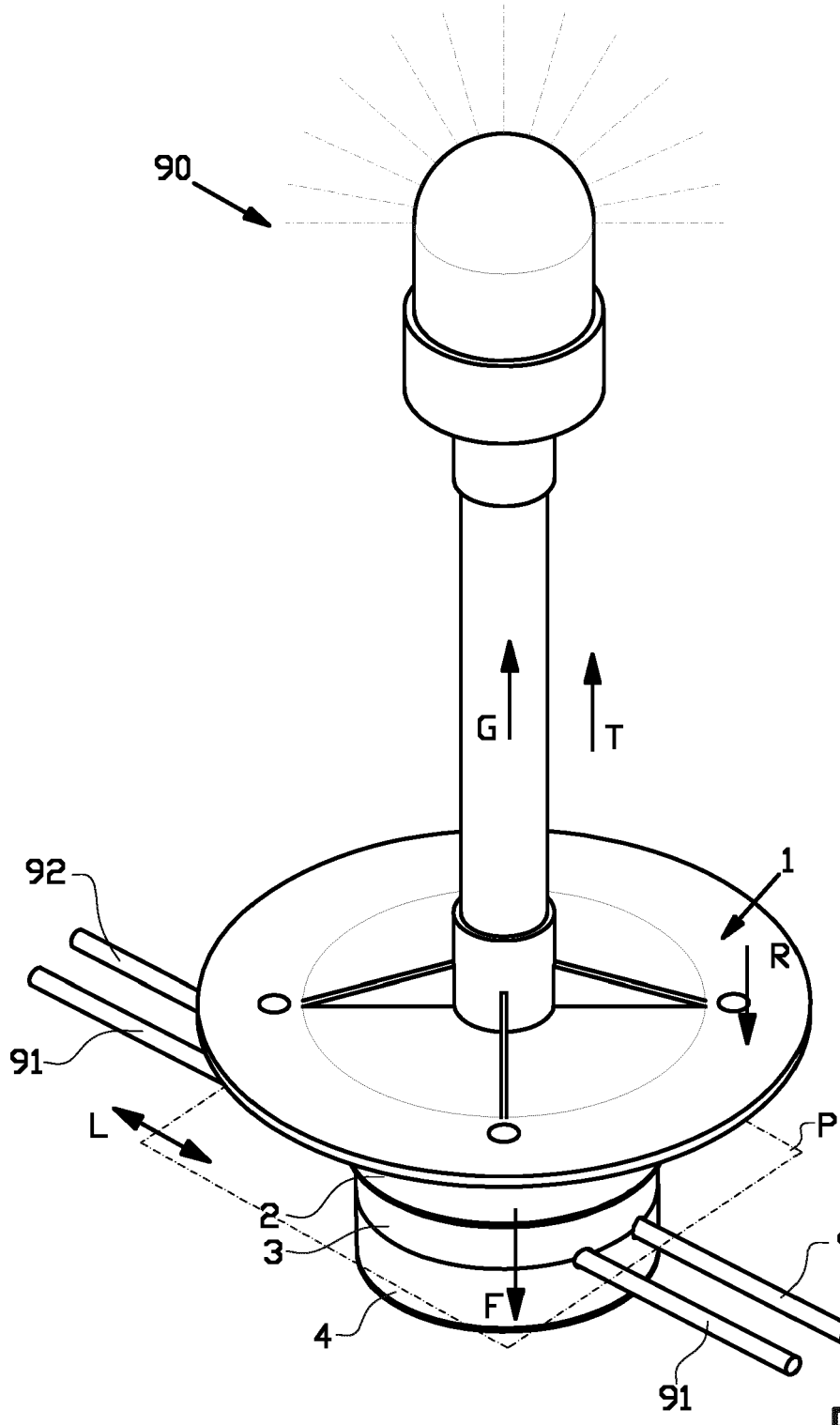

FIG. 1A

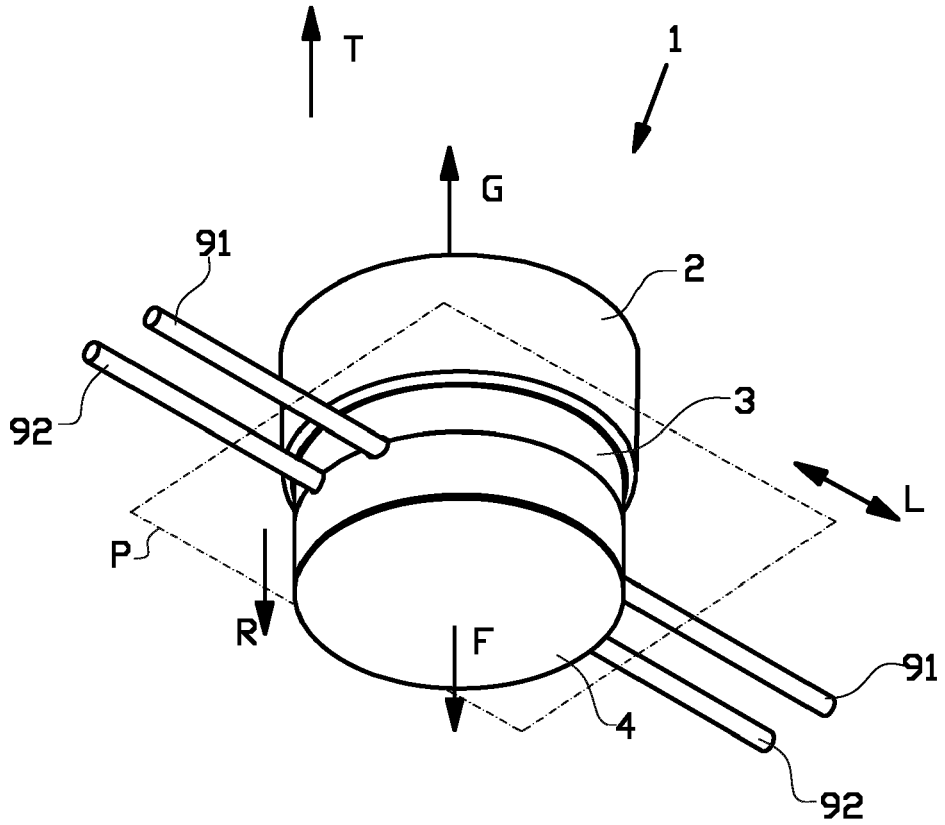

FIG. 1B

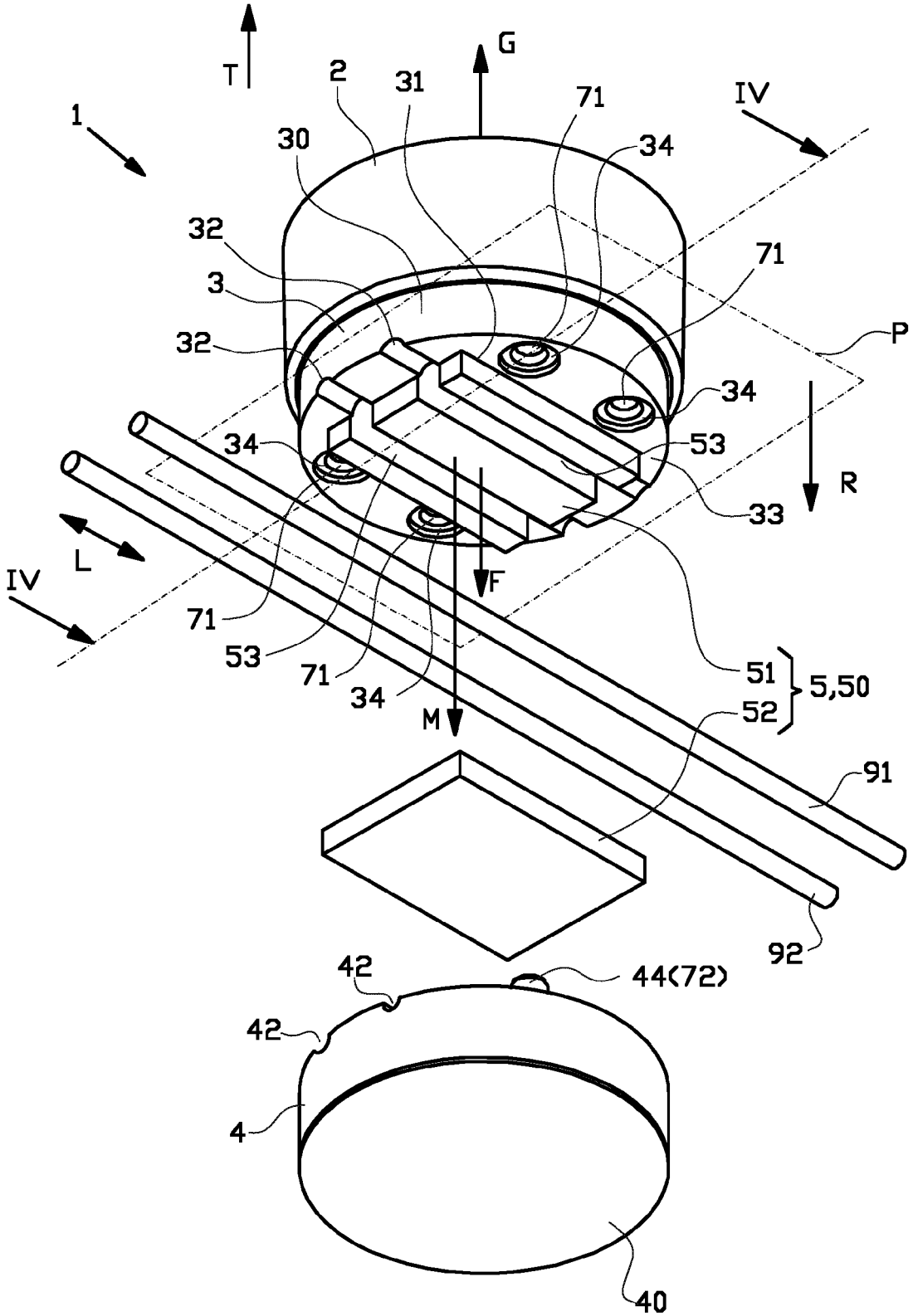
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FIG. 2

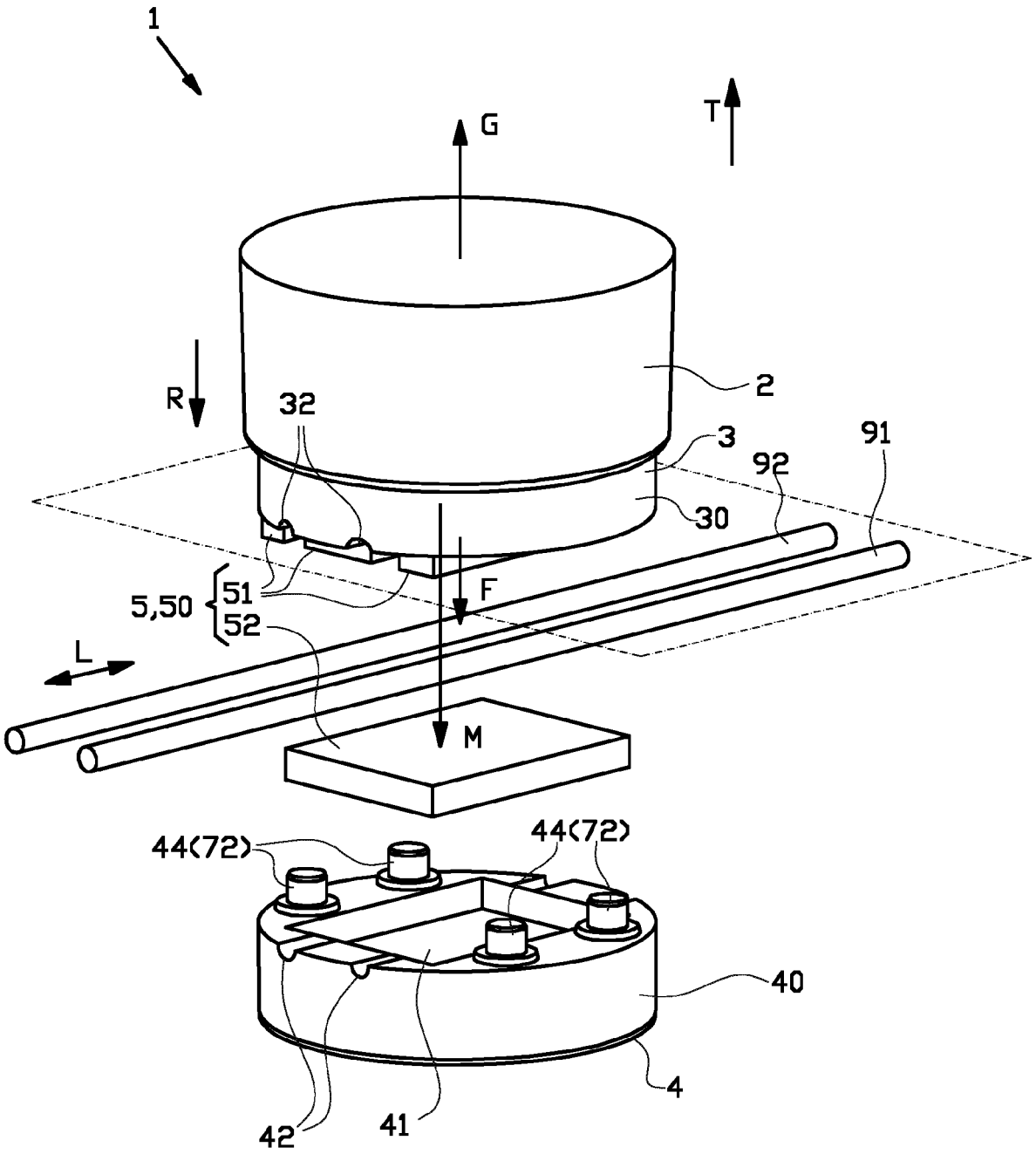
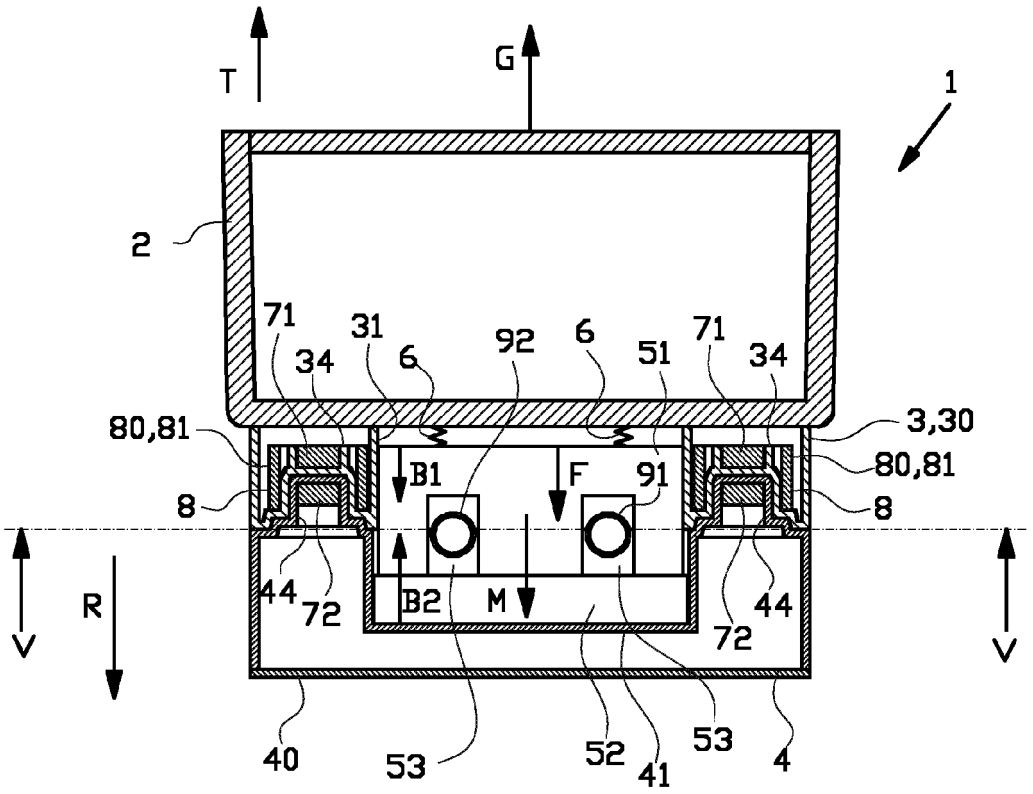


FIG. 3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53
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FIG. 4

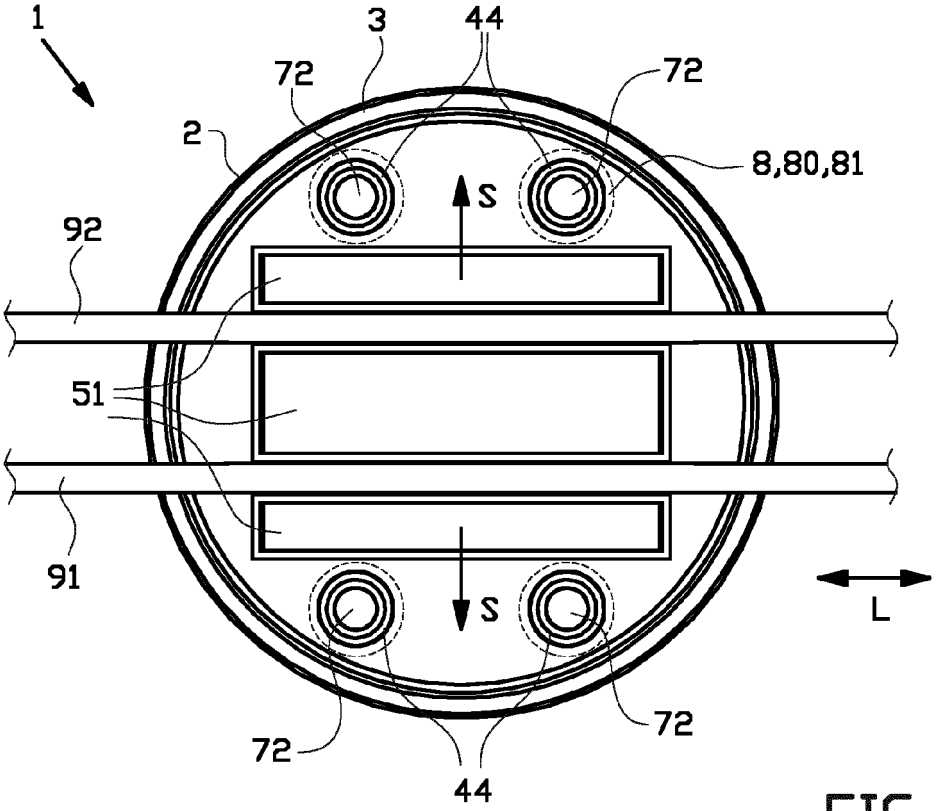
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FIG. 5

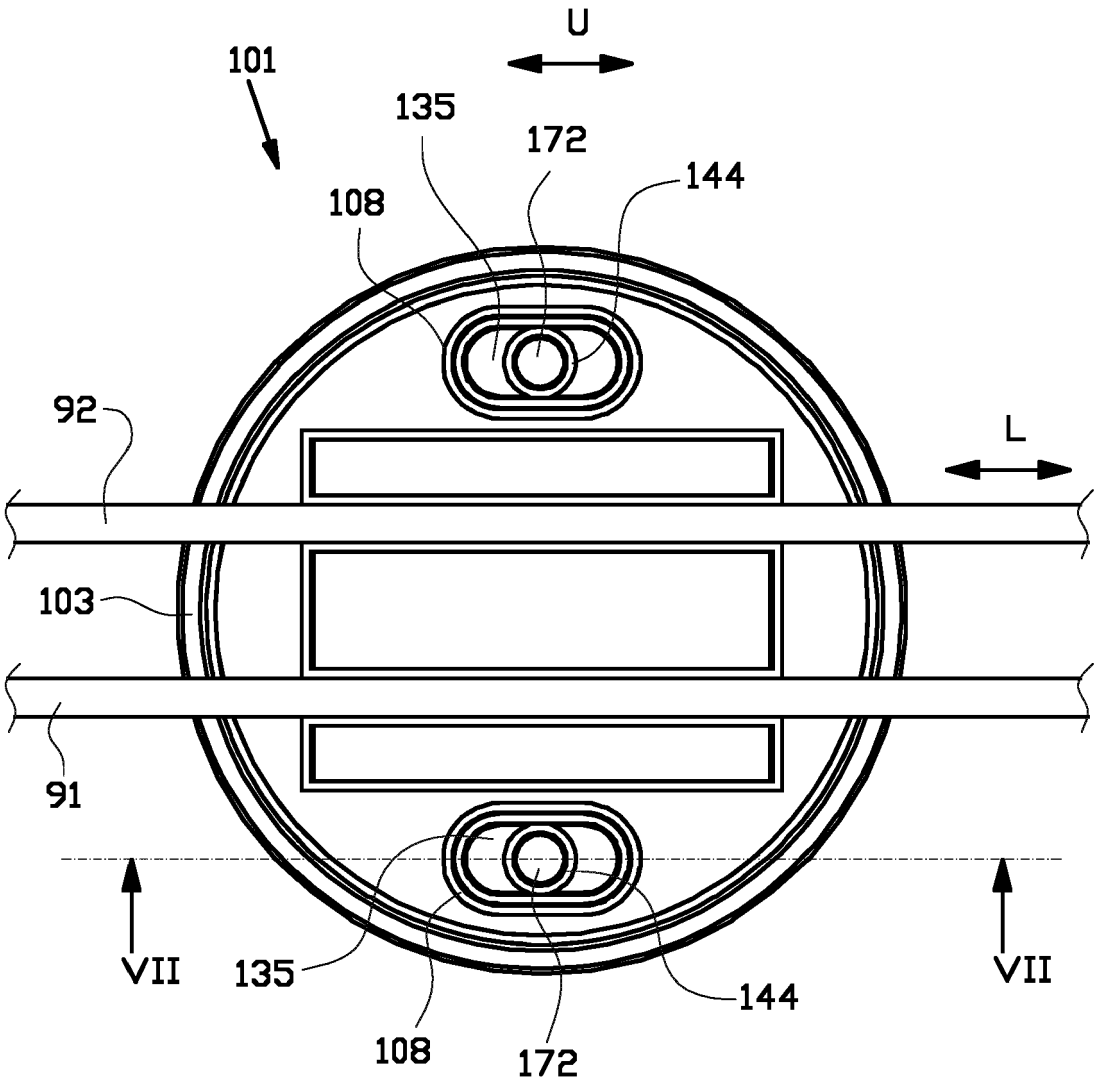

FIG. 6

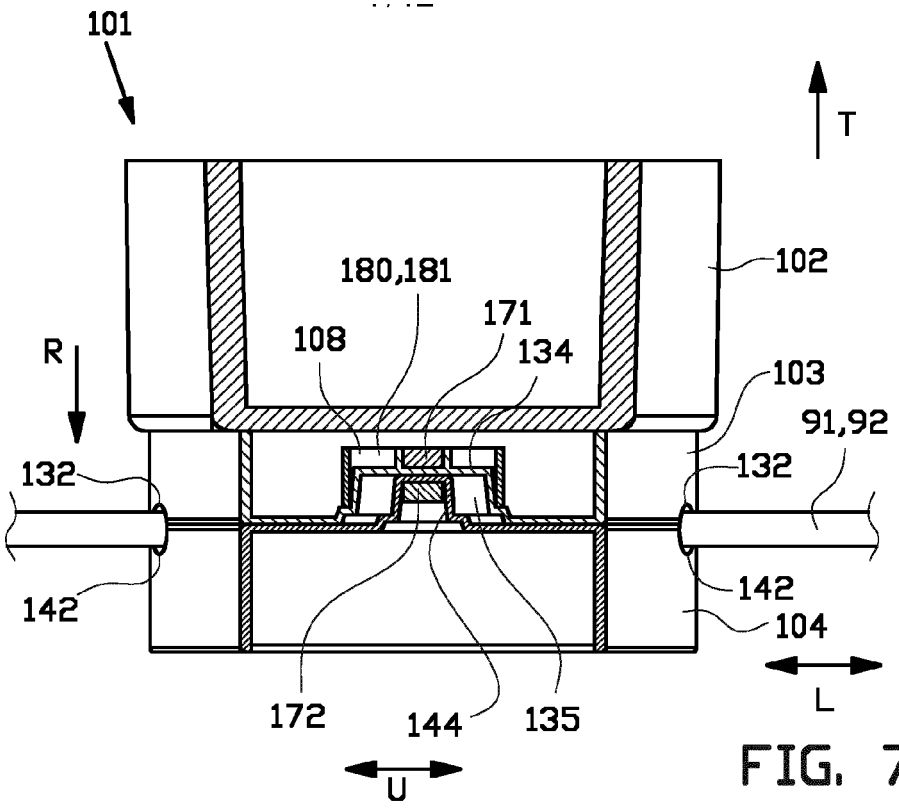
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FIG. 7A

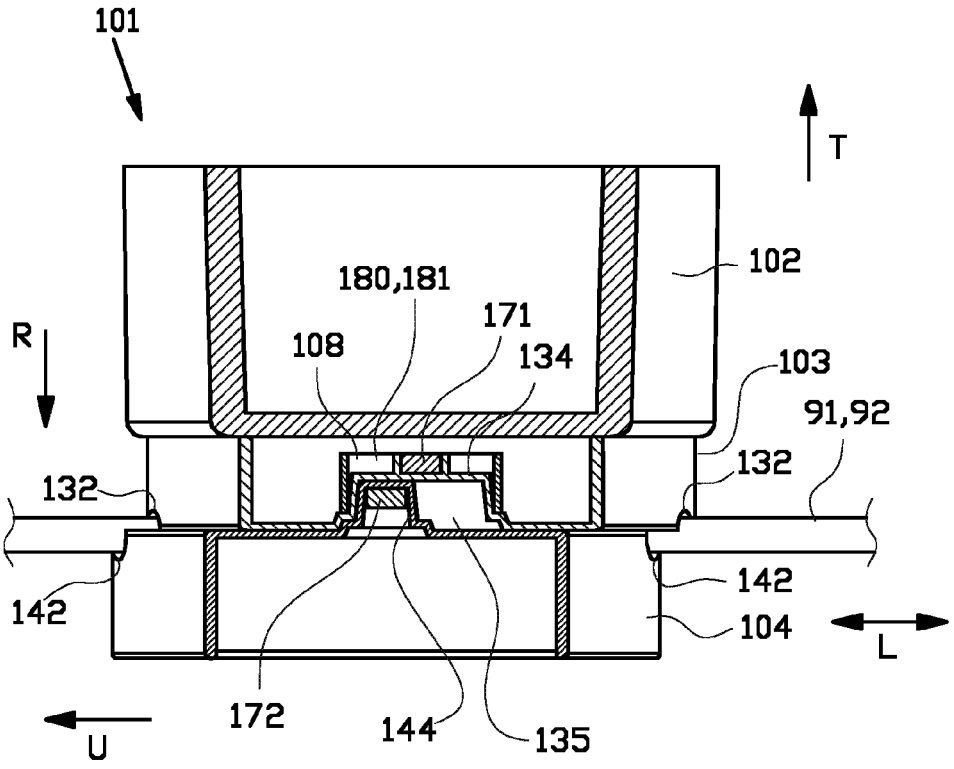
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FIG. 7B

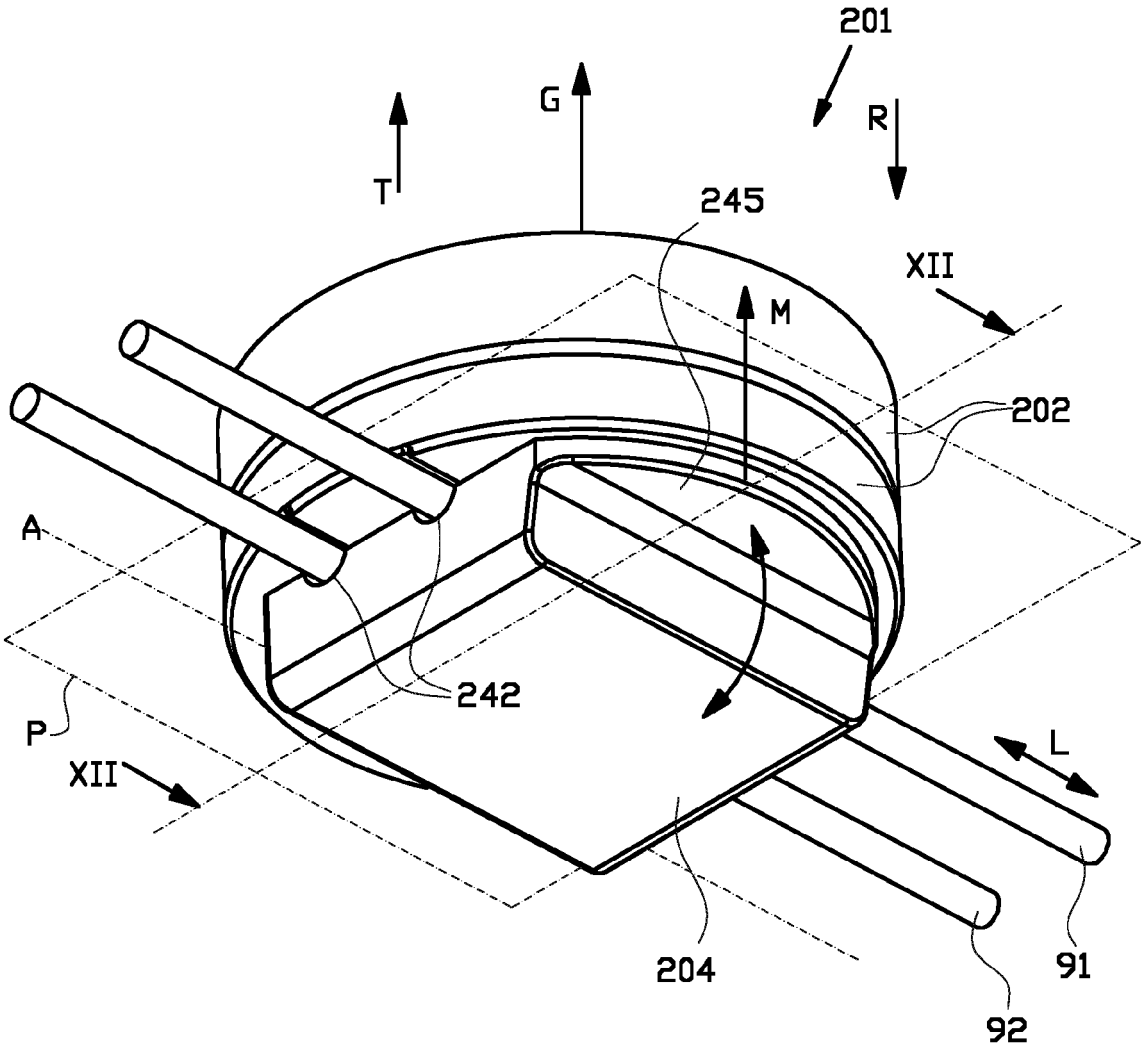

FIG. 8

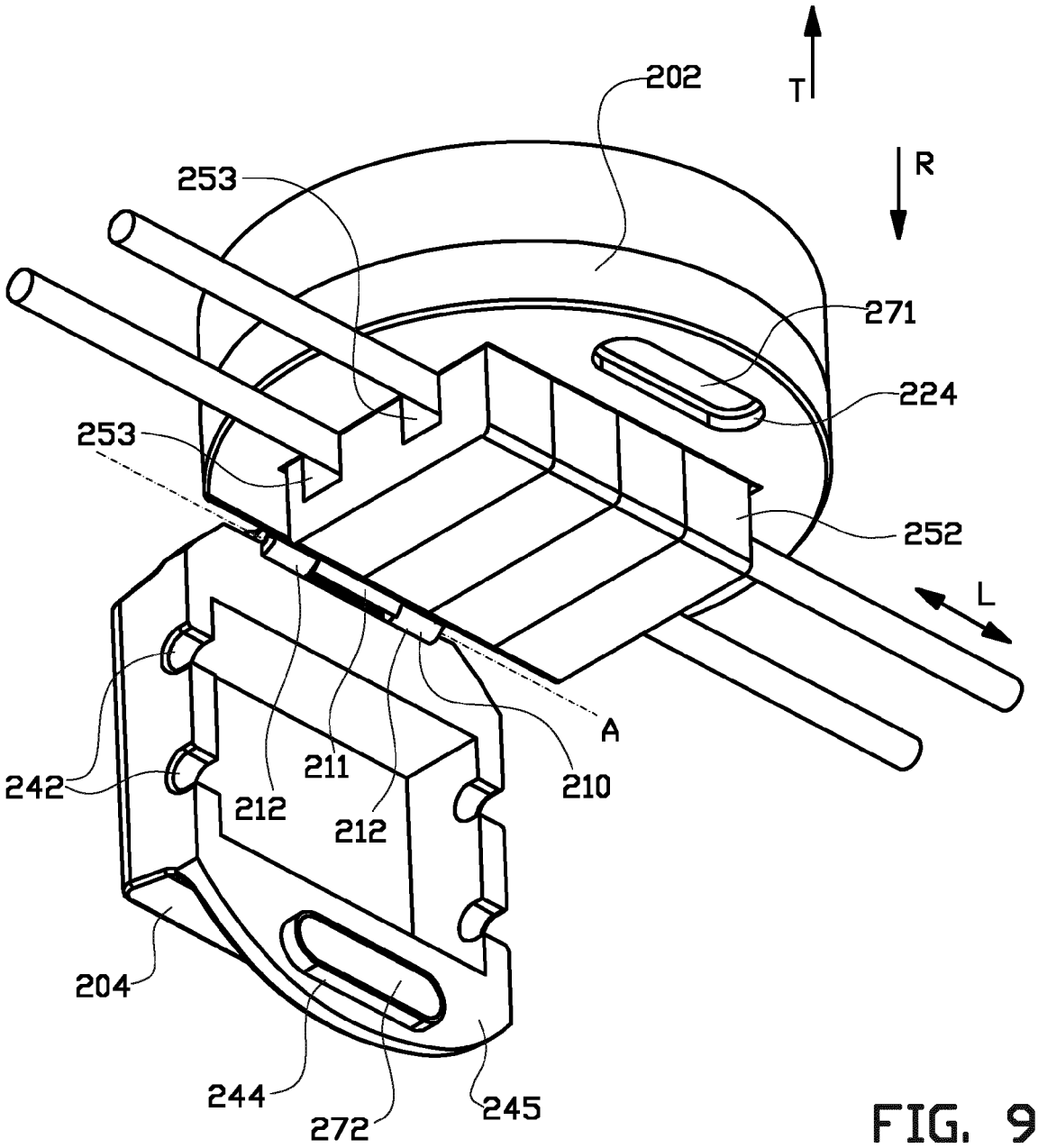

FIG. 9

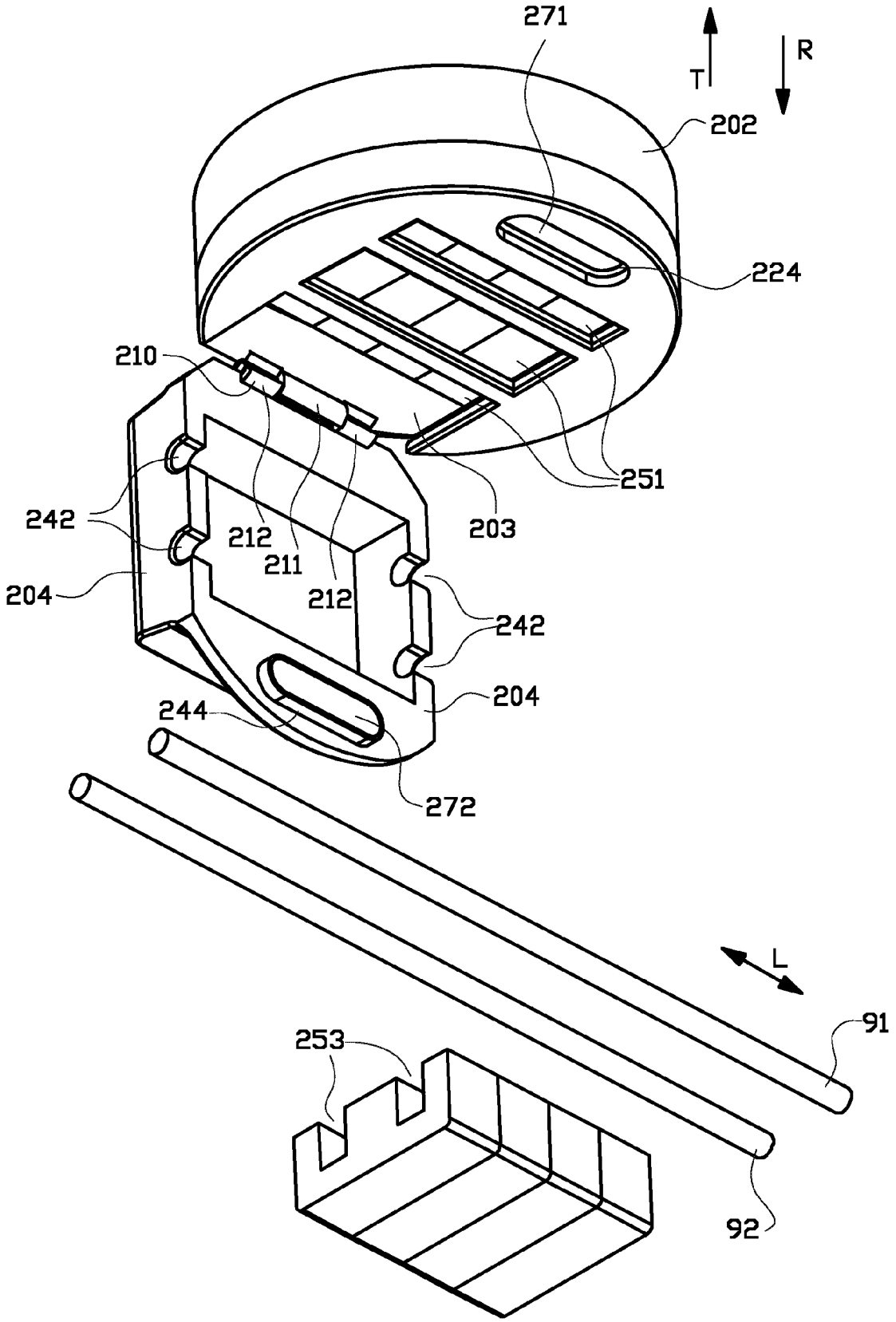
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FIG. 10

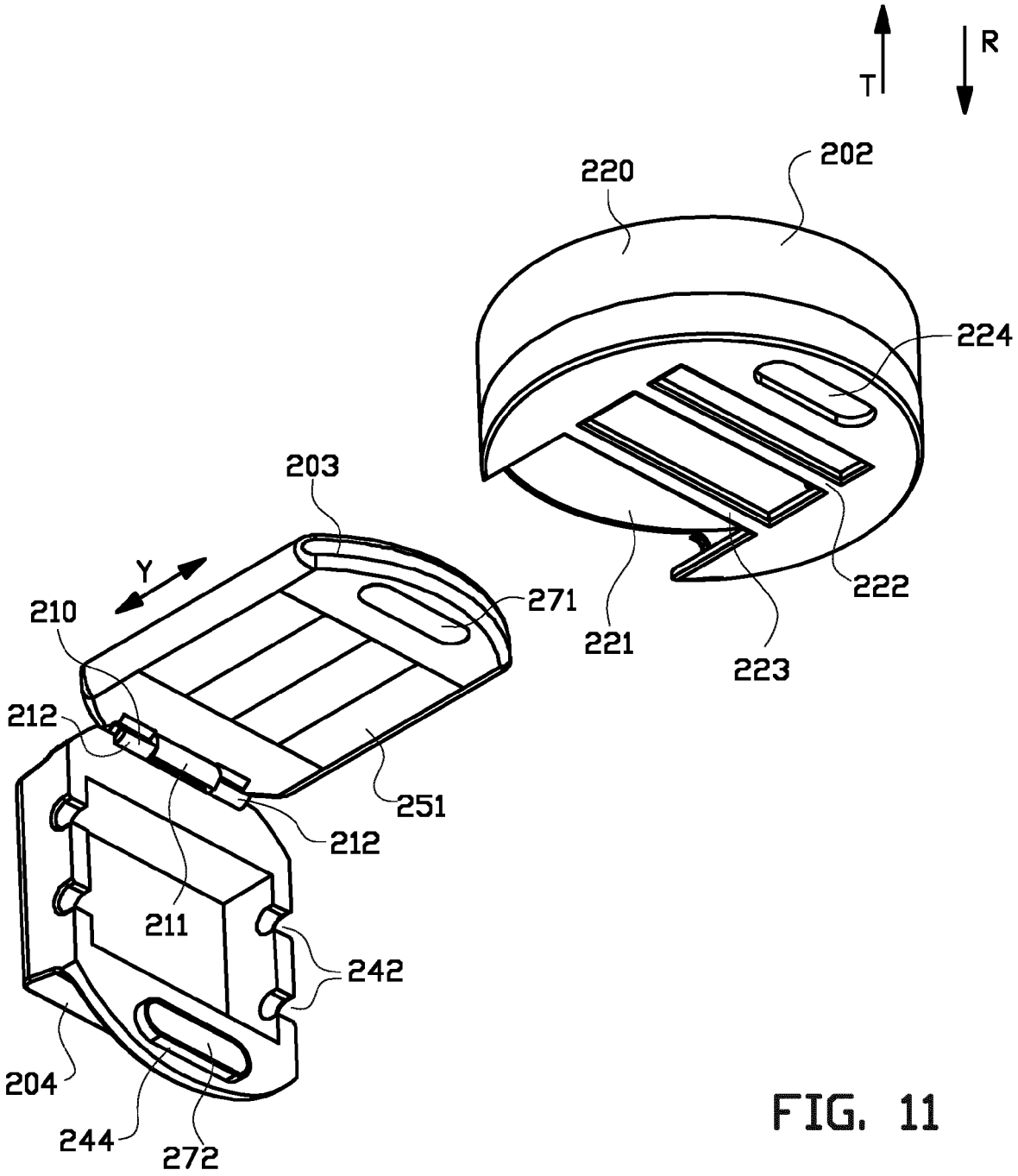
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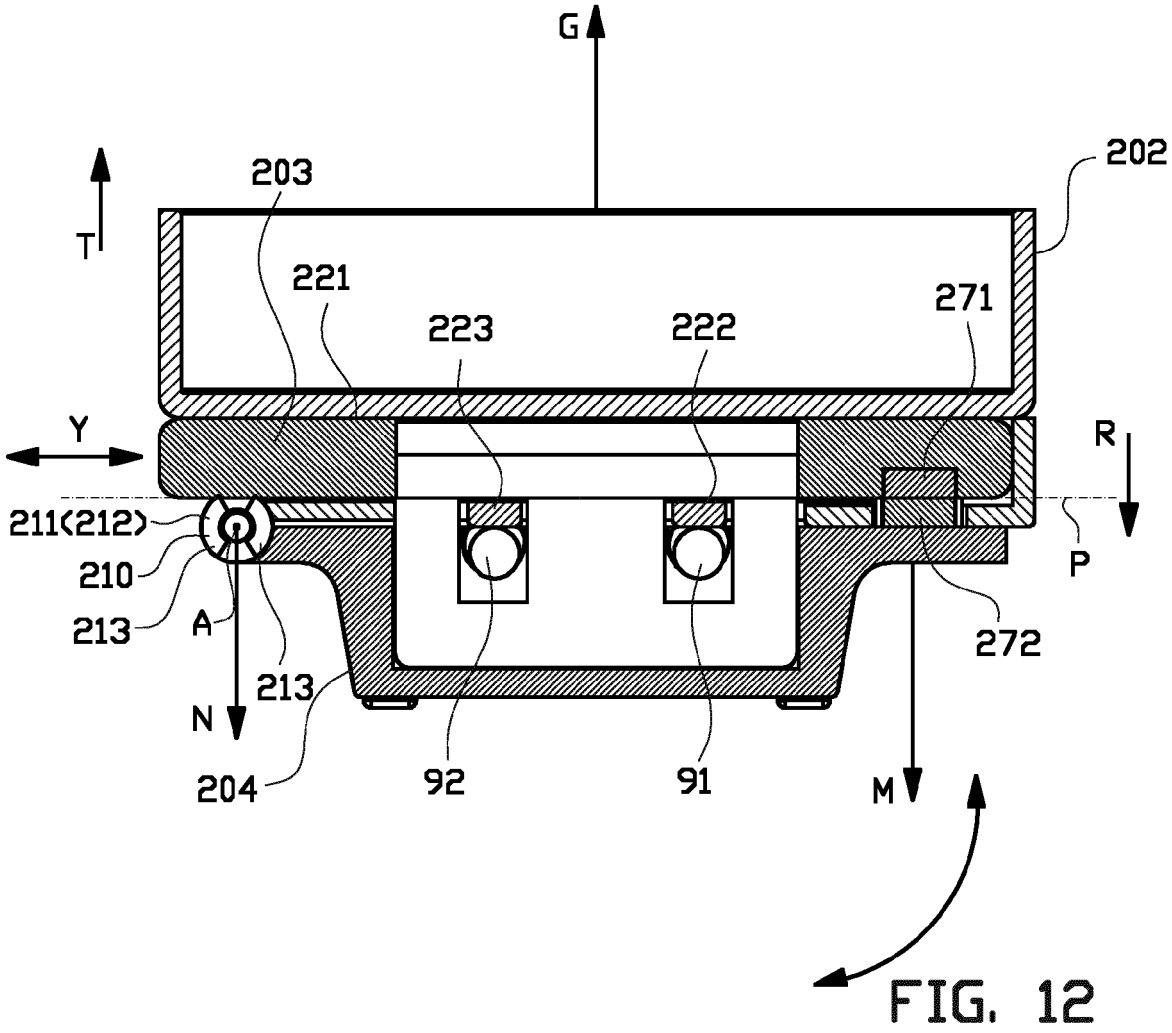
FIG. 11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M
272
P

FIG. 12

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EUROPEAN SEARCH REPORT

Application Number
EP 16 19 4347

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	WO 2014/029472 A1 (PHOENIX CONTACT GMBH & CO [DE]) 27 February 2014 (2014-02-27) * abstract; figure 2 *	1-18	
A	US 3 316 447 A (HOCHSTEIN ALEXANDER E) 25 April 1967 (1967-04-25) * column 2, line 60 - column 3, line 19; figure 1 *	1-18	
A	FR 2 695 285 A3 (CABLECO SA [FR]; POUMEY MICHEL) 4 March 1994 (1994-03-04) * page 6, line 9 - page 7, line 3; figure 3 *	1-18	TECHNICAL FIELDS SEARCHED (IPC) H01F H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	11 November 2016	Kreutz, Joseph

CATEGORY OF CITED DOCUMENTS

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11-11-2016

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