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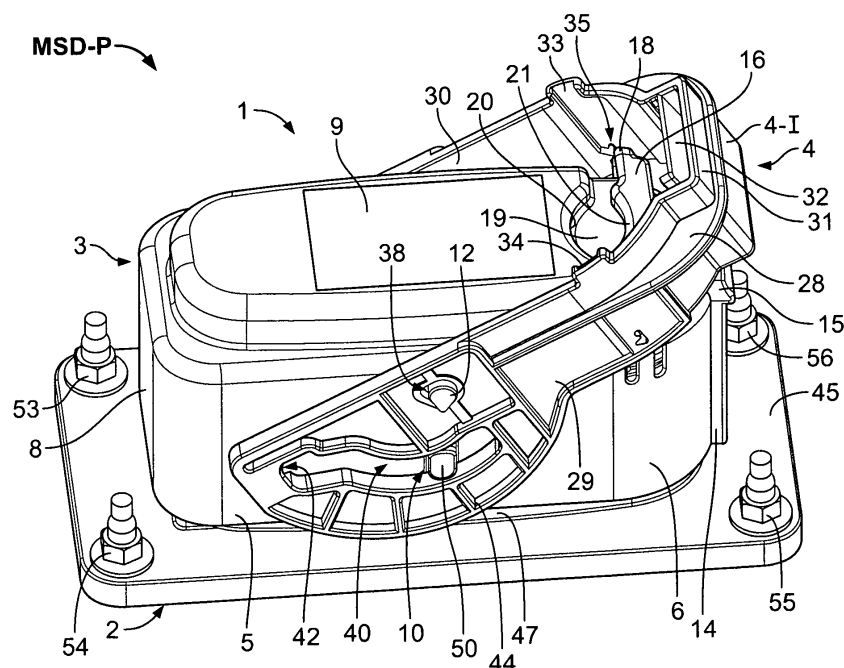
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80802 München (DE)(54) **Manual service disconnect**

(57) The invention relates to a plug (1) for mating a receptacle (2) of a Manual Service Disconnect, MSD, the plug (1) comprising an outer housing (3) and a lever (4) arranged on the outer housing (3) and configured for pivotal movement relative to the outer housing (3) from a locked position (4-L) to an unlocked position (4-U). According to the invention, the outer housing (3) is config-

ured for blocking or releasing the lever (4) in or from an intermediate position (4-I) between the locked position (4-L) and the unlocked position (4-U). The invention further relates to a corresponding receptacle (2) of a Manual Service Disconnect, a Manual Service Disconnect, and a method for unmating a Manual Service Disconnect of a high voltage module.

**Fig. 5****EP 2 672 573 A1**

Description

[0001] The invention relates to a Manual Service Disconnect, in particular in the context of high voltage module applications such as battery packs of hybrid or electric vehicles.

[0002] A Manual Service Disconnect, or MSD, comprises an electric connector plug with high voltage contacts mated to a receptacle with mating high voltage contacts, which in turn can be mounted on or fixed to a high voltage module, for instance a battery pack of a hybrid or electric vehicle. The MSD may be unmated by an operator, i.e. the operator may remove the plug from the receptacle, to physically interrupt the high voltage cables connecting the high voltage module to further system electronics. In the particular case of hybrid or electric vehicles battery packs, such an unplugging can be necessary for example during normal operations such as service or maintenance of the vehicle, or during an emergency situation such as an intervention during a car accident. It is therefore necessary to ensure that the high voltage system is disabled when the plug is unmated from the receptacle, since a hot unplugging can be dangerous for the surrounding electronics and in particular for the operator. For instance, electric arcs can appear when unplugging high voltage contacts when using voltages of at least about 35 V and more, which can result in burning of the operator and the surrounding electronic system components. For higher voltages, for example at least about 60 V and more, electric shocks in combination with high current intensities can be life threatening.

[0003] MSDs are known in the art comprising a so-called High Voltage Interlock Loop, or HVIL, which is a low voltage loop used during the unmating sequence in order to communicate to the system's electronics that the high voltage must be shut down because an unplugging is being carried out, such that the high voltage contacts between the plug and the receptacle of the MSD can be safely unmated. However, when using high voltage modules, after receiving a signal indicating that the HVIL has been interrupted, the system's electronics needs time to power down the high voltage supply of the high voltage module, for example in order to discharge capacitors and any other devices linked to the high voltage module.

[0004] MSDs are known in the art, which use a finger actuated two-stage lever mechanism for unmating the plug from the receptacle. Such MSDs known in the art comprise two levers pivotally attached to an outer housing of the MSD plug, arranged with the same orientation, in a configuration such that one lever is an inner lever and the other lever is an outer lever with respect to the outer housing, the inner lever being comprised between the outer housing of the plug and the outer lever, such that only one lever can be actuated at a time, and the levers must be actuated sequentially one after the other in order to carry out the unmating sequence. The first lever, i.e. the outer lever, is actuated by the operator in

a first stage to open the High Voltage Interlock Loop, HVIL, thereby informing the system's electronics that the high voltage supply of the high voltage module needs to be shut down, prior to actuating the second lever, i.e. the inner lever, in a second stage for unplugging the high voltage contacts. Thus, in MSDs known in the art, the operator must start by actuating the first lever and then move his/her hand above the released first lever in order to be able to reach for the second lever and complete the unmating sequence.

[0005] For applications related to battery packs of hybrid or electric vehicles, the MSD is mounted in a confined space such that an operator can only access it in a restricted position and actuate it sometimes only with one hand. When using high voltage modules, in particular modules of at least about 35 to 40 V or higher voltages, in particular in the case of battery packs for hybrid or electric cars, which can have voltages of at least about 40 V and up to about 1000 V or even more, unplugging the MSD can produce electric arcs, which are not seen for lower voltage module, and which are both dangerous for the operator and for the MSD and its surroundings, as such electric arcs can electrocute the operator, melt plastic or even parts of the MSD itself or of surrounding components in the environment in which the MSD is mounted. Thus, compared to lower voltage applications, for modules with at least 35 V or more, the operators are required to use at least a protective glove, and when available an insulating glove. Different types of protective and/or insulating gloves can be used, depending on the safety norms and on the situations, up to thick fireman gloves. Manipulating a system with two levers, such as MSDs known in the art, is therefore not practical and even not possible in some confined environments since thick safety gloves do not allow the operator to reach the second lever once the first lever has been actuated when the MSD is installed in a confined space such as in the case of hybrid or electric vehicle battery packs.

[0006] There is thus a need, in particular in the automotive industry, for a Manual Service Disconnect suitable not only for voltages lower than those at which electric arcs appear, but also for high voltage modules with voltages of at least about 35 V and more, up to about 1000 V and even more, for which an operator needs to manipulate the MSD with thick safety gloves. As consequence, there is also a need for an MSD practical enough to be handled by an operator wearing such thick safety gloves, in particular also when the MSD can only be reached and operated with one hand.

[0007] Furthermore, an MSD responding to the above needs should also comprise the advantages of existing prior art MSDs relative to operator and electronics safety, in particular regarding the interruption of the high voltage supply prior to unmating the high voltage contacts inside the MSD. Thus, there is also a need for an MSD which allows sufficient time to the system's electronics for powering down the high voltage supply before safely unplugging the high voltage contacts inside the MSD not only

during normal maintenance of the high voltage module where an operator can take all the time and safety measures required for safely unplugging the MSD, but also in extreme conditions like emergency situations during which the MSD needs to be unplugged as fast as possible.

[0008] The object of the invention is achieved with a plug for mating a receptacle of a Manual Service Disconnect, MSD, according to claim 1, the plug comprising an outer housing and a lever arranged on the outer housing and configured for pivotal movement relative to the outer housing from a locked position to an unlocked position. According to the invention, the outer housing is configured for blocking or releasing the lever in or from an intermediate position between the locked position and the unlocked position.

[0009] The inventive solution allows a temporization after disconnecting or opening the High Voltage Interlock Loop, HVIL, even if an operator tries to continuously carry out the unmating sequence, because the operator cannot rotate the lever to the unlocked position in one go, since the outer housing of the plug is configured for blocking the lever in an intermediate position in its pivotal movement. Given the reaction time of the operator to unblock the lever from its intermediate position, a temporization of about 1 second or more is thus created, which allows sufficient time for using the signal produced by the interruption of the HVIL to communicate with the system's electronics in order to power down the high voltage supply and thus safely unplug the high voltage contacts in the MSD. Thus, the creation of electric arcs, which could hurt the operator or damage components of the MSD and its environment, is prevented. The invention is thus advantageous in automotive applications such as hybrid or electric vehicle battery packs, since a temporization in the unplugging sequence allows the system's electronics to power down the high voltage supply of the battery before unmating the high voltage contacts of the MSD.

[0010] Furthermore, the outer housing can be adapted to allow a manipulation by an operator equipped with a thick safety glove such as a fireman glove like in the case of high voltage modules of at least about 35 V or even much higher voltage modules up to about 1000 V or more, whereas MSDs known in the art employing two levers cannot be manipulated with such safety gloves and are thus inappropriate for high voltage modules. For automotive applications, the MSDs are usually mounted in confined areas, in particular when used in combination with battery packs of hybrid or electric vehicles. In such cases, the inventive plug can be configured such that the locking mechanisms are accessible even when wearing different types of insulating gloves or other types of safety gloves.

[0011] Compared to two lever MSDs known in the art, the inventive plug and MSD only requires one lever, as the second lever is replaced advantageously by an element directly reachable on the outer housing of the plug. Therefore, the operator does not need to actuate a first

lever and then access the second lever by reach over the first lever. Advantageously, the inventive solution does not require more separate components than MSDs known in the art. The inventive solution is also simpler to assemble than the MSDs known in the art described above comprising two levers.

[0012] Preferably, the lever can comprise a latch configured for releasing the lever from the locked position into the intermediate position. In this way, the lever is advantageously maintained in the locked position when no intervention is required on the receptacle of the MSD.

[0013] Preferably, the outer housing can comprise a latch, in particular a hooped latch, configured for releasing the lever from the intermediate position into the unlocked position. This solution is advantageous particularly when an operator is equipped with thick safety gloves. An integrated solution in the outer housing of the plug allows an easy manipulation compared to a two lever solution known in the art. A hooped latch is also advantageous, as it gives a grip easy to identify and to actuate with a finger, even when wearing thick safety gloves, such as firemen gloves. In an advantageous embodiment, the latch of the outer housing can be arranged such that the operator's actions on the lever and on the latch can be carried out with the same orientation of the operator's hand, in particular in a continuous movement, without needing to first actuate the lever, and then reach for the latch.

[0014] Advantageously, the latch, in particular the hooped latch, of the outer housing can comprise at least one blocking element, in particular at least one pin, configured for blocking the lever in the intermediate position. According to the invention, the outer housing is configured for blocking the lever in its pivotal movement from the locked to the unlocked position. It is therefore possible and advantageous to combine the blocking and unlocking of the lever in the intermediate position in a single element of the outer housing, such that the blocking element is part of the latch or hooped latch.

[0015] Advantageously, the lever can further comprise at least one groove configured for receiving the at least one blocking element of the outer housing. It is thus possible to adapt the lever for engaging with the blocking element of the outer housing during the pivotal movement of the lever.

[0016] Advantageously, in the locked position, the at least one groove of the lever can be configured for blocking the latch, in particular the hooped latch, of the outer housing. Thus, in the locked position, an inappropriate manipulation of the latch or hooped latch can be prevented.

[0017] Advantageously, the at least one groove of the lever can further comprise a stop spigot, wherein said at least one groove and said stop spigot are configured such that the lever can be released from the intermediate position into the unlocked position by the latch when the at least one blocking element reaches the stop spigot in the at least one groove. Thus, the blocking elements of the

outer housing, in particular of the latch or hooped latch, can engage with the lever during its pivotal movement but will also stop said pivotal movement in an intermediate position before reaching the unlocked position. This advantageously provides for the necessary temporization, in particular for a temporization of about 1 second or more, between the interruption of the HVIL and the disconnection of the high voltage contacts in the MSD.

[0018] The object of the invention is also achieved with a receptacle of a Manual Service Disconnect, MSD, according to claim 8, for mating a plug according to one of claims 1 to 7, comprising an outer housing header, at least one pair, in particular at least two pairs, of power receptacle contacts and at least one pair of interlock signal contacts.

[0019] A receptacle of an MSD can thus be configured for a mating plug according to the invention. In automotive applications such as hybrid or electric vehicle battery packs, Manual Service Disconnects comprise two high voltage lines connected to the positive and negative terminals of the battery, respectively, and passing through the MSD, HV+ and HV- hereafter. Therefore, a receptacle according to the invention can comprise at least one power receptacle contacts for each high voltage line, HV+ and HV-. Accordingly, a plug according to the invention can comprise at least one mating power busbar for each high voltage line as well. In particular, according to advantageous embodiments of the invention, a receptacle of an MSD can comprise two power receptacle contacts for each high voltage line such that each line has an inlet and an outlet power receptacle contact, in total four power receptacle contacts, inlet HV+, inlet HV-, outlet HV+ and outlet HV-, respectively. Thus, a plug according to the invention can also comprise mating power busbars for mating the inlet HV+, inlet HV-, outlet HV+ and outlet HV-power receptacle contacts. According to further advantageous embodiments of the invention, if more high voltage lines need to be connected/disconnected via the MSD, a receptacle according to the invention, and therefore also a plug according to the invention, can comprise as many power receptacle contacts as needed, or as many power busbars respectively, depending on the number of high voltage lines.

[0020] MSDs further comprise one interlock loop for monitoring the high voltage. According to the invention, the receptacle thus comprises at least one pair of interlock signal contacts, or interlock outputs for mating corresponding interlock shunt contacts on the mating plug of the MSD. In advantageous embodiments, the invention could be used for monitoring more than one high voltage module. The inventive receptacle and the inventive plug can thus comprise more than one interlock loop, or HVIL, and therefore more than one pair of interlock signal contacts, or interlock shunt contacts, respectively. Advantageously, the interlock loop works with a voltage lower than 35 V in order to avoid the formation of electric arcs when disconnecting the interlock signal contacts from the interlock shunt contacts, in particular the voltage

of the interlock loop, or HVIL, can be lower than about 30 V.

[0021] The object of the invention is also achieved with a Manual Service Disconnect, MSD, according to claim 9, comprising a plug according to one of claims 1 to 7 and a receptacle according to claim 8, wherein the plug and the receptacle are configured for being plugged to each other in a mated state.

[0022] The mated state of the MSD is when the plug and the receptacle are fully mated, in particular when the respective high voltage and interlock contacts of the plug and the receptacle are connected. Furthermore, in the mated state of the MSD, the lever is in the locked position and locks the plug with the receptacle.

[0023] Preferably, the lever can further comprise at least one other groove and the receptacle can further comprise at least one pin, said at least one other groove being configured for engaging said at least one pin such that a movement, in particular a translation, of the plug respectively to the receptacle is prevented in the mated state. The outer housing, the lever and the receptacle can thus all be configured in order to ensure the stability of the mated state and prevent any relative displacements of a component to another.

[0024] Advantageously, the geometry of the at least one other groove of the lever can be configured for engaging the at least one pin of the receptacle such that the plug and the receptacle are in a partially unmated state when the lever is in the intermediate position and in an unmated state when the lever is in the unlocked position. It is thus possible to configure the lever such that actuating the lever, in particular pivoting the lever from the locked to the intermediate position, results in a disconnection of the interlock contacts while the high voltage contacts are still connected, corresponding to the partially unmated state of the MSD. The temporization resulting of the lever being blocked in the intermediate position and the time needed by an operator to release the lever into the unlocked position allows the system's electronics to receive the signal that the interlock loop has been interrupted and consequently power down the high voltage supply. The lever can further be configured such that the high voltage contacts are disconnected only when the lever has reached the unlocked position after having been released from the intermediate position. When the lever is in the unlocked position, the interlock loop is interrupted, and the high voltage contacts are also disconnected, which eventually corresponds to the unmated state of the MSD.

[0025] Advantageously, the plug can further comprise at least one pair of interlock shunt contacts configured for being connected to the at least one pair of interlock signal contacts of the receptacle in the mated state and disconnected from the at least one pair of interlock signal contacts in the partially unmated state. The components of the MSD, in particular the plug and the receptacle, can be chosen and configured such that in the partially unmated state, corresponding to the intermediate position

of the lever, the interlock loop is opened, communicating to the system's electronics that the high voltage needs to be powered down. Depending on the embodiment of the invention, the MSD can comprise one pair of high voltage lines, HV+ and HV-, connected to respective positive and negative terminals of a high voltage module, with one interlock loop, but in other embodiments, the inventive MSD can comprise any desired number of high voltage lines and corresponding interlock loops.

[0026] Advantageously, the plug can further comprise at least one pair, in particular at least two pairs, of power busbars configured for being connected to the at least one pair, in particular to the at least two pairs, of mating power receptacle contacts of the receptacle in the partially unmated state and in the mated state. In an advantageous embodiment, the plug can comprise inlet HV+, inlet HV-, outlet HV+ and outlet HV- power busbars for mating corresponding power receptacle contacts for the high voltage lines HV+ and HV- running through a mating receptacle and connected to the positive and negative terminals of a high voltage module, respectively. The MSD can thus be configured such that the high voltage contacts, in particular the power busbars and power receptacle contacts, are only completely disconnected in the unmated state, corresponding to the unlocked position of the lever, which can only be reached after a temporization imposed by the intermediate state.

[0027] In a variant of the inventive MSD, it can be preferred that the MSD does not comprise any fuse component connected to any of the power busbars (22, 23, 24, 25) or power receptacle contacts (57, 58, 59, 60). MSDs known in the art comprise a fuse component whose main function is to protect the electric circuitry when the MSD is in the mated state and the high voltage is running through the system. However, it might also be possible to use an MSD without a protecting fuse, for example when the inventive MSD is used with voltages which cannot damage the system's electronic components, or when a fuse is already present in other parts of the high voltage lines, in particular outside the MSD.

[0028] In another variant of the invention, an MSD can comprise at least one fuse component connected to at least one of the power busbars (22, 23, 24, 25) and/or at least one of the power receptacle contacts (57, 58, 59, 60). This has the advantage that at least one of the high voltage lines, HV+ or HV- when two lines are connected to respective positive and negative terminals of a high voltage module, can be provided with a fuse in order to protect the electronics in the mated state of the MSD, when the high voltage module is in use. However, depending on the embodiment, more than one fuse might be used, for example if more than one high voltage module is connected to the MSD.

[0029] The object of the invention is also achieved with a method for unmating a Manual Service Disconnect, MSD, of a high voltage module, in particular of a high voltage battery pack of a hybrid or electric vehicle, comprising the steps of:

- a. providing a Manual Service Disconnect, MSD, according to one of claims 9 to 13 in the mated state,
- b. in the mated state, releasing the lever of the plug from the locked position into the intermediate position, and
- c. in the partially unmated state, releasing the lever from the intermediate position into the unlocked position.

[0030] According to the invention, a time lapse for carrying out steps b and c continuously is sufficient for the high voltage of the module, in particular of the high voltage battery pack, to be disabled when the MSD reaches the unmated state.

[0031] In order to obtain the necessary temporization for interrupting the high voltage supply of the high voltage module and safely unmating the MSD, in particular when using voltages of at least about 35 V or higher voltages such as 200 V to 450 V, or even 1000 V or more, an operator can actively decide to wait after interrupting the HVIL of the MSD, which corresponds to pausing the unmating sequence when the lever is in the intermediate position, in order to leave time to the electronics to react to the interruption of the HVIL, shut down the high voltage and make sure that components such as capacitors are discharged before disconnecting the high voltage contacts inside the MSD. However, MSDs can be used in environments such as automotive applications like hybrid or electric vehicle battery packs which need to be disconnected not only in the quiet environment of a maintenance operation, but also for example in stress situations such as an intervention after a car accident. The unmating or unplugging sequence thus includes a minimal forced temporization for the safety of the operator. Therefore, by the expression "carrying out steps b and c continuously", it should be understood that an operator will not intentionally pause between method steps b and c, but will at least try to carry out the sequence in one go, i.e. the operator will release the lever from the locked to the intermediate position, and then try to release the lever from the intermediate to the unlocked position in a minimal time.

[0032] Preferably, the time lapse can be the elapsed time between the disconnection of the at least one pair of interlock shunt contacts of the plug from the at least one pair of interlock signal contacts of the receptacle and the disconnection of the at least one pair, in particular at least two pairs, of power busbars of the plug from the at least one pairs, in particular at least two pairs, of power receptacle contacts of the receptacle, in particular the time lapse can be at least equal or superior to about 1 second. This minimal temporization after the interruption of the HVIL allows sufficient time for the system's electronics to receive the signal that the HVIL has been interrupted, consequently send the signal for shutting down the high voltage supply, allowing a minimal temporization required for discharging electric components, such that the high voltage contacts can eventually safely be un-

plugged by an operator.

[0033] The invention will be described in more detail hereafter using advantageous embodiments in combination with the following figures, wherein:

- Figure 1 illustrates a plug for a Manual Service Disconnect, or MSD, according to an exemplary embodiment of the invention;
- Figure 2A illustrates the outer housing of the plug illustrated in Figure 1;
- Figure 2B illustrates the lever of the plug illustrated in Figure 1;
- Figure 3 illustrates a receptacle for mating the plug of Figure 1;
- Figure 4 illustrates a Manual Service Disconnect according to an exemplary embodiment of the invention, in a mated state;
- Figure 5 illustrates the MSD of Figure 4 in a partially unmated state;
- Figure 6 further illustrates the exemplary MSD in an unmated state, before removing the plug;
- Figure 7 further illustrates the exemplary MSD in the unmated state, with the plug completely removed; and
- Figure 8 schematically illustrates the unmating sequence.

[0034] Figures 1, 2A and 2B illustrate an exemplary embodiment of a plug 1 for a Manual Service Disconnect, MSD, according to the invention. The plug 1 comprises an outer housing 3 and a lever 4, which are illustrated unassembled in Figures 2A-2B and assembled in Figure 1. Figure 3 illustrates a mating receptacle 2 for the plug 1 of Figures 1 and 2A-2B, also according to the invention.

[0035] As illustrated in Figures 1 and 2A, the plug 1 comprises the outer housing 3. As further illustrated in Figures 1 and 2A, the outer housing 3 comprises four side walls 5, 6, 7, 8, and a protruding cap 9 on top thereof. The four side walls 5, 6, 7, 8 and the cap 9 thereby form a hollow structure as illustrated in the view of Figure 1. Out of the four side walls 5, 6, 7, 8, two opposing side walls 5, 7 comprise a groove 10, 11 for receiving a respective pin 50, 51 of a mating receptacle 2, as described hereafter in reference to Figure 3, as well as a pin 12, 13 arranged respectively above the groove 10, 11 in a direction going from the opening defined by the hollow structure of the plug 1 to the cap 9. Thus, the pins 12, 13 are arranged respectively on side walls 5, 7 substantially between the end of the grooves 10, 11 and the cap 9. In the embodiment described with the illustrations of Figures 1 and 2A, the two pins 12, 13 are substantially of cylindrical shape and serve as axes for the pivotal movement of the lever 4 when it is assembled to the outer housing 3, as illustrated in Figure 1. One of the remaining two side walls 6, 8, side wall 6 in the exemplary embodiment of Figures 1 and 2A, comprises a protruding element 14 which in turn comprises a locking element 15 on its upper part, just below the cap 9 of the plug 1. The

locking element 15 is configured for engaging with a latch 32 of the lever 4 as will be described hereafter.

[0036] Further illustrated in Figure 2A, a latch 16 extends from side wall 5 to the opposite side wall 7, above the cap 9 of the plug 1, towards the side wall 6 comprising the protruding element 14 with the locking element 15. The latch 16 comprises two blocking elements 17, 18, substantially in shape of pins. Below the latch 16, the cap 9 comprises a notch or a flat portion 19 with an arc shaped recess 20. In the embodiment illustrated in Figures 1 and 2A, the latch 16 also comprises an arc shaped recess 21, visible in Figure 2A, and therefore forms a hooped latch 16. As further illustrated in Figure 2A, the respective concave parts of the two arc shaped recesses 20, 21 face each other such that an operator using a thick safety glove such as a fireman glove can insert at least one finger, for example a thumb, in order to actuate the hooped latch 16.

[0037] As illustrated in Figure 1, inside the outer housing 3, the plug 1 further comprises at least one pair of power busbars. In the embodiment illustrated in Figures 1 and 2A, the plug 1 comprises four power busbars 22, 23, 24, 25. However, in other embodiments of the invention, the plug 1 can also comprise more or less power busbars, depending on the number of connections required, in particular depending also on the mating receptacle 2 of the MSD. As further illustrated in Figure 1, the plug 1 also comprises at least two interlock shunt contacts 26a, 26b surrounded by an inner housing 27. The interlock shunt contacts 26a, 26b are configured for engaging corresponding interlock signal contacts in a mating receptacle 2 of an MSD, for instance as described hereafter in reference with Figure 3, for forming a High Voltage Interlock Loop, HVIL. In the embodiment represented in Figures 1 and 2A, the plug 1 comprises only the interlock shunt contacts 26a, 26b.

[0038] However, other embodiments of the invention might require more than one interlock loop and therefore comprise more than one pair of interlock shunt contacts.

[0039] In this embodiment, the plug 1 can further comprise a fuse, not illustrated, provided on one of the high voltage lines. For example if one high voltage line runs between power busbars 22 and 25, and the other high voltage line runs between power busbars 23 and 24, a fuse can be mounted on any of the two lines, or even on each of the two lines, between the power busbars 22 and 25, and/or between the power busbars 23 and 24, respectively, for protecting the system's electronics when the plug 1 is mated to a corresponding MSD receptacle. In variants of this embodiment, depending on how many high voltage lines run through the MSD, more than one of the high voltage lines can comprise a fuse, and even all the lines can comprise a fuse component in order to protect more than one high voltage line and its related electronic components. In further variants, none of the high voltage lines may be protected by a fuse, for example when the inventive MSD is used for low voltage modules where the system's electronic components do not

risk any particular damage and therefore do not require such protection.

[0040] Figure 2B illustrates the lever 4 of the plug 1, which is configured for being assembled to the outer housing 3 illustrated in Figure 2A, in particular pivotally arranged on the outer housing 3. As illustrated in Figure 2B, the lever 4 comprises a handle portion 28 and two stems 29, 30. The handle portion 28 of the lever 4 comprises a recess 31 with a latch 32, which, in the locked position 4-L illustrated in Figure 1, is engaged with the locking element 15 of the outer housing 3. The locked position 4-L of the lever 4 will be described more in detail hereafter. At the junction of the handle portion 28 and each stem 29, 30, the lever 4 further comprises two grooves 33, 34, each comprising a stop spigot 35, 36 configure for receiving and being blocked, respectively, by the blocking elements 17, 18 of the latch 16 of the outer housing 3 in an intermediate position, 4-I, which will be described hereafter in reference to Figure 5. The lever 4 is thus configured for pivoting from the locked position, 4-L, illustrated in Figures 1 and 4, into the unlocked position, 4-U, illustrated in Figures 6 and 7 and described hereafter. However, according to the invention, the outer housing 3 is configured for blocking the lever 4 in the intermediate position, 4-I, such that it cannot directly be pivoted from the locked position, 4-L, to the unlocked position, 4-U.

[0041] As further illustrated in Figure 2B, each stem 29, 30 of the lever 4 comprises two pin holes 37, 38 for receiving the two axial pins 12, 13 of the outer housing 3, such that the lever 4 is pivotally arranged on the outer housing 3 when the plug 1 is assembled, as illustrated in Figure 1. Each stem 29, 30 further comprises another groove 39, 40, different from the grooves 33, 34 with the stop spigots 35, 36. The grooves 39, 40 are at least partially open at the end of the stems 29, 30 in a direction going away from the handle portion 28 of the lever 4. The openings 41, 42 at the end of grooves 39, 40 on the stems 29, 30 of the lever 4 substantially finish a respective arc shaped portion 43, 44 of each stem 29, 30 and are configured for receiving a respective pin 50, 51 of a mating receptacle 2, in particular the same pins 50, 51 which shall engage in the grooves 10, 11 of the outer housing 3.

[0042] Figure 3 illustrates a mating receptacle 2 of an MSD for the plug 1 of the embodiment illustrated in Figures 1 and 2A-2B, according to the invention. The receptacle 2 comprises an outer housing header 45 and four side walls 46, 47, 48, 49 substantially perpendicular to the outer housing header 45, thereby forming a mating structure for the plug 1. One of the side walls 46, 47, 48, 49, side wall 48 in the illustrative example of Figure 3, comprises a protruding element 52 configured for engaging in the protruding element 14 of the plug 1. As further illustrated in Figure 3, two opposing side walls 47, 49, adjacent to side wall 48, comprise two pins 50, 51 which are configured for engaging in grooves 10, 11 of the outer housing 3 of the plug 1 and which also engage in grooves 39, 40 of the lever 4 through the openings 41, 42 at the

end of said grooves 39, 40, at the end of the two stems 29, 30 of the lever 4.

[0043] In the exemplary embodiment illustrated in Figure 3, the outer housing header 45 of the receptacle 2 is fixed on four locations 53, 54, 55, 56 to a high voltage module, which is not illustrated. In the embodiment described in reference to Figure 3 and in the following, the high voltage module can be a hybrid or electric vehicle battery pack with a voltage of more than about 35 V, in particular more than 40 V, more in particular between 200 V and 450 V. However, the invention should not be restricted to battery packs for hybrid or electric vehicles, nor such voltage values only. For instance, the receptacle 2 of the MSD could be mounted on or fixed to lower voltages or to higher voltage electrical energy sources of up to 1000 V or even more.

[0044] As further illustrated in Figure 3, the receptacle 2 also comprises at least one pair of power receptacle contacts. In the embodiment illustrated in Figure 3, the receptacle 2 is a mating receptacle 2 for the plug 1 illustrated in Figures 1 and 2A-2B and therefore comprises four power receptacle contacts 57, 58, 59, 60 for receiving the mating four power busbars 22, 23, 24, 25 of the plug 1, respectively, when the MSD is assembled in the mated state MSD-M. The mated state MSD-M and the mating or unmating sequence will be described more in detail hereafter. Each pair of power receptacle contacts 57, 58, 59, 60 is part of a high voltage line connected to a positive and a negative terminal of the high voltage module, not illustrated, HV+ and HV-, respectively. For example, in the embodiment illustrated in Figure 3, the power receptacle contacts 57, 58, 59, 60 can be inlet HV-, inlet HV+, outlet HV+ and outlet HV- contacts, respectively. However, the invention should not be restricted to this configuration, and any inlet/outlet configuration can be achieved with the appropriate circuitry connections. Further according to the invention, the receptacle 2 also comprises at least one pair of interlock signal contacts 61 a, 61 b for mating the interlock shunt contacts 26a, 26b of the plug 1, forming the High Voltage Interlock Loop, or HVIL. In this illustrative embodiment, the receptacle 2 is intended for mating the plug 1 of Figures 1 and 2A and therefore comprises only one pair of interlock signal contacts 61 a, 61 b. However, it should be understood that the receptacle 2 may comprise more than one pair of interlock signal contacts 61 a, 61 b if more high voltage lines need to be monitored before unmating the MSD. As illustrated in Figure 3, several electrical components inside the receptacle 2, for example the interlock signal contacts 61 a, 61 b, can be isolated from other components of the receptacle 2 by an inner housing 62. In the embodiment illustrated in Figure 3, the HVIL works with a voltage of about 30 V or less, which has the advantage that the formation of electric arcs is prevented when unplugging the interlocks shunt contacts 26a, 26b from the interlock signal contacts 61 a, 61 b. Further, in the embodiment of Figure 3, since the MSD is connected to a battery pack of a hybrid or electric vehicle, the HVIL

can be connected to the vehicle's electronic system. In further embodiments, depending on the high voltage module, the HVIL can be connected to any other electronic system.

[0045] In a variant of this embodiment, at least one of the high voltage lines, HV+ or HV-, can comprise a fuse, for example mounted in series after any one of the power receptacle contacts 57, 58, 59, 60. Depending on the embodiment and on how many lines and respective electronic components require protection when the MSD is in a mated state, more than one high voltage line can comprise such a fuse. In the embodiment illustrated in Figure 3, however, none of the high voltage lines running through the power receptacle contacts 57, 58, 59, 60 is provided with a fuse arranged inside the MSD. However, it is still possible that a fuse is arranged on any of the high voltage lines outside the MSD at another level of the circuitry.

[0046] Figures 4 to 7 illustrate steps of the manual unplugging or unmating sequence of an exemplary embodiment of an MSD according to the invention, from a mated state, MSD-M, in Figure 4 to an unmated state, MSD-U, in Figures 6 and 7. The mating or plugging sequence is essentially the reverse sequence. Figure 8 is a diagram illustrating the unmating sequence of Figures 4 to 7 in parallel with a corresponding status of the HVIL signal 63 and of the high voltage supply 64. In the embodiment illustrated in Figures 4 to 7 and 8, the MSD comprises a plug 1 and a receptacle 2 such as the ones illustrated above in reference to Figures 1, 2A-2B and 3.

[0047] Figure 8 is a diagram illustrating the unmating sequence shown in Figures 4 to 7, from the MSD mated state of Figure 4, MSD-M, to the MSD unmated state of Figure 7, MSD-U, in which the plug 1 is completely separated from the receptacle 2. The first row "MSD State" of the diagram of Figure 8 indicates the state of the MSD (Mated / Partially Unmated / Unmated, Plug ON / Unmated, Plug OFF) and corresponds to the states and steps described in Figures 4 to 7, respectively. The second row "Lever Position" of the diagram illustrated in Figure 8 indicates the position of the lever 4 during the respective sequence steps (Locked / Intermediate / Unlocked). The different states of the MSD and positions of the lever 4 will be described more in detail in what follows. The third row "Figures" in the diagram of Figure 8 recalls Figures 4 to 7 below the corresponding MSD states and positions of the lever 4. The fifth row "Electrical Circuit" of the diagram of Figure 8 is a plot illustrating the ON or OFF status 63 of the High Voltage Interlock Loop, HVIL, in particular of the connection between the interlock shunt contacts 26a, 26b of the plug 1 and the interlock signal contacts 61 a, 61 b of the receptacle 2. In the same plot, the ON or OFF status 64 of the high voltage supply to the high voltage lines HV+ and HV-, and therefore to the power busbars 22, 23, 24, 25 of the plug 1 and the power receptacle contacts 57, 58, 59, 60 of the receptacle 2, respectively, is illustrated in parallel to the HVIL status 63. The HVIL status 63 and the high voltage supply status

64 are illustrated as a function of the time lapsed during the unmating sequence, in parallel to the sequence steps illustrated in Figures 4 to 7.

[0048] Figure 4 illustrates the Manual Service Disconnect, MSD, in a mated state, MSD-M. In the mated state, MSD-M, the outer housing 3 of the plug 1 is fully mated to the receptacle 2, thereby closing it as illustrated in Figure 4, the power busbars 22, 23, 24, 25 and the interlock shunt contacts 26a, 26b of the plug 1 are connected with the power receptacle contacts 57, 58, 59, 60 and the interlock signal contacts 61 a, 61 b of the receptacle 2, respectively, such that on one side the HVIL is closed and therefore its status 63 is ON, and on the other side the high voltage supply status 64 is also ON, as illustrated in Figure 8. Furthermore, in the mated state, MSD-M, the lever 4 of the plug 1 is in a locked position, 4-L.

[0049] Further illustrated in Figure 4, in the mated state, MSD-M, the pins 50, 51 of the receptacle 2 are engaged in corresponding grooves 10, 11 of the outer housing 3 of the plug 1, respectively. The same pins 50, 51 are also engaged in the grooves 39, 40 of the lever 4, in particular the pins 50, 51 are engaged in the part of grooves 39, 40 which is the furthest away from the end 41, 42 of the stems 29, 30 in direction of the handle portion 28 of the lever 4. The configuration of the pins 50, 51 on both sides 47, 49 of the receptacle 2, engaged in the grooves 10, 11 of the plug 1 on one hand, and engaged in the grooves 39, 40 of the receptacle 2 on the other hand, is such that the plug 1 is blocked in translation respectively to the receptacle 2. The lever 4 is in its locked position, 4-L, relatively to the outer housing 3 of the plug 1. Both stems 29, 30 of the lever 4 are thus essentially parallel to the outer housing 3 of the plug 1 and to the outer housing header 45 of the receptacle. In this position, the recess 31 in the handle portion 28 of the lever 4 covers partially the protruding element 14 of the outer housing 3 of the plug 1 such that the latch 32 of the lever is engaged with the locking element 15 of the protruding element 14. Thus, in the mated state, MSD-M, the locked position, 4-L, of the lever 4 locks the plug 1 with the receptacle 2.

[0050] Also illustrated in Figure 4, the two blocking elements 17, 18 of the hooped latch 16 on top of the plug 1 are engaged in respective grooves 33, 34 of the lever 4, such that the hooped latch 16 cannot be actuated in the mated state, MSD-U, because the lever 4 is in the locked position 4-L, also restricting the movement of the hooped latch 16.

[0051] Starting from the mated state, MSD-M, illustrated in Figure 4, in order to begin the unmating sequence, an operator needs to press the latch 32 on the handle portion 28 of the lever 4, and release the lever 4 from the blocking element 15 of the outer housing 3.

[0052] In the embodiment illustrated in Figures 4 to 8, the MSD is used for a battery pack of a hybrid or electric vehicle. The MSD is thus mounted in a confined space, and an operator, not illustrated in the figures, cannot access the MSD at least from the sides 5, 7, possibly also

not from side 8 of the plug 1. The operator needing to unplug the MSD, in particular to interrupt the HVIL of the high voltage module, can only access the MSD from the top or upper area of the plug 1, i.e. from the cap 9, and has just enough space around side 6 of the plug 1 to reach the lever 4, in particular the latch 32 of the handle portion 28 of the lever 4, with at least one finger. The operator can also reach the hooped latch 16 on top of the outer housing 3 of the plug 1, for example the operator can place a thumb between the space defined by the recesses 20, 21 of the cap 9 and the hooped latch 16. Due to the risks of high voltage electrical energy sources, the operator needs to wear a thick safety glove such as a thick fireman glove. The position of the latch 32 and the hooped latch 16 and their respective size are compatible with the use of thick fireman gloves or any other similar safety glove.

[0053] After the operator presses the latch 32 and unlocks or releases the lever 4 from the blocking element 15 of the outer housing 3 of the plug 1, the lever 4 can rotate around the axes of the two pins 12, 13 located on both sides 5, 7 of the outer housing 3. The movement of pushing the latch 32 away from the outer housing 3, in particular away from the locking element 15, is ergonomic with operations using thick safety gloves. Furthermore, the position of the latch 32 at the end or handle portion 28 of the lever 4 is compatible with an access using only a few fingers from above the cap 9 of the plug 1. Since both pins or blocking elements 17, 18 of the hooped latch 16 have a limited travel in the grooves 33, 34 of the lever 4, an overriding movement of the hooped latch 16 is not possible in the mated state, MSD-M, because the lever 4 is in the locked position, 4-L.

[0054] Once the lever 4 is unlocked, the operator starts rotating the lever 4 around the axes of pins 12, 13 in a direction going away from the outer housing header 45 of the receptacle 2. Because of the rotation of the lever 4, the blocking elements 17, 18 start sliding in the grooves 33, 34 of the lever 4, and the pins 50, 51 of the receptacle start sliding in the other grooves 39, 40 of the lever 4 in a direction towards the openings 41, 42 at the end of the stems 29, 30. The relative movement of pins 50, 51 with respect to the grooves 39, 40 of the lever 4 starts unmating the plug 1 from the receptacle 2, in particular the plug 1 is thereby lifted from the receptacle 2 and the electrical components, in this case the interlock shunt contacts 26a, 26b and the power busbars 22, 23, 24, 25 start disengaging from the interlock signal contacts 61 a, 61 b and the power receptacle contacts 57, 58, 59, 60, respectively. This only starts the disconnection of the electrical components, such that the components are still partially connected, in particular, the HVIL is still a closed loop, and both the HVIL status 63 and the high voltage supply status 64 are both still ON.

[0055] The rotation of the lever 4 can continue until the blocking elements 17, 18 of the hooped latch 16 reach the stop spigots 35, 36 at the end of grooves 33, 34. When this position is reached, the lever 4 cannot con-

tinue its rotation and its unlocking movement away from the outer housing header 45 of the receptacle 2. The lever 4 this reaches an intermediate position, 4-I, as illustrated in Figure 5. When the lever 4 reaches the intermediate position, 4-I, the interlock shunt contacts 26a, 26b of the plug 1 are completely disengaged or disconnected from the interlock signal contacts 61 a, 61 b of the receptacle 2, such that the HVIL status 63 is now OFF because the loop is interrupted. However, the power busbars 22, 23, 24, 25 are only partially disengaged from the power receptacle contacts 57, 58, 59, 60, but still connected to them, and the high voltage supply status 64 is still ON, as illustrated in Figure 8. The side walls 46, 47, 48, 49 of the receptacle 2 can now be partially visible below the plug 1, as the plug 1 is partially lifted from the receptacle 2. Figure 5 illustrates the MSD in this situation, with the lever 4 in the intermediate position, 4-I, which corresponds to a partially unmated state, MSD-P.

[0056] According to the invention, the outer housing 3 is configured such as to prevent the lever 4 from going from the locked position, 4-L, to an unlocked position, 4-U, directly, and the lever 4 must first go through the intermediate position, 4-I. Thus, the high voltage contacts 22, 23, 24, 25, 57, 58, 59, 60 cannot be disconnected promptly before the high voltage supply is powered down, which prevents the formation of electric arcs, burning of the operator or of any surrounding circuitry. In this variant of the invention, as long as the two pins or blocking elements 17, 18 of the hooped latch 16 on the outer housing 3 are in the grooves 33, 34, no manipulation of the hooped latch 16 is possible. However, as illustrated in Figure 5, when the intermediate position, 4-I, of the lever 4 is reached in the partially unmated state, MSD-P, the two blocking elements 17, 18 have reached the stop spigots 35, 36 at the end of the grooves 33, 34 such that the hooped latch 16 can now be actuated by the operator. To continue the unmating sequence, the operator needs to press the hooped latch 16 of the outer housing 3 in order to completely release the lever 4 to the unlocked position, 4-U, illustrated in Figures 6 and 7.

[0057] The position and geometry of the hooped latch 16, essentially a bar with the recess 21, which can be used ergonomically for placing an operator's finger, in particular the size of the hooped latch 16, are compatible with a manipulation using thick safety gloves. Furthermore, the hooped latch 16 is actuated by pushing it away from the recess 20 on the cap 9 of the plug 1, in a movement which is also ergonomic with the use of thick safety gloves. For instance, the operator can hold the handle portion 28 of the lever 4 with at least one finger, for example the index, while pressing the hooped latch 16 using the thumb. In a single operation of the hooped latch 16, the operator advantageously releases both blocking elements 17, 18 from the stop spigots 35, 36, thereby releasing the lever 4 from the intermediate position, 4-I, into the unlocked position, 4-U. Also in embodiments where the MSD is mounted in confined spaces where an operator can only access it from above but not from the

sides, the position of the hooped latch 16 is compatible with a restricted access.

[0058] In order to safely completely unplug the plug 1 from the receptacle 2, in particular in order to avoid the formation of dangerous electric arcs, a temporization is necessary in order to shut down the high voltage in the contacts of the receptacle 2, in particular to make sure that any electronic components such as capacitors are at least partially or totally discharged before unmating the MSD. Thus, after the HVIL is interrupted, i.e. after the interlock shunt contacts 26a, 26b and the interlock signal contacts 61 a, 61b are disconnected, and before completely disconnecting the high voltage contacts, i.e. before disconnecting the power busbars 22, 23, 24, 25 from the power receptacle contacts 57, 58, 59, 60, the MSD is blocked in the partially disconnected state, MSD-P, such that the operator is forced to carry out an additional action before being able to completely open and unplug the plug 1 from the receptacle 2 of the MSD. In Figure 8, this time lapse Δt is indicated in parallel to the partially unmated state, MSD-P, when the lever 4 reaches the intermediate position, 4-I, and the HVIL signal status 63 is thus OFF, and the moment the high voltage supply status 64 is OFF. Under quiet conditions, for example a regular maintenance, the operator can decide to wait after reaching the intermediate position, 4-I, of the lever 4, before actuating the hooped latch 16 and continuing the unmating sequence, in order to allow this temporization. However, in a more stressful environment such as a fireman intervening after a car accident, if the operator continuously carries out the unmating sequence and tries to immediately press the hooped latch 16 in order to fully release the lever 4 and disconnect the plug 1 from the receptacle 2, the MSD is configured such that this action will be carried out in a time lapse Δt of at least about 1 s, in particular in a range from about 1 s to at about 5 s, allowing the vehicle's electronic system to receive the HVIL signal 63 OFF that the HVIL is interrupted, further allowing the electronic system to power down the high voltage supply of the battery pack, in particular allowing sufficient time such that electronic component are discharged, leading to a safe interruption of the high voltage supply to the high voltage contacts of the MSD. Thus, the formation of dangerous electric arcs, which could electrocute or burn the operator and/or burn, or even melt, various components of the MSD or of components of the environment surrounding the MSD, is prevented since the MSD cannot be opened in one go. When the high voltage supply is finally interrupted, the high voltage supply signal 64 becomes OFF.

[0059] The presence of the intermediate position, 4-I, of the lever 4, which forces the partially unmated state, MSD-P, during the unmating sequence, allows this temporization and ensures that the unmating sequence is not carried out in one go from the mated state, MSD-M, and locked position, 4-L, to the unmated state, MSD-U, and unlocked position, 4-U.

[0060] By pressing the hooped latch 16, the operator

then unlocks the lever 4 from the intermediate position, 4-I, and continues the unlocking movement of the lever 4. During the unlocking movement of the lever 4, the pins 50, 51 of the receptacle 2 continue sliding in the grooves 39, 40 of the stems 29, 30 of the lever 4. Like for the transition to the intermediate position, 4-I, and partially unmated state, MSD-P, this movement forces the plug 1 to be lifted from the receptacle 2, continuing the disconnection of the power busbars 22, 23, 24, 25 from the power receptacle contacts 57, 58, 59, 60.

[0061] By the time the lever 4 reaches the unlocked position, 4-U, illustrated in Figure 6, which is essentially perpendicular to the locked position, 4-L, illustrated in Figure 4, a time of at least about 1 s will have elapsed during the partially unmated state, MSD-P, such that the high voltage supply status 64 is OFF, as illustrated in Figure 8, allowing eventually for a safe full disconnection of the power busbars 22, 23, 24, 25 of the plug 1 from the power receptacle contacts 57, 58, 59, 60 of the receptacle 2 when the lever 4 reaches the unlocked position, 4-U. Furthermore, as also illustrated on Figure 6, when the lever 4 reaches the unlocked position, 4-U, the pins 50, 51 have been pushed to the end of the grooves 39, 40 of the stems 29, 30 of the lever 4, and the plug 1 has been lifted further from the receptacle 2, showing the side walls 46, 47, 48, 49 of the receptacle 2 below. With the power busbars 22, 23, 24, 25 disconnected from the power receptacle contacts 57, 58, 59, 60, the MSD is now in an unmated state, MSD-U.

[0062] Figure 6 illustrates the unmated state, MSD-U, with the plug 1 still on top of the receptacle 2, but with all electrical contacts disconnected between the two, in particular with the HVIL signal status 63 and the high voltage supply status 64 both OFF, as further illustrated in Figure 8. The HVIL is open, i.e. the interlock shunt contacts 26a, 26b are disconnected from the interlock signal contacts 61 a, 61 b. The high voltage supply is interrupted and the power busbars 22, 23, 24, 25 are disconnected from the power receptacle contacts 57, 58, 59, 60.

[0063] When the lever 4 is fully rotated to the unlocked position, 4-U, like in Figure 6, the two pins 50, 51 of the receptacle 2 can slide through the openings 41, 42 at the end of the grooves 39, 40 on each stem 29, 30 of the lever 4, and the plug 1 can be completely removed from the top of the receptacle 2. Figure 7 illustrates the MSD in the unmated state, MSD-U, now with the plug 1 completely removed from the receptacle 2. The assembling or mating sequence is essentially the sequence described in relation with Figures 4 to 7, in a reverse order.

[0064] According to the invention, no additional component is required with respect to prior art MSDs, in particular with respect to two-stage lever MSDs. The assembly process of the inventive MSD is less complex than that of MSDs known in the art. Furthermore, the plug 1 of the MSD according to the invention is easy to handle and manipulate with only one hand, even one or two fingers, and does not require any specific tool for the mating or unmating sequence. The invention also provides a forced

temporization before unmating the high voltage contacts, which advantageously allows sufficient time for interrupting the high voltage supply and therefore safely unmating the high voltage contacts of the MSD. An advantage of the MSD according to the invention compared to MSDs known in the art is that both unlocking manipulations, going from the locked position, 4-L, to the intermediate position, 4-I, and going from the intermediate position, 4-I, to the unlocked position, 4-U, have the same orientation, in other words can be carried out in the same direction or with the same hand movement by an operator. The invention is also advantageous for an operator wearing safety gloves, even thick insulating fireman gloves, which make any complex movement impossible.

Claims

1. Plug (1) for mating a receptacle (2) of a Manual Service Disconnect, MSD, the plug (1) comprising an outer housing (3) and a lever (4) arranged on the outer housing (3) and configured for pivotal movement relative to the outer housing (3) from a locked position (4-L) to an unlocked position (4-U),
characterized in that
the outer housing (3) is configured for blocking or releasing the lever (4) in or from an intermediate position (4-I) between the locked position (4-L) and the unlocked position (4-U).
2. Plug (1) according to claim 1, wherein the lever (4) comprises a latch (32) configured for releasing the lever (4) from the locked position (4-L) into the intermediate position (4-I).
3. Plug (1) according to any of the precedent claims, **characterized in that** the outer housing (3) comprises a latch (16), in particular a hooped latch, configured for releasing the lever (4) from the intermediate position (4-I) into the unlocked position (4-U).
4. Plug (1) according to claim 3, **characterized in that** the latch (16), in particular the hooped latch, of the outer housing (3) comprises at least one blocking element (17, 18), in particular at least one pin, configured for blocking the lever (4) in the intermediate position (4-I).
5. Plug (1) according to claim 4, **characterized in that** the lever (4) further comprises at least one groove (33, 34) configured for receiving said at least one blocking element (17, 18).
6. Plug (1) according to claim 5, **characterized in that**, in the locked position (4-L), the at least one groove (33, 34) is configured for blocking the latch (16), in particular the hooped latch, of the outer housing (3).
7. Plug (1) according to any of claims 5 or 6, **characterized in that** said at least one groove (33, 34) further comprises a stop spigot (35, 36), wherein said at least one groove (33, 34) and said stop spigot (35, 36) are configured such that the lever (4) can be released from the intermediate position (4-I) into the unlocked position (4-U) by the latch (16) when the at least one blocking element (17, 18) reaches the stop spigot (35, 36) in the at least one groove (33, 34).
8. Receptacle (2) of a Manual Service Disconnect, MSD, for mating a plug (1) according to one of claims 1 to 7, comprising an outer housing header (45), at least one pair, in particular at least two pairs, of power receptacle contacts (57, 58, 59, 60) and at least one pair of interlock signal contacts (61 a, 61 b).
9. Manual Service Disconnect, MSD, comprising a plug (1) according to one of claims 1 to 7 and a receptacle (2) according to claim 8, wherein the plug (1) and the receptacle (2) are configured for being plugged to each other in a mated state (MSD-M).
10. Manual Service Disconnect according to claim 9, **characterized in that** wherein the lever (4) further comprises at least one other groove (39, 40) and the receptacle (2) further comprises at least one pin (50, 51), said at least one other groove (39, 40) being configured for engaging said at least one pin (50, 51) such that a movement, in particular a translation, of the plug (1) respectively to the receptacle (2) is prevented in the mated state (MSD-M).
11. Manual Service Disconnect according to claim 10, **characterized in that** the geometry of said at least one other groove (39, 40) is configured for engaging said at least one pin (50, 51) of the receptacle (2) such that the plug (1) and the receptacle are in a partially unmated state (MSD-P) when the lever (4) is in the intermediate position (4-I) and in an unmated state (MSD-U) when the lever is in the unlocked position (4-U).
12. Manual Service Disconnect according to any of claims 9 to 11, wherein the plug (1) further comprises at least one pair of interlock shunt contacts (26a, 26b) configured for being connected to the at least one pair of interlock signal contacts (61 a, 61b) of the receptacle (2) in the mated state (MSD-M) and disconnected from the at least one pair of interlock signal contacts (61 a, 61 b) in the partially unmated state (MSD-P).
13. Manual Service Disconnect according to any of claims 9 to 12, wherein the plug (1) further comprises at least one pair, in particular at least two pairs, of power busbars (22, 23, 24, 25) configured for being connected to the at least one pair, in particular to the

at least two pairs, of power receptacle contacts (57, 58, 59, 60) of the receptacle (2) in the partially unmated state (MSD-P) and in the mated state (MSD-M).

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14. Manual Service Disconnect according to any of claims 9 to 13, not comprising any fuse component connected to any of the power busbars (22, 23, 24, 25) or power receptacle contacts (57, 58, 59, 60).

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15. Manual Service Disconnect according to any of claims 9 to 13, comprising at least one fuse component connected to at least one of the power busbars (22, 23, 24, 25) and/or at least one of the power receptacle contacts (57, 58, 59, 60).

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16. Method for unmating a Manual Service Disconnect, MSD, of a high voltage module, in particular of a high voltage battery pack of a hybrid or electric vehicle, comprising the steps of:

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a. providing a Manual Service Disconnect according to one of claims 9 to 13 in the mated state (MSD-M),

b. in the mated state (MSD-M), releasing the lever (4) of the plug (1) from the locked position (4-L) into the intermediate position (4-I), and

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c. in the partially unmated state (MSD-P), releasing the lever (4) from the intermediate position (4-I) into the unlocked position (4-U),

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characterized in that

a time lapse (Δt) for carrying out steps b and c continuously is sufficient for the high voltage of the module, in particular of the high voltage battery pack, to be disabled when the MSD reaches the unmated state (MSD-U).

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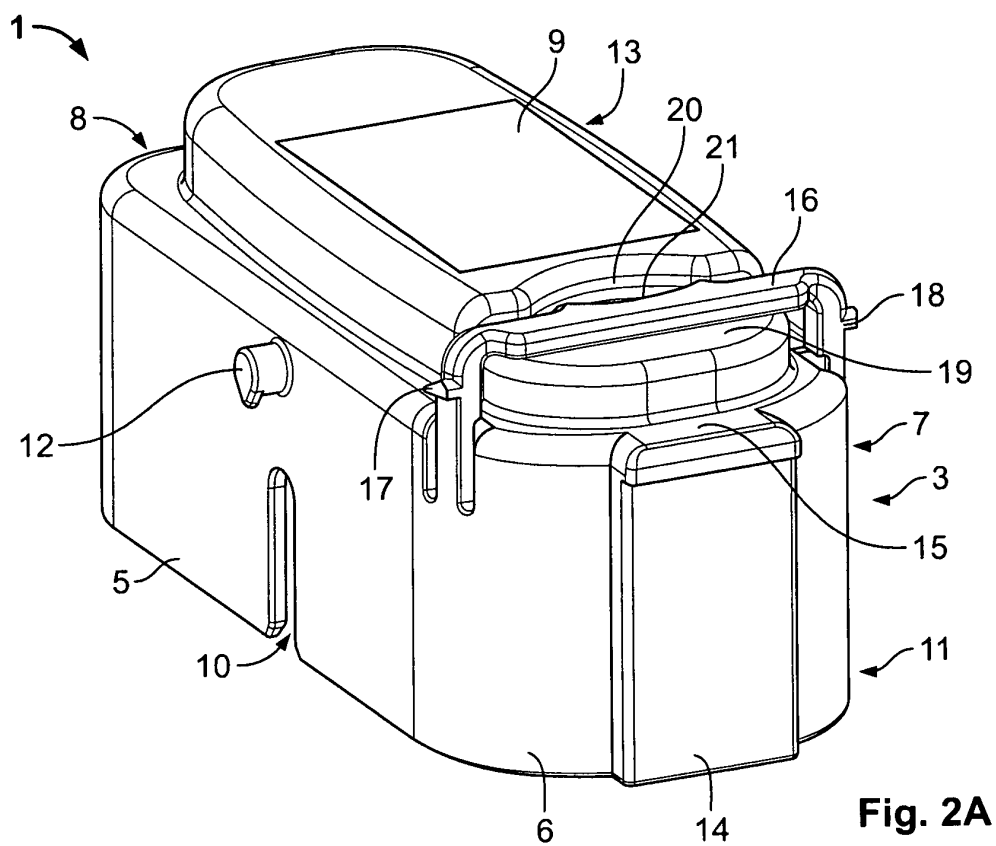
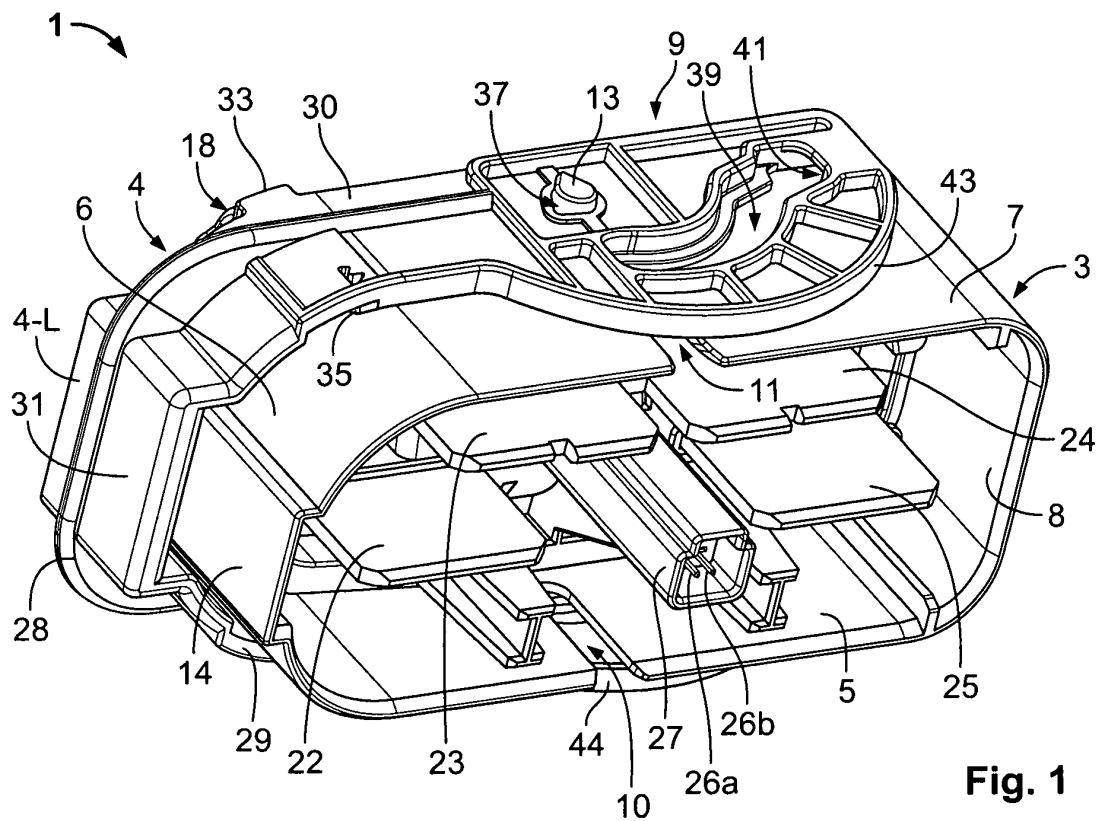
17. Method according to claim 14, **characterized in that** the time lapse (Δt) is the elapsed time between the disconnection of the interlock shunt contacts (26a, 26b) from the interlock signal contacts (61 a, 61 b) and the disconnection of the power busbars (22, 23, 24, 25) from the power receptacle contacts (57, 58, 59, 60), in particular the time lapse (Δt) is at least equal or superior to about 1 second.

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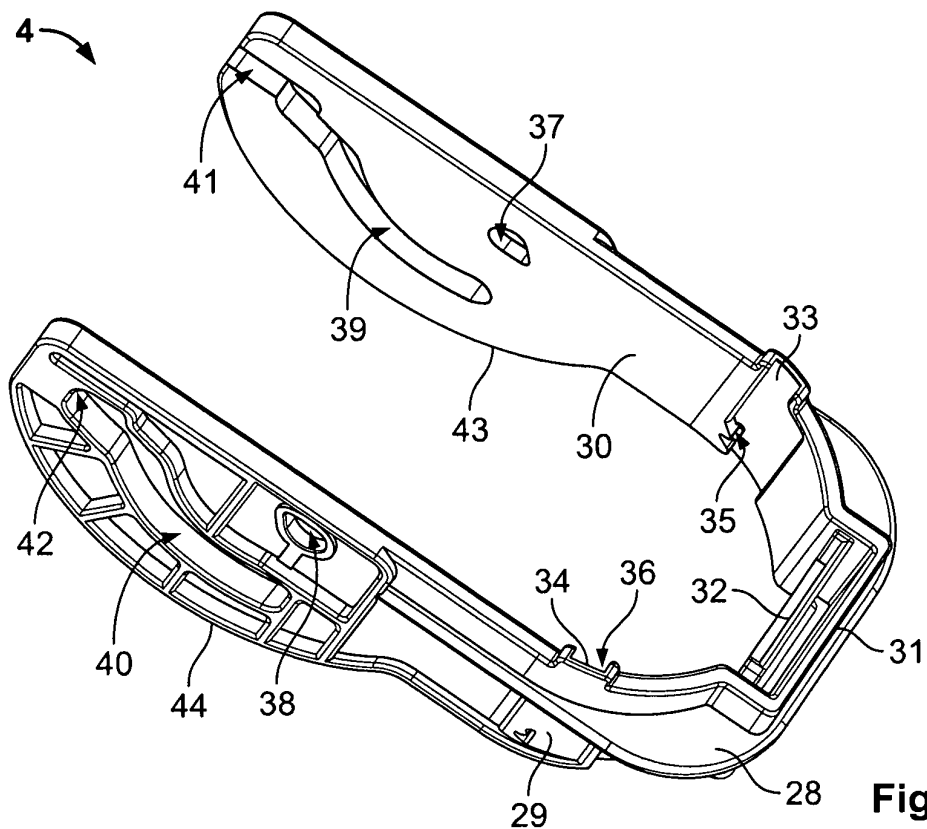


Fig. 2B

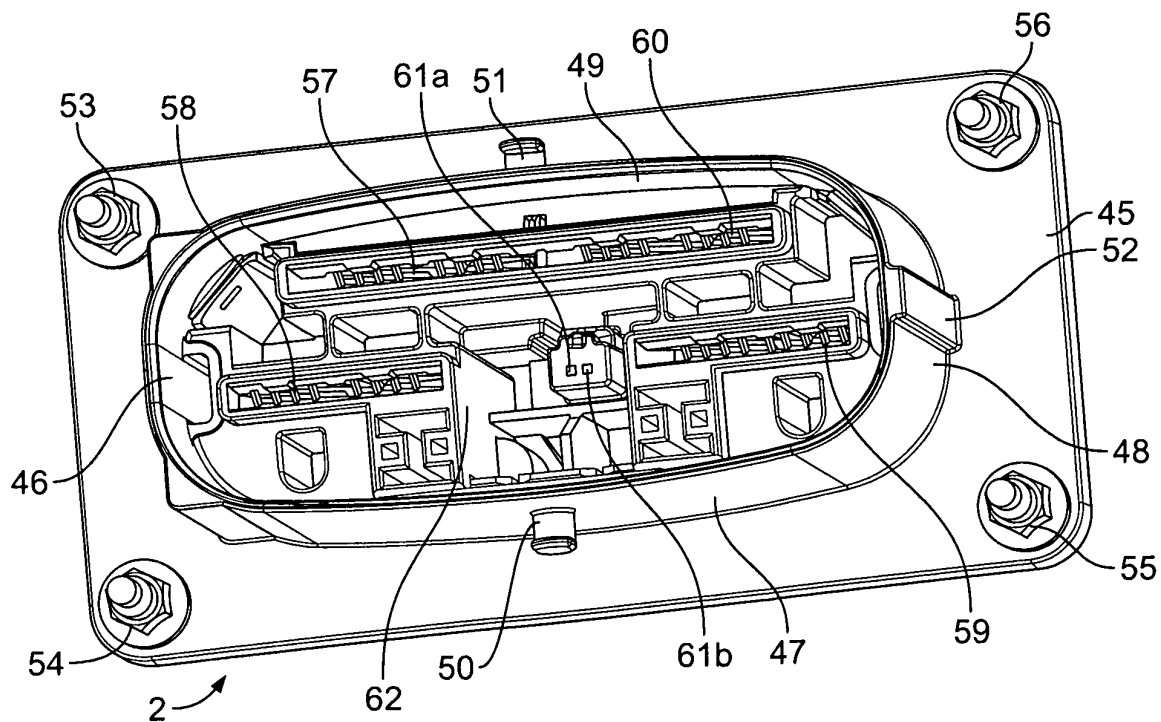


Fig. 3

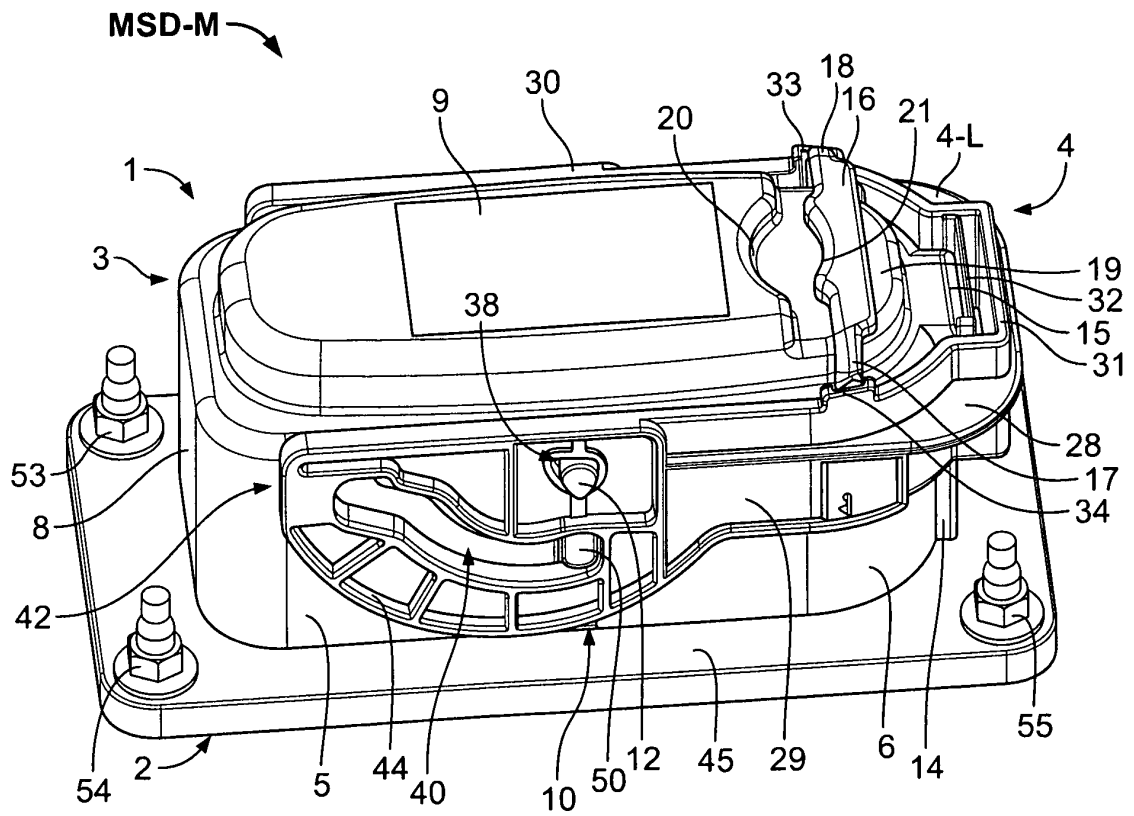


Fig. 4

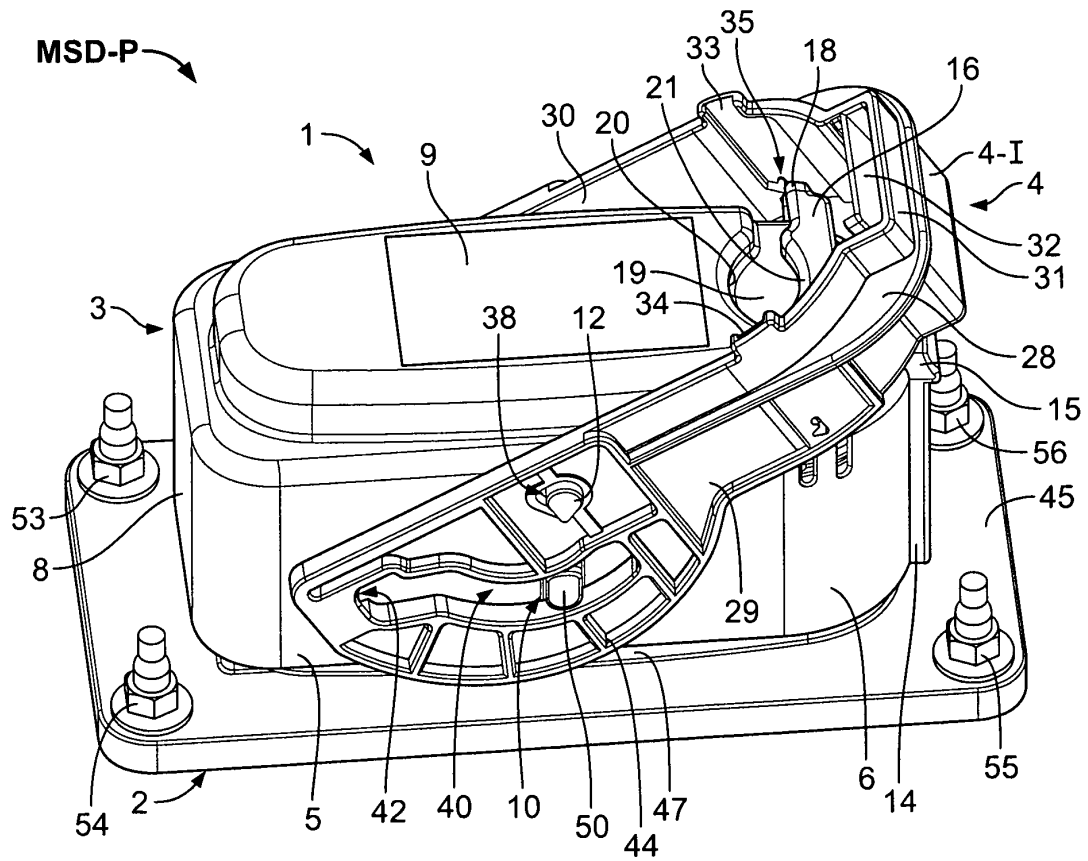


Fig. 5

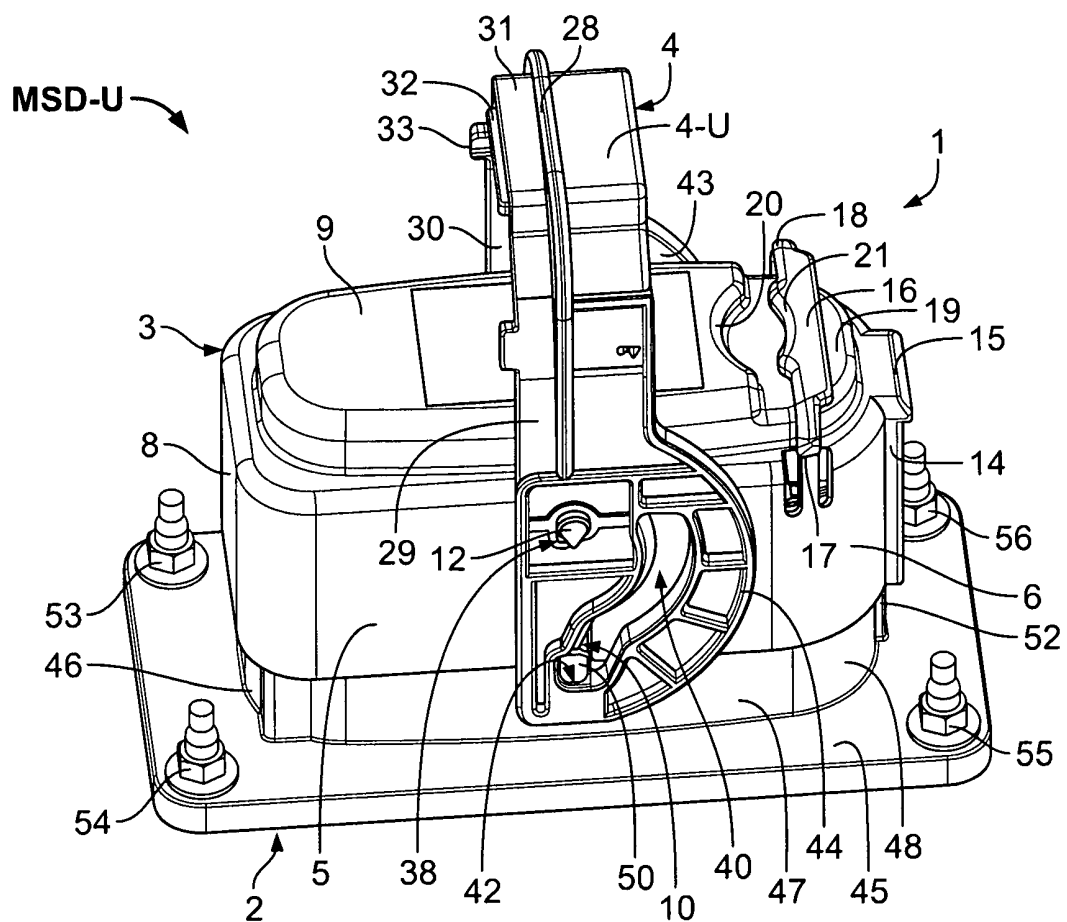


Fig. 6

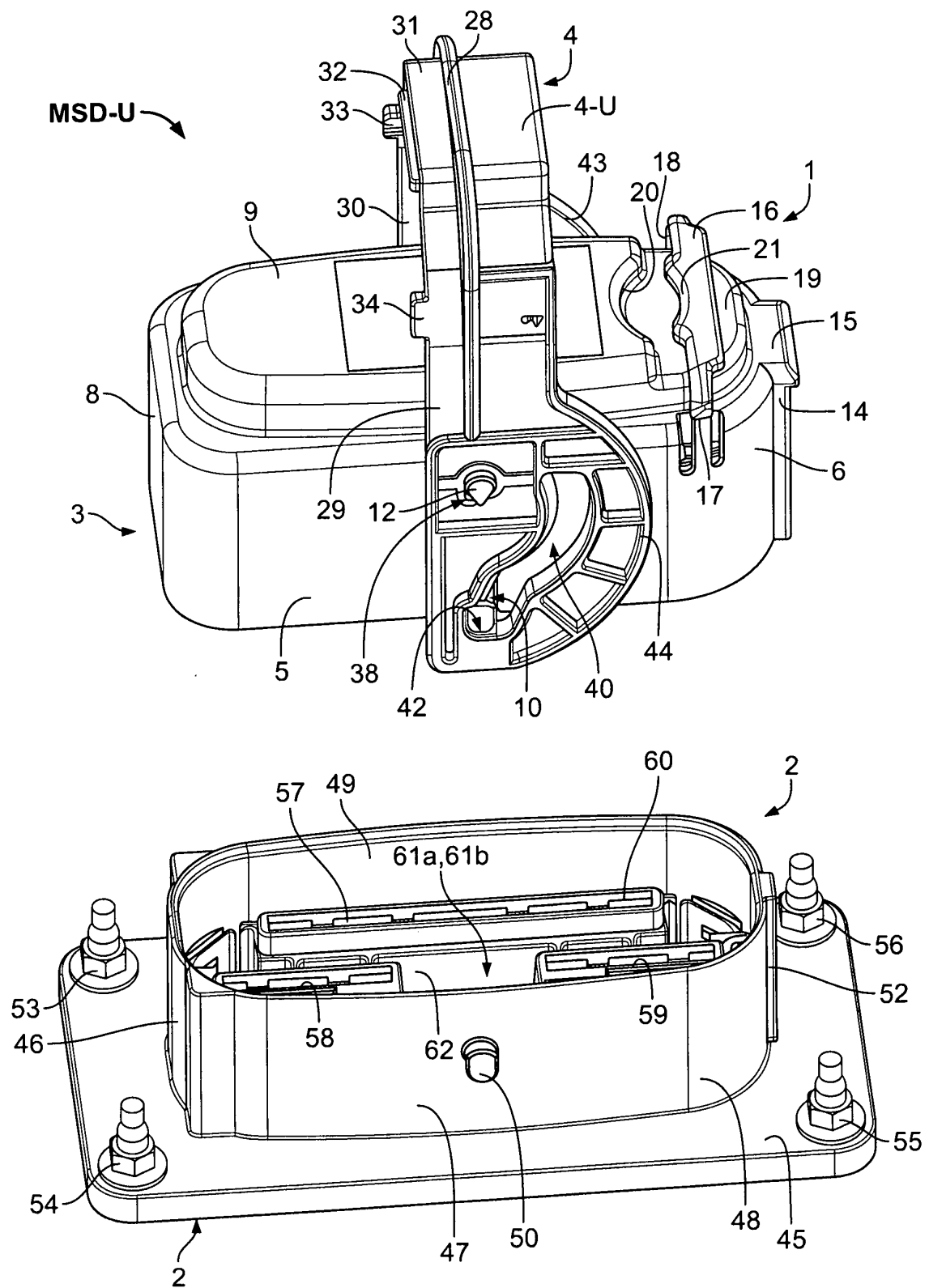


Fig. 7

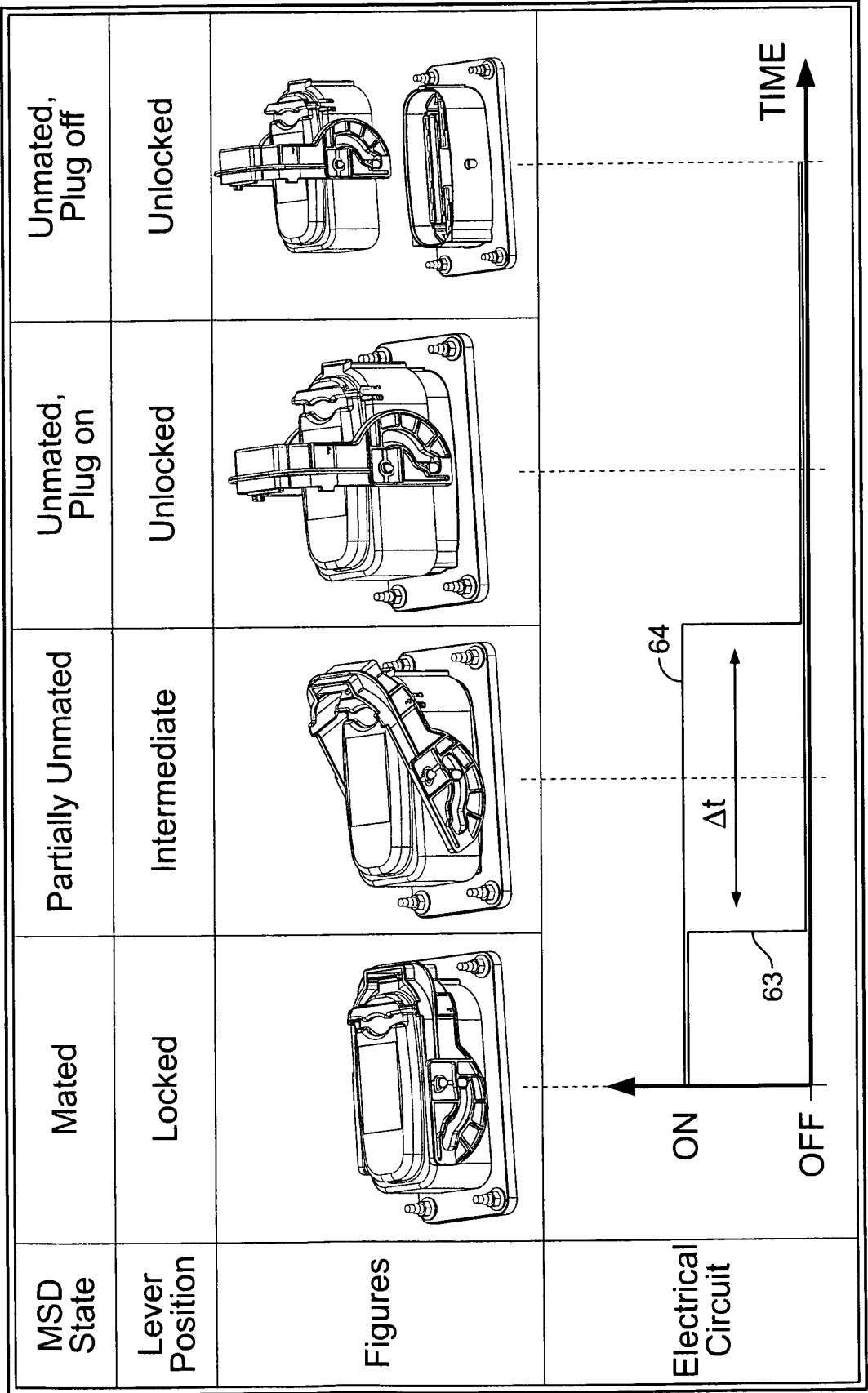


Fig. 8



EUROPEAN SEARCH REPORT

Application Number
EP 12 29 0184

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2012/063549 A1 (YAZAKI CORP [JP]; IKEDA TOMOHIRO [JP]; HENMI FUMITOSHI [JP]; MOTOSHIGE) 18 May 2012 (2012-05-18) * paragraph [0054] - paragraph [0056]; figures 1-11 *	1-17	INV. H01R13/53 H01R13/629 ADD. H01R13/707
X	US 7 789 690 B1 (RHEIN DAVID JAMES [US]) 7 September 2010 (2010-09-07) * the whole document *	1-5,8,16,17	
A	WO 2012/007343 A1 (TYCO ELECTRONICS FRANCE SAS [FR]; CHATELUS ERIC [FR]) 19 January 2012 (2012-01-19) * figure 2 *	5-7	
A	WO 2010/015641 A1 (FRAMATOME CONNECTORS INT [FR]; CASSES CLAUDE [FR]; CAPPE PATRICE [FR];) 11 February 2010 (2010-02-11) * the whole document *	1-17	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01R
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 16 October 2012	Examiner Vautrin, Florent
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