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(54) **A MATING DETECTION DEVICE, A CONNECTOR AND A CONNECTOR ASSEMBLY THEREWITH**

EINRICHTUNG ZUR KUPPLUNGSERKENNUNG UND DAMIT VERSEHENE VERBINDER UND VERBINDERANORDNUNG

DISPOSITIF DE DÉTECTION D'ACCOUPLEMENT, CONNECTEUR ET ENSEMBLE CONNECTEUR ASSOCIÉS

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to mating detection devices for connectors, and connectors comprising such mating detection devices.

BACKGROUND OF THE INVENTION

[0002] In the past, various connector, like for instance in document US 5 417 586 A, have been proposed to verify that connectors were fully mated to one another, as a way of resolving the problem encountered when pairs of connectors that visually appeared to be connected were not.

[0003] Some of these assemblies included mechanical means, sometimes with audible markers or with so-called connector position assurance (CPA) elements, that were only able to be mechanically activated until a connector assembly was fully connected, for example by clicking or sliding into place.

[0004] Other assemblies have used an electrical circuit present in both of the pair of connectors, such that mating the connectors allows contact of both parts of the circuit, signifying a "lock".

[0005] The present invention has notably for object to provide a simple and more reliable mating detection device.

SUMMARY OF THE INVENTION

[0006] Therefore, according to the present invention, there is provided a mating detection device according to claim 1.

[0007] With these features, the mating detection device is wholly dependant on the mechanical locking elements of the connector itself. Thus, the mating can only be detected after the connectors are mechanically coupled. Therefore it can only indicate a pair of locked connectors if the connectors are mechanically locked, ensuring that the mating detection device cannot indicate a false mating.

[0008] Furthermore, with these features, the whole functionality of mating detection may be found on a single device or on a single connector of the connector pair when the device is applied to a conventional connector

[0009] Lastly, these features permit the present invention to removably associate a mating detection device with traditional connectors to add mating detection functionality to detectors which were not designed with this feature in mind.

[0010] In various embodiments of the present invention, one may also find one or more of the following features corresponding to claims 2-11 considered either independently or in combination.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Other characteristics and advantages of the invention will readily appear from the following description of various embodiments, provided as non-limitative examples, and of the accompanying drawings.

[0012] On the drawings :

- Figures 1a to 1c are perspective views of a first embodiment of the mating detection device,
- Figure 2 illustrates an alternate embodiment of the mating detection device,
- Figure 3 illustrates a typical connector known from the prior art,
- Figure 4 illustrates a known connector fitted with a mating detection device according to an aspect of the invention,
- Figure 5 is a sectional view along the Y-Z plane of the connector illustrated in figure 4,
- Figures 6 and 7 illustrate a sectional view of a connector assembly according to an aspect of the invention,
- Figures 8a to 8d illustrate schematically the workings of a connector assembly according to the invention. On the different Figures, the same reference signs designate like or similar elements, and
- Figure 9 illustrates an alternate embodiment of the mating detection device.

DETAILED DESCRIPTION

[0013] Figures 1a to 1c illustrate perspective views of a mating detection device 1 according to a first embodiment of the invention. The mating detection device 1 is suitable for associating with a conventional connector.

[0014] The mating detection device 1 comprises a housing 2 presenting a top face 3, a rear face 4, and two lateral legs 5. The housing 2 further defines two front protruding forks 6 defining therebetween a void 6a.

[0015] The mating detection device further comprises an electrical member 7, disposed in the X-Y plane, which is fitted in a longitudinal direction (Y) through a slot 4a defined in the rear face 4 of the housing 2. This electrical member 7 is for example a printed circuit board, the forward portion of which protrudes freely from the front of the housing and is positioned between the two front forks 6. The electrical member is thus carried on a part which is removably mounted on the housing 2.

[0016] In this example, the electrical member 7 is a Printed Circuit Board conferring a certain resiliency permitting it to flex in the vertical (Z) direction in the void 6a defined between the two forks 6. Alternatively, the first electrical member 7 is an integral surface of the housing 3 of the mating detection device.

[0017] An electrical mating detection loop 8 is integrated to the electrical member (fig 2), and has a pair of electrical tracks 9 etched on the inner surface 7a of the electrical member 7. The mating detection loop is open when

the connector is not mated with a counterpart. The tracks 9 are terminated by open ended terminals 10 to form an open circuit. The terminals 10 are disposed on the forward portion of the electrical member 7 able to flex.

[0018] The tracks 9 may alternatively be printed on the electrical member 7 using electrically conductive ink, or may constitute metallic tracks adhered to the electrical member 7.

[0019] A longitudinally extending, resilient, electrically conductive member such as a tongue 11 is fixed by adhesion or overmolding to a bridging portion 12 of the housing 2. The bridging portion 12 extends between the two legs 5 and also supports the inner surface 7a of the board 7.

[0020] The resilient tongue 11 is positioned so that its enlarged free end 11a of the tongue is adapted to contact both terminals 10 under bending, in such a way as to provide electrical contact from one terminal to the other by intermediary of the tongue 11.

[0021] The resilient member 11 is made of an electrically conductive material or is made of a non-conductive material, and wherein at least a portion 11a of said resilient member coming into contact with the conductive terminals presents an electrically conductive surface.

[0022] Figure 2 illustrates an alternate embodiment of the mating detection device 1. The device is illustrated in an exploded representation of a top part 13a rotated by 180° about imaginary axis X_1 to be illustrated removed from the bottom part 13b.

[0023] Analogously to the electrical member 7 protruding freely between the two forks 6 of the housing 2 as illustrated on figures 1a-1c, the top part 13a incorporates a forwardly protruding lip 13c delimitated by a pair of lateral cutouts 13d. The lip 13c is resilient to movement.

[0024] The top part 13a presents an inner surface 14 onto which is disposed the mating detection loop 8 and tracks 9. The lip 13c comprises the open-circuited terminals 10.

[0025] The top part 13a further comprises hooks 15 for cooperating with recesses 16 on the bottom part, thereby forming a unitary device.

[0026] The bottom part 13b comprises a top surface 18, a pair of lateral legs 5 for associating with a connector, and a resilient tongue 17 formed or molded out of the same material as bottom part 13b and preferably during the same manufacturing operation. The resilient part 13b is preferably, although not necessarily, electrically non-conductive.

[0027] The end tip 17a of the tongue 17 is coated with a conductive coating such that it may come into contact and bridge terminals 10 in order to close the mating detection loop 8.

[0028] It will be evident for those skilled in the art that the mating detection device 1 body may be preferably molded of a synthetic material such as plastic.

[0029] It will be further evident for a person skilled in the art that a resilient tongue 11, 17, is able to be resiliently bent to come into contact with the two terminals 10 of the mating detection loop 8 in order to change the state (open/closed) of the loop 8, thereby signifying a mating state of the connectors.

[0030] Figure 3 illustrates a perspective view of a typical conventional connector, which may be used in conjunction with the mating detection device 1.

[0031] The connector 20 comprises a front end 21 for mating with a complementary connector (not shown), and means for locking 22 the connector 20 to the complementary connector.

[0032] In particular, according to this embodiment, the locking means or features 22 comprises a pair of resilient lever arms 24 connected together at their extremity with a joining portion (or latch portion) 25(see Figure 5) designed to cooperate with a lug on a corresponding mating connector. The lever arms 24 are further connected together by a ledge 23 for user activation to lift and release the latch 25 from a locked position.

[0033] Figures 4 and 5 illustrate the connector 20 fitted with the mating detection device 1.

[0034] Fixation portions 5a of the legs 5 of the mating detection device cooperate with catches 26 on the connector to be fixed thereon. In an operational position, the electrical member 7, or the protruding lip 13c, of the mating detection device 1 rests on the upper surface of the lever arms 24, a protective cover 27 of the connector covering the void 6a to protect accidental contact with it.

[0035] As Figure 5 more clearly illustrates, thus duly assembled, the tongue 11 of the mating detection device 1 is fitted between the pair of resilient lever arms 24 and before the latch 25. It is thus safely separated from contact with the terminals 10 of the mating detection loop 8.

[0036] Figures 6 and 7 illustrate the above-mentioned connector 20 in a mating position with a complementary connector 30.

[0037] The connector 30 represents a female-type connector being complementary to connector 20. Connector 30 presents a front end portion 34 sleeve-like fitting over the connecting portion 21 of the connector 20.

[0038] The connector 30 presents a locking feature such as a lug 31 designed to cooperate with the latch 25 of the locking means 22 of the connector 20, in the locked state of the connector assembly, in a completely conventional manner which would is known to those skilled in the art.

[0039] Both connectors 20 and 30 are thus deemed to be positively mated, fully mated, or electrically connected together, when the latch 25 latches (falls behind) the corresponding lug 31 of the connector 30.

[0040] In this mated position, the resilient tongue 11 is deflected upwardly by, and sits on, the lug 31. The enlarged free end of the tongue 11a is dimensioned such that, in the mated position, it contacts the terminals 10 of the mating detection loop 8. In the presently illustrated embodiment, the free end of the tongue 11a is sized and positioned so as to deflect upwardly the electrical member 7, providing greater pressure contact between the tongue 11 and the terminals 10 of the mating detection

loop 8 for better connection assurance.

[0041] Figures 8a to 8d illustrate schematically the mating operation of a pair of typical, conventional, connectors using a mating detection device according to the present invention. Figure 8a illustrates the step in which the pair of connectors are not yet mated, figures 8b and 8c illustrate intermediate mating steps, and figure 8d illustrates the pair of connectors positively mated with each other.

[0042] As represented on figure 8a, as the connectors draw closer together, the latch member 25 of the first connector 20 will contact the lug 31 of the second connector 30.

[0043] As the pair of connectors 20,30 are further urged together (Fig. 8b), the latch member 25 will begin to ride up the lug 31. As a result, the latching arms 24 will solicit the electrical member 7, 13c to bend. The electrical member 7 is further separated from the tongue 11, which is not bent at this stage. The mating detection loop is thus prevented from falsely indicating a mating of the connectors.

[0044] As the pair of connectors 20, 30 continue the mating operation, the tongue 11 will eventually, in turn, also be solicited to ride over the lug 31. This is illustrated in figure 8c. In this position, the tongue will be once again returned to its nested position between the latch arms 24, and safely spaced from the electrical member 7 by virtue of the latch arms 24 supporting the electrical member 7, thus preventing the latch arm 11 from contacting it.

[0045] The latching arms 24 will continue to keep the electrical member 7 upwardly solicited until the latch 25 is able to resiliently fall back such that the latch 25 is longitudinally blocked behind the lug 31 (Fig. 8d). This position is designed to assuredly correspond to the pair of connectors 20, 30 being positively locked with each other.

[0046] Furthermore, in this position, the latching arms 24 will release the electrical member 7 to fall back towards its rest position, allowing it into contact with the tongue 11. This contact will allow the free end 11a to contact and bridge the terminals 10 of the mating detection loop 8, indicating a state whereby the pair of connectors are fully mated.

[0047] When the tongue 11 comes in contact with, and bridges the two terminals 10, the loop 8 can be detected as closed with an RFID transceiver, the closing of the circuit signalling under normal circumstances that a pair of connectors (not shown) are securely locked and properly connected.

[0048] According to another embodiment, illustrated on Figure 9, the loop 8 comprises a mating detection circuit 8a. When, the loop 8 is closed as explained above, the circuit 8a becomes active and can exchange information with an RFID emission/detection device via the loop 8 working as an antenna.

[0049] While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiments disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

[0050] In particular, although the present embodiment illustrate a separate mating detection device affixed to a conventional connector, those skilled in the art will understand that a connector may be designed and manufactured to incorporate the following teachings in a unitary connector.

Claims

1. An electrical connector (20) comprising a housing and a first locking feature (23) for latching with a corresponding second locking feature (31) of a second connector designed to mate with said connector, said connector further comprising a mating detection device for detecting the locked state of said connector with said second connector, the first locking feature (22) being designed to come into locking relation with the second locking feature (31) of the second connector when said first and second connectors mate, said mating detection device comprising

- a mating detection loop (8) for detecting a mated state of said first and second connectors, comprising,
- a first electrical member (7), and
- a resilient member (11) for electrically cooperating with said first electrical member for selectively opening or closing said mating detection loop only when the first locking feature (22) is in locking relation with the second locking feature (31),

characterized in that

the first locking feature (22) is a resilient arm, wherein the first electrical member (7) is resilient, wherein the resilient arm (24) is adapted to cooperate with the resilient first electrical member (7) so as to displace it away from said resilient member (11) upon mating of the connector with the second connector.

2. An electrical connector according to any preceding claim, wherein:

- the first electrical member (7) constitutes a resilient support comprising conductive terminals (9) forming an open circuit, said conductive terminals being connected to circuitry (8) reacting to when said conductive terminals form a closed

circuit, and wherein
- the resilient member (11) is disposed to electrically contact said conductive terminals such that said conductive terminals form a closed circuit upon contact.

3. An electrical connector according to any preceding claim, comprising a first part carrying the first electrical member (7), a second part (3) carrying the resilient member (11), wherein said first and second parts are removably attached to each other.

4. A connector according to any preceding claim, wherein the resilient member (11) is adapted to be displaced by said second connector toward said first electrical member upon mating of the connector with the second connector.

5. A connector according to any of preceding claim, wherein the first locking feature (22) contacts the first electrical member (7), and surrounds the resilient member (11) thus preventing said resilient member from contacting said first electrical member in an unmated state of the connectors.

6. A connector according to any preceding claim, wherein the resilient member (11) is mechanically prevented from cooperating with the first electrical member (7) until the first connector is in a locked state with the second connector.

7. A connector according to any preceding claim, wherein the mating detection device is removably fitted (5a, 26) on said housing.

8. A connector according to any preceding claim, wherein the mating detection device is integrally formed with said housing.

9. An electrical connector assembly comprising a first connector according to any preceding claims and the second connector comprising the second locking feature (31), said first and second connector designed to mate with one another, the first and second locking features coming into locking relation when said connectors mate.

10. A connector assembly according to claim 9, wherein the resilient member (11) is urged against the first electrical member (7) when the first locking feature (22) is in locking relation with the second locking feature (31).

11. A connector assembly according to claim 9, wherein said second locking feature (31) is dimensioned to actuate the first locking feature (22) and the first electrical member (7) away from the resilient member (11) when the first and second connectors are in an unlocked state, and to actuate the resilient member (11) toward the first electrical member (7) when said first and second connectors are in a locked state.

Patentansprüche

1. Ein elektrischer Verbinder (20), der ein Gehäuse und ein erstes Verriegelungsmerkmal (22) aufweist zum Verriegeln mit einem entsprechenden zweiten Verriegelungsmerkmal (31) eines zweiten Verbinders, der ausgebildet ist zum Zusammenfügen mit dem Verbinder, wobei der Verbinder weiter eine Zusammenfügen-Erfassungsvorrichtung aufweist zum Erfassen des verriegelten Zustands des Verbinders mit dem zweiten Verbinder, wobei das erste Verriegelungsmerkmal (22) ausgebildet ist, in eine Verriegelungsbeziehung mit dem zweiten Verriegelungsmerkmal (31) des zweiten Verbinders zu kommen, wenn die ersten und zweiten Verbinder zusammengefügt werden, wobei die Zusammenfügen-Erfassungsvorrichtung aufweist

- eine Zusammenfügen-Erfassungsschleife (8) zum Erfassen eines zusammengefügten Zustands der ersten und zweiten Verbinder, aufweisend
- ein erstes elektrisches Element (7), und
- ein elastisches Element (11) zum elektrischen Zusammenwirken mit dem ersten elektrischen Element zum selektiven Öffnen oder Schließen der Zusammenfügen-Erfassungsschleife nur dann, wenn das erste Verriegelungsmerkmal (22) mit dem zweiten Verriegelungsmerkmal (31) in einer Verriegelungsbeziehung ist,

dadurch gekennzeichnet, dass
das erste Verriegelungsmerkmal (22) ein elastischer Arm ist, wobei das erste elektrische Element (7) elastisch ist, wobei der elastische Arm (24) ausgebildet ist zum Zusammenwirken mit dem elastischen ersten elektrischen Element (7) derart, um dieses weg von dem elastischen Element (11) zu versetzen bei einem Zusammenfügen des Verbinders mit dem zweiten Verbinder.

2. Ein elektrischer Verbinder gemäß einem vorhergehenden Anspruch, wobei:

- das erste elektrische Element (7) einen elastischen Träger bildet, der leitende Anschlüsse (9) aufweist, die eine offene Schaltung bilden, wobei die leitenden Anschlüsse mit einer Schaltungsanordnung (8) verbunden sind, die darauf reagiert, wenn die leitenden Anschlüsse eine geschlossene Schaltung bilden, und wobei
- das elastische Element (11) angeordnet ist zum elektrischen Kontaktieren der leitenden An-

schlüsse derart, dass die leitenden Anschlüsse bei Kontakt eine geschlossene Schaltung bilden.

3. Ein elektrischer Verbinder gemäß einem vorhergehenden Anspruch, der einen ersten Teil aufweist, der das erste elektrische Element (7) trägt, einen zweiten Teil (3), der das elastische Element (11) trägt, wobei die ersten und zweiten Teile entfernbar aneinander befestigt sind.

4. Ein Verbinder gemäß einem vorhergehenden Anspruch, wobei das elastische Element (11) ausgebildet ist, durch den zweiten Verbinder in Richtung des ersten elektrischen Elements versetzt zu werden bei einem Zusammenfügen des Verbinders mit dem zweiten Verbinder.

5. Ein Verbinder gemäß einem vorhergehenden Anspruch, wobei das erste Verriegelungsmerkmal (22) das erste elektrische Element (7) kontaktiert und das elastische Element (11) umgibt, wodurch verhindert wird, dass das elastische Element das erste elektrische Element in einem nichtzusammengefügten Zustand der Verbinder kontaktiert.

6. Ein Verbinder gemäß einem vorhergehenden Anspruch, wobei das elastische Element (11) mechanisch daran gehindert wird, mit dem ersten elektrischen Element (7) zusammenzuwirken, bis der erste Verbinder mit dem zweiten Verbinder in einem verriegelten Zustand ist.

7. Ein Verbinder gemäß einem vorhergehenden Anspruch, wobei die Zusammenfügen-Erfassungsvorrichtung entfernbar an dem Gehäuse angebracht ist (5a, 26).

8. Ein Verbinder gemäß einem vorhergehenden Anspruch, wobei die Zusammenfügen-Erfassungsvorrichtung integral mit dem Gehäuse ausgebildet ist.

9. Eine elektrische Verbinderanordnung, die einen ersten Verbinder gemäß einem vorhergehenden Anspruch und den zweiten Verbinder mit dem zweiten Verriegelungsmerkmal (31) aufweist, wobei der erste und der zweite Verbinder ausgebildet sind, miteinander zusammengefügt zu werden, wobei die ersten und zweiten Verriegelungsmerkmale in eine Verriegelungsbeziehung kommen, wenn die Verbinder zusammengefügt werden.

10. Eine Verbinderanordnung gemäß Anspruch 9, wobei das elastische Element (11) gegen das erste elektrische Element (7) gedrückt wird, wenn das erste Verriegelungsmerkmal (22) in einer Verriegelungsbeziehung mit dem zweiten Verriegelungsmerkmal (31) ist.

11. Eine Verbinderanordnung gemäß Anspruch 9, wobei das zweite Verriegelungsmerkmal (31) dimensioniert ist zum Betätigen des ersten Verriegelungsmerkmals (22) und des ersten elektrischen Elements (7) weg von dem elastischen Element (11), wenn der erste und der zweite Verbinder in einem nicht-verriegelten Zustand sind, und zum Betätigen des elastischen Elements (11) hin zu dem ersten elektrischen Element (7), wenn der erste und der zweite Verbinder in einem verriegelten Zustand sind.

Revendications

1. Connecteur électrique (20) comprenant un boîtier et un premier moyen de blocage (23) pour le verrouillage avec un second moyen de blocage correspondant (31) d'un second connecteur conçu pour s'accoupler avec ledit connecteur, ledit connecteur comprenant en outre un dispositif de détection d'accouplement pour détecter l'état bloqué dudit connecteur avec ledit second connecteur, le premier moyen de blocage (22) étant conçu pour venir en relation de blocage avec le second moyen de blocage (31) du second connecteur quand ledit premier et ledit second connecteur s'accouplent, ledit dispositif de détection d'accouplement comprenant

- une boucle de détection d'accouplement (8) pour détecter un état accouplé dudit premier et dudit second connecteur, comprenant :
- un premier élément électrique (7), et
- un élément élastique (11) pour coopérer électriquement avec ledit premier élément électrique afin d'ouvrir ou de fermer sélectivement ladite boucle de détection d'accouplement uniquement quand le premier moyen de blocage (22) est en relation de blocage avec le second moyen de blocage (31),

caractérisé en ce que
le premier moyen de blocage (22) est un bras élastique, le premier élément électrique (7) est élastique, et le bras élastique (24) est adapté à coopérer avec le premier élément électrique élastique (7) de manière à le déplacer en éloignement dudit élément élastique (11) lors de l'accouplement du connecteur avec le second connecteur.

2. Connecteur électrique selon l'une quelconque des revendications précédentes, dans lequel :

- le premier élément électrique (7) constitue un support élastique comprenant des bornes conductrices (7) formant un circuit ouvert, lesdites bornes conductrices étant connectées à des circuits (8) qui réagissent lorsque lesdites bornes conductrices forment un circuit fermé, et dans

lequel

- l'élément élastique (11) est disposé de manière à venir électriquement en contact avec lesdites bornes conductrices de telle façon que lesdites bornes conductrices forment un circuit fermé lors du contact.

3. Connecteur électrique selon l'une quelconque des revendications précédentes, comprenant une première partie qui porte le premier élément électrique (7), une seconde partie (3) qui porte l'élément élastique (11), et dans lequel ladite première et ladite seconde parties sont attachées l'une à l'autre de manière amovible.

4. Connecteur selon l'une quelconque des revendications précédentes, dans lequel l'élément élastique (11) est adapté à être déplacé par ledit second connecteur vers ledit premier élément électrique lors de l'accouplement du connecteur avec le second connecteur.

5. Connecteur selon l'une quelconque des revendications précédentes, dans lequel le premier moyen de blocage (22) est en contact avec le premier élément électrique (7) et entoure l'élément élastique (11), empêchant ainsi audit élément élastique de venir en contact avec ledit premier élément électrique dans un état non accouplé des connecteurs

6. Connecteur selon l'une quelconque des revendications précédentes, dans lequel l'élément élastique (11) est empêché mécaniquement de coopérer avec le premier élément électrique (7) jusqu'à ce que le premier connecteur soit dans un état bloqué avec le second connecteur.

7. Connecteur selon l'une quelconque des revendications précédentes, dans lequel le dispositif de détection d'accouplement est monté de façon amovible (5a, 26) sur ledit boîtier.

8. Connecteur selon l'une quelconque des revendications précédentes, dans lequel le dispositif de détection d'accouplement est formé de manière intégrale avec ledit boîtier.

9. Ensemble formant connecteur électrique comprenant un premier connecteur selon l'une quelconque des revendications précédentes et un second connecteur comprenant le second moyen de blocage (31), ledit premier et ledit second connecteur étant conçus pour s'accoupler l'un avec l'autre, le premier et le second moyen de blocage venant en relation de blocage lorsque lesdits connecteurs s'accouplent.

10. Ensemble formant connecteur selon la revendication 9, dans lequel l'élément élastique (11) est forcé contre le premier élément électrique (7) quand le premier moyen de blocage (22) est en relation de blocage avec le second moyen de blocage (31).

11. Ensemble formant connecteur selon la revendication 9, dans lequel ledit second moyen de blocage (31) est dimensionné pour actionner le premier moyen de blocage (22) et le premier élément électrique (7) en éloignement de l'élément élastique (11) quand le premier et le second connecteur sont dans un état non bloqué, et pour actionner l'élément élastique (11) vers le premier élément électrique (7) quand ledit premier et ledit second connecteur sont dans un état bloqué.

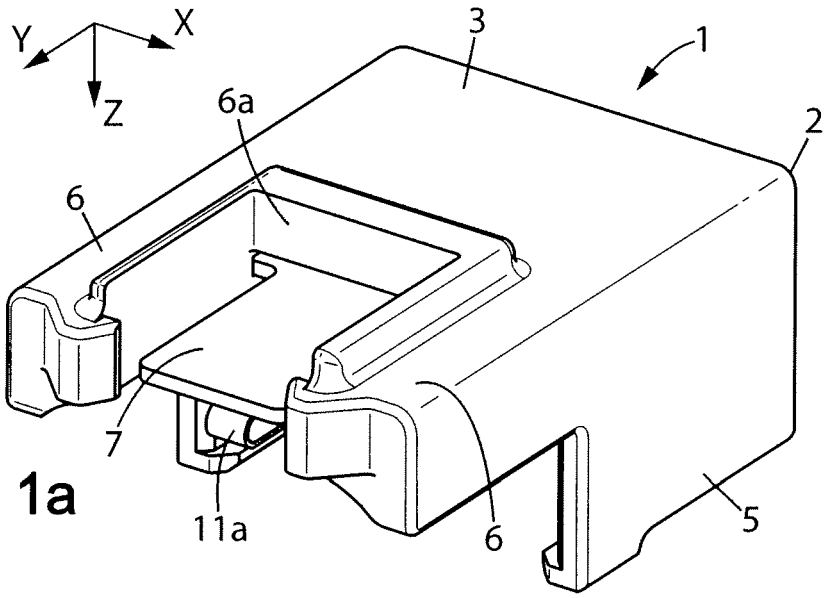


FIG. 1a

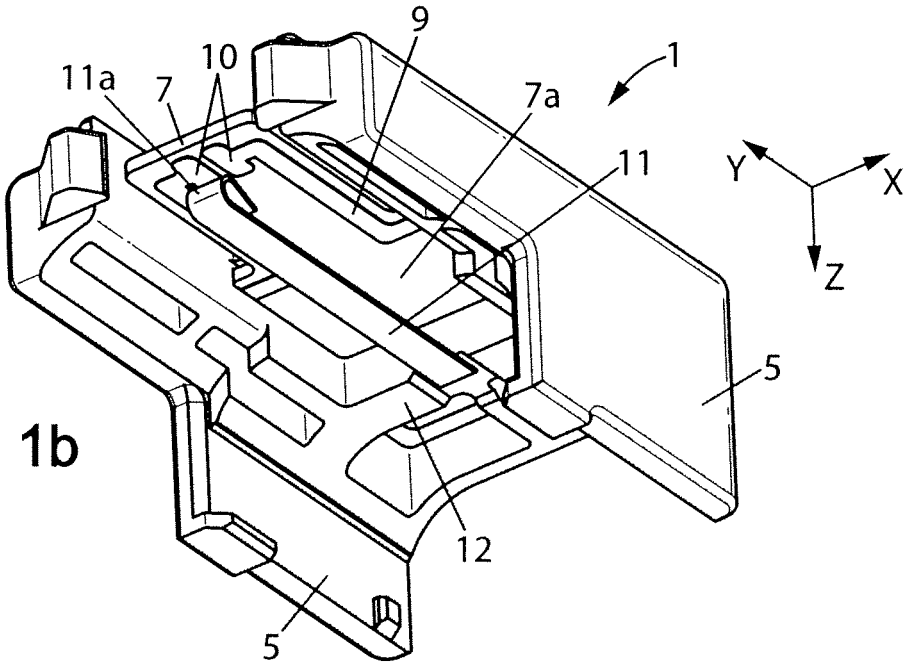


FIG. 1b

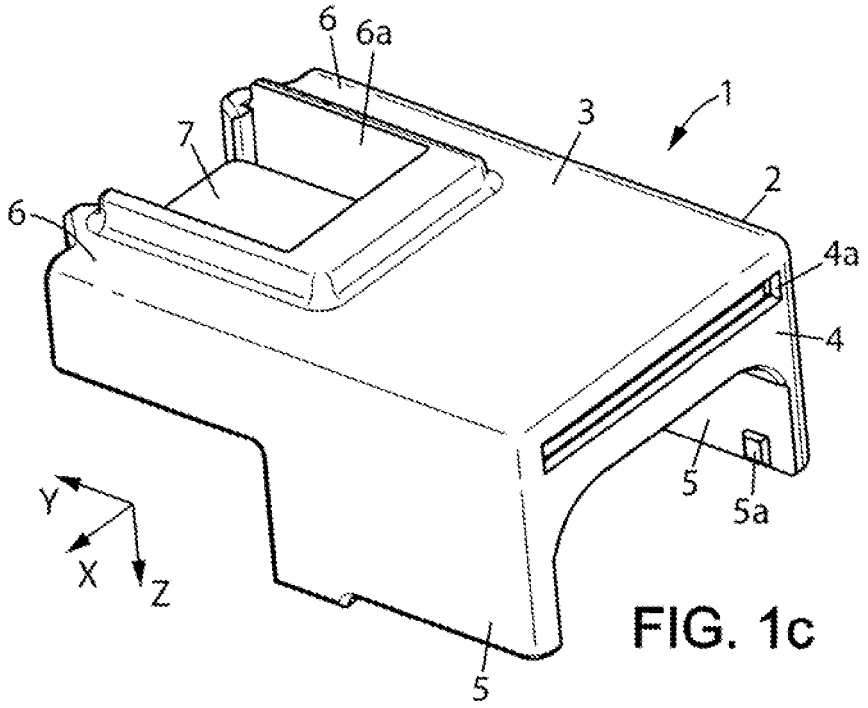

6
6a
1
3
7
2
6
4a
4
5
5a
Y
X
Z
5

FIG. 1c

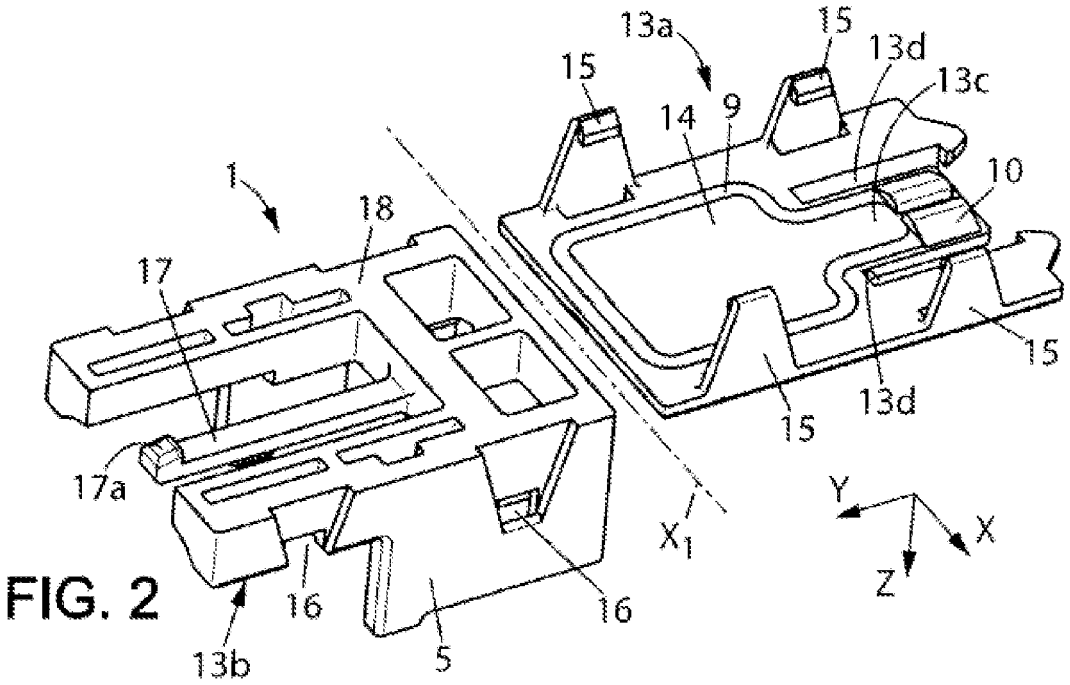

13a
15
15
13d
13c
14
9
1
10
18
17
15
13d
15
17a
Y
X
X_1
Z
16
16
13b
5

FIG. 2

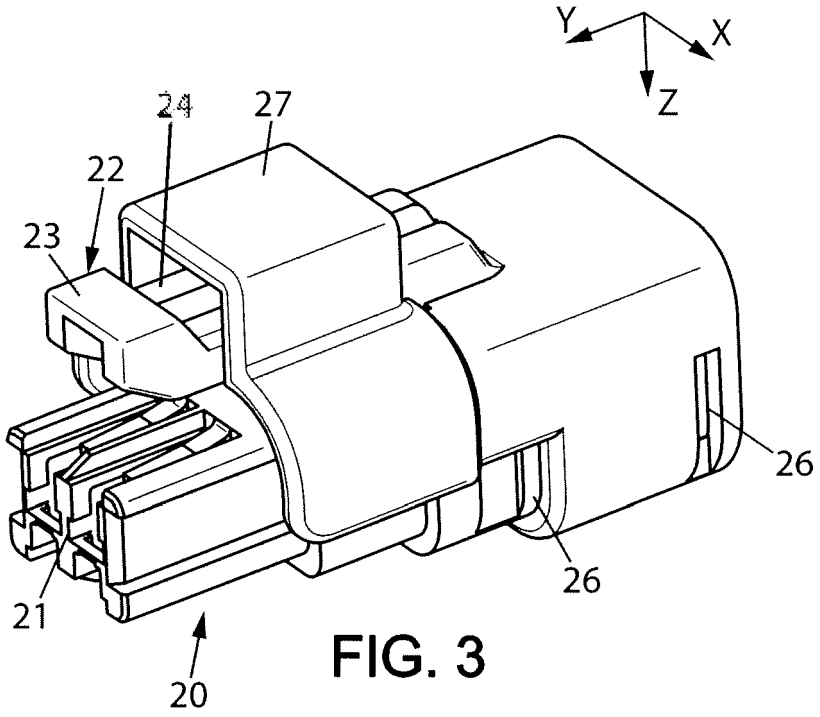


FIG. 3

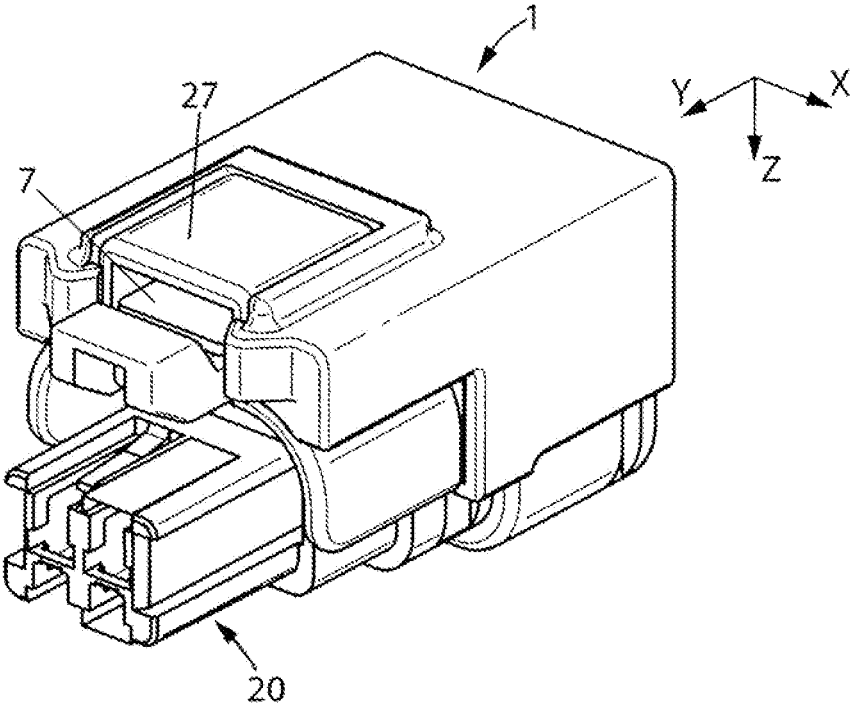


FIG. 4

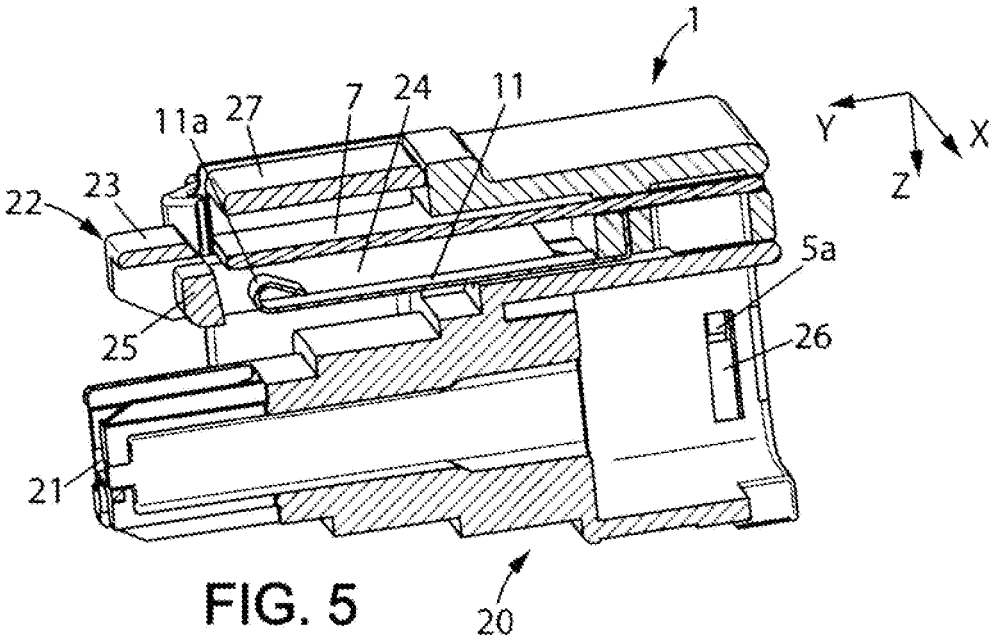


FIG. 5

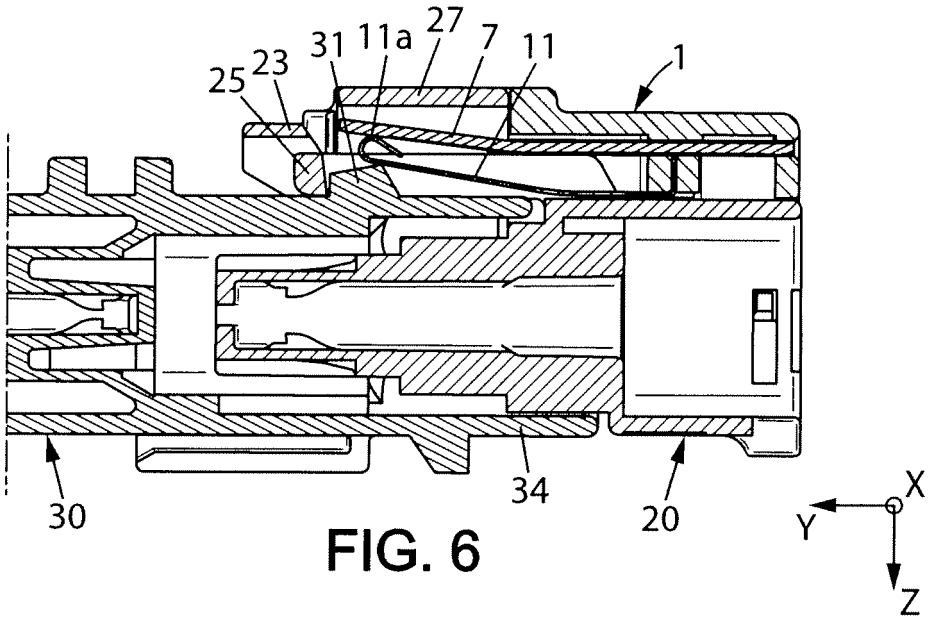


FIG. 6

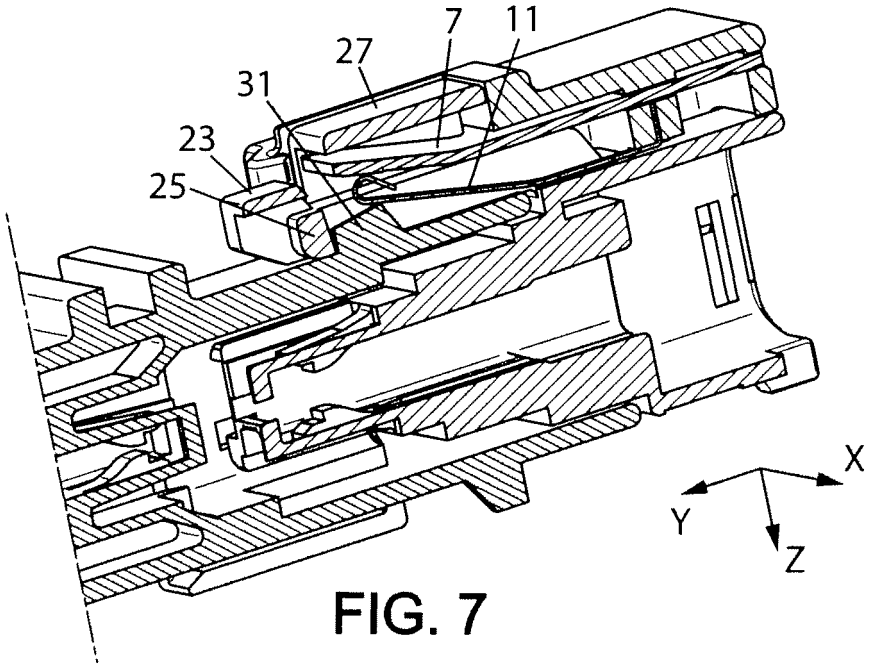


FIG. 7

FIG. 8a

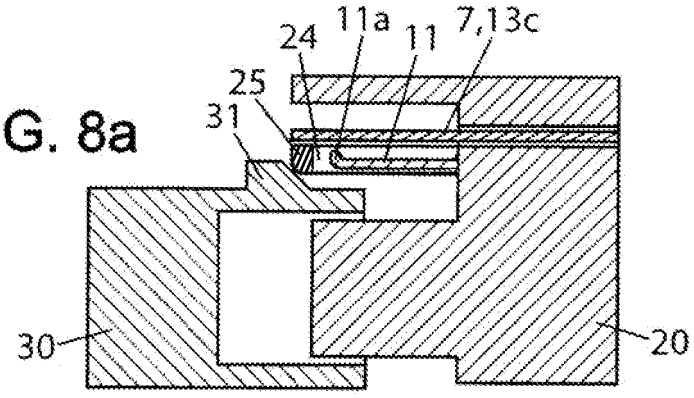
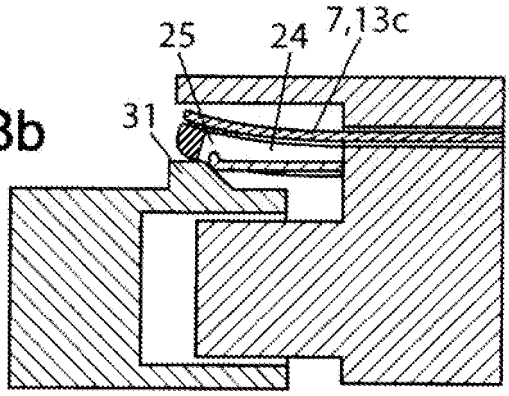


FIG. 8b



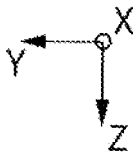


FIG. 8c

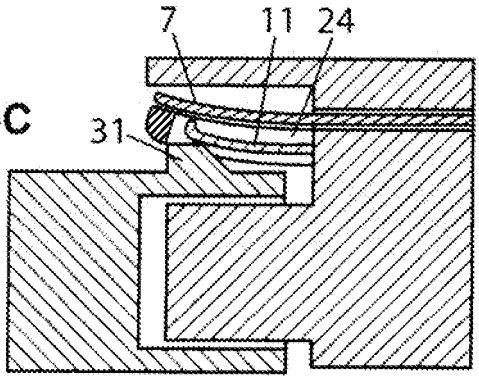
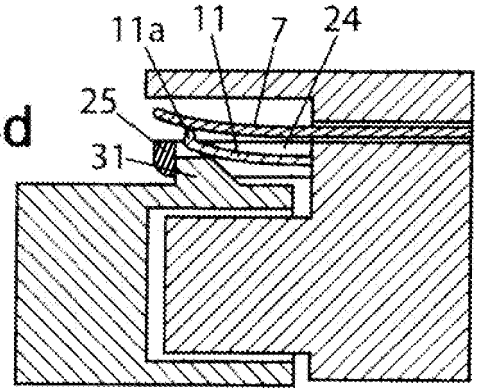


FIG. 8d



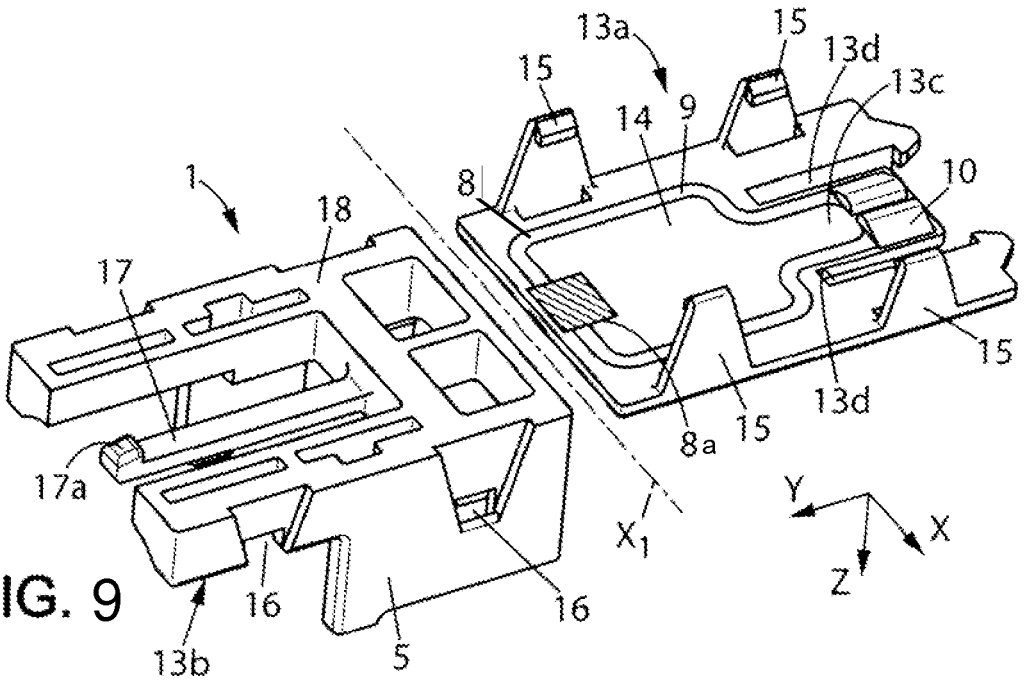


FIG. 9

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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