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(71) Applicant: **Aptiv Technologies AG**
8200 Schaffhausen (CH)

(72) Inventors:
- **SUKUMAR, Nithish**
  639002 Nadu (IN)
- **POSMIK, Mirko**
  90763 Fürth (DE)

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

(54) **FEMALE ELECTRICAL CONNECTOR WITH CAGED MODULAR INSERTS**

(57) Female electrical connector 1 comprising an outer housing to defining a mating direction X of the female electrical connector 1; at least one female electrical terminal 20, 21; at least one insert 30, 31, individually surrounding the at least one female electrical terminal 20, 21; a cage inner housing 40, connected to the inside of the outer housing 10, extending in mating direction X out of the outer housing 10, and surrounding the at least one insert 30, 31 in mating direction X; wherein the insert 30, 31 is shiftable in mating direction X between an assembly position 32 in which the female electrical terminal 20, 21 is insertable into the female electrical connector 1 and a locking position 33 in which the female electrical terminal 20, 21 is locked within the female electrical connector 1.

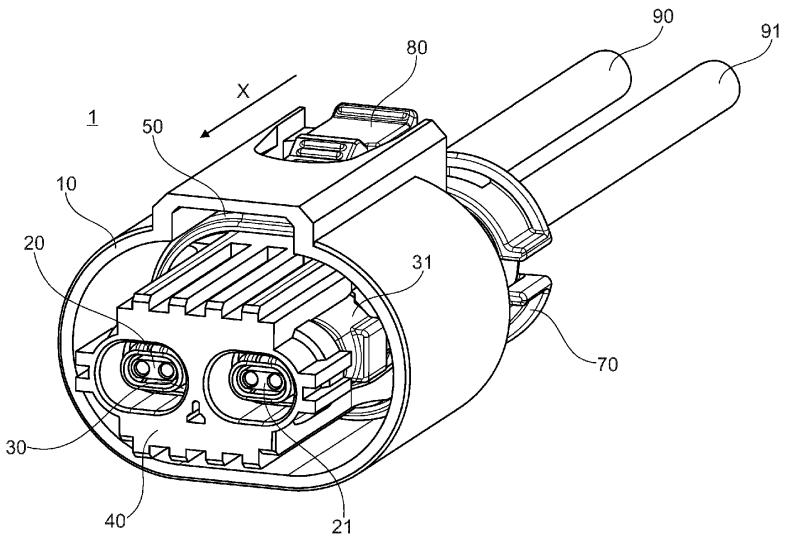

Fig. 1

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Description

1. Field of the invention

[0001] The present invention relates to a female electrical connector with caged modular inserts. The female electrical connector is particularly useful as High-Speed Modular Twisted-Pair Data (H-MTD®) female connector for automotive applications.

2. Prior art

[0002] Electrical connectors are widely used in automotive applications. On the one hand such electrical connectors are used to transmit electrical power to electric consumers. On the other hand electric connectors are more often used to distribute data in automotive vehicles.

[0003] Vehicles are adding high-resolution radars and cameras to support ever more sophisticated automated driving capabilities, and those devices create high-bandwidth streams of data to centralized computing platforms. To accommodate these emerging requirements, the industry is moving to networking technologies such as Automotive Ethernet and MIPI A-PHY, a new physical-layer interface for in-vehicle data transmission.

[0004] Ethernet has a long and successful history in IT, but the most common connectors used with Ethernet in the IT world-such as the RJ-45 jack found on many laptops and in data centers-are not nearly robust enough for automotive environments, which present unique challenges related to heat, vibration, electromagnetic interference, space constraints, dirt and dust. Keeping the connections clean and securely attached in that environment is critical to ensuring that the automated driving features operate as expected.

[0005] High-Speed Modular Twisted-Pair Data (H-MTD®) is a connector system used in automotive networking applications that supports frequencies up to 20 GHz and data transmission rates up to 56G bit/sec. To protect against electromagnetic interference, the connectors provide a fully shielded interface. The H-MTD® cable assembly design supports the use of shielded twisted-pair cables for high bandwidths.

[0006] The object of the present invention is to provide a female electrical connector, particularly for high-bandwidth data applications, that is easy to assemble, reliable, serviceable and robust enough for automotive applications.

3. Summary of the invention

[0007] The above-mentioned object is realized by a female electrical connector according to claim 1 or by a system of a female electrical connector and an assembly tool according to claim 11 or by a method for an assembly of a female electrical connector according to claim 14.

[0008] Particularly, the above-mentioned object is realized by a female electrical connector comprising an outer housing defining a mating direction of the female electrical connector; at least one female electrical terminal; at least one insert, individually surrounding the at least one female electrical terminal; a cage inner housing, connected to the inside of the outer housing, extending in mating direction out of the outer housing, and surrounding the at least one insert in mating direction; wherein the insert is shiftable in mating direction between an assembly position in which the female electrical terminal is insertable into the female electrical connector and a locking position in which the female electrical terminal is locked within the female electrical connector.

[0009] Thus, each female electrical terminal is individually surrounded by its insert, what makes the female electrical connector modular in terms of the number of female electrical terminals. It should be noted that one female electrical terminal can comprise more than one female electrical contact. For example, in case of a female H-MTD® terminal two electrical contacts for the twisted pair cable are provided in one female electrical terminal. Preferably, the female H-MTD® terminal provides a common shielding for the two electrical contacts of the twisted pair cable. In another example the female electrical terminal for a coaxial cable can only comprise one female electrical contact, that is shielded by an outer shield.

[0010] The insert is shiftable in mating direction between an assembly position and a locking position. Thereby, an easy assembly of the electrical terminal and a secure locking of the female electrical terminal within the female electrical connector is ensured. Further, since the insert can be shifted between both positions a plurality of times, it is possible to easily disassemble the female electrical terminal from the female electrical connector. This allows servicing or adapting the electrical connection if needed.

[0011] Since the cage inner housing extends in mating direction out of the outer housing and surrounds the at least one insert in mating direction it mechanically protects the shiftable insert prior and after assembly of the respective female electrical terminal. Preferably, the cage inner housing builds a protective "cage" around the shiftable insert to avoid accidental shifting of the insert during transport in pre-assembled condition or later during use. Thus, in a pre-assembled condition of the female electrical connector the insert is securely maintained in the assembly position that allows a female electrical terminal to be inserted into the female electrical connector for assembly. In the assembled condition the cage inner housing prevents the insert from being accidentally shifted from the locking position to the assembly position and, thus, protects the female electrical terminal to be accidentally disassembled, i.e. pulled out of, the female electrical connector.

[0012] All in all the combination of a shiftable insert individually for one female electrical terminal and a cage inner housing that surrounds the respective insert in mating direction significantly facilitates assembly and signif-

icantly improves the reliability of the connector and the serviceability thereof.

[0013] Preferably, the outer housing comprises at least one latching element for latching with the female electrical terminal. By the latching element the female electrical terminal is initially held within the outer housing. Thus, the female electrical terminal can be mounted to the outer housing by simple insertion and latching.

[0014] Preferably, a movement of the latching element is prevented by the insert, when the insert is shifted to its locking position and a movement of the latching element is allowed by the insert, when the insert is shifted to its assembly position. Thus, the insert secures the initial mounting of the female electrical terminal by the latching element. On the one hand this significantly improves the reliability of assembly of the female electrical terminal within the outer housing. On the other hand it allows to provide a latching element that can be moved to a disassembly position in which the female electrical terminal is free to be disassembled from the female electrical connector.

[0015] Preferably, the cage inner housing is connected to the outer housing by a retaining latch of the cage inner housing. By the retaining latch the cage inner housing can be easily assembled to the outer housing by simply inserting the cage inner housing into the outer housing.

[0016] Preferably, the cage inner housing comprises coding features for allowing connection with a suitable male electrical connector and for preventing a connection with a non-suitable male electrical connector. Thus, by different cage inner housings with different coding features the female electrical connector can be encoded to be used only with a corresponding male electrical connector. Only the cage inner housing needs to be exchanged for the mechanical encoding. The remaining parts of the female electrical connector can be common to all differently encoded female electrical connectors.

[0017] Preferably, the female electrical connector further comprises an elastic seal, wherein the seal has a V-shaped cross-section and is arranged between the outer housing and the cage inner housing. Preferably, he seal waterproofs the connection between the outer housing and the cage inner housing. In addition the seal also waterproofs the connection between the female electrical connector and a male electrical connector connected to the female electrical connector. The two legs of the V-shaped cross-section, thus, provide two sealing surfaces of the seal.

[0018] Preferably, the seal comprises ridges at both sealing surfaces, which improve the sealing performance.

[0019] Preferably, the seal comprises at least one retaining pin, which extends from the seal and is held within corresponding retaining cavities of the outer housing.

[0020] Preferably, the cage inner housing comprises a tubular end that introduces into a cavity formed by the V-shaped cross-section of the elastic seal. Thus, the cage inner housing holds the seal in place and reinforces the seal.

[0021] Preferably, the female electrical terminal is a high-speed data terminal, preferably a shielded coaxial terminal or a shielded high-speed modular twisted pair data terminal. Thus, the female electrical connector is suitable for high-bandwidth data transmission.

[0022] Preferably, the female electrical connector comprises more than one, preferably two, three, four, five or six female electrical terminals, and correspondingly more than one, preferably two, three, four, five or six inserts. Thus, each of the female electrical terminals can individually be assembled or locked by the corresponding insert.

[0023] Preferably, each insert is individually shiftable in mating direction between the assembly position and the locking position. Thus, it is possible to disassemble one female electrical terminal whereas the other female electrical terminals are still locked within the female electrical connector.

[0024] The above-mentioned objects are also achieved by a system of a female electrical connector as previously described and an assembly tool, wherein the assembly tool comprises a tubular end for pushing one of the inserts from the assembly position to the locking position. By the tool the insert can be easily, preferably manually, pushed into the locking position to lock the female electrical terminal within the female electrical connector.

[0025] Preferably, the assembly tool further comprises a hook for pulling one of the inserts from the locking position to the assembly position. By the hook an insert can be pulled to the assembly position for unlocking the corresponding female electrical terminal.

[0026] Preferably, the assembly tool further comprises a wedge for releasing the latching element from the female electrical terminal. The wedge preferably pushes the latching element to the outside such that it comes out of engagement with the female electrical terminal.

[0027] The above-mentioned objects are also achieved by a method for an assembly of a female electrical connector comprising the following steps:

a. providing an outer housing defining a mating direction of the female electrical connector;

b. providing an insert, which is axially movable in mating direction within the female electrical connector;

c. providing a cage inner housing, connected to the inside of the outer housing, extending in mating direction out of the outer housing, and surrounding the at least one insert in mating direction;

d. inserting at least one female electrical terminal into a cable side of the outer housing such that the female electrical terminal is at least partially surrounded by the insert; and

e. shifting the insert in mating direction from an assembly position to a locking position in which the female terminal is locked within the connector.

[0028] By this assembly method, the same advantages are achieved as explained above in view of the female electrical connector.

4. Short description of the drawings

[0029] In the following, preferred embodiments of the invention are disclosed by reference to the accompanying figure, in which shows:

Fig. 1 a three-dimensional view of a preferred embodiment of a female electrical connector;

Fig. 2 a three-dimensional explosion view of the female electrical connector of Fig. 1;

Fig. 3 a sectional view of the female electrical connector of Fig. 1;

Fig.4A-D different views of a preferred embodiment of an insert of the female electrical connector of Fig. 1;

Fig. 5A-F different views of a preferred embodiment of a seal and the female electrical connector of Fig. 1 during and after assembly of the seal;

Fig. 6A-D different views of the female electrical connector of Fig. 1 during and after assembly of the insert of Figs. 4A-D;

Fig.7A-C different views of a cage inner housing of the female electrical connector of Fig. 1;

Fig. 8A-D different views of the female electrical connector of Fig. 1 during and after assembly of the cage inner housing of Figs. 7A-D;

Fig. 9A-C different views of the female electrical connector of Fig. 1 during and assembly of two female electrical terminals;

Fig. 10A-B three-dimensional views of the female electrical connector of Fig. 1 wherein the insert is in the assembly position, wherein in Fig. 10B the cage inner housing is not shown;

Fig. 10C-D three-dimensional views of the female electrical connector of Fig. 1 wherein the insert is in the locking position, wherein in Fig. 10D the cage inner housing in not shown;

Fig. 11A a three-dimensional partial sectional view of the female electrical connector of Fig. 1 wherein the insert is in the assembly position;

Fig. 11B a three-dimensional partial sectional view of the female electrical connector of Fig. 1 wherein the insert is in the locking position;

Fig. 12A-B a side view and a three-dimensional partial view of a first preferred embodiment of an assembly tool;

Fig. 13A a partial sectional view of the female electrical connector of Fig. 1 and the assembly tool of Figs. 12A-B prior to moving the insert from the assembly position into the locking position;

Fig. 13B a partial sectional view of the female electrical connector of Fig. 1 and the assembly tool of Figs. 12A-B after moving the insert from the assembly position into the locking position;

Fig. 14 a partial sectional view of the female electrical connector of Fig. 1 and the assembly tool of Figs. 12A-B during shifting an insert from the locking position to the assembly position;

Fig. 15A a three-dimensional view of a second preferred embodiment of an assembly tool; and

Figs. 15B-C different partial sectional views of the female electrical connector of Fig. 1 ant the assembly tool of Fig. 15A during releasing the latching element from the female electrical terminal.

5. Detailed description of preferred embodiments

[0030] In the following, preferred embodiments of the invention are described in detail with respect to the figures.

[0031] Figs. 1, 2 and 3 show a female electrical connector 1 according to a preferred embodiment of the present invention. The female electrical connector 1 comprises as main components an outer housing 10, two female electrical terminals 20, 21, two inserts 30, 31 and a cage inner housing 40. Further the female electrical connector 1 preferably comprises an elastic seal 50 that

is arranged between the outer housing 10 and the cage inner housing 40. The female electrical terminals 20, 21 are electrically and mechanically connected to corresponding electrical cables 90, 91. Further, the female electrical connector 1 preferably comprises for each of the cables 90, 91 cable seal 60, 61 that are arranged between each of the cables 90, 91 and cable receptacles of the outer housing 10. The cable seals 60, 61 and the cables 90, 91 are held in place within the outer housing 10 by an end cap 70 that is inserted into and latches with the back end of the outer housing 10. Thus, the end cap 70 also serves as a seal retention for the single wire seals 61, 61. The female electrical connector 1 further preferably comprises a latching tab 80 for latching with a corresponding male electrical connector (not shown). The latching tab 80 also serves as CPA (Connector Position Assurance) element, thus it ensures that the mating male electrical connector (not shown) can only be inserted into the female electrical connector with the correct orientation. The latching tab 80 is mounted to the outer housing 10 so that it can be manually pushed to release the latching with the male electrical connector.

[0032] The female electrical connector 1 comprises a connector side 2 where it connects with a corresponding male electrical connector (not shown) and a cable side 4 where the electrical cables extend. The mating direction is indicated by an arrow X and shows the movement direction for establishing connection with a corresponding male electrical connector.

[0033] As particularly shown in Fig. 3, in the preferred embodiment the female electrical connector 1 is a High-Speed Modular Twisted-Pair Data (H-MTD) female connector for automotive applications. The female electrical connector 1 comprises two female electrical terminals 20, 21 each one for one shielded twisted pair high-speed data cable 90, 91. Thus, each electrical terminal 20, 21 is shielded by a metal shield 22 and comprises two female electrical contacts 24, one for each line of the twisted pair cable 90, 91 (see also Fig. 9C). Of course, in other embodiments the female electrical connector 1 can comprise only one or up to six or even more female electrical terminals 20, 21 for three, four, five or up to six or even more twisted pair cables 90, 91 with up to twelve or even more individual electrical data lines. As a replacement for standard Ethernet connectors the female electrical connector 1 can comprise four female electrical terminals 20, 21 with eight individual electrical data lines.

[0034] The female electrical connector 1 provides a robust, reliable and preferably water-resistant connector for shielded high-speed twisted-pair data cables. Thereby, the female electrical terminals 20, 21 are reliably individually locked within the female electrical connector 1. Since the outer housing 10 is a one-piece element the female electrical terminals 20, 21 are held exactly in place, what improves contact overlap of the electrical connection. In addition, the female electrical terminals 20, 21 can be individually removed from the female electrical connector 1, when the locking is released. All locking elements female electrical connector 1 are caged in the inside of the female electrical connector 1 by the cage inner housing 40, what prevents any unintentional locking or unlocking of the female electrical terminals 20, 21. For the locking and unlocking of the female electrical terminals 20, 21 specially designed tools 110 (see Figs. 12-15) are provided to enable assembly or disassembly without damaging the female electrical connector 1.

[0035] Each female electrical terminal 20, 21 is individually surrounded by a corresponding insert 30, 31 which is shown in detail in Figs. 4A-D. The inserts 30, 31 are shiftable in mating direction X between an assembly position 32 in which the female electrical terminal 20, 21 is insertable into the female electrical connector 1 and a locking position 33 in which the female electrical terminal 20, 21 is locked within the female electrical connector 1. Preferably, the insert 30, 31 in the locking position 33 blocks the movement of a corresponding latching element 12, 13 of the outer housing 10 that latches with a corresponding female electrical terminal 20, 21, when the female electrical terminal 20, 21 is inserted into the female electrical connector 1. For blocking of the latching elements 12, 13 the inserts 30, 31 further comprises a collar 36. The inserts 30, 31 comprise an essentially hollow body 37 that in assembled condition surrounds one of the female electrical terminals 20, 21. Further, for installing and shifting the inserts 30, 31 they comprise an actuation face 38. The actuation face 38 is adapted to the cross-section of the female electrical terminals 20, 21 and is preferably essentially oval. The inserts 30, 31 further comprise a latching hook 34 and an indexing leg 35 at the end of the body 37 opposite to the actuation face 38.

[0036] In Fig. 3 the inserts 30, 31 are positioned in the assembly position 32, such that the latching elements 12, 13 can be bent to the outside to release the latching with the corresponding female electrical terminal 20, 21. This assembly position 32 of the insert 30, 31 is also shown in Fig. 11A. Fig. 11B on the other hand shows the insert 30, 31 in the locking position 33, in which the insert 30, 31 blocks the outward movement of the latching element 12, 13 by its collar 36.

[0037] The assembly of the female electrical connector 1 and the individual components are shown in detail in Figs. 4 to 11.

[0038] In a first step as shown in Figs. 5A-F the elastomeric seal 50 is inserted into the outer housing 10 of the female electrical connector 1 from the connector side 14 thereof, as indicated by the arrow in Fig. 5A.

[0039] The outer housing 10 is a generally hollow insulating plastic part, which comprises a connector side cavity 15 for receiving the seal 50, the inserts 30, 31 and the cage inner housing 40. Opposite to the connector side cavity 15 the outer housing 10 comprises a cable side cavity 16 for receiving the female electrical terminals 20, 21 and the cables 90, 91. In the central portion of the connector side cavity 16 the outer housing comprises integral mounting elements 17 for mounting the inserts

30, 31 and the cage inner housing 40 and comprises the latching elements 12, 13 which lock the female electrical terminals 20, 21 in inserted condition.

[0040] The elastomeric seal 50 is made of an elastomeric material and seals the connector side cavity 15 to a male electrical connector (not shown) and simultaneously between the outer housing 10 and the cage inner housing 40. The elastomeric seal 50 is essentially annular and has a V-shaped cross section 52. The V-shaped cross-section 52 forms an inner sealing wall 55, an outer sealing wall 56 and an annular cavity 54 in-between the sealing walls 55, 56. The elastomeric seal 50 further comprises inner rims 57 that extend from an inner sealing wall 55 to the inside and outer rims 58 that extend from the outer sealing wall 55. The rims further improve the tightness of the final connection.

[0041] As shown in Figs. 5D-F the seal 50 further comprises mushroom shaped plugs 51 at the underside 59 of the seal for securing the seal 50 at the outer housing 10. The plugs 51 extend into corresponding tapered mounting holes 18 at the bottom of the connector side cavity 15 and lock with the same. Thus, the seal 50 has its correct rotation and securely maintains its place already in this pre-assembled condition.

[0042] When the seal 50 is mounted within the outer housing 10 as shown in Fig. 5B, in the next mounting step as shown in Figs. 6A-D the inserts 30, 31 are mounted to the outer housing 10. Particularly, as shown in Fig. 6A the two inserts 30, 31 are inserted into the connector side cavity 15 and then latch with the mounting elements 17 as shown in the sectional views of Figs. 6C-D. To this end each of the inserts 30, 31 comprise at the lower end a latching hook 34 that latch with corresponding edge 19 of the mounting element 17 and an indexing leg 35 that contacts a tapered ridge 11 of the mounting element 17. The latching hook 34 and the edge 19 holds the insert 30, 31 at the mounting element 17, thus preventing the insert 30, 31 from being pulled out of the outer housing 10. The indexing leg 35 and the ridge 11 secure the axially movable insert 30, 31 in either the assembly position 32 or the locking position 33. The Figs. 6B-D show the inserts 30, 31 in the assembly position 32, where the inserts 30, 31 are at the highest mounted position in Figs. 6C and 6D. Therein the indexing leg 35 is arranged vertically higher than the ridge 11. In the locking position 33 the indexing leg 35 would be arranged vertically lower than the ridge 11 (not shown in Fig. 6D).

[0043] Figs. 7A-C show the cage inner housing 40 in detail. The cage inner housing 40 serves as a protection for the inserts 30, 31 in assembled condition. Preferably, the cage inner housing protects all inserts 30, 40 of a female electrical connector 1. To this end, the shown cage inner housing 40 comprises an essentially hollow body 41 with two openings 48 at the front end 43 for the male and female electrical terminals. The cage inner housing 40 is rigidly connected to the outer housing 10 by a retaining latch 42 that latches with a pocket 14 of the outer housing (see Fig. 8d). The cage inner housing 40 further comprises coding features 44 for allowing connection with a suitable male electrical connector (not shown) and for preventing a connection with a non-suitable male electrical connector (not shown). In the shown embodiment the coding features 44 comprise a plurality of ribs that are arranged in mating direction X. The cage inner housing further comprises an essentially tubular end 46 at the back end 47 that during assembly enters into the cavity 54 of the elastomeric seal 50 (see Fig. 8C).

[0044] Figs. 8A-8D show the assembly of the cage inner housing 40 to the outer housing 10. The cage inner housing 40 is pushed into the interior of the outer housing 10 in opposite mating direction X as shown in Fig. 8A by an arrow. Fig. 8B-D show the assembled condition, wherein in the sectional view of Fig. 8D the inserts 30, 31 are eliminated for better visibility. Fig. 8C shows that the axially movable inserts 30, 31 are protected and surrounded by the cage inner housing 40 in mating direction X to avoid any undesired shifting of the inserts 30, 31. Now the female electrical connector 1 is in a pre-assembled condition ready for shipping and for later cable mounting.

[0045] Figs. 9A-C show the insertion of the two female electrical terminals 20, 21 into the outer housing 10 and inserts 30, 31 from the cable side 4. The female electrical terminals 20, 21 comprise edges 26 preferably at the back sides thereof that latch with the latching elements 12, 13 when the female electrical terminals 20, 21 have been pushed to the final position into the female electrical connector 1. The edge 26 is preferably part of the metal shield 22 around the two female electrical contacts 24 The latching elements 12, 13 prevent that the female electrical terminals 20, 21 can be simply pulled out of the female electrical connector 1.

[0046] When the female electrical contacts 24 are mounted to the pre-assembled female electrical connector 1 the inserts 30, 31 are shifted in mating direction X from the assembly position 32 shown in Fig. 10A and 10B to the locking position 33 shown in Fig. 10C and 10D. Note that in Figs. 10B and 10D the cage inner housing 40 is not shown for better visibility of the inserts 30, 31. The shifting of the inserts 30, 31 effects that the latching elements 12, 13 are movable and can be unlatched as shown in Fig. 11A or are locked in place and cannot be unlatched as shown in Fig. 11B.

[0047] For a convenient shifting of the inserts 30, 31 and/or disassembly of the female electrical terminals 20, 21 an assembly tool 110 is provided, that is shown in Fig 12A and partially shown in Fig. 12B. The female electrical connector 1 and the corresponding assembly tool 110 together form a system 100. The assembly tool 110 comprises a tubular end 112 for pushing one of the inserts 30, 31 from the assembly position 32 to the locking position 33 as shown in Figs. 13A and 13B. The tubular end 112 has a shape to fit into the annular space between the female electrical terminals 20, 21 and the openings 48 of the cage inner housing 40 and has a length long enough to push each of the inserts 30, 31 from the as-

sembly 32 to the locking position. This locking process is shown in detail by the Figs. 13A and 13B, wherein the locking motion is shown by an arrow in Fig. 13A. In the locking position 33 the inserts 30, 31 are located further inwards of the female electrical connector 1 thus axially further away from the connector side 2 end thereof.

[0048] The axially shiftable inserts 30, 31 further provide the advantage that they can be shifted also from the locking position 33 back to the assembly position 32 if the female electrical terminals 20, 21 need to be disassembled from the female electrical connector. To this end the assembly tool 110 further comprises a hook 114 for pulling one of the inserts 30, 31 from the locking position 33 to the assembly position 32 as shown in Fig. 14. The hook has an essentially elongated shape and can be inserted into the annular space between the outer housing 10 and the cage inner housing 40 respectively the inserts 30, 31. For pulling the inserts 30, 31 from the locking position 33 to the assembly position 32 the hook 114 preferably under an edge of the respective insert 30, 31, preferably below the collar 36. Then, the assembly tool 110 is moved axially in mating direction X as shown bx the arrow in Fig. 14 to shift the respective insert 30, 31.

[0049] As shown particularly in Figs. 15A-C the assembly tool 110 further comprises a wedge 116 for releasing the latching element 12, 13 from the female electrical terminal 20, 21 such that the female electrical terminal 20, 21 can be pulled out of the female electrical connector 1. The wedge 116 is arranged at an end of a lever 117 and is positioned to reach behind the corresponding latching element 12, 13 to move it out of engagement with the female electrical terminal 20, 21. The wedge 116 is inserted into the annular space between the outer housing 10 and the cage inner housing 40 respectively insert 30, 31. To ensure the correct position of the wedge 116 within the female electrical connector 1 the assembly tool 110 further comprises an additional tubular end 118 that extends in direction of the lever 117 and that fits into the openings 48 of the cage inner housing 40. When the assembly tool 110 is positioned correctly, the lever 117 can be manually pushed by a force F as shown in Fig. 15B to move the wedge 116 forward such that it pushes the latching element 12, 13, preferably outwardly, out of engagement with the female electrical terminal 20, 21. Then, the corresponding female electrical terminal 20, 21 can be pulled out of the outer housing 10.

[0050] The system 100 of female electrical connector 1 and assembly tool 100 thus provides a simple an reliable solution for securely assemble individual female electrical terminals 20, 21 to the female electrical connector 1 and to be able to individually release the female electrical terminals 20, 21 without damaging any of the elements. Further, the assembly and disassembly of the individual female electrical terminals 20, 21 to the remainder of the female electrical connector 1 is particularly easy and reliable and can be done manually or automated.

List of reference signs:

[0051]

1	female electrical connector
2	connector side
4	cable side
10	outer housing
11	ridge
12, 13	latching elements
14	pocket
15	connector side cavity
16	cable side cavity
17	mounting element
18	mounting holes
19	edge
20, 21	female electrical terminal
22	metal shield
24	female electrical contacts
26	edge
30, 31	inserts
32	assembly position
33	locking position
34	latching hook
35	indexing leg
36	collar
37	body
38	actuation face
40	cage inner housing
41	body
42	retaining latch
43	front end
44	coding features
46	tubular end
47	back end
48	openings
50	elastomeric seal
51	plugs
52	V-shaped cross section
54	cavity
55	inner sealing wall
56	outer sealing wall
57	inner rims
58	outer rims
59	underside
60, 61	cable seals
70	cable locking element
80	latching tab
90, 91	cables
100	system
110	assembly tool
112	tubular end
114	hook
116	wedge
117	lever
118	tubular end

Claims

1. Female electrical connector (1) comprising:

   - an outer housing (10) defining a mating direction (X) of the female electrical connector (1);
   - at least one female electrical terminal (20, 21);
   - at least one insert (30, 31), individually surrounding the at least one female electrical terminal (20, 21);
   - a cage inner housing (40), connected to the inside of the outer housing (10), extending in mating direction (X) out of the outer housing (10), and surrounding the at least one insert (30, 31) in mating direction (X);
   - wherein the insert (30, 31) is shiftable in mating direction (X) between an assembly position (32) in which the female electrical terminal (20, 21) is insertable into the female electrical connector (1) and a locking position (33) in which the female electrical terminal (20, 21) is locked within the female electrical connector (1).

2. Female electrical connector according to claim 1, wherein the outer housing (1) comprises at least one latching element (12, 13) for latching with the female electrical terminal (20, 21).

3. Female electrical connector according to claim 2, wherein a movement of the latching element (12, 13) is prevented by the insert (30, 31), when the insert (30, 31) is shifted to its locking position (33) and wherein a movement of the latching element (12, 13) is allowed by the insert (30, 31), when the insert (30, 31) is shifted to its assembly position (32).

4. Female electrical connector according to one of the claims 1 to 3, wherein the cage inner housing (40) is connected to the outer housing (10) by a retaining latch (42) of the cage inner housing (40).

5. Female electrical connector according to one of the claims 1 to 4, wherein the cage inner housing (40) comprises coding features (44) for allowing connection with a suitable male electrical connector and for preventing a connection with a non-suitable male electrical connector.

6. Female electrical connector according to one of the claims 1 to 5, further comprising an elastic seal (50), wherein the seal has a V-shaped cross-section (52) and is arranged between the outer housing (10) and the cage inner housing (40).

7. Female electrical connector according to claim 6, wherein the cage inner housing (40) comprises a tubular end (46) that introduces into a cavity (54) formed by the V-shaped cross-section (52) of the elastic seal (50).

8. Female electrical connector according to one of the claims 1 to 7, wherein the female electrical terminal (20, 21) is a high-speed data terminal, preferably a shielded coaxial terminal or a shielded high-speed modular twisted pair data terminal.

9. Female electrical connector according to one of the claims 1 to 8, comprising more than one, preferably two, three, four, five or six female electrical terminals (20, 21), and correspondingly more than one, preferably two, three, four, five or six inserts (30, 31).

10. Female electrical connector according to claim 9, wherein each insert (30, 31) is individually shiftable in mating direction (X) between the assembly position (32) and the locking position (33).

11. System (100) of a female electrical connector according to one of the claims 1 to 10 and an assembly tool (110), wherein the assembly tool (110) comprises a tubular end (112) for pushing one of the inserts (30, 31) from the assembly position (32) to the locking position (33).

12. System (100) according to claim 11, wherein the assembly tool (110) further comprises a hook (114) for pulling one of the inserts (30, 31) from the locking position (33) to the assembly position (32).

13. System (100) according to claim 2 and claim 11, wherein the assembly tool (110) further comprises a wedge (116) for releasing the latching element (12, 13) from the female electrical terminal (20, 21).

14. Method for an assembly of a female electrical connector (1) comprising the following steps:

   a. providing an outer housing (10), defining a mating direction (X) of the female electrical connector (1);
   b. providing an insert (30, 31), which is axially movable in mating direction (X) within the female electrical connector (1);
   c. providing a cage inner housing (40), connected to the inside of the outer housing (10), extending in mating direction (X) out of the outer housing (10), and surrounding the at least one insert (30, 31) in mating direction (X);
   d. inserting at least one female electrical terminal (20, 21) into a back side (4) of the outer housing (10) such that the female electrical terminal (20, 21) is at least partially surrounded by the insert (30, 31); and
   e. shifting the insert (30, 31) in mating direction (X) from an assembly position (32) to a locking position (33) in which the female terminal (30,

31) is locked within the connector (1).

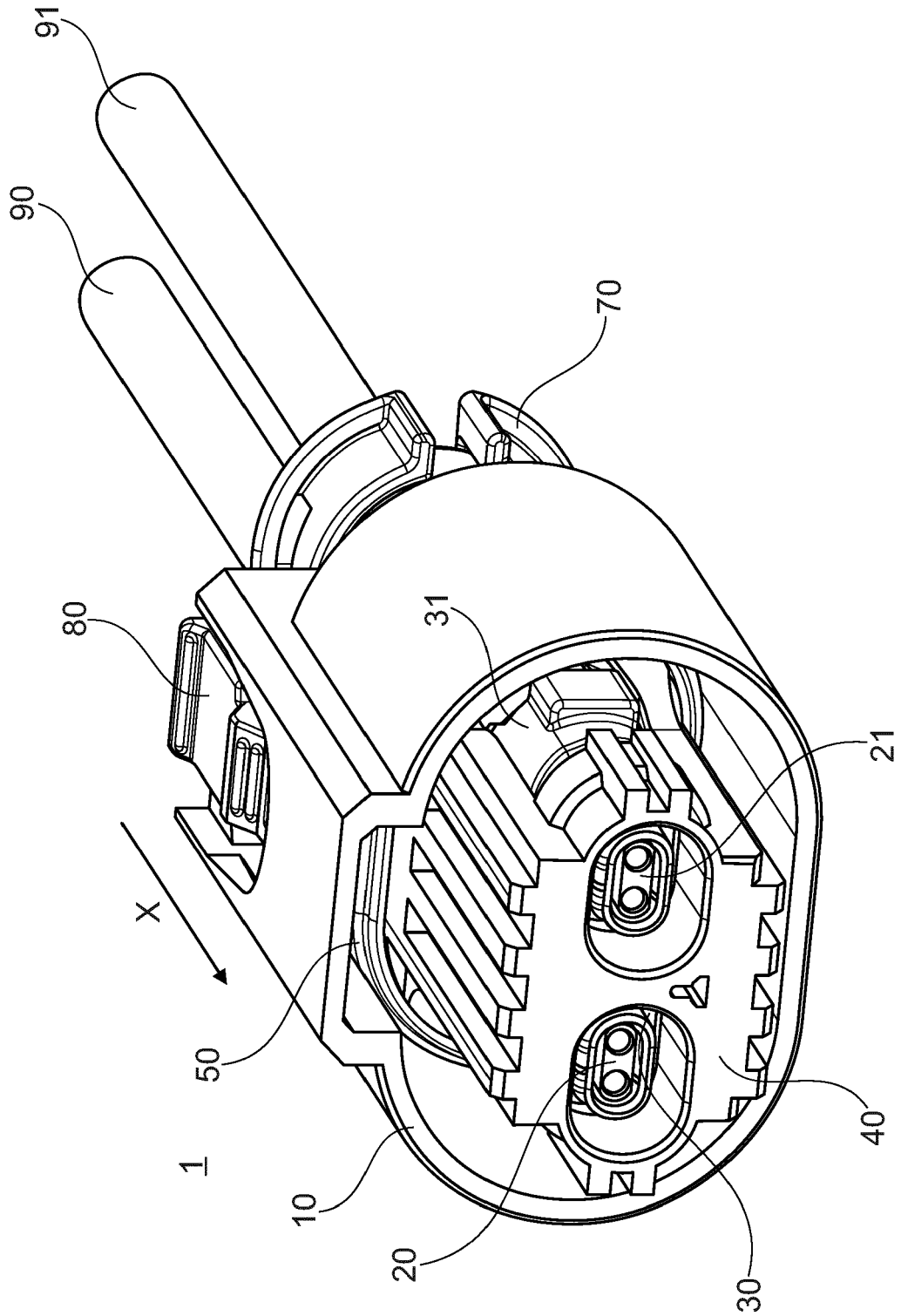

Fig. 1

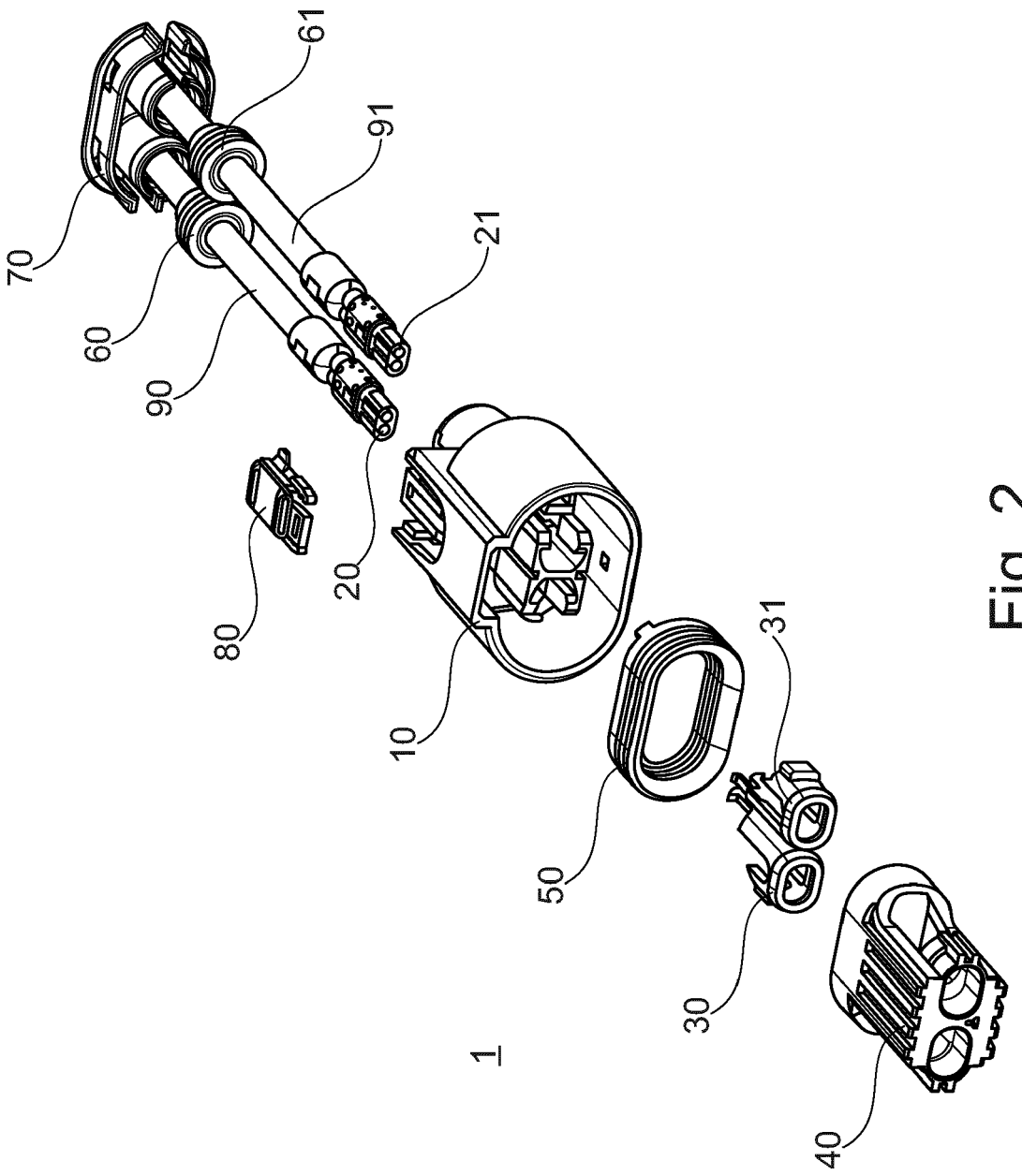

Fig. 2

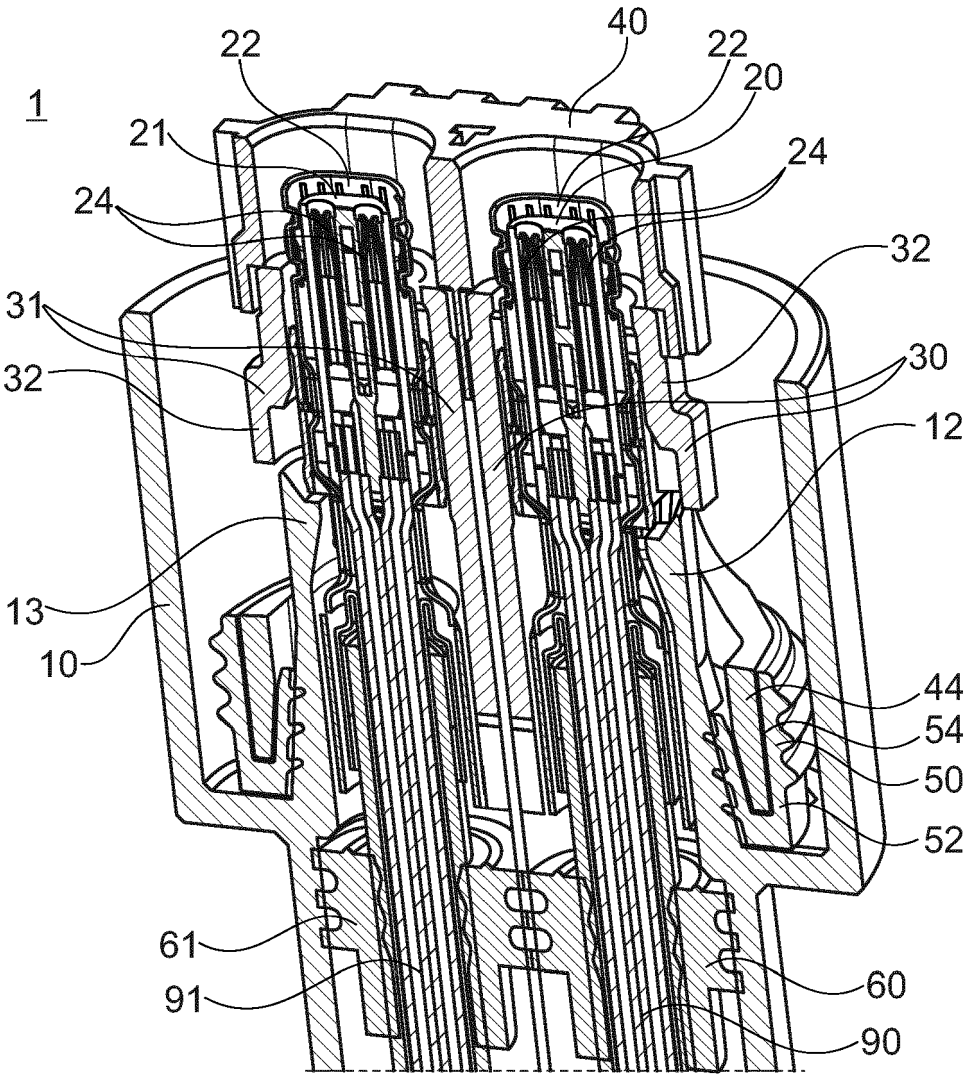

Fig. 3

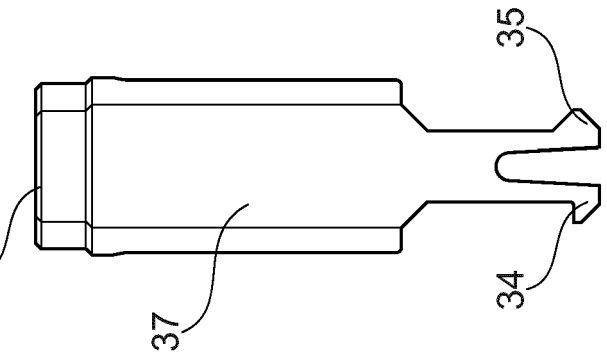

Fig. 4D

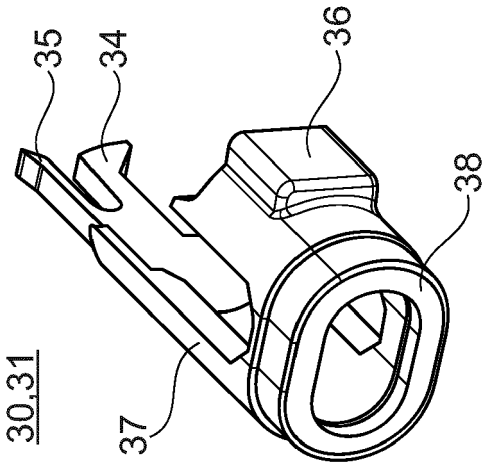

Fig. 4B

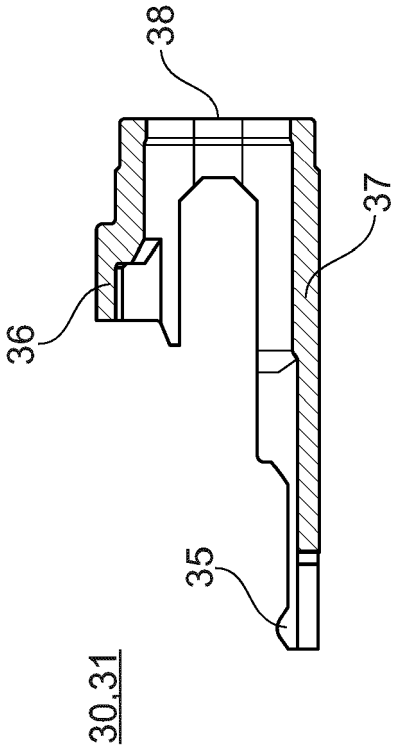

Fig. 4C

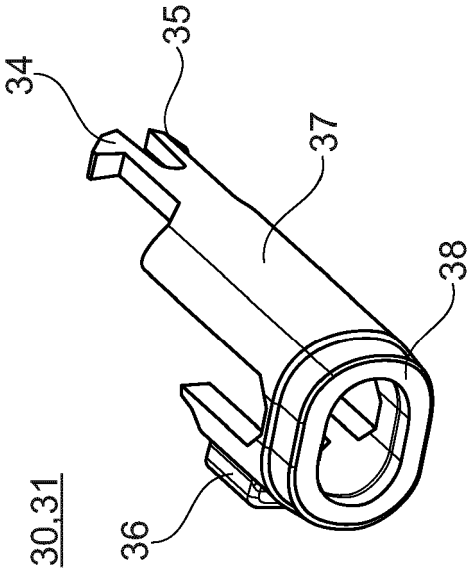

Fig. 4A

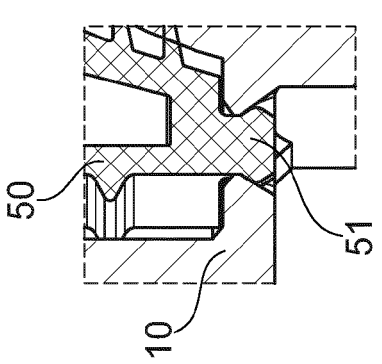

Fig. 5F

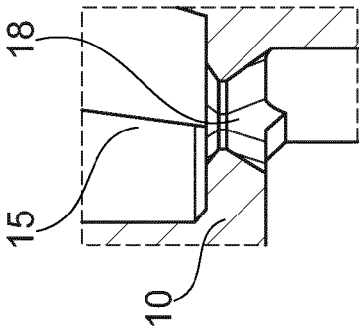

Fig. 5E

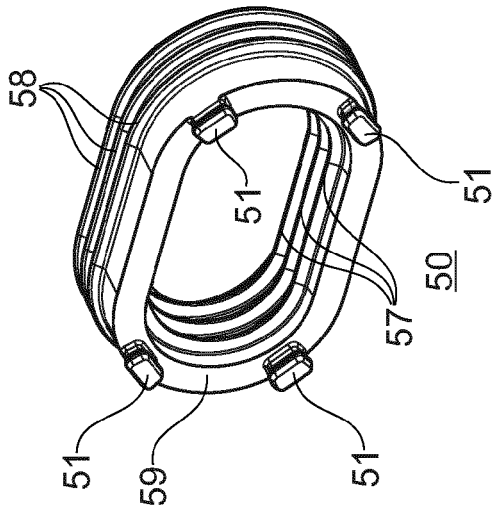

Fig. 5D

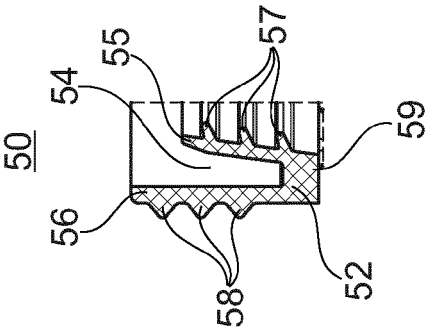

Fig. 5C

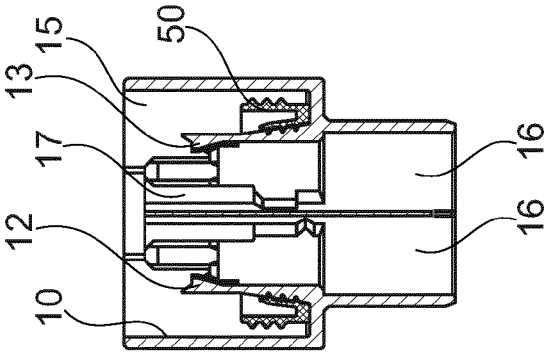

Fig. 5B

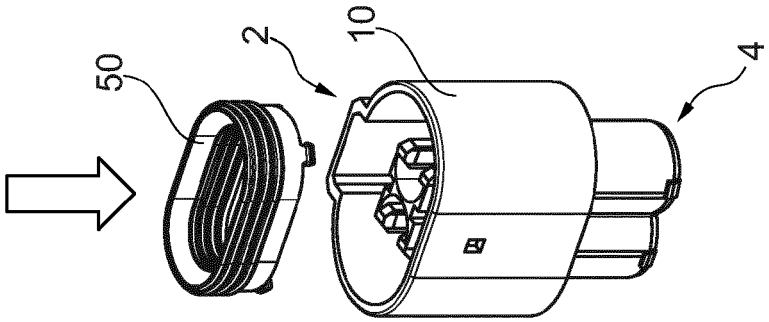

Fig. 5A

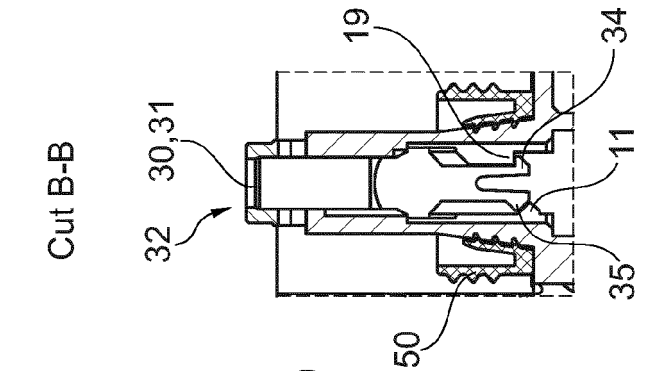

Fig. 6D

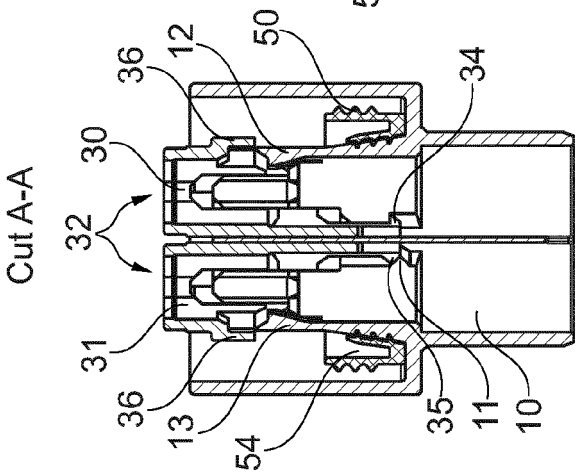

Fig. 6C

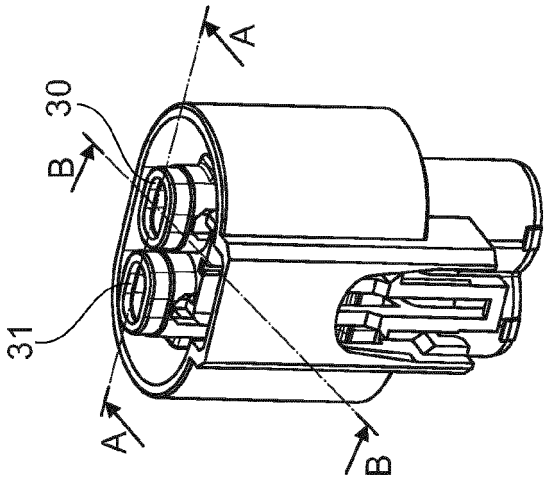

Fig. 6B

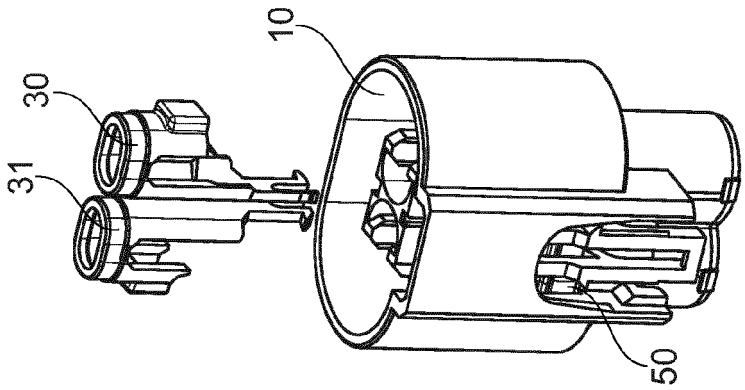

Fig. 6A

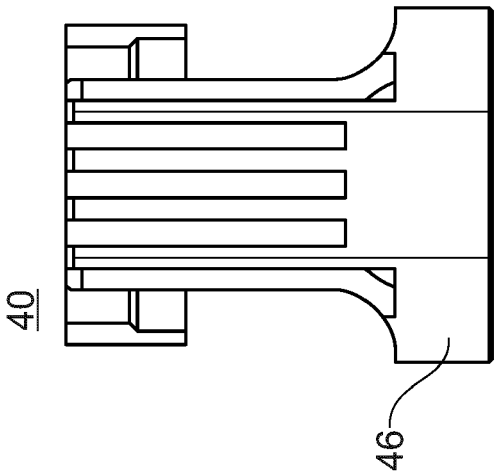

Fig. 7C

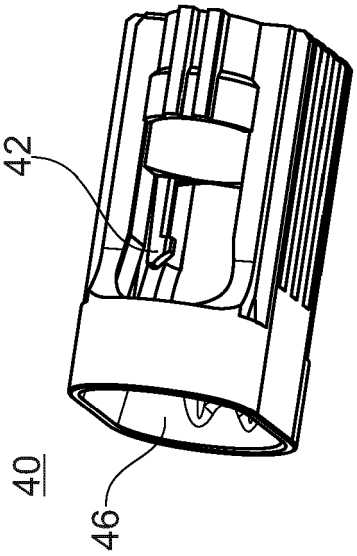

Fig. 7B

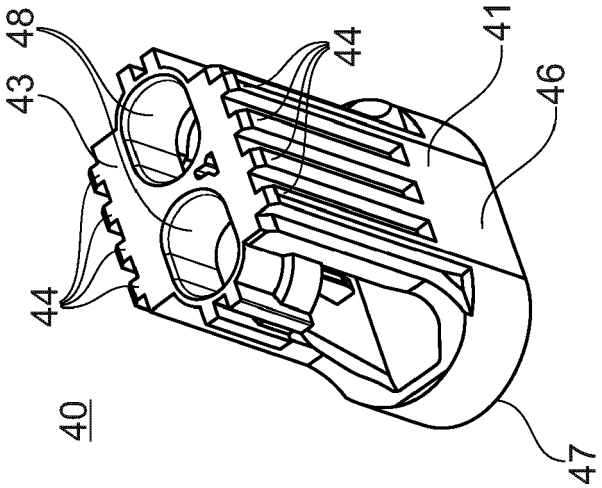

Fig. 7A

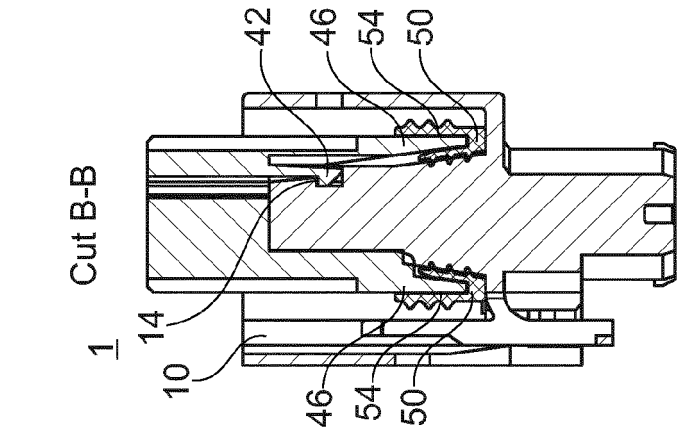

Fig. 8D

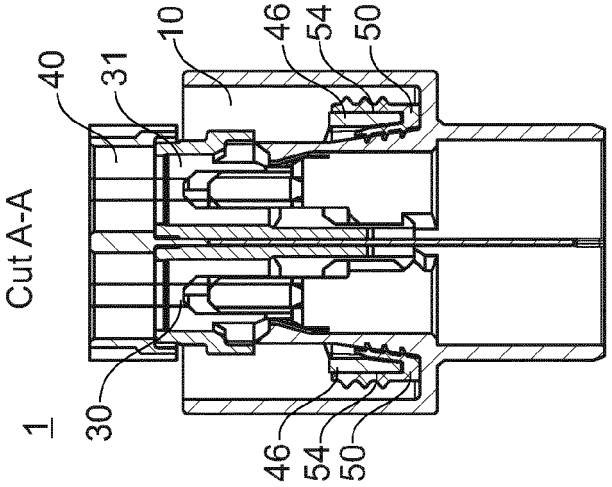

Fig. 8C

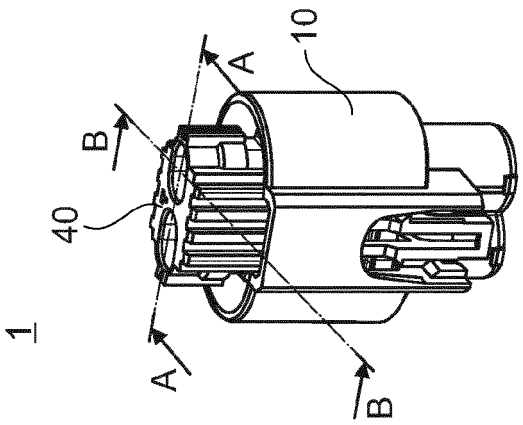

Fig. 8B

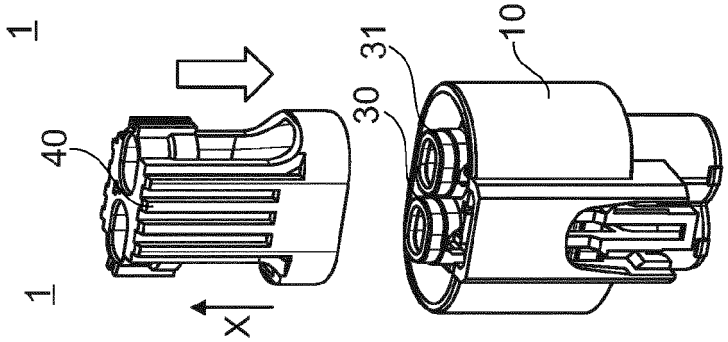

Fig. 8A

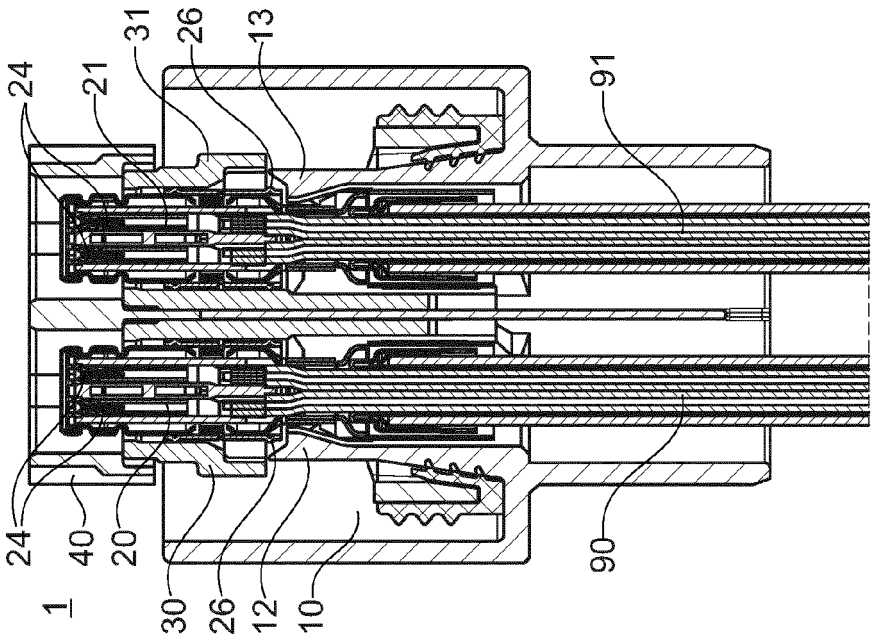

Fig. 9C

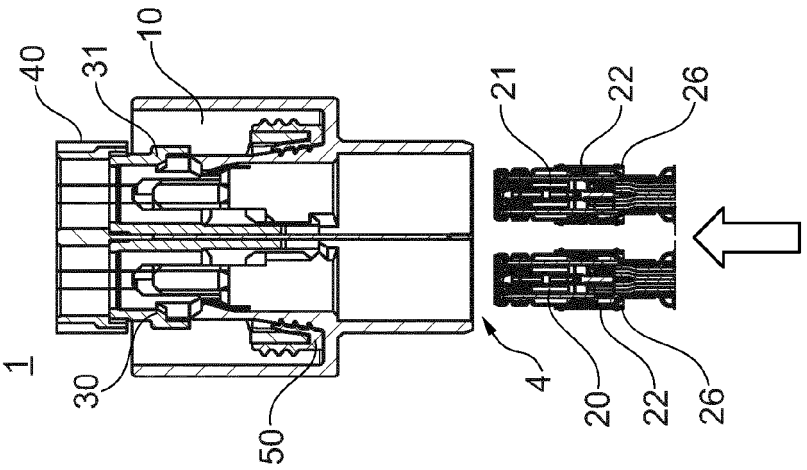

Fig. 9B

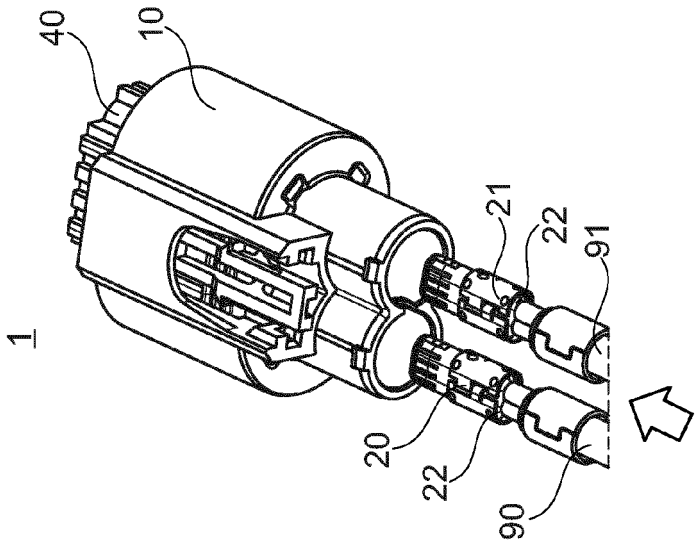

Fig. 9A

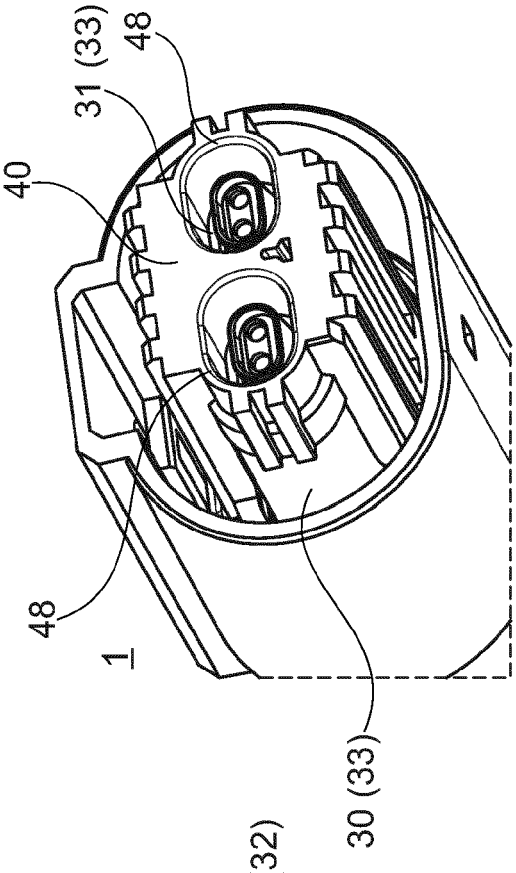

Fig. 10C

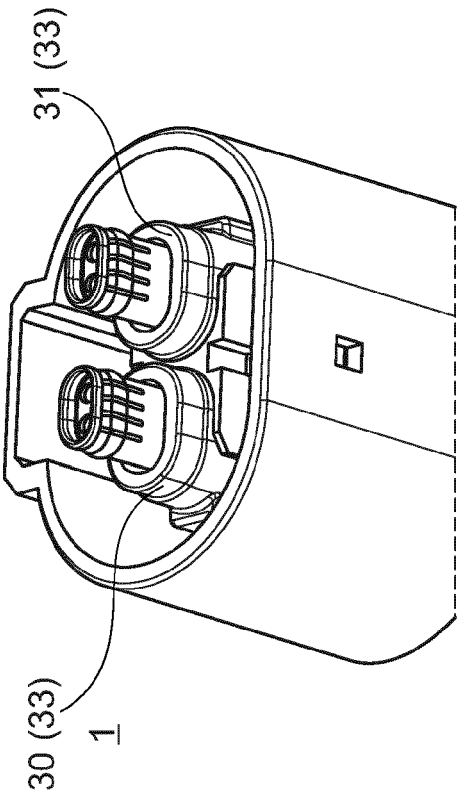

Fig. 10D

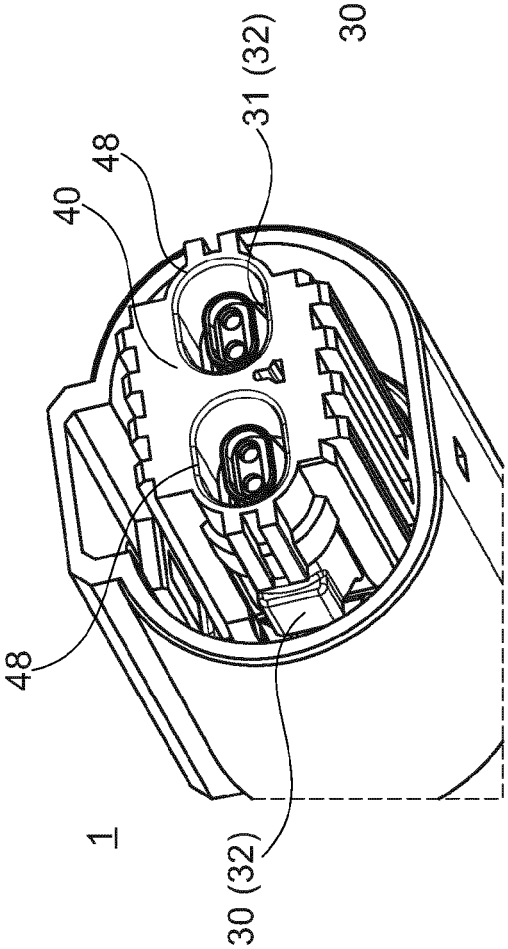

Fig. 10A

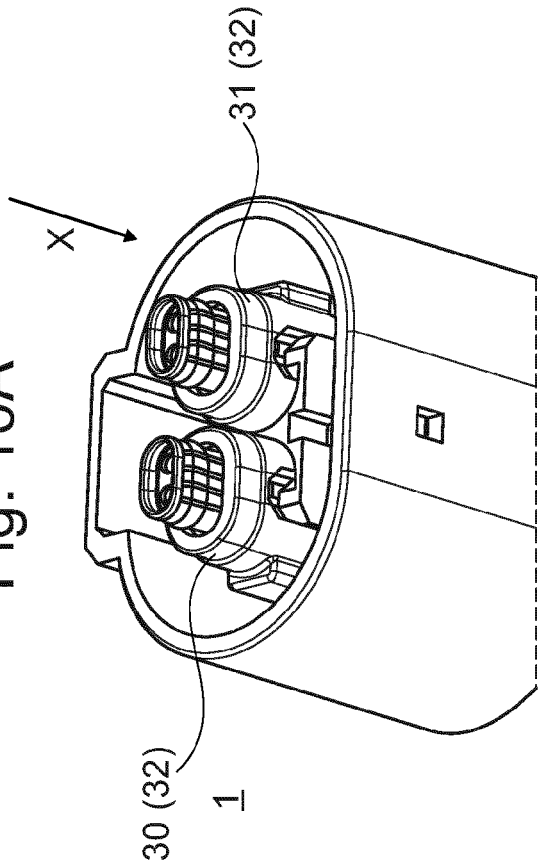

Fig. 10B

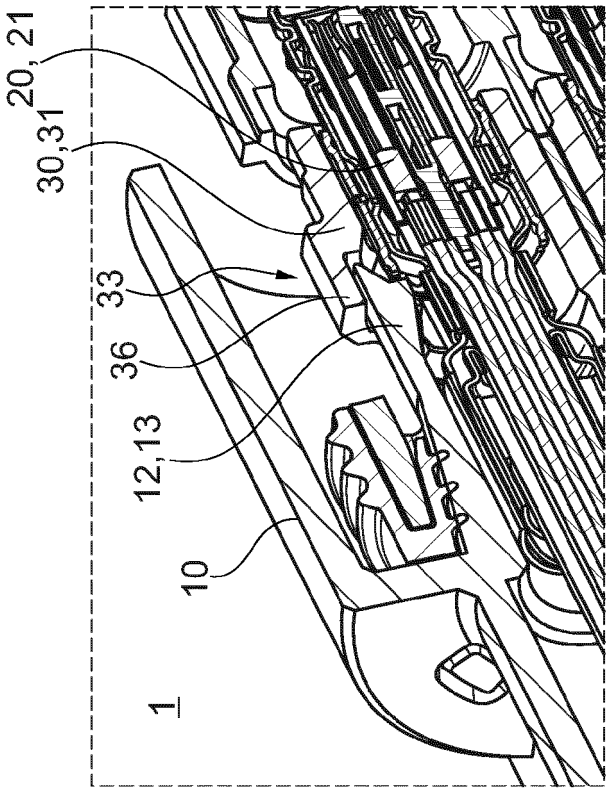

Fig. 11B

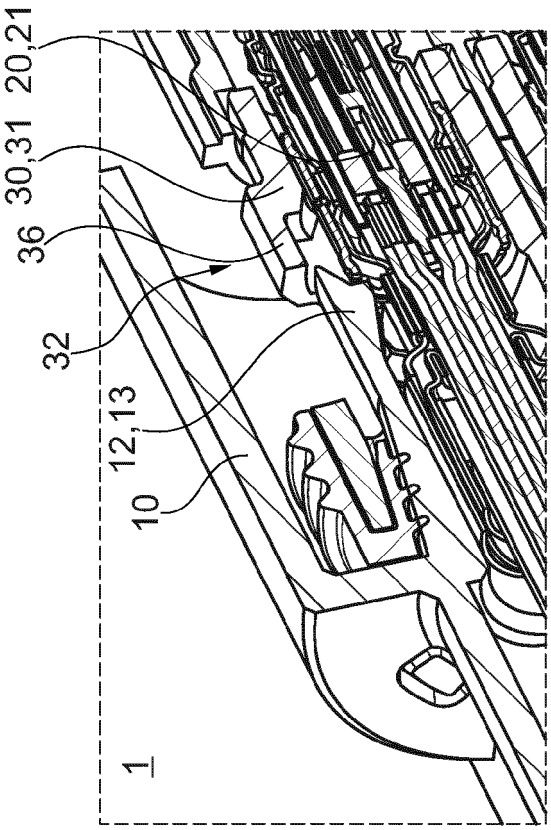

Fig. 11A

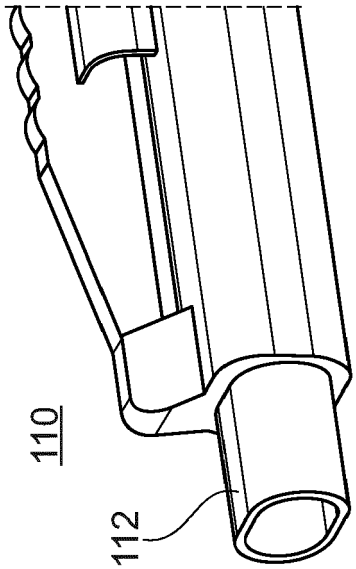

Fig. 12B

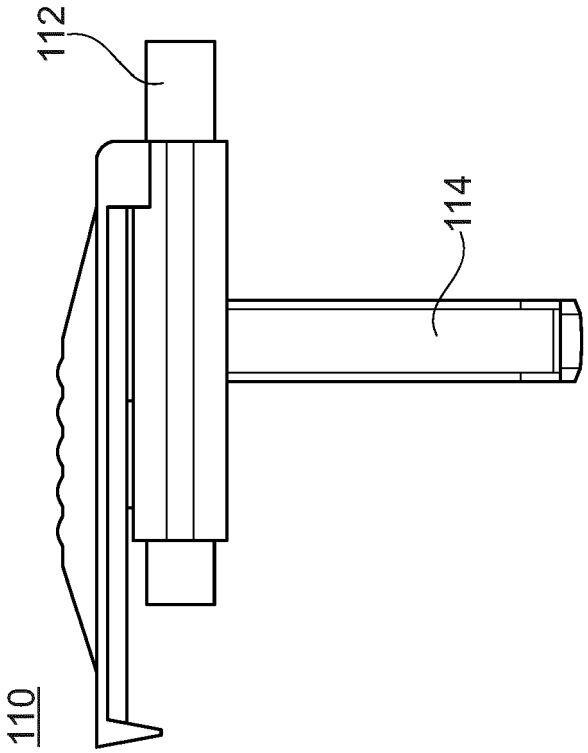

Fig. 12A

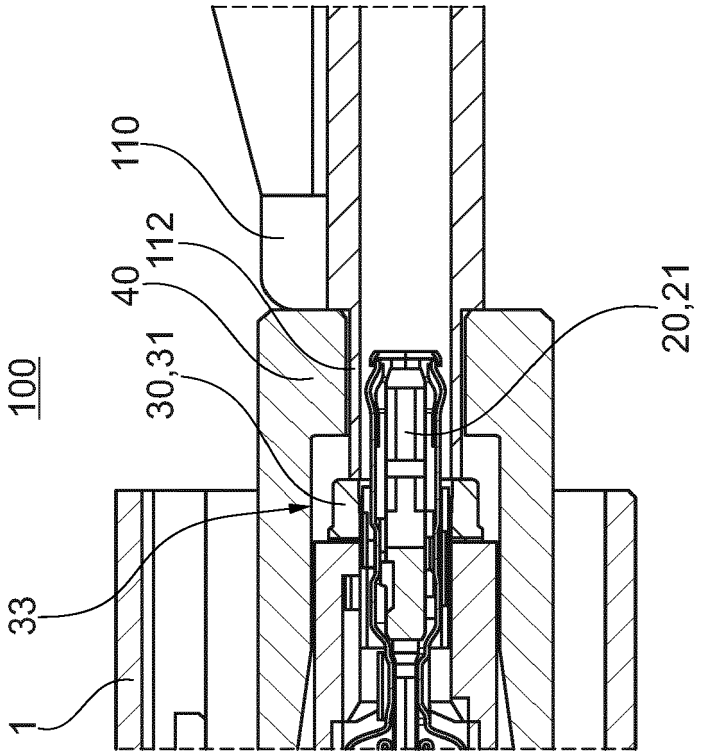

Fig. 13B

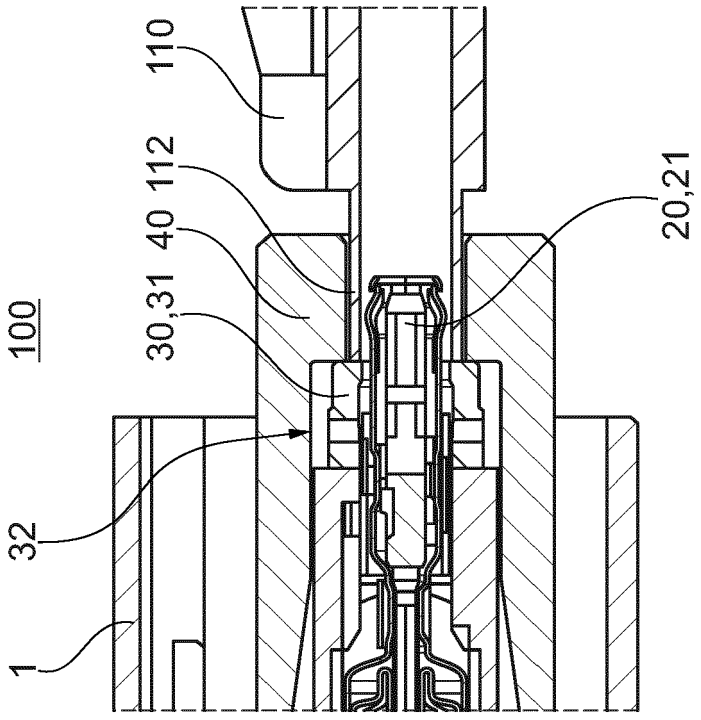

Fig. 13A

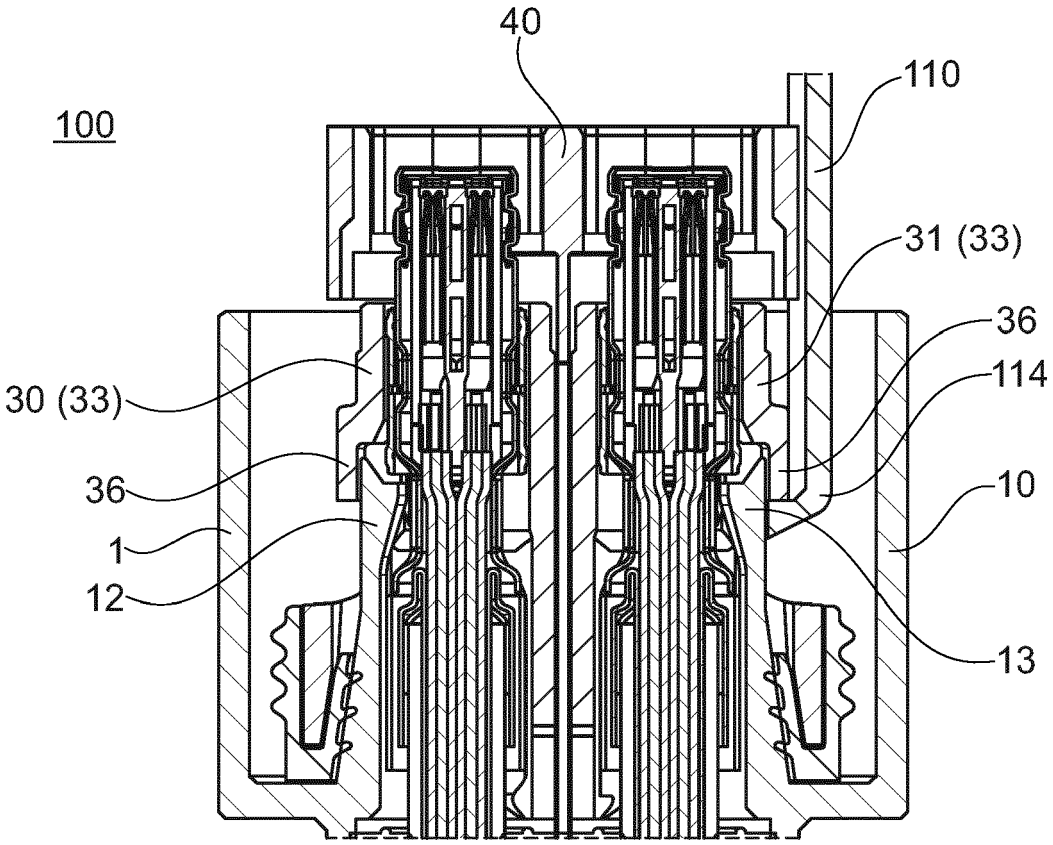

Fig. 14

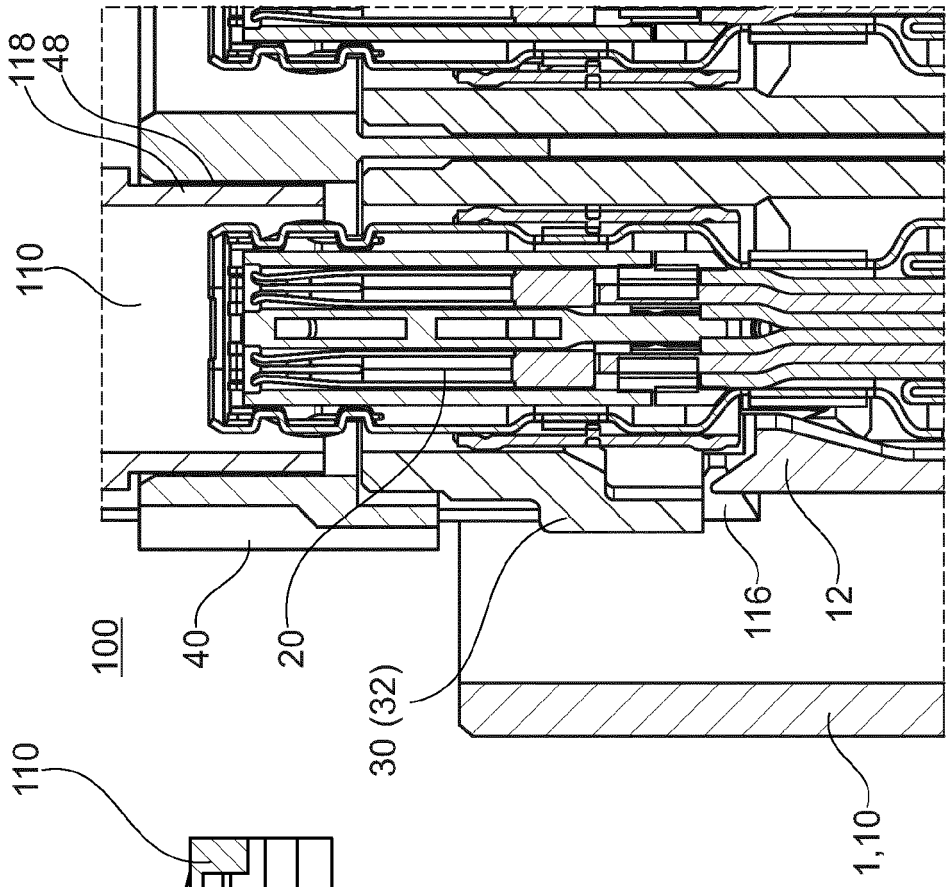

Fig. 15C

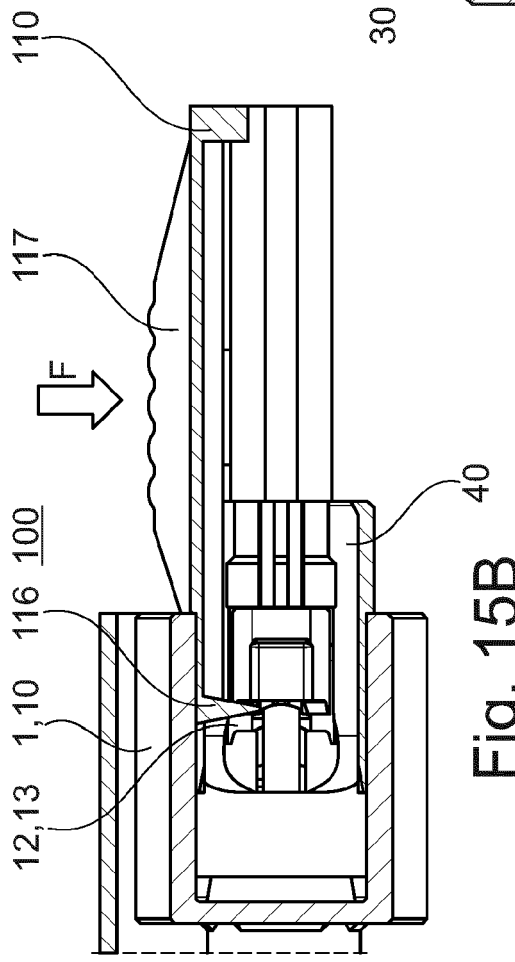

Fig. 15B

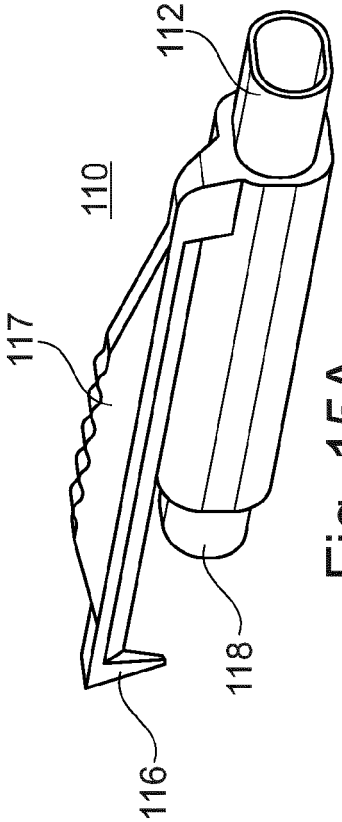

Fig. 15A

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EUROPEAN SEARCH REPORT

Application Number
EP 23 17 3441

DOCUMENTS CONSIDERED TO BE RELEVANT

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X Y	JP 2010 170968 A (YAZAKI CORP) 5 August 2010 (2010-08-05) * paragraphs [0022], [0030], [0029], [0037], [0038]; figures 6,3,21 *	1-14 6,7, 10-13	INV. H01R13/506 H01R43/20 H01R13/424
Y	US 2017/310040 A1 (GAGNON JEREMY JOSEPH [US] ET AL) 26 October 2017 (2017-10-26) * figure 1 *	6,7	ADD. H01R13/422 H01R13/52 H01R13/436
Y	US 8 926 364 B2 (SAITOH MASAYUKI [JP]; YAZAKI CORP [JP]) 6 January 2015 (2015-01-06) * figure 6 *	10-13	H01R13/645
A	GB 2 282 497 A (CARDELL CORP [US]) 5 April 1995 (1995-04-05) * figures 1,4 *	1-14	

TECHNICAL FIELDS SEARCHED (IPC)

H01R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24 October 2023	Vautrin, Florent

CATEGORY OF CITED DOCUMENTS

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