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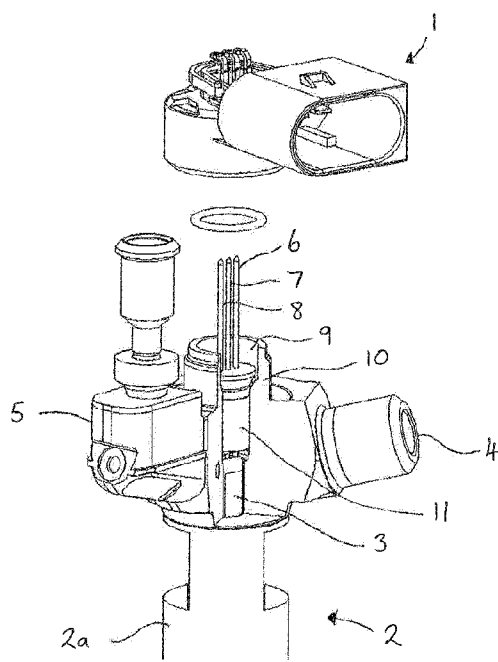


Fig. 1a

(57) Abstract: A connector (1) for a fuel injector (2) comprises a body (20) and a plurality of connector tabs (26, 27, 28) for connecting to a corresponding plurality of wires (6, 7, 8) extending from a component of the fuel injector, wherein the body (20) of the connector (1) provides a plurality of guide channels (36, 37, 38) corresponding to the plurality of connector tabs (26, 27, 28), wherein each guide channel (36, 37, 38) is arranged to guide a wire (6, 7, 8) when passed therethrough in use towards a respective one of the connector tabs (26, 27, 28). The present invention also provides a fuel injector assembly comprising a connector (1) coupled to a fuel injector (2), and a method of fitting a connector (1) to a fuel injector (2).

FUEL INJECTOR

5 Technical field

The present invention relates to a connector for a fuel injector, to a fuel injector assembly comprising a connector, and to a method of fitting a connector to a fuel injector.

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Background

Fuel injectors for internal combustion engines generally comprise a valve needle that is controlled by a valve needle actuation system. The valve needle actuation system may include a solenoid actuator or a piezoelectric actuator arranged to control a three-way valve to vary fuel pressure in a control chamber located above the valve needle to thereby control the valve needle, although other arrangements are also possible. In some cases a fuel injector may also comprise an additional electronic system, for example a measurement system for measuring the performance or position of the valve needle.

The valve needle actuation system requires connection to an external lead in order to provide power to and to control the valve needle actuation system. The measurement system, if present, may also require connection to an external lead in order to enable measurement of the performance or position of the valve needle. In order to provide the required connections, wires coupled to the valve needle actuation mechanism (and one or more wires forming part of the measurement system, if present) may extend from a component of the fuel injector in order to be connected to tabs of a connector that is arranged to be connected to an external lead.

During the process of fitting a connector to a fuel injector, it is necessary to align the wires correctly with corresponding connector tabs of the connector in order to establish electrical connections between the wires and the connector tabs. This generally requires the use of a specific tool, for example a comb-like tool, to spread out and align the wires either before or after the connector has been attached to the fuel injector. The need to align the wires with the connector tabs therefore results in an additional aligning step during the assembly process, and

the need for a specific tool for spreading out and aligning the wires. It is also necessary to design the connector to allow space for the specific tool to land and engage the wires. In addition, due to space constraints, in the fuel injector, the wires extending therefrom may be closely packed together with a small pitch, which may make aligning and connecting the wires to their respective connector tabs difficult.

It is an object of the invention to provide a connector for a fuel injector which addresses the shortcomings of the prior art.

Summary of the invention

A first aspect of the present invention provides a connector for a fuel injector, the connector comprising a body and a plurality of connector tabs for connecting to a corresponding plurality of wires extending from a fuel injector component, wherein the body of the connector provides a plurality of guide channels corresponding to the plurality of connector tabs, wherein each guide channel is arranged to guide a wire when passed therethrough in use towards a respective one of the connector tabs. By providing a connector with a plurality of guide channels each arranged to guide a wire towards a respective connector tab, the present invention allows wires extending from a fuel injector component to be automatically aligned individually with the respective connector tabs during attachment of the connector to a fuel injector. In this way the connector may be fitted to a fuel injector more quickly and easily than is possible with prior art connectors. It will be understood that wires are not required to be present in the guide channels before the connector has been fitted to a fuel injector.

The guide channels may be arranged adjacent to one another along a line extending perpendicular to longitudinal axes of the guide channels. The line along which the guide channels are arranged may be at least substantially straight. For example, the connector may comprise exactly three guide channels arranged along a straight line. Alternatively, where three or more guide channels are present, the guide channels may be arranged in another configuration, for example in a triangular formation. The formation of the guide channels preferably corresponds to the formation of wires that the connector is intended to receive.

The guide channels may be arranged to increase the pitch of a plurality of wires as the wires are passed through the guide channels towards the connector tabs in use. The ability to increase the pitch of the plurality of wires as the wires are passed through the guide channels may facilitate the connection of wires to the connector tabs in a case where the wires have a pitch prior to insertion into the guide channels that is less than the pitch of the connector tabs. This may be achieved, for example, by widening at least one guide channel towards at least one adjacent guide channel and/or by arranging the guide channels to converge, as described below. The guide channels may be arranged to increase the pitch of wires by at least 20% or at least 40% or at least 50%, or even more than 100%, depending on the shape and arrangement of the guide channels. The maximum desirable pitch increase may in practice be limited by the material of the wires.

At least one of the guide channels may widen towards at least one adjacent guide channel as it approaches its end furthest from the connector tabs. In this way the distance between the openings of adjacent guide channels may be reduced compared to the distance between the sidewalls of adjacent guide channels at the ends of the guide channels closest to the connector tabs. This may be the case even if the guide channels are otherwise parallel to each other. The guide channels are therefore arranged to accept a plurality of wires having a pitch that is less than the pitch of the guide channels, and to increase the pitch of the wires as the wires are passed through the guide channels towards the connector tabs. The widening of one or more of the guide channels may therefore facilitate the connection of wires to the connector tabs in a case where the wires have a pitch prior to insertion into the guide channels that is less than the pitch of the connector tabs. The at least one guide channel may widen towards an adjacent guide channel by at least 25% or at least 50% or at least 100% of its width before widening.

It will be appreciated that widening may occur only in a single direction only (towards an adjacent guide channel). Alternatively, widening may occur in multiple directions (for example towards two adjacent guide channels on either side). Widening may also occur in a direction that is not towards any adjacent guide channel, for example in a lateral direction that is perpendicular to a line

along which the guide channels are arranged. In some cases a guide channel may widen symmetrically around its longitudinal axis.

- 5 The or each guide channel that widens towards at least one adjacent guide channel may also comprise a section of at least substantially constant cross section. The section of at least substantially constant cross section may extend up to the end of the guide channel closest to the connector tabs. The section of at least substantially constant cross-section may be similar in dimension to the wire that the guide channel is intended to guide in order to most effectively
- 10 constrain the wire in both x and y directions perpendicular to the longitudinal axis of the guide channel. The section of at least substantially constant cross-section may have a substantially circular cross-section. The or each guide channel that widens may widen over at least 20% or at least 40% or at least 50% of its length.
- 15 The guide channels may converge towards their ends furthest from the connector tabs. In this way the distance between adjacent guide channels may be reduced at the ends of the guide channels furthest from the connector tabs compared to the distance between adjacent guide channels at the ends of the guide channels closest to the connector tabs. The guide channels are therefore arranged to
- 20 accept a plurality of wires having a pitch that is less than the pitch of the guide channels at their ends closest to the connector tabs, and to increase the pitch of the wires as the wires are passed through the guide channels towards the connector tabs. The converging guide channels may therefore facilitate the connection of wires to the connector tabs in a case where the wires have a pitch
- 25 prior to insertion into the guide channels that is less than the pitch of the connector tabs.

It will be appreciated that converging guide channels may additionally widen towards each other along at least a portion of their lengths, although converging

30 guide channels may alternatively each have a substantially constant cross section.

The converging guide channels may also run at least substantially parallel to each other along another a non-converging portion of their lengths. The non-

35 converging portion may extend up the ends of the guide channels closest to the connector tabs.

In other cases, the guide channels may be arranged to decrease the pitch of a plurality of wires as the wires are passed through the guide channels towards the connector tabs in use in a similar manner.

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The guide channels may be arranged to shift the plurality of wires together in a lateral direction that is perpendicular to the longitudinal axes of the wires prior to insertion into the guide channels as the wires are passed through the guide channels towards the connector tabs in use. This may be achieved, for example, by providing guide channels that each widen in the lateral direction as they approach their ends furthest from the connector tabs and/or by providing guide channels that are each inclined towards the lateral direction. Where the guide channels are arranged along a line, the lateral direction may be perpendicular to the line along which the guide channels are arranged, as well as being perpendicular to the direction towards the connector tabs.

The guide channels may be arranged to change the formation of a plurality of wires as the wires are passed through the guide channels towards the connector tabs in use. For example, the guide channels may transition from a triangular formation at their ends furthest from the connector tabs into a linear formation at their ends closest to the connector tabs in order to receive wires arranged in a triangular formation and move them into a linear formation for connection to connector tabs in a linear formation, or vice-versa. Other changes in the formation of the plurality of wires are also possible using appropriately arranged guide channels.

It will be appreciated that any change in the pitch or formation of the plurality of wires and any lateral shift of the wires is governed by the geometry of the guide channels.

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Each guide channel may be formed by a separate hole in the body of the connector. The holes are preferably entirely separate to each other and not linked to each other at any point along their lengths. Alternatively adjacent holes may be linked by a split. Alternatively multiple separate guide channels may be provided in a common hole with one or more guide features defining the individual guide channels.

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Each connector tab may comprise an aperture adapted to receive a wire that has been passed through a respective one of the guide channels to establish an electrical connection with the wire.

- 5 Each wire-receiving aperture may comprise a hole into which a wire that has been passed through a respective one of the guide channels may be received. The holes may be arranged to circumferentially surround wires received therein, and may not include any breaks around their circumferences. Alternatively, the apertures may comprise split loops or open splits.

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Each wire-receiving aperture may be located adjacent to a respective one of the guide channels. The guide channels may therefore act to automatically guide wires that have passed through the guide channels directly into the wire receiving apertures. In this case it may not be necessary to perform any additional
15 alignment operations in order to position the wires correctly with respect to the connector tabs in order to establish an electrical connection.

20

The body of the connector may further comprise an attachment portion for attaching the connector to a fuel injector. The attachment portion may be arranged to be press-fitted onto or into a corresponding feature provided on a fuel injector in an attachment direction parallel to an axis of the attachment portion. The longitudinal axes of the guide channels may be at least substantially parallel to the attachment direction and the axis of the attachment portion (although one or more of the guide channels may be slightly inclined to the attachment direction for example in cases where the guide channels converge
25 and/or where the guide channels are inclined towards a lateral direction). The attachment portion may comprise a socket arranged to be attached over a corresponding protrusion provided on a fuel injector. The attachment portion may be arranged around the portion of the body in which the guide channels are provided. The attachment portion may define an opening through which wires to
30 be connected to the connector tabs pass before entering the guide channels.

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The body of the connector may further comprise an external connection portion for connection to an external lead. The external connection portion may comprise a socket arranged to receive a plug of an external lead. Each of the

connector tabs may be electrically connected to a contact provided in the external connection portion.

5 The body of the plug may be integrally formed as a single component, or alternatively assembled from multiple components.

10 The portion of the connector body in which the guide channels are provided may further comprise at least one additional through hole for venting a chamber formed below the portion of the connector body in which the guide channels are provided.

15 A further aspect of the present invention provides a fuel injector assembly comprising a connector according to any preceding claim coupled to a fuel injector, the fuel injector comprising a plurality of wires extending from a fuel injector component, the plurality of wires extending through the guide channels and into contact with the connector tabs. The fuel injector may, for example, be a diesel injector or a gasoline injector. The fuel injector may comprise a valve needle actuation system, with the wires (or two or the wires) being connected to the valve needle actuation system. The valve needle actuation system may, for
20 example, comprise a solenoid actuator or a piezoelectric actuator. In addition, a further one of the wires may be a wire forming part of a measurement system for measuring the performance or position of a valve needle of the fuel injector. The wires may extend from the fuel injector through an aperture formed in a housing of the fuel injector. The aperture may be sealed by a seal assembly through
25 which the wires extend and from which the wires project.

30 The pitch of the wires may increase from the fuel injector component towards the connector tabs as the wires extend through the guide channels as a result of the configuration of the guide channels. The wires may also be shifted together in a lateral direction that is perpendicular to their longitudinal axes prior to insertion into the guide channels as a result of the configuration of the guide channels.

35 In one embodiment, the plurality of wires comprises a pair of wires for supplying an electric current to an actuator of the injector, and a third wire for supplying a measurement signal to indicate the position of a valve needle of the injector. The invention provides the advantage that all three wires can be accommodated

easily within the injector body, whilst connection to the connector is still convenient due to the configuration of the guide channels.

5 A further aspect of the present invention provides a method of fitting a connector to a fuel injector, the method comprising approximately aligning a plurality of wires extending from a fuel injector component with a corresponding plurality of guide channels provided in a body of the connector, each guide channel being arranged to guide a respective one of the wires towards a connector tab; moving the connector towards the fuel injector thereby passing the wires into and through
10 the guide channels; and guiding each wire towards and into contact with a respective one of the connector tabs using the guide channels.

The method may further comprise using the guide channels to increase the pitch of the wires as the wires are passed through the guide channels towards the
15 connector tabs. The method may further comprise using the guide channels to shift the wires together in a lateral direction that is perpendicular to the longitudinal axes of the wires prior to insertion into the guide channels.

The connector may be a connector as described above in relation to the first
20 aspect of the invention. The method may further comprise any steps associated with the normal operation of such a connector.

Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding
25 paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any aspect or embodiment can be combined in any way and/or combination with those in other aspects and/or embodiments, unless such features are incompatible.

30

Brief description of the drawings

In order that the present invention may be more readily understood, an example of the invention will now be described in detail with reference to the
35 accompanying figures, in which:

Figures 1a and 1b illustrate a connector for a fuel injector according to one possible embodiment of the present invention before and after attachment to a fuel injector;

- 5 Figures 2a and 2b illustrate a cross section of the connector and the fuel injector illustrated in Figure 1 and a view of the connector as seen from the fuel injector before attachment of the connector to the fuel injector;

- Figures 3a and 3b illustrate a cross section of the connector and the fuel injector
10 illustrated in Figure 1 at different stages during attachment of the connector to the fuel injector; and

- Figures 4a to 4c schematically illustrate various other possible arrangements of guide channels according to other possible embodiments of the present
15 invention.

Detailed description

- For the purpose of the following description it will be appreciated that references
20 to upper, lower, upward, downward, above and below, for example, are not intended to be limiting and relate only to the orientation of the injector as shown in the illustration.

- Figure 1a illustrates a connector 1 for the fuel injector according to one possible
25 embodiment of the present invention and a fuel injector 2 to which the connector is adapted to be fitted. Figure 1b illustrates the connector 1 and the fuel injector 2 after the connector has been attached to the fuel injector.

- The fuel injector 2 is a diesel injector including an injector housing 2a, including a
30 nozzle body (not shown). The fuel injector 2 also includes a valve needle slideably located within a bore of the nozzle body, and a solenoid-type valve needle actuation system 3 located within the injector housing 2a for controlling operation of the valve needle. The fuel injector 2 further comprises a high pressure fuel supply 4 for supplying high pressure fuel to the bore of the nozzle
35 body and to a control chamber located above the valve needle, and a back leak connection, defined within a housing 5, to allow a return flow of low pressure fuel to a low pressure fuel drain. Possible arrangements of the valve needle, nozzle

body, valve needle actuation system, control chamber, high pressure fuel supply and back leak will be well understood by those skilled in the art and will not be described further.

- 5 The valve needle actuation system 3 is connected to a supply wire 6 and a ground wire 8 which are arranged to provide power to and control the valve needle actuation system in use.

The fuel injector 2 further comprises a measurement system, typically referred to
10 as the Injector Closed Loop (ICL) system, for measuring the position of the valve needle by detecting when the valve needle is fully seated in a closed position. The measurement system comprises a wire 7 that is electrically connected to the valve needle via a piston guide having a sliding electrical connection with the valve needle. The wire 7 forming part of the measurement system is arranged to
15 apply a voltage to the valve needle and to measure the voltage at the valve needle. When the valve needle is fully seated in a closed position, an electrical connection is established between the valve needle and the nozzle body so that the voltage on the valve needle drops. The wire 7 therefore allows the position of the valve needle to be determined by an external processor (not shown) to which
20 the wire 7 may be electrically connected.

The three wires (including the two wires 6, 8 that are connected to the valve needle actuation system 3 and the wire 7 forming part of the measurement system) all require electrical connection to an external lead in use of the fuel
25 injector 2. In order to allow connection to an external lead, the three wires 6, 7, 8 extend to an exterior of the fuel injector 2 through an aperture 9 extending through a boss 10 provided on the fuel injector 2. The aperture 9 is sealed by a seal assembly 11 comprising a shape seal and an anti-extrusion washer through which the wires 6, 7, 8 extend and from which the wires project. The wires 6, 7, 8
30 run parallel to each other as they project outwardly from the seal assembly 11, and are arranged along a straight line extending perpendicular to their longitudinal axes, as shown in Figure 1a. The wires 6, 7, 8 have a pitch (or spacing) prior to attachment of the connector 1 to the fuel injector 2 that is defined by the geometry of the seal assembly 11.

Turning to the connector itself, the connector 1 comprises an integrally moulded plastic body 20 providing an attachment portion 21 and an external connection portion 22, as shown in Figure 2a. The attachment portion 21 comprises an annular socket 23 that is arranged to be press-fitted with an interference fit onto the boss 10 provided on the fuel injector 2 when the attachment portion 21 is moved towards the boss 10 in an attachment direction aligned with an axis of the attachment portion, as shown in Figures 3a and 3b. The external connection portion 22 comprises a socket 24 arranged to receive a plug of the external lead.

The connector 1 further comprises three conductive connector tabs 26, 27, 28, as shown in Figure 1b. Each of the connector tabs 26, 27, 28 corresponds to one of the wires 6, 7, 8 and is adapted to be electrically connected to the respective one of the wires when the connector 1 has been fitted to the fuel injector 2. Each of the connector tabs 26, 27, 28 comprises an aperture in the form of a hole that is arranged to receive its respective wire and establish an electrical connection with the wire. Each of the connector tabs 26, 27, 28 leads to a contact in the socket 24 of the external connection portion 22 in order to electrically connect the wires with contacts of a plug of the external lead (when the connector 1 has been fitted to the fuel injector 2 and the plug has been inserted into the socket). The pitch of the connector tabs 26, 27, 28 is greater than the pitch of the wires prior to attachment of the connector 1 to the fuel injector 2, as shown in Figures 3a and 3b.

The connector body 20 further comprises a guide portion 25 through which the wires 6, 7, 8 pass before coming into engagement with the connector tabs 26, 27, 28 during attachment of the connector 1 to the fuel injector 2. The guide portion 25 comprises three guide channels 36, 37, 38 formed by three separate holes extending through the guide portion, as shown in Figures 2a and 2b and Figures 3a and 3b. The guide channels 36, 37, 38 have longitudinal axes that run parallel to each other, and are arranged along a straight line extending perpendicular to the axes of the guide channels. The longitudinal axes of the guide channels 36, 37, 38 are substantially parallel to the axis of the attachment portion 21. Each guide channel 36, 37, 38 corresponds to one of the connector tabs 26, 27, 28, and extends from an opening located within the socket 23 of the attachment portion 21 towards its respective connector tab 26, 27, 28. The pitch of the guide channels 36, 37, 38 is equal to the pitch of the connector tabs 26, 27, 28.

During attachment of the connector 1 to the fuel injector 2 (described in more detail below) the wires 6, 7, 8 move through the body 20 of the connector 1 towards the connector tabs 26, 27, 28. Each of the guide channels 36, 37, 38 is arranged to receive one of the wires 6, 7, 8 and guide it towards its corresponding connector tab 26, 27, 28 as the wires move through the body 20 of the connector 1. The guide channels 36, 37, 38 therefore allow the wires 6, 7, 8 to be automatically aligned with the connector tabs 26, 27, 28 when the wires are passed through the guide channels during attachment of the connector 1 to the fuel injector 2.

The wire-receiving hole of each connector tab 26, 27, 28 is located adjacent to the outlet of its corresponding guide channel 36, 37, 38 and is axially aligned with its corresponding guide channel so as to automatically receive a wire 6, 7, 8 when the wire is passed through the guide channel without requiring any further alignment operations to be performed.

Although the guide channels 36, 37, 38 run parallel to each other and are equal in pitch to the connector tabs 26, 27, 28, each of the two outer guide channels 26, 28 widens towards the central guide channel 27 as it approaches its end furthest from the connector tabs 26, 27, 28, as shown in Figures 3a and 3b. In this way the distance between the openings of the guide channels 36, 37, 38 is reduced compared to the distance between the sidewalls of the guide channels at their ends closest to the connector tabs. The guide channels 36, 37, 38 are therefore arranged to readily accept the wires 6, 7, 8 extending from the fuel injector 2 by virtue of the widened openings, even though the pitch of the wires 6, 7, 8 prior to insertion into the guide channels 36, 37, 38 is less than the pitch of the guide channels (and the connector tabs 26, 27, 28). In this way, the guide channels 36, 37, 38 are arranged to increase the pitch of the wires 6, 7, 8 as the wires pass through the guide channels towards the connector tabs 26, 27, 28 during attachment of the connector 1 to the fuel injector 2, thereby facilitating connection of the wires 6, 7, 8 to the connector tabs 26, 27, 28.

In addition to a widening section, each of the outer guide channels 36, 38 also comprises a section of constant cross-section extending from the widening section up to its end closest to its respective connector tab 26, 28 in order to

provide more reliable guiding of a wire 6, 8 towards its respective connector tab. The guide channels are similar in dimension to the wires along their sections of substantially constant cross-section in order to most effectively constrain a wire in both x and y directions perpendicular to the longitudinal axes of the guide
5 channel.

The guide channels 36, 37, 38 are also arranged to shift the wires 6, 7, 8 together in a lateral direction that is perpendicular to the longitudinal axes of the wires prior to insertion into the guide channels as the wires are passed through
10 the guide channels towards the connector tabs 26, 27, 28. In order to achieve this, each of the guide channels 36, 37, 38 widens in a lateral direction L perpendicular to its longitudinal axis and perpendicular to the line along which the guide channels are arranged towards its end furthest from its respective connector tab 26, 27, 28, as shown in Figs. 2a and 2b. (As shown in Figure 2b,
15 each of the outer guide channels 26, 28 widens both towards the central guide channel 27 and in the lateral direction L perpendicular to the direction towards the central guide channel as it approaches its end furthest from the connector tabs 26, 27, 28; whereas the central guide channel 27 only widens in the lateral direction as it approaches its end furthest from the connector tabs.)

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The guide portion 25 of the connector body 20 is also provided with two vent holes 29 (in addition to the guide channels) which are not arranged to receive any wires, but which instead are for venting a chamber formed by the socket 23 of the attachment portion 21 around the guide portion 25.

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The connector 1 may be fitted to the fuel injector 2 as follows:

1. The attachment portion 21 of the connector 1 is aligned with the boss 10 of the fuel injector 2, with the wires 6, 7, 8 approximately aligned with the openings of the guide channels 36, 37, 38;
- 30 2. The connector 1 is moved towards the fuel injector 2 in an attachment direction such that the wires 6, 7, 8 enter the socket 23 of the attachment portion 21 and move into the guide channels 36, 37, 38;
3. The connector 1 continues to be moved towards the fuel injector 2 such that the wires 6, 7, 8 pass through the guide channels 36, 37, 38 towards
35 the connector tabs 26, 27, 28;

4. As the wires 6, 7, 8 pass through the guide channels 36, 37, 38, the guide channels increase the pitch of the wires, and also shift the wires together in a lateral direction L that is perpendicular to the axes of the wires prior to their insertion into the guide channels;
5. As the wires 6, 7, 8 exit the guide channels 36, 37, 38, the guide channels guide the wires automatically into the wire-receiving holes of the connector tabs 26, 27, 28, thereby establishing an electrical connection between each wire and its respective connector tab;
6. The socket 23 of the attachment portion 21 forms an interference fit with the boss 10 of the fuel injector 2, thereby securely attaching the connector 1 to the fuel injector 2.

After the connector 1 has been attached to the fuel injector 2 the wires 6, 7, 8 may be soldered to their respective connector tabs 26, 27, 28 without the need to perform any further alignment operations. After soldering, a connector cover (not shown) may be fitted to the connector body 20 to cover the connector tabs 26, 27, 28 and their connections with the wires 6, 7, 8. In some cases it may not be necessary to solder the wires to the connector tabs, and the wires may instead simply be held within the apertures of the connector tabs.

20

In the above-described embodiment, the connector comprises three guide channels and three connector tabs arranged to receive three wires extending from a fuel injector component, namely two wires for supplying current to a solenoid-type actuation system for the injector valve needle and one wire for measuring the position of the valve needle as part of an ICL system. However, in other embodiments, for example in the case of a connector for use with a fuel injector that does not include any measurement system for measuring the position of the valve needle, the connector may have only two channels 36, 37 and two connector tabs 26, 27 arranged to receive two wires 16, 17 extending from a fuel injector, as schematically illustrated in Figure 4a.

30

In the above-described embodiment, the guide channels 36, 37 are arranged to receive a plurality of wires 26, 27 having a pitch that is less than the pitch of the guide channels (and the connector tabs 26, 27) and to increase the pitch of the wires as the wires are passed through the guide channels towards the connector

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tabs 26, 27 by widening the outer guide channels towards the central guide channel.

5 Alternatively, or in addition, and as schematically illustrated in Figure 4b, the guide channels 36, 37, 38 may be arranged to converge along at least a portion of their lengths towards their ends furthest from the connector tabs 26, 27, 28 in order to receive a plurality of wires 6, 7, 8 having a pitch that is less than the pitch of the guide channels 36, 37, 38 at their ends closest to the connector tabs.

10 In the above-described embodiment, the guide channels 36, 37, 38 are arranged to increase the pitch of a plurality of wires 6, 7, 8 as the wires are passed through the guide channels. However, in other embodiments the guide channels 36, 37, 38 may simply guide the wires 6, 7, 8 towards the connector tabs 26, 27, 28 without altering their pitch, in which case no widening or converging of the guide
15 channels is required, as schematically illustrated in Figure 4c. Similarly, in other embodiments the guide channels 36, 37, 38 may not be arranged to shift a plurality of wires 6, 7, 8 together in a lateral direction as the wires are passed through the guide channels.

20 It will be understood that various other modifications may be made within the scope of the appended claims.

Claims:

1. A connector (1) for a fuel injector (2), the connector (1) comprising a
5 body (20) and a plurality of connector tabs (26, 27, 28) for connecting to a
corresponding plurality of wires (6, 7, 8) extending from a component of the fuel
injector (2), wherein the body (20) of the connector (1) provides a plurality of
guide channels (36, 37, 38) corresponding to the plurality of connector tabs (26,
27, 28), wherein each guide channel (36, 37, 38) is arranged to guide a wire (6,
10 7, 8) when passed therethrough, in use, towards a respective one of the
connector tabs (26, 27, 28).
2. A connector (1) according to claim 1, wherein the guide channels (36,
37, 38) are arranged adjacent to one another along a line extending
15 perpendicular to longitudinal axes of the guide channels (36, 37, 38).
3. A connector (1) according to claim 1 or claim 2, wherein the guide
channels (36, 37, 38) are arranged to increase the pitch of the plurality of wires
(6, 7, 8) as the wires are passed through the guide channels towards the
20 connector tabs (26, 27, 28), in use.
4. A connector (1) according to claim 3, wherein at least one of the guide
channels (36, 37, 38) widens towards at least one adjacent guide channel as it
approaches its end furthest from the connector tabs (26, 27, 28).
25
5. A connector (1) according to claim 4, wherein the or each guide channel
(36, 37, 38) that widens towards at least one adjacent guide channel also
comprises a section of at least substantially constant cross section.
- 30 6. A connector (1) according to any of claims 3 to 5, wherein the guide
channels (36, 37, 38) converge towards their ends furthest from the connector
tabs (26, 27, 28).
7. A connector (1) according to claim 6, wherein the converging guide
35 channels (36, 37, 38) also run at least substantially parallel to each other along
another a non-converging portion of their lengths.

8. A connector (1) according to any preceding claim, wherein the guide channels (36, 37, 38) are arranged to shift the plurality of wires (6, 7, 8) together in a lateral direction that is perpendicular to the longitudinal axes of the wires (6, 7, 8) prior to insertion into the guide channels (36, 37, 38) as the wires are
5 passed through the guide channels towards the connector tabs (26, 27, 28) in use.

9. A connector (1) according to any preceding claim, wherein each guide channel (36, 37, 38) is formed by a separate hole in the body of the connector
10 (1).

10. A connector (1) according to any preceding claim, wherein each connector tab (26, 27, 28) comprises an aperture adapted to receive an associated one of the plurality of wires that has been passed through a
15 respective one of the guide channels (36, 37, 38) to establish an electrical connection with the wire (6, 7, 8).

11. A connector (1) according to claim 10, wherein each wire-receiving aperture comprises a hole into which an associated one of the plurality of wires
20 (6, 7, 8) that has been passed through a respective one of the guide channels (36, 37, 38) may be received.

12. A connector according to claim 10 or claim 11, wherein each wire-receiving aperture is located adjacent to a respective one of the guide channels
25 (36, 37, 38).

13. A fuel injector (2) assembly comprising a connector according to any preceding claim coupled to a fuel injector (2), the fuel injector comprising a plurality of wires (6, 7, 8) extending from the fuel injector component, the plurality
30 of wires extending through the guide channels (36, 37, 38) and into contact with the connector tabs (26, 27, 28).

14. A fuel injector (2) as claimed in claim 13, wherein the plurality of wires comprises a pair of wires for supplying an electric current to an actuator of the
35 injector, and a third wire for supplying a measurement signal to indicate the position of a valve needle of the injector.

15. A method of fitting a connector (1) to a fuel injector (2), the method comprising approximately aligning a plurality of wires (6, 7, 8) extending from a fuel injector component with a corresponding plurality of guide channels (36, 37, 38) provided in a body (20) of the connector (1), each guide channel (36, 37, 38) being arranged to guide a respective one of the wires (6, 7, 8) towards a connector tab (26, 27, 28); moving the connector (1) towards the fuel injector (2) thereby passing the wires (6, 7, 8) into and through the guide channels (36, 37, 38); and guiding each wire (6, 7, 8) towards and into contact with a respective one of the connector tabs (26, 27, 28) using the guide channels (36, 37, 38).

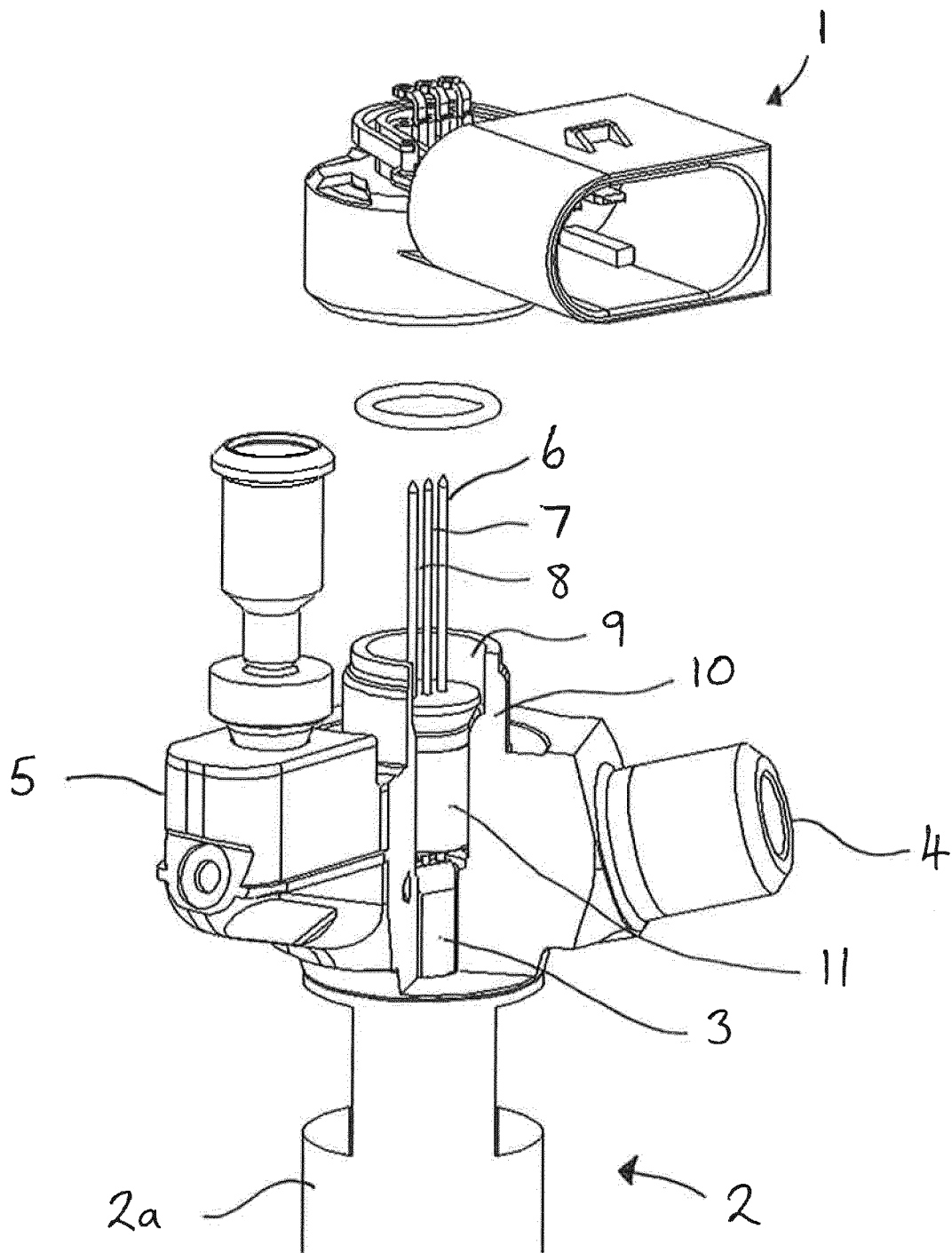


Fig. 1a

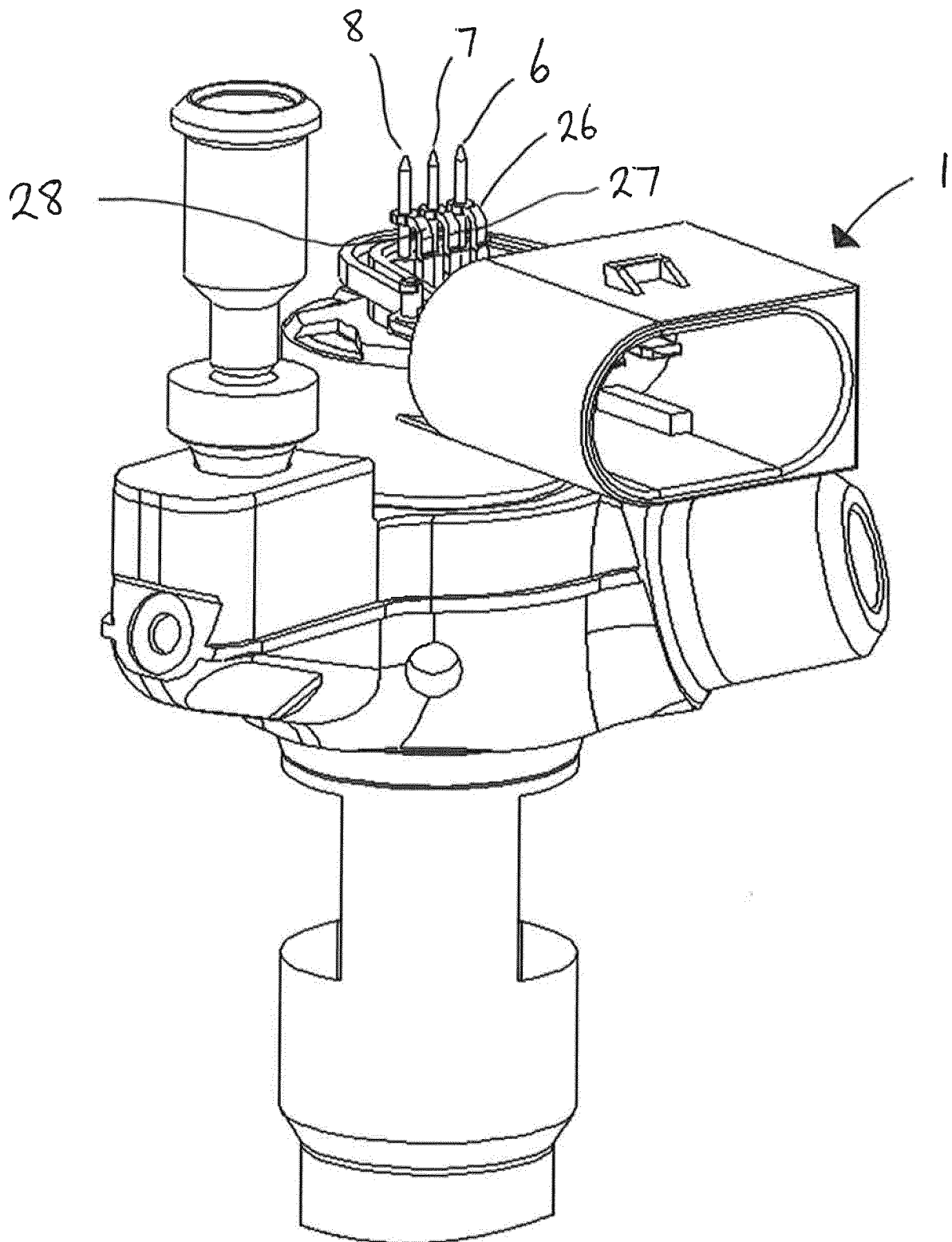


Fig. 1b

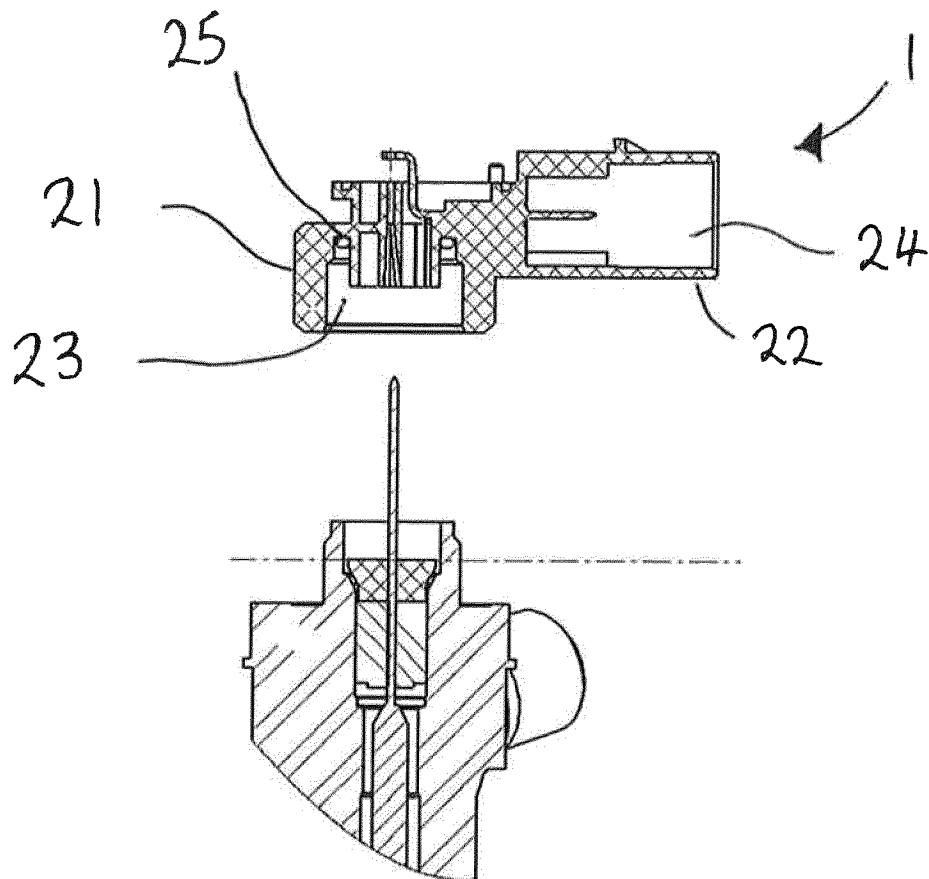


Fig. 2a

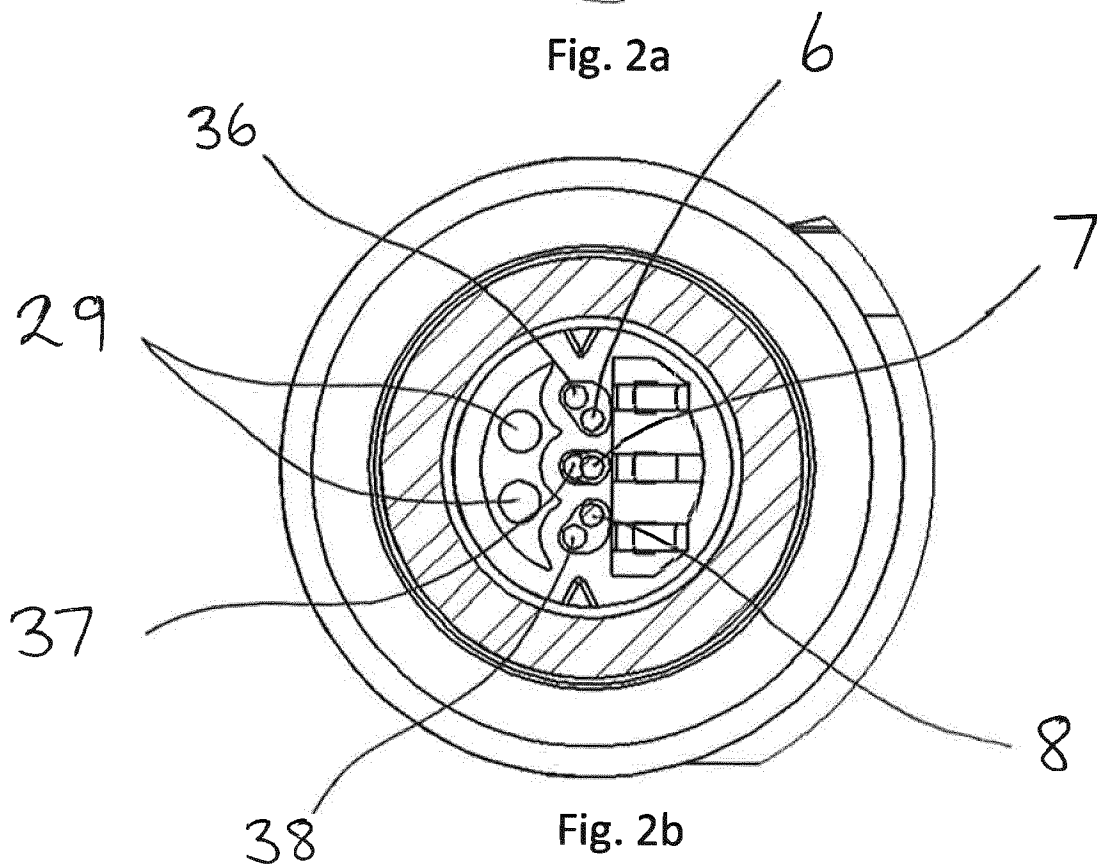


Fig. 2b

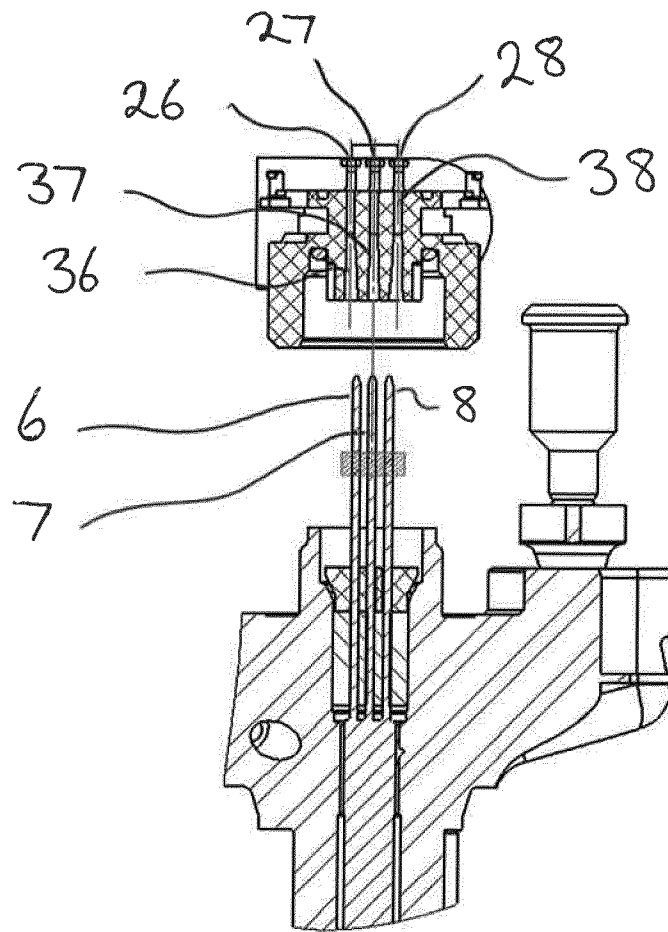


Fig. 3a

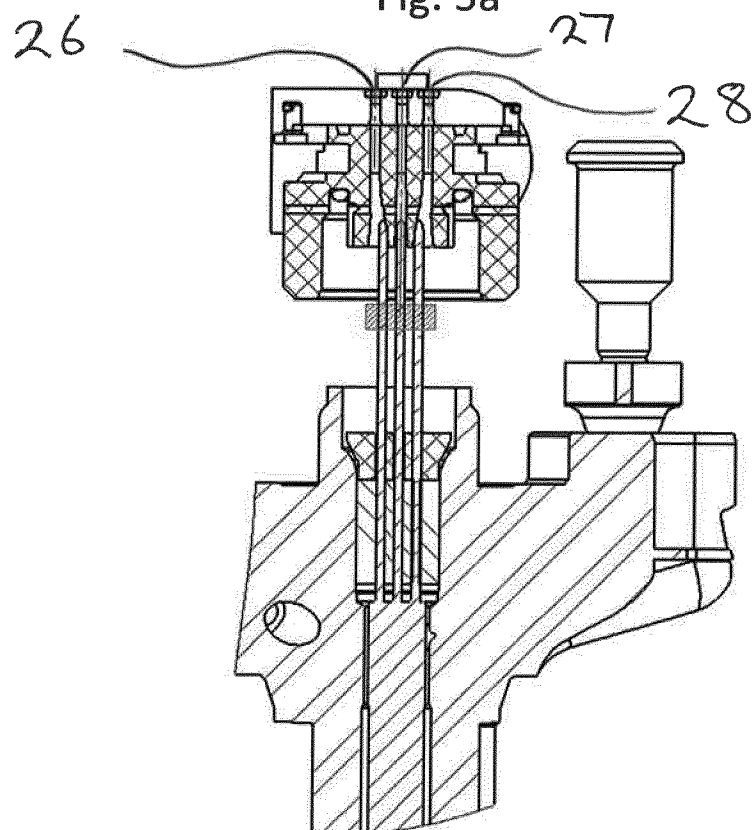


Fig. 3b

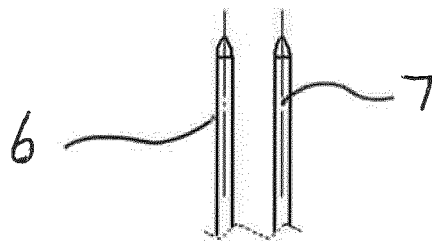
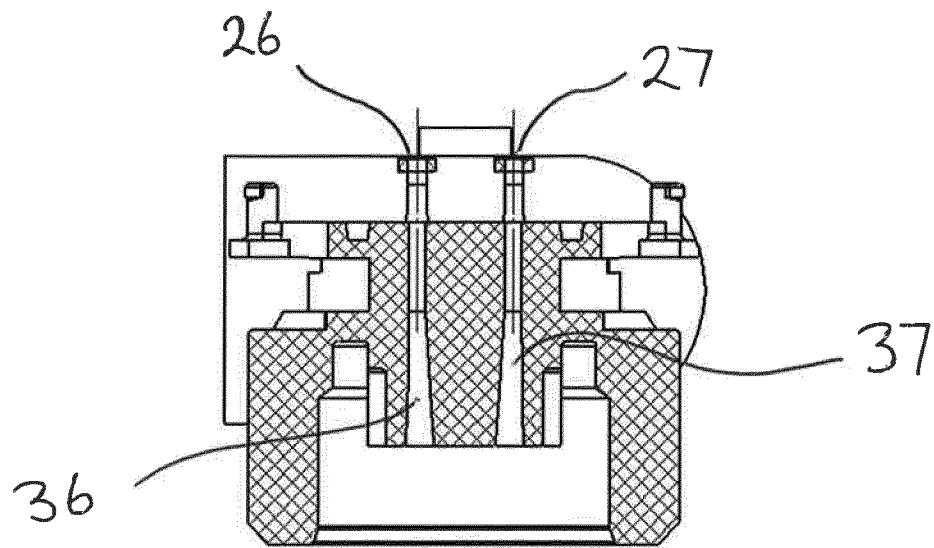


Fig. 4a

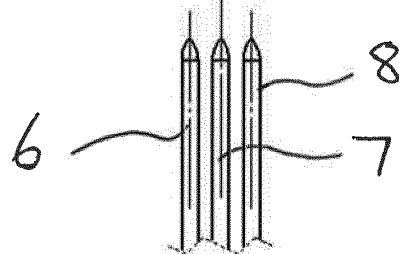
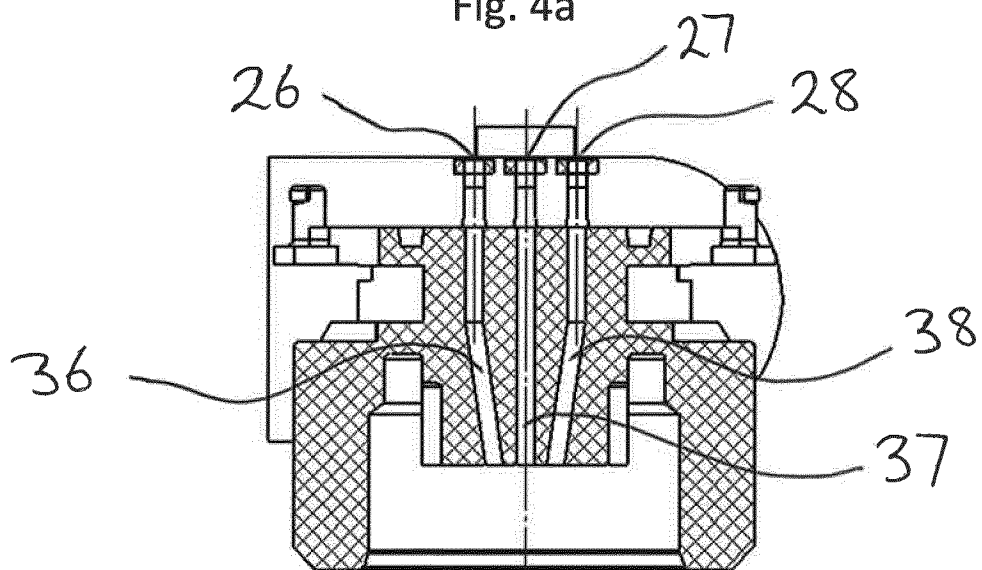


Fig. 4b

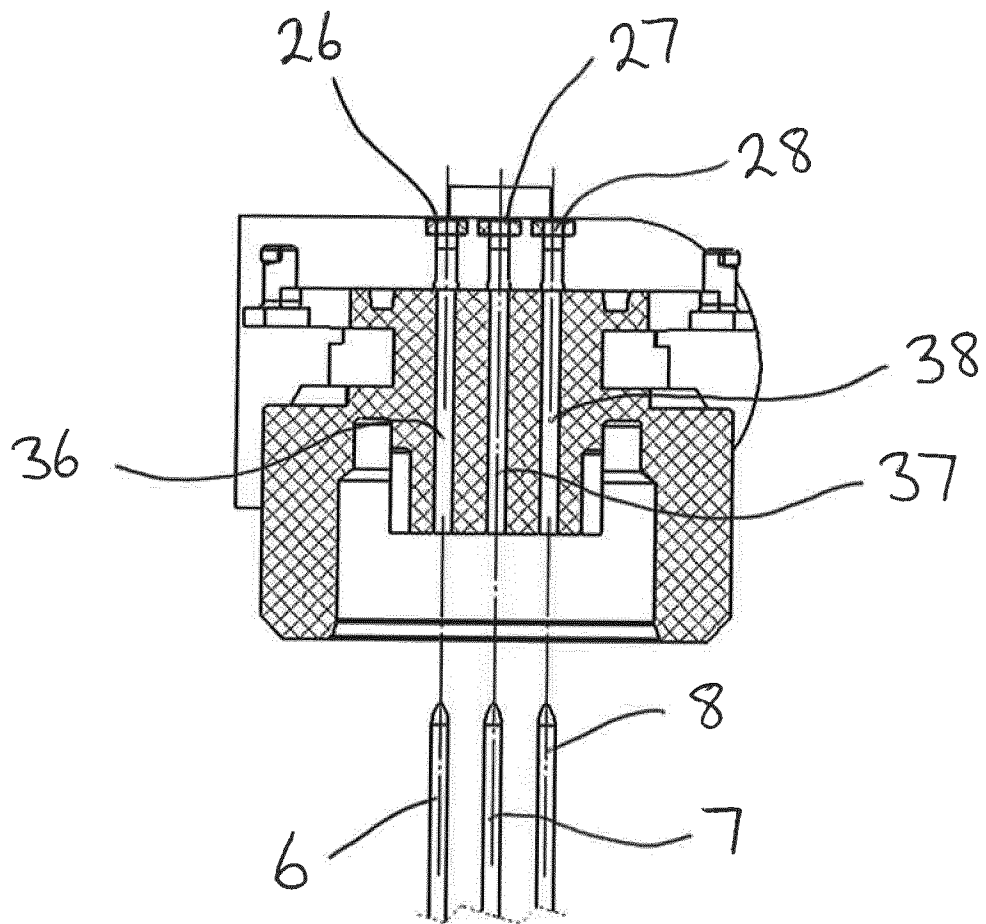


Fig. 4c

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/053313

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02M51/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2009 044604 A1 (DENSO CORP [JP]) 1 July 2010 (2010-07-01)	1-5,13, 15
Y	the whole document	6-8,14
Y	EP 2 202 404 A1 (BOSCH GMBH ROBERT [DE]) 30 June 2010 (2010-06-30) paragraphs [0021] - [0024]; figure 2	6-8
Y	DE 103 13 623 A1 (SIEMENS AG [DE]) 21 October 2004 (2004-10-21) paragraphs [0037], [0039]; figure 1	14
X	DE 10 2010 005158 A1 (CONTINENTAL AUTOMOTIVE GMBH [DE]) 21 April 2011 (2011-04-21) the whole document	1,3-5, 9-13,15
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Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

12 April 2017

Date of mailing of the international search report

24/04/2017

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2017/053313

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

International application No

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