(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 492 202 A1

# (12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
**29.12.2004 Bulletin 2004/53**

(51) Int Cl.[7]: **H01R 13/52**

(21) Application number: **04014506.2**

(22) Date of filing: **21.06.2004**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PL PT RO SE SI SK TR**
Designated Extension States:
**AL HR LT LV MK**

(30) Priority: **25.06.2003 EP 03014296**

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## (54) Seal carrying electrical contact

(57) An electrical contact (37) formed for receipt in a substantially cylindrical contact receiving passageway (18) having an inner diameter (47), a first axial end (19), and a second axial end (20). The contact (37) comprises a substantially cylindrical contact body (43) with an outer diameter (45) smaller than the inner diameter (47) of the contact receiving passageway (18). The contact body (43) has a first conductor engaging portion (49) at a first conductor receiving end (51) for forming an electrical connection with a first conductor (57) and a second conductor engaging portion (53) at a second conductor receiving end (55) for forming an electrical connection with a second conductor (59). At least one seal member (67, 83) having a first plurality of annular projections (79) is mounted on the contact body (43). The first plurality of annular projections (79) extend from the seal member (67, 83) such that radial outer ends of the first plurality of annular projections (79) are bent towards the first axial end (19) when the contact (37) is pushed into the contact receiving passageway (18) from the first axial end (19) of the contact receiving passageway (18).

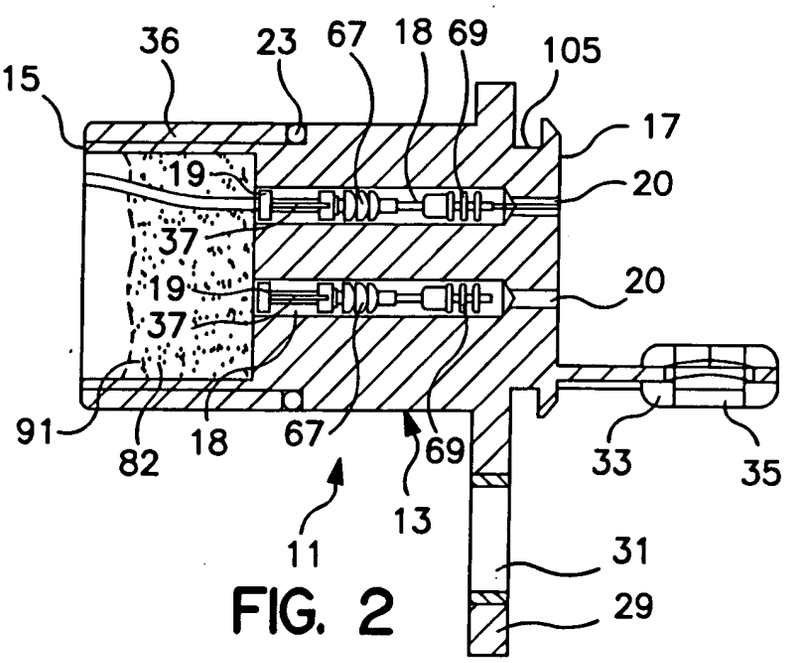



FIG. 2

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## Description

**[0001]** The invention relates to an electrical contact and, in particular, to a contact having at least one seal member that forms a seal between a contact receiving passageway and the contact received therein such that liquid is prevented from passing through the contact receiving passageway. Moreover, the invention relates to an electrical connector comprising at least one of such contacts.

**[0002]** One field of use of such a contact and electrical connector is to electrically connect electrical conductors on an outer side of a cylinder head wall of a combustion engine with electrical conductors on an inner side of the cylinder head wall of the combustion engine. Examples of such a use include terminating electrical components on the inner side of the cylinder head wall for engine brake management or terminating electromagnetic fuel valves for fuel injection management. In this environment, the contacts and the electrical connectors are exposed to vibrations, high temperatures, and external forces, particularly on the outer side of the cylinder head wall. Additionally, adequate sealing is needed to prevent pressurised engine oil on the inner side of the cylinder head wall from passing through to the outer side of the cylinder head wall and for preventing water on the outer side of the cylinder head wall from passing through to the inner side of the cylinder head wall.

**[0003]** An example of such a conventional electrical connector is disclosed in DE-A-196 30 333. The electrical connector has a housing with a plurality of contact receiving passageways that receive contacts. Each of the contacts has a body portion including a conductor engaging end for forming an electrical connection with a corresponding conductor and a terminal end for engaging a mating contact of a mating connector. First and second recesses are formed along each of the body portions for receiving first and second seal members. The first and second seal members are, for example, O-rings, and form,a seal between the contact and the contact receiving passageway for preventing liquid from passing through the contact receiving passageway.

**[0004]** To use the conventional electrical connector as a lead-through through a cylinder head wall of a combustion engine, the housing of the electrical connector is mounted in a passageway of the cylinder head wall such that the mating connector is on the inner side of the cylinder head wall. In view of the limited space available at the cylinder head wall, the number of contacts that the electrical connector can accommodate is correspondingly limited. For example, if the housing is mounted in a passageway having a diameter of 30 millimeters (mm), then the electrical connector can only accommodate eight contacts.

**[0005]** Although the conventional electrical connector operated very well for the applications that is was designed for, as the number of parameters handled by the motor management of combustion engines and the number of electrical sensors and/or actuators located on the inner side of the cylinder head wall increases, it is desirable to increase the number of contacts that can be accommodated in the housing fitting in the 30 mm passageway.

**[0006]** Additionally, the location of the plug connection of the two mating connectors is at the cylinder head wall. Because the cylinder head wall is exposed to particularly strong vibrations, the plug connections are affected by the vibrations, particularly, the contacts having smaller dimensions. Moreover, vibrations and forces exerted on the conductors may cause the contacts to tilt as a result of the resilience of the first and second seal members. If the contacts tilt, the first and second seal members may become deformed. If the first and second seal members become deformed, the seal between the contact and the contact receiving passageway may deteriorate. Because the risk of such deterioration increases with a decrease in the dimensions of the first and second seal members, the ability to reduce the dimensions of the contacts is further limited. It is therefore desirable to provide an electrical connector that can house more than eight contacts in a passageway having a diameter of 30 mm without adversely effecting the performance of the electrical connector.

**[0007]** For accomplishing this and other objects, the invention provides an electrical contact as indicated in claim 1 and an electrical connector as indicated in claim 10, which can be used as indicated in claims 18 and 19. Further embodiments of the contact and the connector of the invention are indicated in the dependent claims.

**[0008]** The invention provides an electrical contact formed for receipt in a substantially cylindrical contact receiving passageway having an inner diameter, a first axial end, and a second axial end. The contact comprises a substantially cylindrical contact body with an outer diameter smaller than the inner diameter of the contact receiving passageway. The contact body has a first conductor engaging portion at a first conductor receiving end for forming an electrical connection with a first conductor and a second conductor engaging portion at a second conductor receiving end for forming an electrical connection with a second conductor. At least one seal member having a first plurality of annular projections is mounted on the contact body. The at least one seal member has a first axial side facing the first conductor receiving end and a second axial side facing the second conductor receiving end of the contact body. The first plurality of annular projections extend from the seal member such that when the contact is pushed into the contact receiving passageway from the first axial end of the contact receiving passageway, the radial outer ends of the first plurality of annular projections are bent towards the first axial end.

**[0009]** In one embodiment of the invention, the first plurality of axially spaced annular projections are prebent, that is to say they are already bent towards the first conductor receiving end in a relaxed state, i.e. be-

fore the contact is pushed into the contact receiving passageway. In another embodiment of the invention, the first plurality of axially spaced annular projections are straight in a relaxed state and are bent towards the first axial end of the contact receiving passageway only when the contact is inserted into the contact receiving passageway.

**[0010]** By the bending the outer ends of the first plurality of axially spaced annular projections towards the first axial end of the contact receiving passageway, the sealing effective of the area of the first plurality of axially spaced annular projections is increased. Further, engine oil pressing against the first plurality of axially spaced annular projections urges the bent outer ends of the first plurality of axially spaced annular projections against the inner wall of the contact receiving passageway to additionally increase the sealing effect of the first plurality of axially spaced annular projections.

**[0011]** Because the first and second conductors that are connected to the contact of the invention are solidly secured to the respective first and second conductor receiving ends of the contact, there is no plug connection in the region of the cylinder head wall so that there is a stable connection with high resistance against vibrations and mechanical forces applied to the first and second conductors.

**[0012]** An embodiment of the invention comprises a second plurality of axially spaced annular projections on the side of the first plurality of axially spaced annular projections which faces away from the first conductor receiving end of the contact body. The radial extension of the second plurality of axially spaced annular projections is designed such that, when the contact is pushed into the contact receiving passageway, outer ends of second plurality of axially spaced annular projections sealingly contact the inner wall of the contact receiving passageway.

**[0013]** In an embodiment of the invention, second plurality of axially spaced annular projections are provided on the first seal member. In another embodiment of the invention, the second plurality of axially spaced annular projections are provided on a second seal member.

**[0014]** In an embodiment of the invention, the second plurality of axially spaced annular projections are not pre-bent but are straight in a relaxed sate. The second plurality of axially spaced annular projections are dimensioned with respect to the inner diameter of the contact receiving passageway such that the second plurality of axially spaced annular projections are bent towards the first axial end of the contact receiving passageway less than the outer ends of the first plurality of axially spaced annular projections when the contact is inserted into the contact receiving passageway. Alternatively, the second plurality of axially spaced annular projections are dimensioned with respect to the inner diameter of the contact receiving passageway such that they are not bent when the contact is inserted into the contact receiving passageway but instead contact the contact receiving passageway in a substantially straight state.

**[0015]** The purpose of the second plurality of axially spaced annular projections is to prevent a liquid, such as water, occurring on the second axial end of the contact receiving passageway from passing through the contact receiving passageway to the first axial end. If the contact was only provided with the first plurality of axially spaced annular projections that has outer ends bent towards the first axial end of the contact receiving passageway, it might be easy for the water to pass the bent first plurality of axially spaced annular projections when there is no engine oil occurring at the first axial end of the contact receiving passageway urging the bent outer parts of the first plurality of axially spaced annular projections towards the inner wall of the contact receiving passageway, e.g. when the engine is not operating. Because all of the annular projections having radial extensions exceeding the radial clearance between the outer diameter of the contact body and the inner diameter of the contact receiving passageway are bent toward the same side, if the contact is inserted into the contact receiving'passageway, it is not possible to have a part of the annular projections bent in different directions in the contact receiving passageway. By dimensioning the second plurality of axially spaced annular projections such that they do not bend or only slightly bend when inserting the contact into the contact receiving passageway, the second plurality of axially spaced annular projections remain straight or substantially straight and touch the inner wall of the contact receiving passageway substantially without bending so that the second plurality of axially spaced annular projections present a resistance against the passing of water occurring at the second axial end of the contact receiving passageway, which is higher than that of the first plurality of axially spaced annular projections bent towards the first axial end of the contact receiving passageway.

**[0016]** The number of the plurality of axially spaced annular projections on the seal member or seal members depends on the desired sealing effect. The more axially spaced annular projections the better the sealing effect. In practical embodiments, the number of first and second axially spaced annular projections is between two and four, however, other numbers are possible. In a practical embodiment having the first and second seal members, the first seal member is provided with three of the first axially spaced annular projections and the second seal member is provided with three of the second axially spaced annular projections. In a practical embodiment wherein the first and second pluralities of axially spaced annular projections are provided on a single seal member, the single seal member is provided with three of the first axially spaced annular projections and two of the second axially spaced annular projections. Other numbers of axially spaced annular projections, however, are possible, for example, three of the first axially spaced annular projections and three of the second axially spaced annular projections.

**[0017]** Tilting of the contact relative to the contact receiving passageway, caused by forces exerted on the conductors, does scarcely or not at all affect the sealing effect either of the first plurality of lips as their bent outer ends remain seated on the inner wall of the contact receiving passageway or of the second plurality of lips if there is a sufficient number thereof.

**[0018]** Tilting of the contact is at least largely prevented in an embodiment of the invention wherein the contact has a contact body comprising at least two radial flanges which are located between the first and second axially spaced annular projections and the first axial end of the contact receiving passageway and have an outer diameter which is substantially equal to the inner diameter of the contact receiving passageway. The outer surfaces of the flanges either have radial teeth, which indent into the material of the inner wall of the contact receiving passageway, or the outer surfaces of the flanges are smooth and are adjusted to the inner diameter of the contact receiving passageway without clearance so that the flanges are received in a press-fit in the contact receiving passageway, for example, with a small clearance of a few 1/10 mm. In at least the latter case, the contact is stabilised by potting as well.

**[0019]** In an embodiment of the invention, the housing comprises a shroud at the first axial face of the housing enclosing part of a first conductor which is adjacent to the first conductor receiving end of the at least one contact. At least a part of the shroud adjacent to the first conductor receiving end of the contact is filled with potting material whereby at least the first conductor receiving end of the at least one contact as well as the first conductor fixed thereto are embedded in the potting material. Such potting material fixes the contact and the conductor, dampens cable movements, and prevents motor oil from intruding between leads or strands of the conductor or between leads or strands and the insulating sheath of the conductor and flowing back to the electrical connector fixed to the conductor at an end of the conductor remote from the housing.

**[0020]** The seal member or members are made of a heat-resistant, stress-resistant and contaminant-resistant resilient material which retains permanent elasticity even in harsh environments. Suitable materials are VMQ and FVMQ.

**[0021]** There are different possibilities to mount the seal member or seal members on the contact body such that liquid does not pass between the outer diameter of the contact body and the inner diameter of the respective seal member. In a first embodiment, the respective seal member is press-fit mounted onto the contact body. In another embodiment, the respective seal member is slid over the contact body. The seal member may be held in position by means of one or more annular ribs formed on the circumference of the contact body co-operating with complementary annular recesses formed in the inner circumference of the seal member. In a further embodiment, the respective seal member is moulded or vulcanised onto the contact body.

**[0022]** In an embodiment of the invention, the contact body has a solid middle portion, a tubular first conductor engaging portion extending between the first conductor receiving end of the contact body and,the solid middle portion for receiving the first conductor, and a tubular second conductor engaging portion extending between the second conductor receiving end of the contact body and the solid middle portion for receiving the second conductor. The solid middle portion prevents liquid creeping along the first and second conductors, either on the outside of the conductor, between the conductor and an insulating coating of the conductor, or between strands of the conductor, from passing from one of the conductor receiving ends of the contact to the other conductor receiving end of the contact.

**[0023]** In an embodiment of the invention, at least one of the conductor engaging portions comprises a crimp section for forming a crimp connection with the respective conductor. The before-mentioned tube portions might form such crimp sections.

**[0024]** If the contact of the invention is used as a lead-through through a cylinder head wall, the contact receiving passageways could be formed in the cylinder head wall itself, which is possible if the cylinder head wall is made of an electrically insulating material, such as, ceramic or plastic, or if the cylinder head wall is made of an electrically conducting material, such as, steel, and the inner wall of each of the contact receiving passageways is coated with an electrically insulating material. This arrangement allows a rather large number of contacts to be arranged in a limited space of the cylinder head wall. However, this arrangement is not applicable if, before pushing the contact into the respective contact receiving passageway, both ends of a harness comprising the contact already have a connector attached thereto that can not be passed through the contact receiving passageway formed in the cylinder head wall.

**[0025]** For other embodiments, where it is not possible or not desired to form the contact receiving passageways in the wall itself, the invention provides an electrical connector. The electrical connector comprises a housing made of an insulating material. The housing has a first axial face and a second axial face and at least one substantially cylindrical contact receiving passageway extending between the first and the second axial face. The contact receiving passageway has a predetermined inner diameter and comprises an electrical contact of the invention as described before.

**[0026]** In an embodiment of the invention, the housing has a substantially cylindrical outer peripheral surface which is provided with a peripheral outer seal member for sealing a housing receiving passageway of a wall, e. g., a cylinder head wall.

**[0027]** Envisioned is the use of the contact of the invention for electrically connecting through a cylinder head wall of an engine a first conductor on an inner side of the cylinder head wall and a second conductor on an

outer side of the cylinder head wall, wherein the contact receiving passageway receiving the contact forms a channel through the cylinder head wall. The first axial end of the contact receiving passageway is adjacent to the inner side of the cylinder head wall and the second axial end of the contact receiving passageway is adjacent to the outer side of the cylinder head wall. The at least one sealing member is mounted on the contact to prevent pressurised oil on the inner side of the cylinder head wall from passing through the contact receiving passageway to the outer side of the cylinder head wall.

**[0028]** Also envisioned is the use of the connector of the invention for electrically connecting through a cylinder head wall of a combustion engine at least one first conductor on an inner side of the cylinder head wall and at least one second conductor on an outer side of the cylinder head wall, wherein the housing of the connector is received in a connector receiving passageway of the cylinder head wall with the first axial face of the housing being adjacent to the inner side of the cylinder head wall and the second axial face of the housing being adjacent to the outer side of the cylinder head wall. The at least one sealing member is mounted on the at least one contact received in the at least one contact receiving passageway of the housing to prevent pressurised oil on the inner side of the cylinder head wall from passing through the contact receiving passageway to the outer side of the cylinder head wall.

**[0029]** The invention will now be described by way of example with reference to the accompanying drawings, wherein:

Figure 1 is an isometric view of an electrical connector according to the invention;

Figure 2 is a cross-sectional view of the electrical connector of Figure 1 showing contacts arranged therein;

Figure 3 is a top schematic view of the electrical connector of Figure 1 taken from a right-hand side of Figure 1;

Figure 4 is a bottom schematic view of the electrical connector of Figure 1 taken from the left-hand side of Figure 1;

Figure 5 is a schematic view in partial cross-section of an arrangement with the electrical connector of Figure 1 showing first and second conductors connected to the contacts of the electrical connector wherein the first and second conductors have terminals at ends remote from the electrical connector;

Figure 6 is a partial cross-sectional view of one of the contacts of Figure 5 shown connected to the first and second conductors before being received in a contact receiving passageway of the electrical connector of Figure 1; and

Figure 7 is a partial cross-sectional view of an alternate embodiment of the contact of Figure 6 shown received in the contact receiving passageway of the electrical connector of Figure 1.

**[0030]** Figure 1 shows an electrical connector 11. The electrical connector 11 will be described in greater detail hereafter and will be described by way of example as an electrical lead-through through a cylinder head wall 26 of a combustion engine of a truck.

**[0031]** As shown in Figure 1, the electrical connector 11 includes an insulating housing 13 having a first axial face 15 and a second axial face 17. Between the first and second axial faces 15, 17 of the housing 13 is a seal receiving recess 21, which is formed to receive an outer seal member 23, such as an O-ring, shown in Figure 2. As shown in Figure 5, the outer seal member 23, for example, seals a housing receiving passageway 25 of a cylinder head wall 26 that has an inner surface 27 and an outer surface 28.

**[0032]** As shown in Figure 1, the second axial face 17 has a flange 29. The flange 29 radially extends from one peripheral side of the housing 13 and has a flange opening 31 for mounting the flange 29 to the cylinder head wall 26 with, for example, a screw. A grommet 33 having a shape of a half shell axially extends from the second axial face 17 of the housing 13 adjacent to the flange 29. The grommet 33 has a grommet opening 35. The second axial face 17 is further provided with an annular recess 105. As best shown in Figure 2, the first axial face 15 comprises an axially extending shroud 36. The shroud 36 forms a cylindrical cavity 91 at the first axial face 15 of the housing 13.

**[0033]** As shown in Figure 2, a plurality of contact receiving passageways 18 axially extend through the housing 13. Each of the contact receiving passageway 18 has a first axial end 19 and a second axial end 20. The first axial end 19 may be formed to have bevels 109 that taper inward toward the contact receiving passageway 18, as best shown in Figure 6.

**[0034]** A contact 37 is received in each of the contact receiving passageways 18 of the housing 13. As best shown in Figure 6, each of the contacts 37 has a substantially cylindrical contact body 43. The contact body 43 has a main part with an outer diameter 45 smaller than an inner diameter 47 of the respective contact receiving passageway 18. The contact body 43 has a tubular first conductor engaging portion 49 at a first conductor receiving end 51 and a tubular second conductor engaging portion 53 at a second conductor receiving end 55. The first conductor engaging portion 49 is in crimp connection with a first stranded conductor 57 that is received in the first conductor engaging portion 49. The first stranded conductor 57 extends from the first conductor receiving end 51 of the contact body 43. The second conductor engaging portion 53 is in crimp connection with a second stranded conductor 59 received in the second conductor engaging portion 53. The second stranded conductor 59 extends from the second conductor receiving end 55 of the contact body 43.

**[0035]** The contact body 43 has a solid middle portion 61 extending between the tubular first and second conductor engaging portions 49, 53. The solid middle por-

tion 61 prevents engine oil, for example, from reaching the second conductor engaging portion 53 by preventing the engine oil from creeping along strands of the first conductor 57 and/or between the strands and an outer insulating coating of the first conductor 57 and/or along the outside of the outer insulating coating. Similarly, water creeping along the strands of the second conductor 59 and/or between the strands and an outer insulating coating of the second conductor 59 and/or along the outside of the outer insulating coating is prevented from reaching the first conductor engaging portion 49.

**[0036]** The contact body 43 has first and second radial collars 63, 65. The first radial collar 63 is located at the first conductor receiving end 51 of the contact body 43 and the second radial collar 65 is located at the inner end of the first conductor engaging portion 49. Each of the first and second radial collars 63, 65 may be formed to have entrance bevels 109. The outer surfaces of the first and second radial collars 63, 65 may be formed to have radial teeth (not shown) that indent into the material of the inner wall of the contact receiving passageway 18. Alternatively, the outer surfaces of the first and second radial collars 63, 65 may be made smooth and adjusted to the inner diameter of the contact receiving passageway 18 either without clearance or with a small clearance of a few millimeters, for example 1/10 mm, so that the first and second radial collars 63, 65 may be press-fit in the contact receiving passageway 18. The first and second radial collars 63, 65 fix the contact 37 within the contact receiving passageway 18, for example, by press-fitting, and prevent the contact body 43 from tilting within the passageway 18.

**[0037]** First and second seal members 67, 69 are mounted on the contact body 43 at an axial distance from each other by, for example, press-fit mounting, moulding, or vulcanising the first and second seal members 67, 69 onto the contact body 43. The first and second seal members 67, 69 are made of a heat-resistant, stress-resistant, and contaminant-resistant resilient material that retains permanent elasticity even in harsh environments.

**[0038]** The first seal member 67 is mounted on the contact body 43 adjacent to the solid middle portion 61. The first seal member 67 has a first axial side 71 facing the first conductor receiving end 51 of the contact body 43 and a second axial side 73 facing the second conductor receiving end 55 of the contact body 43. The first seal member 67 includes a first plurality of axially spaced annular projections 79. The first plurality of projections 79 axially extend such that when the contact 37 is pushed into the contact receiving passageway 18 from the first axial end 19 thereof, outer ends of the first plurality of projections 79 are bent towards the first conductor receiving end 51 of the contact body 43.

**[0039]** The second seal member 69 is mounted on the contact body 43 adjacent to the second conductor receiving end 55 and has a portion that axially extends beyond the second conductor receiving end 55 of the contact body 43. The second seal member 69 has a first axial side 75 facing the first conductor receiving end 51 of the contact body 43 and a second axial side 77 facing the second conductor receiving end 55 of the contact body 43. The second seal member 69 has a second plurality of axially spaced annular projections 81. The second plurality of projections 81 axially extend such that when the contact 37 is pushed into the contact receiving passageway 18 from the first axial end 19 thereof, outer ends of the second plurality of projections 81 substantially contact the inner wall of the contact receiving passageway 18 but either remain straight or are bent less than the first plurality of projections 79.

**[0040]** Although the first and second seal members 67, 69 are illustrated as each having three of each of the first and second annular projections 79, 81, the number of projections is not limited to three and may vary depending on the desired sealing effect for a particular application.

**[0041]** Figure 7 shows an alternate embodiment of the contact 37. In the alternate embodiment, the contact 37 has a single seal member 83 made of the same material as the first and second seal members 67, 69. The single seal member 81 has the first and second pluralities of annular projections 79, 81. The first plurality of projections 79 is arranged to face the first conductor receiving end 51, and the second plurality of projections 81 is arranged to face the second conductor receiving end 55. The axial part of the single sealing member 83 having the second plurality of projections 81 extends beyond the second conductor receiving end 55 of the contact body 43. When the contact 37 is pushed into the contact receiving passageway 18 from the first axial end 19 thereof, the outer ends of the first plurality of projections 79 are bent towards the first conductor receiving end 51 of the contact body 43 and the outer ends of the second plurality of projections 81 substantially contact the inner wall of the contact receiving passageway 18 without being bent or by being bent less than the first plurality of projections 79. By bending the outer ends of the first plurality of projections 79 towards the first axial end 19 of the passageway 18, the seal between the passageway 18 and the first plurality of projections is increased when engine oil pressing against the first plurality of projections 79 urges the bent outer ends of the first plurality of projections 79 against the inner wall of the passageway 18.

**[0042]** The axial region of the second plurality of projections 81 of the single seal member 83 is provided with a plurality of small projections 85 extending inwardly from an inner diameter of the single sealing member 83. The small projections 85 contact an outer periphery of the second conductor 59 to prevent, for example, water from passing from the second axial side 17 between the second conductor 59 and the inner periphery of the single sealing member 83. Water, therefore, is blocked from passing by either the inner periphery or the outer periphery of the sealing member 83.

**[0043]** Although the single seal member 83 is illustrated as having three first annular projections 79 and two second and small annular projections 81, 85 the number of projections is not limited to these amounts and may vary depending on the desired sealing effect for a particular application.

**[0044]** The contact body 43 has a plurality of radially extending annular metal ribs 87 in a region where the single seal member 83 is seated. The inner periphery of the single seal member 83 has a plurality of complementarily formed radially extending annular recesses 89 for receiving the metal ribs 87. The ribs 87 and the recesses 89 thereby secure the single seal member 83 to the contact body 43. The single seal member 83 may be placed on the contact body 43 by pressing it over the contact body 43 with a tool or by moulding or vulcanising the single seal member 81 onto the contact body 43.

**[0045]** Although the single seal member 83 is only shown having the small projections 85, the inner periphery of the second sealing member 69 of the embodiment of Figure 6 may also be formed with small projections 85 depending on the desired application. Additionally, the first seal member 67 and/or the second seal member 69 and the contact body 43 of the embodiment of Figure 6 may be formed with the ribs 87 and recesses 89, respectively, depending on the desired application.

**[0046]** An arrangement showing the electrical connector 11 positioned in the cylinder head wall 26 of an engine will now be explained in greater detail with reference to Figure 5. As shown in Figure 5, a first plurality of the first conductors 57 extending from the first axial face 15 of the housing 13 are each arranged as twisted-pairs. Each of the twisted-pairs is terminated by a 2-position connector 93. A second plurality of the first conductors 57 is arranged as straight pairs. Each of the two conductors of each of the straight pairs is terminated by a 1-position connector 95. In one application of the invention, the 2-position connectors 93 make a plug connection to electromagnetic fuel injection valves (not shown), and the 1-position connectors 95 make a releasable connection to engine brake management components (not shown). The first conductors 57 are arranged as flying leads and are heat-protected by means of heat-resistant tubing 97, which secures the cables and protects the cable insulation against wear.

**[0047]** The second conductors 59 extending from the second axial face 17 of the housing 13 are bent by 90 degrees and are bundled by the grommet opening 35. The grommet 33 thereby prevents the cable having the second conductors 59 from axially twisting and further prevents insulation rubbing. The second conductors 59 extend through a bellow 99 to a 12-position connector 101. The free end of the bellow 99 is adapted to be mounted on a collar 103, which is pre-mounted on the connector 101. The connector 101 has, for example, twelve contacts 102, by means of which the second conductors 59 may be connected to a motor management system (not shown). A tube (not shown) extends between the second axial face 17 of the housing 13 and the grommet 33. The tube (not shown) has a 90 degree bend and accommodates parts of the second conductors 59 extending between the second axial face 17 of the housing 13 and the grommet 33. The tube (not shown) is snapped into and secured by the annular recess 105 of the housing 13.

**[0048]** To mount the arrangement of Figure 5, the first conductor 57 is inserted into the tubular first conductor engaging portions 49 and is crimped therein. The contacts of the connectors 93, 95 are crimped on the free ends of the first conductors 57. The first seal member 67 is mounted on the contact body 43. The second conductor 59 is inserted into the tubular second conductor engaging portions 53 and crimped therein. The second seal member 39 is mounted on the contact body 43. The second conductor 59 with the second seal member 69 mounted thereon and the contact 37 connected to the second conductors 59 is then slid into the respective contact receiving passageway 18 of the housing 13 (twisted pair by twisted pair in the case of the embodiment shown in Figure 5 where each of the connectors 93, 95 terminates two of the first conductors 57). The bevels 109 formed on the housing 13 and the entrance bevels 107 formed on each of the collars 63, 65 facilitate entry of the contact 37 into the respective contact receiving passageway 18. The second conductor 59 is then fed through the grommet opening 35 and the contacts 102 are crimped to the free end of the second conductor 59. The contacts 102 are led through the bellows 99 and are inserted into the housing of the connector 101 with the pre-mounted collar 103. The resulting harness is now mounted on the cylinder head wall 26 by inserting the housing 13 of the harness into the housing receiving passageway 25 of the cylinder head wall 26. Because the first and second conductors 57, 59 are directly connected to the contact 37, there is no plug connection in the region of the cylinder head wall 26. Thus, a stable connection is provided that has a high resistance to vibrations and mechanical forces applied to the first and second conductors 57, 59.

**[0049]** When using the contact 37 as a lead-through through the cylinder head wall 26, the contact receiving passageways 18 could also be formed in the cylinder head wall 26 itself. This arrangement is possible if the cylinder head wall 26 is made of an electrically insulating material, such as, ceramic or plastic, or if the cylinder head wall 26 is made of an electrically conducting material, such as, steel, and the inner wall of each of the contact receiving passageways 18 is coated with an electrically insulating material. This arrangement allows a rather large number of contacts 37 to be arranged in a limited space. This arrangement, however, can not be used when both ends of the harness comprising the contact 37 already have connectors 93, 95 attached thereto that can not be passed through the contact receiving passageway 18 formed in the cylinder head wall 26.

**[0050]** In an embodiment wherein the contacts 37 are

pushed into contact receiving passageways directly formed in the cylinder head wall 26 as well in the embodiment wherein the contacts 37 are received in passageways 18 of the housing 13, the cylinder head wall 26 is removed from the cylinder head while the contacts 37 crimped to the respective first conductors 57 are pushed into the respective contact receiving passageway of either the cylinder head wall 26 or the housing 13, which is already fixed in the housing receiving passageway 25 of the cylinder head wall 26.

**[0051]** The first axial ends 51 of the contact body 43 may additionally be fixed by potting 82 instead of or in addition to press-fitting the collars 63, 65 into the contact receiving holes 18. Fixing the contact 37 with the potting 82 is advantageous in that the contact 37 and the cable comprising the first conductors 57 are fixed and movements thereof are damped. The potting 82 additionally protects against high temperature and blocks oil from entering into the cable and flowing back to the connectors 93, 95.

**[0052]** Suitable materials for the contact body include $CuSn_x$ and $CuZn_{xx}$. Suitable materials for the first, second, and single seal members 67, 69, 83 include VMQ and FVMQ. Suitable materials for the housing include PA66 and reinforced PBT.

## Claims

1. An electrical contact (37) formed to be received in a substantially cylindrical contact receiving passageway (18), the contact receiving passageway (18) having an inner diameter (47), a first axial end (19), and a second axial end (20), the contact (37) comprising:

   a substantially cylindrical contact body (43) with an outer diameter (45) smaller than the inner diameter (47) of the contact receiving passageway (18), the contact body (43) having a first conductor engaging portion (49) at a first conductor receiving end (51) and a second conductor engaging portion (53) at a second conductor receiving end (55), the first conductor engaging portion (49) being designed for forming an electrical connection with a first conductor (57) and the second conductor engaging portion (53) being designed for forming an electrical connection with a second conductor (59); and

   at least one seal member (67, 83) mounted on the contact body (43), the at least one seal member (67, 83) having a first axial side (71) facing the first conductor receiving end (51) of the contact body (43) and a second axial side (73) facing the second conductor receiving end (55) of the contact body (43), the seal member (67, 83) comprising a first plurality of axially spaced annular projections (79) extending therefrom and formed such that radial outer ends of the first plurality of projections (79) are bent towards the first axial end (19) when the contact (37) is pushed into the contact receiving passageway (18) from the first axial end (19) of the contact receiving passageway (18).

2. The contact of claim 1, wherein the at least one seal member (83) comprises a second plurality of axially spaced annular projections (81) on a side of the first plurality of projections (79) that faces away from the first conductor receiving end (51) of the contact body (43), the second plurality of projections (81) extends such that when the contact (37) is pushed into the contact receiving passageway (18) radial outer ends of the second plurality of projections (81) contact the inner wall of the contact receiving passageway (18) without being bent or being bent towards the first axial end (19) less than the first plurality of projections (79).

3. The contact of claim 1, having a second seal member (69) positioned on the side of the at least one seal member (67) that faces away from the first conductor receiving end (51) of the contact body (43), the second seal member (69) comprises a second plurality of axially spaced annular projections (81) that extend away from the contact body (43) such that when the contact (37) is pushed into the contact receiving passageway (18), radial outer ends of the second plurality of projections (81) contact the inner wall of the contact receiving passageway (18) without being bent or being bent towards the first axial end (19) less than the first plurality of projections (79).

4. The contact of any of claims 1-3, wherein the radial outer ends of at least the first plurality of projections (79) are pre-bent towards the first axial end (19) in a relaxed state.

5. The contact of any of claims 1-3, wherein the radial outer ends of at least the second plurality of projections (81) are straight in a relaxed state.

6. The contact of any of claims 1-5, wherein,the at least one seal member (67, 69, 83) is press-fit onto the contact body (43).

7. The contact of any of claims 1-5, wherein the at least one seal member (67, 69, 83) is vulcanised onto the contact body (43).

8. The contact of any of claims 1-7, wherein at least one of the conductor engaging portions (49, 53) includes a crimp section for forming a crimp connection with the respective conductor (57, 59).

**9.** The contact of any of claims 1-8, wherein the contact body (43) has a solid middle portion (61), a first tube portion (49) extending between the first conductor receiving end (51) of the contact body (43) and the solid middle portion (61) for receiving the first conductor (57), and a second tube portion (53) extending between the second conductor receiving end (55) of the contact body (43) and the solid middle portion (61) for receiving the second conductor (59).

**10.** An electrical connector, comprising:

an insulated housing (13) having at least one substantially cylindrical contact receiving passageway (18) with a predetermined inner diameter (47) extending between a first axial face (15) and a second axial face (17) of the housing (13);

a contact (37) arranged in the contact receiving passageway (18) having a substantially cylindrical contact body (43) with an outer diameter (45) smaller than the inner diameter (47) of the contact receiving passageway (18), the contact body (43) having a first conductor engaging portion (49) at a first conductor receiving end (51) and a second conductor engaging portion (53) at a second conductor receiving end (55), the first conductor engaging portion (49) being designed for forming an electrical connection with a first conductor (57) and the second conductor engaging portion (53) being designed for forming an electrical connection with a second conductor (59); and

at least one seal member (67, 83) mounted on the contact body (43), the at least one seal member (67, 83) having a first axial side (71) facing the first conductor receiving end (51) of the contact body (43) and a second axial side (73) facing the second conductor receiving end (55) of the contact body (43), the at least one seal member (67, 83) having a first plurality of axially spaced annular projections (79) extending therefrom that have radial outer ends bent towards the first axial end (19) of the contact receiving passageway (18).

**11.** The electrical connector of claim 10, wherein the at least one seal member (83) comprises a second plurality of axially spaced annular projections (81) on a side of the first plurality of projections (79) that faces away from the first conductor receiving end (51) of the contact body (43), the second plurality of projections (81) extends such that the second plurality of projections (81) contact the inner wall of the contact receiving passageway (18) without being bent or being bent towards the first axial end (19) less than the first plurality of projections (79).

**12.** The electrical connector of claim 10, having a second seal member (69) having a second plurality of axially spaced annular projections (81) is positioned on a side of the at least one seal member (67) that faces away from the first conductor receiving end (51) of the contact body (43), the second plurality of projections (81) extends such that radial outer ends of the second plurality of projections (81) contact the inner wall of the contact receiving passageway (18) without being bent or being bent towards the first axial end (19) less than the first plurality of projections (79).

**13.** The electrical connector of any of claims 10-12, wherein the contact body (43) has a solid middle portion (61), a first tube portion (49) extending between the first conductor receiving end (51) of the contact body (43) and the solid middle portion (61) for receiving the first conductor (57), and a second tube portion (53) extending between the second conductor receiving end (55) of the contact body (43) and the solid middle portion (61) for receiving the second conductor (59).

**14.** The electrical connector of any of claims 10-13, comprising an electrical contact (37) of any of claims 6-8.

**15.** The electrical connector of any of claims 10-14, wherein the housing (13) has a substantially cylindrical outer peripheral surface provided with a peripheral outer seal member (23).

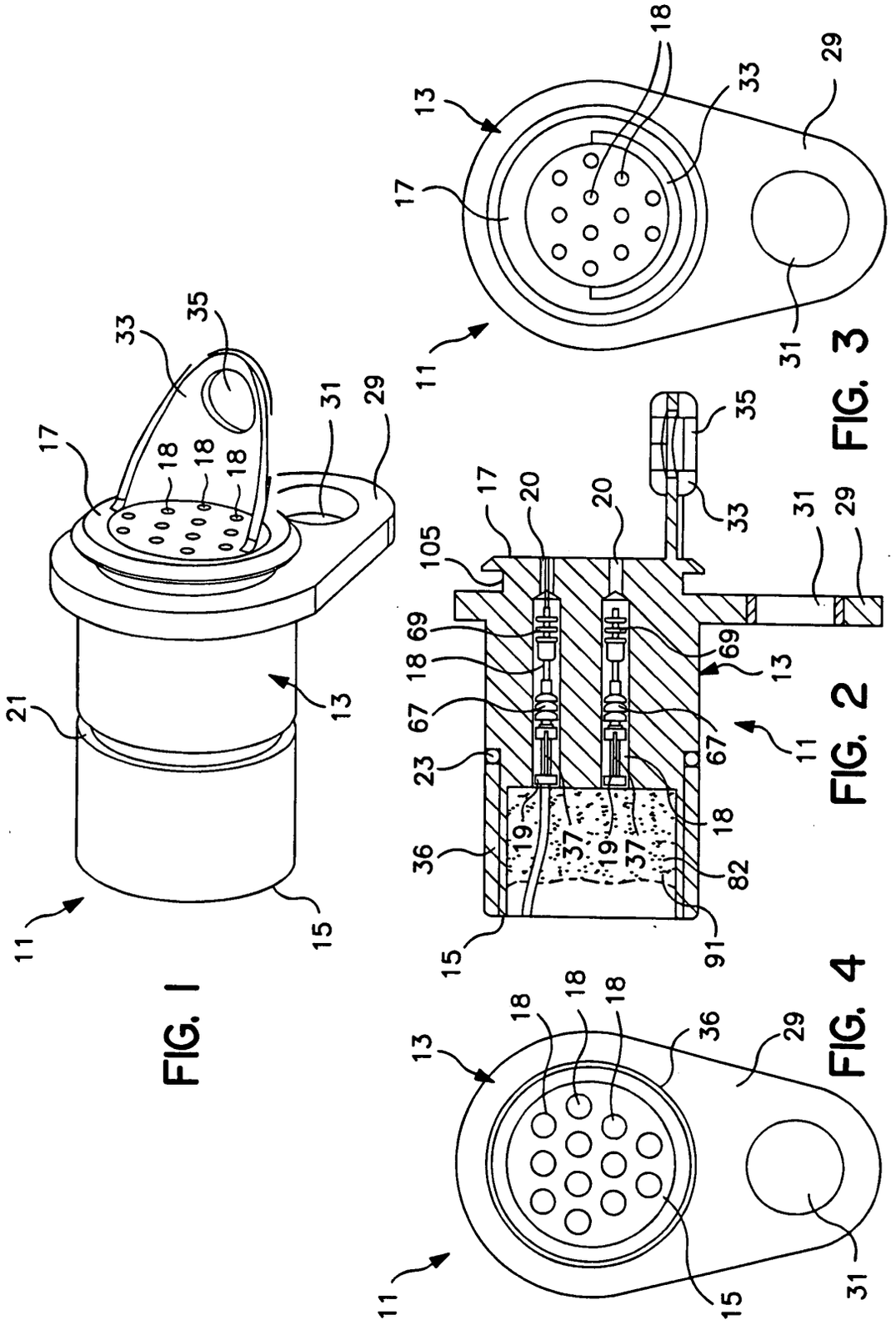
**16.** The electrical connector of any of claims 10-15, wherein the second conductor receiving end (55) of the at least one contact (37) is press-fit into the contact receiving passageway (18).

**17.** The electrical connector of any of claims 10-15, wherein the at least one contact (37) is fixed in the housing (13) by means of potting (82).

**18.** Use of the electrical contact (37) of any of claims 1-9 for electrically connecting a first conductor (57) on an inner side (27) of a cylinder head wall (26) of a combustion engine to a second conductor (59) on an outer side (28) of the cylinder head wall (26), wherein the contact receiving passageway (18) forms a channel through the cylinder head wall (26), the first axial end (19) of the contact receiving passageway (18) being adjacent to the inner side (27) of the cylinder head wall (26) and the second axial end (20) of the contact receiving passageway (18) being adjacent to the outer side (28) of the cylinder head wall (26), and the at least one sealing member (67, 69, 83) is mounted on the contact (37) such that pressurised oil on the inner side (27) of the cylinder head wall (26) is prevented from passing through

the contact receiving passageway (18) to the outer side (28) of the cylinder head wall (26).

**19.** Use of the electrical connector (11) of any of claims 10-17 for electrically connecting a first conductor (57) on an inner side (27) of a cylinder head wall (26) of a combustion engine to a second conductor (59) on an outer side (28) of the cylinder head wall (26), wherein the housing (13) of the electrical connector (11) is received in a passageway (25) of the cylinder head wall (26) with the first axial face (15) of the housing (13) being adjacent to the inner side (27) of the cylinder head wall (26) and the second axial face (17) of the housing (13) being adjacent to the outer side (28) of the cylinder head wall (26), and the at least one sealing member (67, 69, 83) is mounted on the at least one contact (37) received in the at least one contact receiving passageway (18) of the housing (13) such that pressurised oil on the inner side (27) of the cylinder head wall (26) is prevented from passing through the contact receiving passageway (18) to the outer side (28) of the cylinder head wall (26).


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FIG. 1
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FIG. 3
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FIG. 2
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FIG. 4

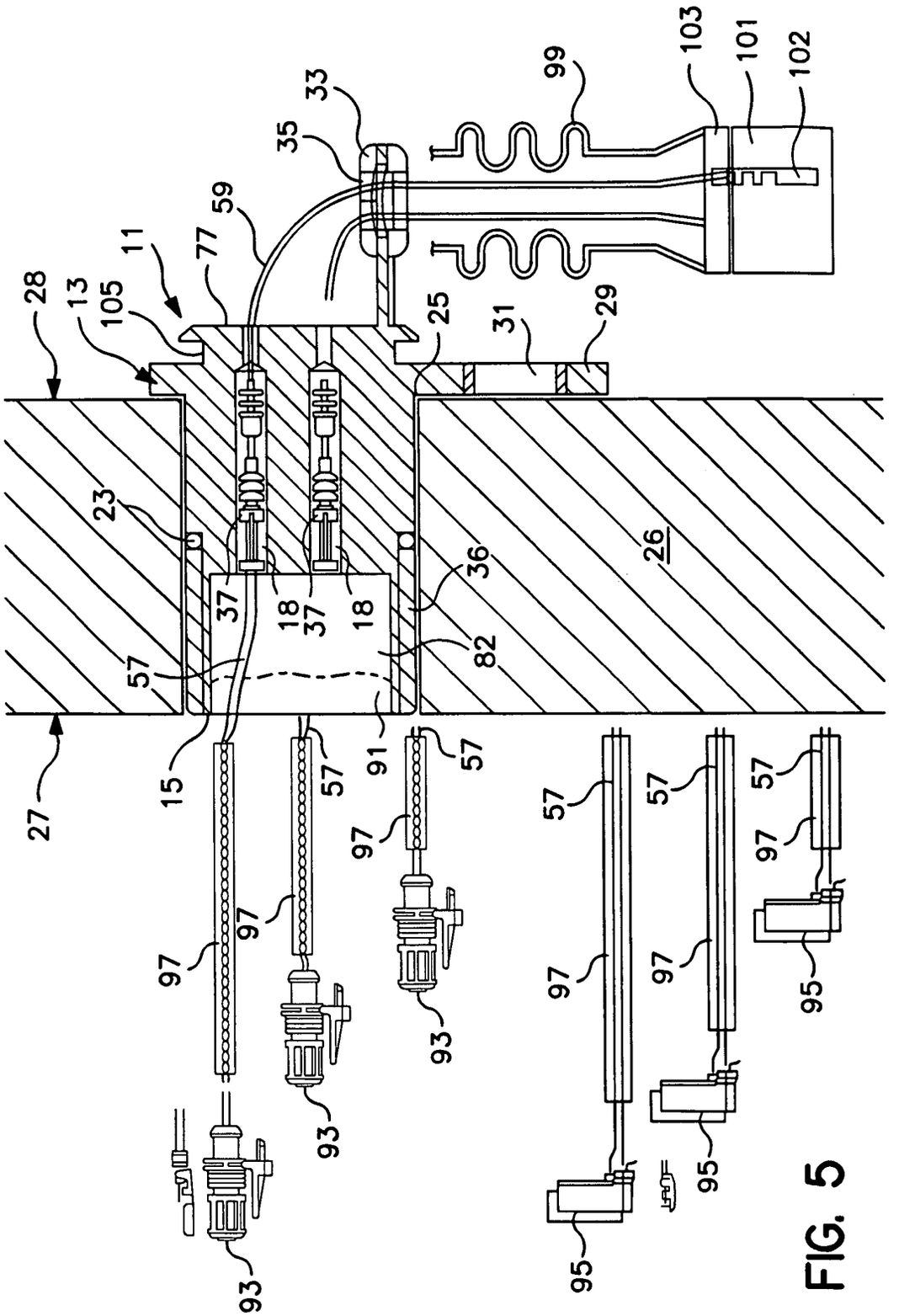

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FIG. 5

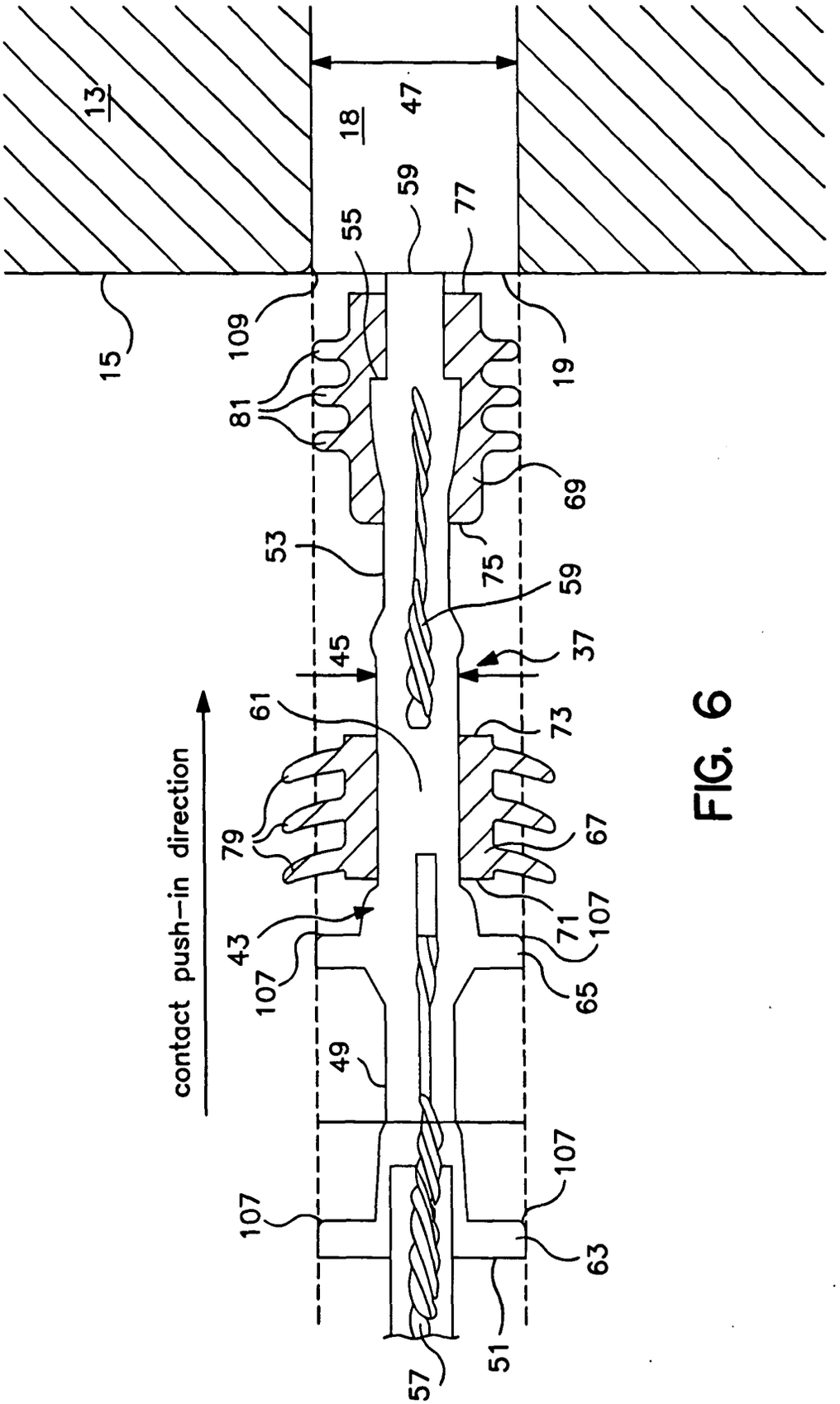

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contact push-in direction

FIG. 6

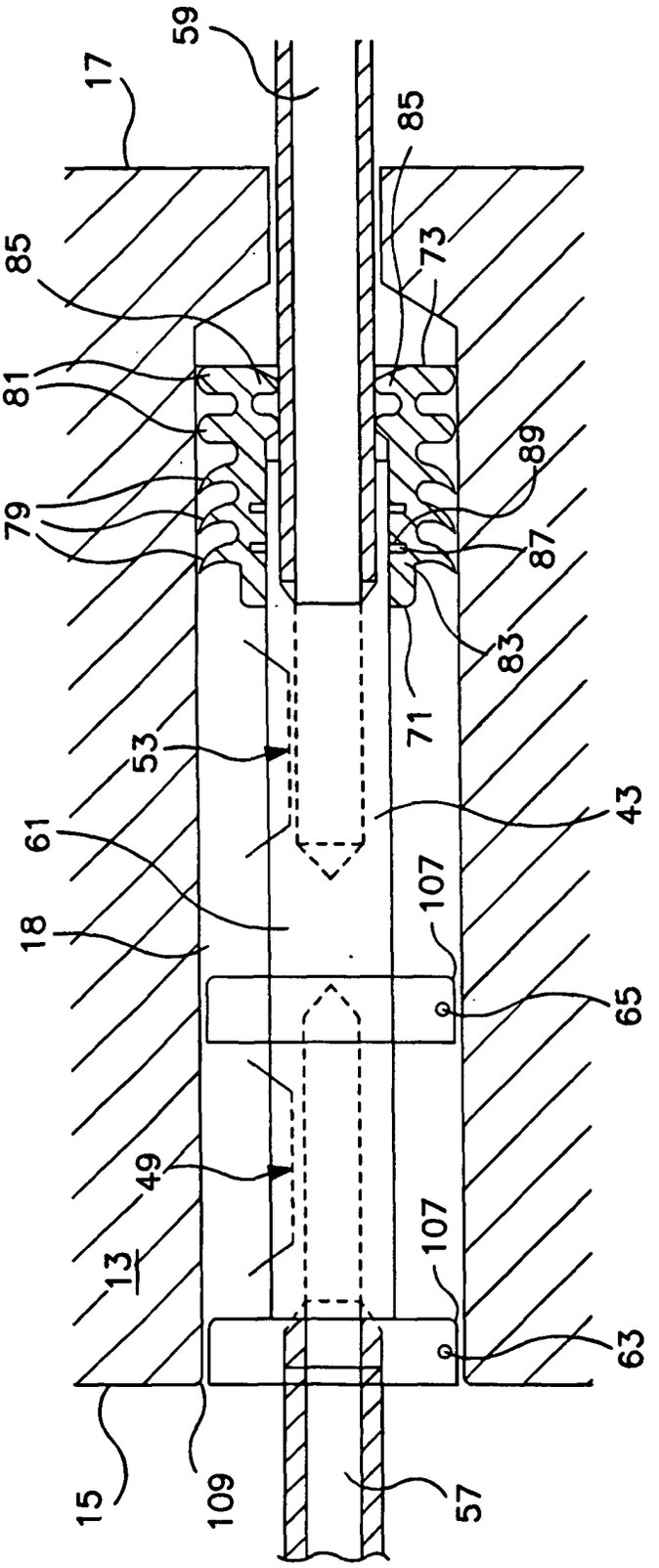

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FIG. 7

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# EUROPEAN SEARCH REPORT

Application Number
EP 04 01 4506

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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.7) |
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| | | | H01R |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 26 July 2004 | Bertin, M |

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26-07-2004

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82