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

(11) EP 0 731 531 A2

# (12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
**11.09.1996 Bulletin 1996/37**

(51) Int. Cl.[6]: **H01R 13/52**

(21) Application number: **96103043.4**

(22) Date of filing: **29.02.1996**

(84) Designated Contracting States:
**DE FR GB IT**

(30) Priority: **07.03.1995 GB 9504581**

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## (54) Electrical connector having gel sealing and post insertion conductor engagement

(57) An electrical connector (2) comprising a terminal block (4) having conductor receiving passageways (18) therein that extend from a rear face (22) to a mating face (14) of the block (4), where a contact (10) having an conductor engaging section (54) for engaging an insulated wire (66) to be terminated thereto is disposed in the passageway (18); a gel-like seal (6) is disposed towards the rear face (22) such that the wire (66) to be terminated to the contact (10) must pass therethrough to be received within the conductor engaging section (54) and, a displacement member (38) for terminating the wire (66) in the conductor engaging section (54) after the wire (66) passes through the seal (6), thereby assuring the residue of the seal does not contaminate the interconnection of the contact to the mating terminal (not shown) or to the conductive lead (70) within the wire (66) as any residue would be disposed upon the coating (68).

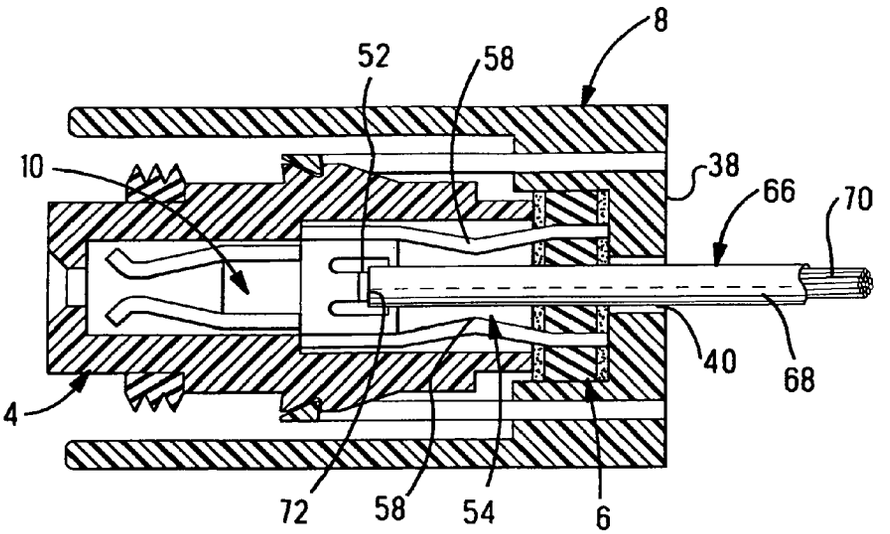


Fig. 3

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## Description

This invention relates to electrical connectors and in particular those electrical connectors having an environmental seal formed of a gel-like substance.

There are many applications where electrical connectors are being used in harsh environments, such as automotive applications where contaminants such as road spray, dust, dirt and oil may find their way into an electrical connector and ultimately degrade the electrical connection formed therein. Modern electrical connectors incorporate sealing structure to prevent this from occurring. Conventional sealing techniques incorporated where the wires enter a connector housing typically involve either single wire grommet-like structures or and en masse seals which incorporate a single gasket member having a multitude of apertures cut therethrough. Both of these sealing techniques rely on the resiliency of the material to form a tight fit with the wires and the connector housing. Problems with this type of sealing techniques may develop as the seals age or excessive forces are exerted on the wires such that the seal is pulled away from the side of the wire or the side of the connector housing. When this occurs, it is possible for contaminants or moisture to find their way into the connector housing and, even if they do not have a path directly to the electrical interconnection, may work their way forward by a pumping action as the seal is repeatedly displaced. Therefore, there is continuous need for improved seal structure and materials in order to assure the integrity of the seal is maintained.

One improved sealing concept envisions using gel-like seal member into an electrical connector assembly. One example of a seal of this type is disclosed in United States Patent 4,662,692 that is incorporated herein by reference for all purposes. This patent discloses an electrical connector with a terminal block portion wherein contacts are received within terminal receiving passageways. The terminal block has a front mating face and a rear contact insertion face. The gel material is disposed across the rear insertion face in a continuous form. The contacts are then inserted into their cavities by being pressed through the gel. The gel is a self-healing material that can be pierced by the contact component and then conforms about an object, such as the wire, that extends therethrough to form a tight seal. The gel materials are described in detail within the patent. A problem with the gel substances is that they can be "oily" to the touch and sometimes "sticky" with respect to the contacts inserted therethrough. As a result, the gel may leave a film upon the contact and, if the contact has a complex shape (other than the pins shown), such as a receptacle contact, when they are inserted through the gel, portions of the seal material may become embedded within the contact. One concern is that this contamination of the contact with the seal material may somehow effect the electrical interconnection either immediately or over time. Another concern is that if the shape of the contact is complex including sharp edges thereupon the gel may be so damaged or displaced that proper sealing is no longer achievable.

United States Patent 4,875,870, incorporated herein by reference for all purposes, discloses a number of improvements over the previously described sealing structure. First, the layer of gel includes a plurality of apertures wherein the contacts are received and the trailing wire extends outward therethrough, thereby improving the chances that the gel is not deleteriously damaged during insertion of the pins or the wires therethrough. Second, the gel is provided with a foam support member which provides mechanical strength to the gel such that during insertion of the contact pins damage to the gel is minimized and migration of the gel is also minimized. Third, a connector is disclosed which includes a component for keeping the gel under compression. The component has a first position where the gel is retained in place and a second position where the gel is compressed causing the seal material to flow tightly about the trailing wires and connector housing to assure satisfactory sealing is maintained for the life of the connector. While this has improved upon some of the problems described above, the contact must still pass through the gel possibly leaving a film on the contact and it is still difficult to utilize complex contacts due to the damage that may occur to the gel seal when pushed through the apertures.

WO 92/05603, incorporated herein by reference for all purposes, further discloses an improvement on the forgoing wherein an improved sealing structure having the gel-sealant is disposed between at least 2 constraining components and the connector further includes means to apply force thereto where resiliency is provided to accommodate displacement of the gel-sealant. This patent also addresses the improvement of the gel-sealant concept to assure a reliable seal; however the practical problems of utilization described above still exist.

What is needed to further realize the advantages of gel sealing technology is to be able to use the seals with complex contacts that are now being incorporated into many applications and to assure that film from the gel does not become disposed at any of the electrical interconnection points along the contact, such as where the conductor or wire which passes through the seal engages the contact or where the contact would engage a complementary terminal. All of this must be incorporated into a commercially useful package. Typical electrical connectors would have multiple electrical contacts for receiving corresponding wires. It is advantageous to be able to supply an electrical connector to an end-user wherein all the components, such as the housing, a secondary locking member, and seals are already mounted in a single unit. The wire harness, typically with the contacts attached, is manufactured separately from the connector housing. While it is known to place conventional seals upon the wires before terminating with the contacts, this is not a practical solution due to the limitations of the gel i.e. its structural integrity. It is highly likely

that the gel would be deformed, the wires would migrate within the seal, or the gel may disperse during or after assembly with the wires and the contacts. Therefore, what is needed is a structure that may be prepackaged for delivery to an end-user, that incorporates a gel-like seal, that assures that contamination from the gel of the seal is not disposed upon contacting surfaces, and the gel is not adversely disturbed during assembly.

In pursuit of satisfying the needs described and with reference now to European Patent 0 102 156, also incorporated herein by reference for all purposes, a contact structure of particular interest disclosed. This electrical contact has a body portion that includes an insulation displacement section comprised of a pair of weakened and generally opposed wall portions where the weakened sections are collapsible inwardly when the body is axially displaced. A wire is insertable into the contact such that when the weakened section collapses, edges therealong cut through the insulation of the wire to engage the conductive core therein. The patent further discloses an electrical connector housing having rearwardly disposed seal means captivated between a main housing and a seal retainer. With the contact within the cavity of the terminal block, the wire is inserted from the rear through the seal member into the terminal block and between the collapsible walls. With the wire properly positioned, the front of the contact is displaced causing the walls to collapse and cut through the insulation and engage the conductive core therein.

United States Patent 5,356,302, incorporated herein by reference for all purposes, discloses another electrical connector assembly utilizing the contact described above. In this connector assembly, receptacle terminals are retained within a terminal block by a cover. The cover includes openings therethrough through which wires are inserted into the collapsible portion of the contact. Pusher members are formed about the openings such that when the wire has been inserted, a tool exerts force on the pusher member causing it to be displaced, thereby collapsing the walls of the contact into engagement with the conductive core of the wire.

Another contact/connector structure of interest is disclosed in European Patent Publication No. 0 554 810 where an electrical connector includes a terminal block portion wherein contacts having a rearwardly open insulation displacement contact (IDC) structure are disposed. A wire positioning block is matable to the terminal block and includes wire channels such that the wire, when inserted therein, includes a segment transverse to the IDC section of the contact so that as the connector halves are brought together, the IDC section cuts through the insulation of the wire forming an electrical connection with a conductive core therein.

Finally, another example of an interesting connector system is disclosed in French Patent Application 94 10 257. In this case a one piece housing is provided wherein contacts are positioned in a first position within a housing, the wires are inserted therein and then the contacts are displaced to a second position such that an IDC slot cuts through the insulation and engages the conductive core therein.

The common aspect of the aforementioned and other contact/connector systems that are of interest is that the conductive wire may be inserted into the connector housing, pre-loaded with contacts where it is then terminated therein. This is especially interesting with respect to the gel sealing technology described above. When electrical connectors of this type incorporate a gel-like seal about the trailing wires at the rear of the connector housing, an electrical connector without the problems presented above, with respect to the gel seals, may be realized. An electrical connector with the contacts therein in a gel seal at the terminal receiving end of the terminal block may be delivered in an at least partially assembled state. The wires may be inserted through the terminal receiving end of the connector and into the terminating region of the contacts. As the wire comprises an insulative jacket about a conductive core, any film or contaminant relating to the gel seal is disposed on the outside of the insulative jacket. Once within the connector housing, the wire is then terminated within the IDC termination region of the contact where the insulation is displaced so that the conductive core is exposed. By displacing the insulation, any film or contaminants thereupon is also displaced so that a clean interconnection is established with the conductive core. This addresses the concern that any contaminant deposited at any electrical interconnection point would somehow deteriorate the electrical interconnection.

Therefore, the objects of providing a sealed electrical connector system that incorporates gel sealing without contamination from the seal occurring at the electrical interconnection points is accomplished by providing an electrical connector comprising a terminal block having conductor receiving passageways therein that extend from a rear face to a mating face of the block, where a contact having a conductor engaging (IDC) section for engaging an insulated wire to be terminated thereto is disposed in the passageway; a gel-like seal is disposed towards the rear face such that the wire to be terminated to the contact must pass therethrough to be received within the IDC section and, a displacement member constructed to effect insulation displacement engagement by the contact section of the insulated wire.

It is an advantage of this invention that an electrical connector may be provided that incorporates a gel-like seal. It is another advantage of this invention that the electrical connector assures that the inner connection points are free from contaminant from the seal. It is yet another advantage of this invention that the connector may be delivered in a partially assembled form such that the insulative wires can be inserted therein and terminated to respective contacts. It is still another advantage of this invention that the contacts used may be receptacle contacts. It is yet still another advantage of this invention that the displacement member that effects the insulation displacement termination of the insulative

wire may also exert a compressive force upon the gel seal such that the sealing is enhanced. It is still yet another advantage of this invention that the conventional connector structure that is simple and economical to manufacture is may be used.

The invention will now be described by way of example with reference to the drawings, wherein;

Figure 1 is a partially exploded side sectional view of an electrical connector according to the present invention;
Figure 2 is a side sectional assembled view of the electrical connector of Figure 1;
Figure 3 is a side sectional view of the assembled electrical connector of Figure 1 showing an insulated wire inserted therein in a pre-terminated state;
Figure 4 is a side sectional view of the assembled electrical connector of Figure 1 having the insulated wire terminated therein;
Figure 5 is a side sectional view of an alternative embodiment of an electrical connector incorporating the present invention showing the insulated wire inserted therein; and
Figure 6 is a side sectional view of the electrical connector of Figure 5 showing the insulated wire terminated therein.

With reference first to Figure 1, an electrical connector according to the present invention is shown generally at 2. The electrical connector 2 includes a terminal block portion 4, a gel-like seal member 6, an outer shell 8 and an electrical contact 10. The terminal block 4 carries thereupon a seal member 12 for forming a contaminant tight seal with the shroud of a mating connector (not shown).

The terminal block 4 includes a mating face 14 from which a nose portion 16 extends rearward upon which the seal 12 is disposed. Within the terminal block 4 is a contact receiving passageway 18 wherein the contact 10 is disposed. The mating face 14 includes a complementary terminal receiving opening 20 extending therethrough so that a complementary terminal (not shown) of the mating connector may be electrically engaged by the contact 10. Opposite the mating face 14 is a terminal receiving face 22 through which the terminal receiving passageway 18 is open. Between the mating face 14 and the terminal receiving face 22 is the body 24 of the terminal block 4. Extending outward from the body are oppositely disposed first latch barbs 26 constructed for retaining the terminal block 4 within the outer shell 8 in a first preloaded position, as shown in Figure 2. Similarly disposed along the body 24 are a second pair of latches 28 located closer to the mating end 14 of the terminal block 4. These latches cooperate with the outer shell 8 to define a fully engaged position, as best seen in Figure 4.

The gel seal 6 includes a gel-like substance 30 that maybe sandwiched between a pair of support members 32 or supported by a matrix as is known from the cited references. The seal 6 may have apertures extending through the support members and the gel to correspond to the terminal receiving passageway 18 of the terminal block 4, if desired. It is envisioned that foam-like support members 32 will be incorporated; however, other structure may be useful. Structure of the seal 6 is best described with reference to the aforementioned patents.

The outer shell 8 includes a peripheral shroud 34 defining an opening 36 wherein the terminal block 4 and the mating connector may be received. Opposite the opening 6 is a rear plate 38. The rear plate 38 includes a wire receiving opening 40 extending therethrough followed by a seal seat 41. The wire receiving opening 40 is in communication with the terminal receiving passage 18 of the terminal block 4 when the connector 2 is assembled, as best seen in Figure 2. Within the shell 8, retention members 42 are constructed to engage the latches 26 and 28 of the terminal block 4 in order to establish the pre-loaded position and the fully engaged position of Figures 2 and 4 respectively. The retention members 42 of this embodiment are arms extending from the rear plate 38 into the opening 36. The retention members 42 are generally U-shaped having a closed end 44 at the extreme end of the member 42 corresponding to the base of the U and configured as a catch such that the latches 26,28 are engaged in a manner that prevents dislodgement of the terminal block 4 from the outer shell 8 while still enabling ease of assembly.

The contact 10 is of the type described in EP 0 102 156 described above. The contact 10 includes a complementary terminal receiving section 46 comprising a pair of resilient cantilevered, forwardly extending arms 48 that define a complementary terminal receiving region aligned with the terminal receiving opening 20 such that the complementary terminal may be received within the terminal block 4 and engaged by the contact 10 therein. The terminal portion 46 extends from a body section 50 which includes a stop 52 for establishing the inserted position of the conductive member 66. Extending from the body portion 50 opposite the terminal engaging portion 46 is a conductor engaging section 54 having a pair of collapsible side walls 56 with insulation displacement cutting edges 58 thereupon. In this embodiment, the side walls 56 extend outward from the terminal block 4 beyond the terminal receiving face 22 to terminal end 60.

With reference now to Figure 2, the electrical connector 2 is shown in a pre-loaded assembled state that could be delivered to an end user. In this state of assembly, the contact 10 resides within the terminal block 4 with shoulders 62 of the body section 50 abutting shoulders 64 of the terminal block 4. The terminal block 4 is disposed within the outer shell 8 such that the catch portion 44 of the retention member 42 has engaged the first latches 26 and is sitting against the second latch 28. In this position there is substantial resistance to removing the terminal block 4 from the shell 8 and there is at least some resistance offered by the retention arms and the catch thereupon to further

insertion of the terminal block 4. The rear face 22 of the terminal block 4 is in close proximity to the gel seal 6 which is seated within seal receiving cavity 41. The arms 56 of the conductor engaging section 54 extend rearward through the gel seal 6 to be in communication with the inner surfaces of the rear plate 38. The gel seal 6 spans the wire receiving opening 40 and, if an aperture has been provided in the gel seal 6, is aligned therewith.

With reference now to Figure 3, an insulated conductor 66 is inserted into the preassembled connector 2 of Figure 2. The insulated wire 66 includes an outer coating 68 and an inner conductive core 70. The wire 66 has a front end 72 that is inserted into the wire receiving opening 40 of the outer shell 8. The wire 66 is then advanced through the gel seal member 6 and into the conductor engaging section 54 until the end 72 abuts the stop 52. In this position, the cutting edges 58 of the contact 10 are disposed along the sides of the insulated wires 66. Once the wire 66 has been passed through the gel 30 and is held stationary, the self healing nature of the gel 30 will tend to form about the insulation 68 forming a seal thereto. If any film from passing the insulated wire 66 through the gel 30 has been left in place, it would either be located at the end 72 of the wire or along the insulation 68 thereof. With reference now to Figure 4, the termination will be described herein. With the wire 66 in place, a compressive force in the direction of Arrow A is exerted upon the connector 2 to effect relative displacement between the terminal block 4 and the outer shell 8. As this occurs, the collapsible walls 56 of the contact 10 collapse inward and cut through the insulating coating 68 upon the conductive core 70. The sharp edges 58 along the collapsible walls 68 pass through the insulation 68 and thereby displace, in addition to the insulation, any film from the gel seal 6 that may have been deposited on the outer surface thereof. A reliable electrical interconnection is then established. While the contact walls 56 are collapsing, as described, the catch 44 of the retention member 42 rides over the second latch 28. Latch 28 is captivated by the catch 44 in a manner that prevents the terminal block 4 from being removed from the outer shell 8. Furthermore, in this position the rear surface 22 of the terminal block 4 is abutting the gel seal member 6 and exerting a compressive force thereupon to further enhance sealing with the insulated wire 66 extending therethrough.

With reference now to Figures 5 and 6, an alternative embodiment of an electrical connector according to the present invention is disclosed. This alternative embodiment is very similar to that described above with reference to Figures 1-4. Where possible, identical elements will incorporate the same reference numbers and will not be described again herein. With reference first to Figure 5, an electrical connector 200 is shown with a terminal block 4, a gel seal member 6, an outer shell 8 and a contact member 210 therein. The contact member 210 is disposed within a contact passageway 212. The contact 210 has a receptacle end 214 for receiving a complementary contact and a wire engagement end 216 adapted to engage an insulated wire 66 in an insulation displacement manner. The wire engaging end 216 is a flat planar element having a teardrop-shaped section where the larger portion is exposed for receiving the wire and the narrowed section includes cutting edges for insulation displacement and engaging the conductive core 70 of the wire 66. This is more further described with reference to the French Application 94 10 257 or European Application 0 554 810 described above. The wire 66 is inserted through wire receiving opening 40 in the shell 8 and into a wire receiving region 218. The wire receiving region 218 includes a biasing surface 220 designed to guide the end 72 of the wire such that the wire is displaced transversely across the axis of the contact 210 and through the wider open section of the teardrop-shaped IDC slot.

With reference now to Figure 6, compressive force A is inserted on the connector 200 such that the shell 8 and the terminal block 4 are drawn together. In this case, the seal 6 is compressed as described above to enhance the sealing. As the terminal block 4 moves rearward, the biasing surface 220 also pushes the insulated wire 66 rearward and into engagement with the cutting and contacting portion of the teardrop-shaped IDC of the contact 210. It is easily envisioned to form the converse of this structure where the wire 66 is carried by the back plate into electrical engagement with the contact. As the cutting surfaces move through the insulation, any contamination of the gel seal thereupon is disposed and the contact becomes cleanly engaged with the conductive core 70 of the wire 66.

Advantageously then, an electrical connector is provided that incorporates a gel seal 6 for contaminant sealing purposes wherein the connector can accommodate electrical terminals of complex shape, such as receptacles or tabs, where any film or other contamination from the seal member is prevented from being disposed upon the electrical interconnection points as termination occurs with the contacts positioned on the other side of the seal reached upon passing the wires therethrough. While the aforegoing has been described with reference to a basic electrical connector structure, it would be obvious to incorporate more advanced features into the terminal block, outer shell or contact. For example, it may be desired to include secondary locking, keying or latching structure for the complementary connector, locking lances and associated shoulders, and seal members of various configurations wherein the side walls of the contact extend through or abut against. It is also further envisioned that the electrical connector 2 could incorporate multiple contacts in various arrangements such as multiple rows as is desired. Individual gel seals may be used or a single gel seal through which multiple wires are inserted may be used. Finally, locating posts may be positioned in the shell 8 to retain the seal 6 in proper position.

## Claims

1. An electrical connector comprising a terminal block (4) having contact receiving passageways (18) therein that extend from a rear face (22) to a mating face (14) of the block (4), where a contact (10) having an conductor engaging section (54) for engaging a coated wire (66) to be terminated thereto is disposed in the passageway; a gel-like seal (6) is disposed towards the rear face such that the wire (66) to be terminated to the contact (10) must pass therethrough to be received within the conductor engaging section (54) and, a displacement member (8) constructed to effect termination of the wire (66) by the conductor engaging section (54) after the wire (66) passes through the seal (6).

2. The connector of claim 1 wherein the conductor engaging section (54) is constructed for insulation displacement termination.

3. The connector of claim 2, further characterized in that the displacement member (8) is disposed on the opposite side of the seal as the rear face (22) and is displaceable between a first position where the seal (6) is captivated therein and a second position where the wires (66) are terminated and the seal is under compression.

4. The connector of claim 2 or claim 3 wherein the contact (10) includes a collapsing wall portion (56) that forms an insulation displacement termination on the wire (66) in response to the displacement of the displacement member (8).

5. The connector of claim 2 or claim 3 wherein the contact includes an opening therein where the wire (66) is received defined by edges (56) having cutting surfaces (58) therealong followed by contact surfaces in the direction of movement of the displacement member (8) such that insulation displacement termination is achieved.

6. The connector of any one of the preceding claims wherein the gel seal (6) includes gel (30) between opposing support members (32).

7. A method of forming a sealed connector for attachment to an coated wire, comprising the steps of:

   providing a connector module (2) having a terminal block (4) having contact receiving passageways (18) therein that extend from a rear face (22) to a mating face (14) of the block (4), where a contact (10) having a conductor engaging section (54) for engaging the wire (66) to be terminated thereto is disposed in the passageway (18); a gel-like seal (6) is disposed towards the rear face (22) across the passageways (18);

   inserting the wire (66) into the connector module (2) through the gel-like seal (6) and into the conductor engaging section (54) of the contact (10); and,

   terminating the wire (66) within the conductor engaging section (54) such that the coating (68) upon the wire (66) is displaced and electrical engagement with the contact (10) is effectuated.

8. The method of claim 7, wherein the connector module (2) further includes a displacement member (8) positioned in a first pre-loaded position wherein the seal (6) is captivated thereto and the terminating of the wire (66) is effectuated by displacing the displacement member (8) to a second position.

9. The method of claim 7, wherein the step of displacing the displacement member (8) to effectuate terminating of the wire (66) further effectuates loading the gel-like seal (6) under compression to improve sealing.

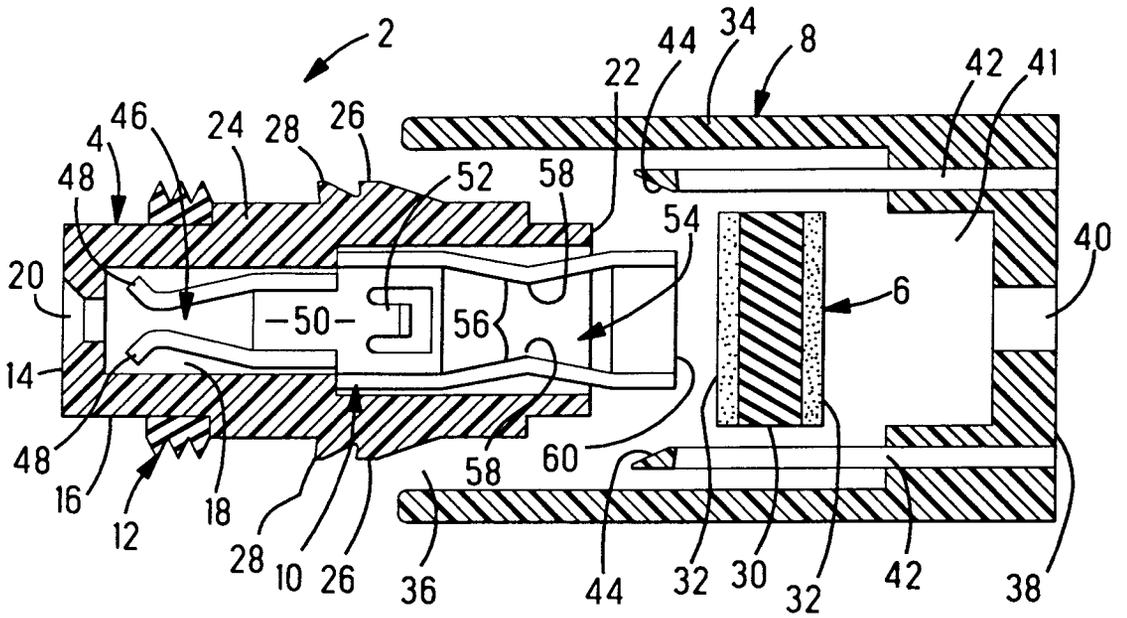
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Fig. 1

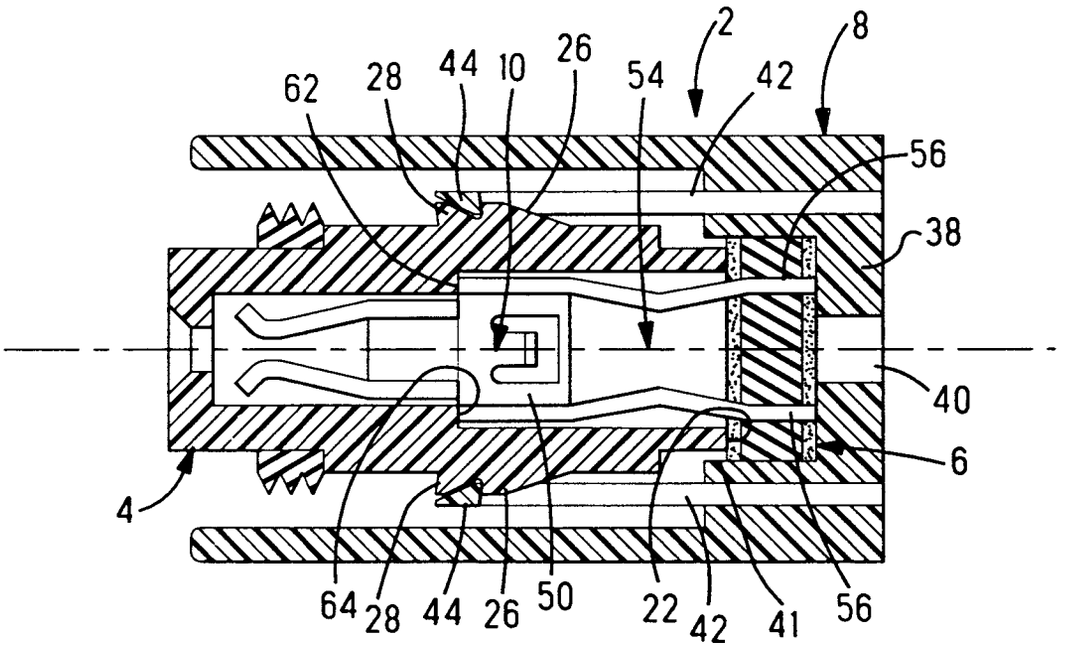
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Fig. 2

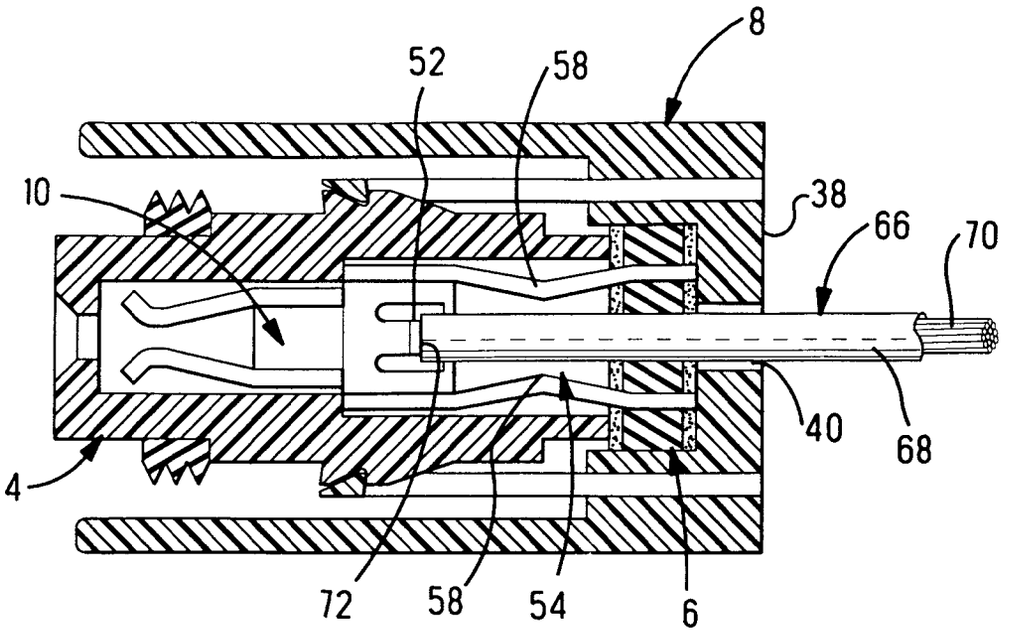
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Fig. 3

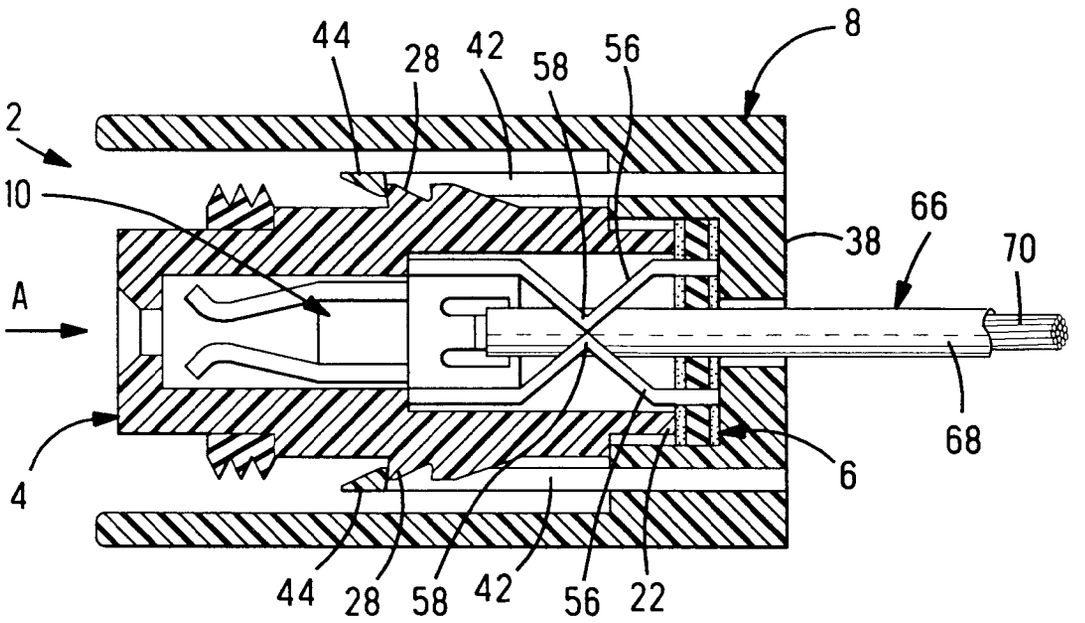
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Fig. 4

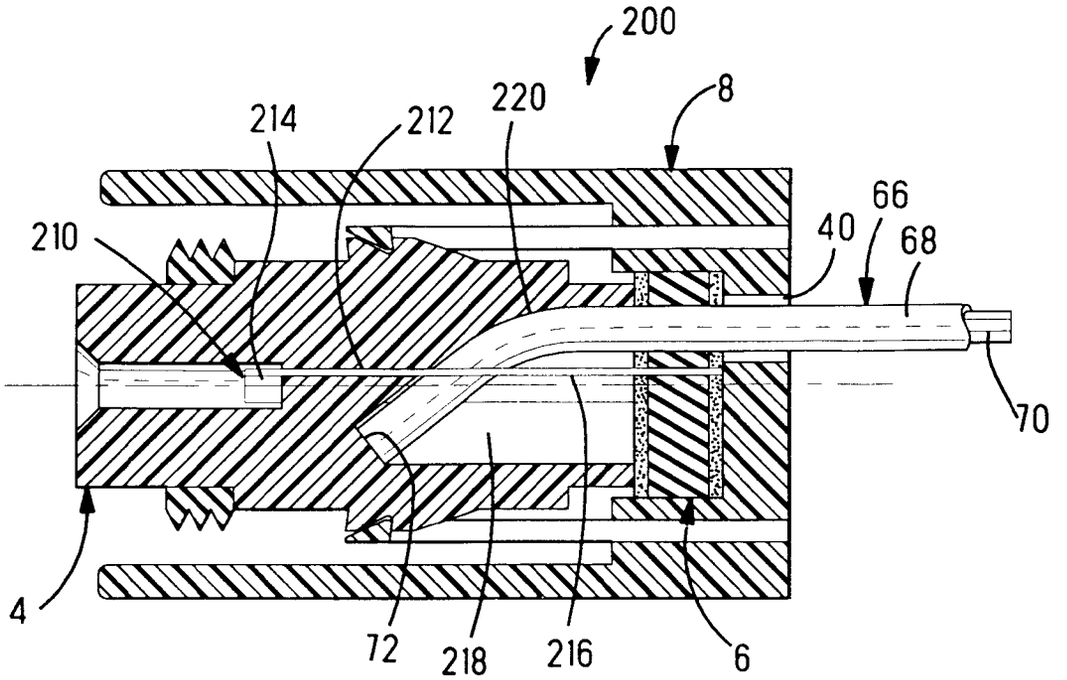
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Fig. 5

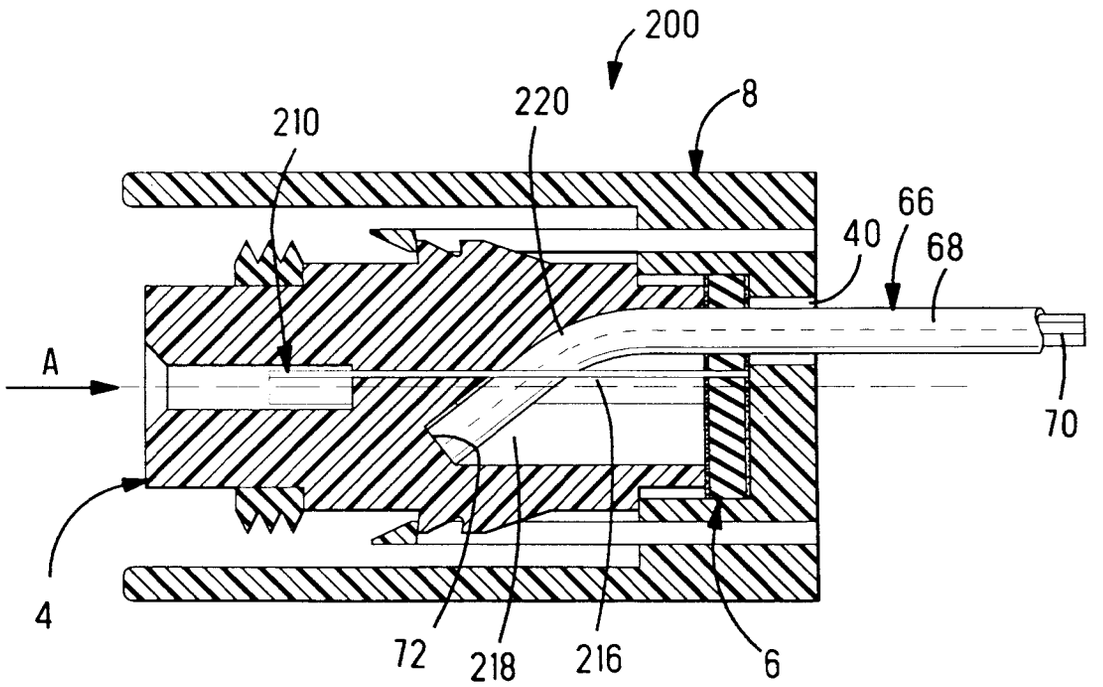
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Fig. 6