March 26, 1968 J. J. PHILLIPS 3,375,483

ELECTRICAL CONNECTOR

Filed Aug. 3, 1966

Fig. 1

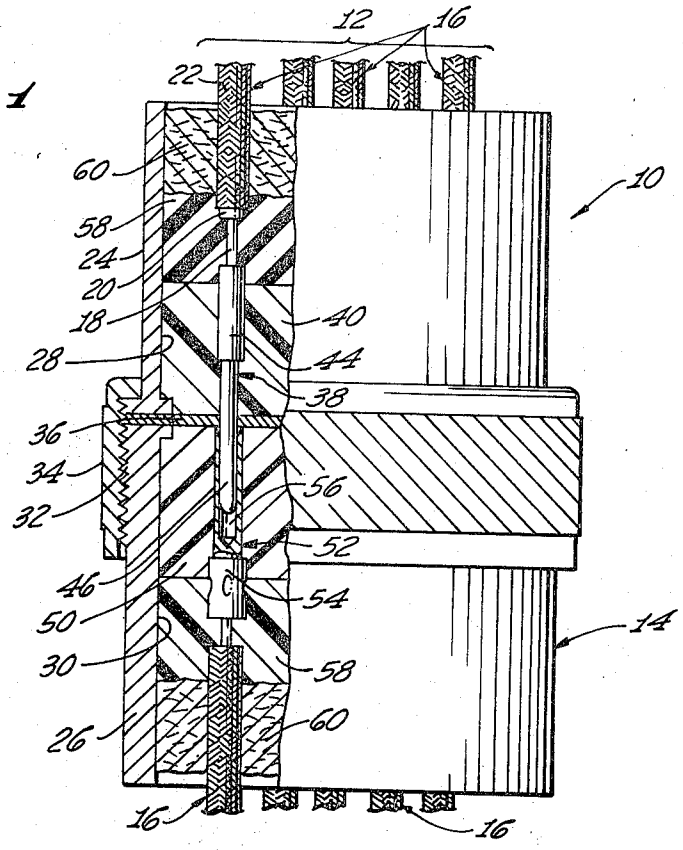
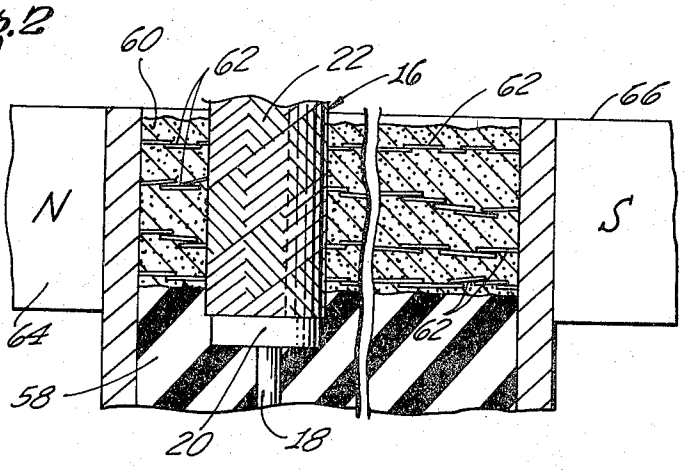


Fig. 2



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United States Patent Office 3,375,483 Patented Mar. 26, 1968

3,375,483

ELECTRICAL CONNECTOR

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Filed Aug. 3, 1966, Ser. No. 569,938
3 Claims. (Cl. 339—143)

ABSTRACT OF THE DISCLOSURE

The present invention relates to electrical connectors for use with a cable having electrically conductive shielding that must be grounded. In the embodimnet of the invention disclosed the space where the cable or bundle of wires enters the connector is filled with a sealing mixture containing a large number of magnetically conductve particles. A magnetic field is maintained across the sealing mixture while it hardens whereby the magnetic particles are attracted together to form a large number of electrically conductive paths which extend between the shielding and the connector. After the sealing mixture has hardened all of the particles are maintained bonded into the conducting relationship.

Electrical circuits and particularly those contained in separate pieces of equipment, are frequently interconnected by a large number of electrical conductors grouped into a bundle or cable. Each conductor includes a central wire covered with electrical insulation so as to be maintained electrically isolated from all of the other conductors. In addition each conductor may be surrounded by an electrically conductive shield. Although the shields, are electrically isolated from the central wires they are electrically connected to ground whereby any stray fields or currents are bypassed to ground before they reach the wire.

In order to facilitate interconnecting the conductors in the bundle or cable with a second group of conductors a pair of mating connectors may be employed. The connectors employ housings that may be fastened together whereby a plurality of contacts in the two housings electrically mate. The wire in each of the conductors is electrically connected to one of these contacts whereby the desired paths are formed between the various conductors.

In order to insure an effective shielding action it is highly desirable, if not essential, that the shielding on the individual conductors be electrically coupled together and to the electrical ground and/or to the connectors. If this condition is satisfied any stray currents present in the shielding or the connector housing will be effectively shorted to ground and prevented from being coupled into the conductors.

Heretofore, in order to overcome this difficulty the shielding around the various conductors and/or the cable have been electrically connected to ground and/or the connector by means of mechanical clamps, soldering etc. Although such arrangements have been satisfactory for many applications it has been found that it is time consuming and/or expensive to provide such connectors. Also it has been found that frequently a discontinuity occurs in the portion of the shielding in the region of the interconnection between the conductors and the connector whereby a complete shielding action is not maintained. This problem becomes particularly acute when it is necessary to also provide a moisture proof seal at the same time.

The present invention provides means for overcoming the foregoing difficulty. More particularly the present invention provides electrical connector means which are not only simple and inexpensive to assemble but also are very effective and reliable in preventing any stray or spurious signals entering into the electrical conductors and/or the coupling connectors. In addition a hermetic, moisture proof seal is also provided that precludes moisture entering into the connector or the cable. In the single embodiment of the present invention disclosed herein this is accomplished by providing a sealing or potting compound at the junction of the cable with the connector. At least a portion of this compound is electrically conductive whereby one or more low resistance paths are formed between the shielding and the connector housing.

These and other features and advantages of the present invention will become readily apparent from the following detailed description of a single embodiment thereof, particularly when taken in connection with the accompanying drawings wherein like reference numerals refer to like parts and wherein;

FIGURE 1 is a cross sectional view of a connector embodying one form of the present invention, and

FIGURE 2 is a fragmentary cross sectional view of a portion of the connector of FIGURE 1 during one step of the assembly thereof.

Referring to the drawings in more detail the present invention is particularly adapted to be embodied in means for sealing a plurality of electrical conductors and electrically connecting the shielding around the conductors to ground. By way of example it may be employed in a connector **10** on the end of a cable **12** or a bundle of conductors **16**. The connector **10** is effective to mate with another connector **14** on the end of a second cable, a bulkhead etc.

Although the electrical conductor **16** may all be enclosed in a single cable **12**, in the present instance they are illustrated as being in a loosely associated bundle. Normally this bundle will include a large number of conductors. However for purposes of illustration, only two conductors are actually illustrated. Each of the conductors **16** includes a center wire **18** or similar device for carrying an electrical current. Each wire **18** is in turn surrounded by an electrically non-conductive insulation **20**. This insulation **20** may include one or more layers of a material, such as rubber, plastic etc.

A suitable shielding **22** in turn surrounds the layers of electrical insulation **20**. Although the shielding **22** may be of any desired variety it is preferably as flexible as the conductors **16**. Also, it is preferably sufficiently electrically conductive to provide a low resistance path. One form of shielding **22** that has been found particularly well adapted for this purpose is braided from a plurality of small conductors. This is so flexible it will not materially interfere with the bending of the conductor **16**.

Since the shielding **22** is electrically conductive if the conductors **16** are present in any stray fields currents will be produced in the shielding **22**. These currents circulate through the shield **22** and along the conductor **16** and prevented from ever reaching the central wire **18**. However, it should be noted that the effectiveness of the shielding **22** is dependent to a large degree on the shielding **22** being electrically connected to ground by a low resistance path.

Each of the connectors **10** and **14** includes a housing **24** and **26**. The housings **24** and **26** are substantially cylindrical with enlarged passages **28** and **30** extending axially therethrough. One of the housings **26** has a threaded exterior **32** while the other has a mating collar **34**. This collar **34** is rotatably mounted and internally threaded so as to engage the external threads **32**. By tightening the collar **34** the mating ends of the housings **24** and **26** are drawn together so as to compress a gasket **36** therebetween. As a consequence the two housings **24** and **26** will be rigidly locked and sealed together.

The housings **24** and **26** are preferably an electrically

conductive material. As a consequence they will also act as an electrical shield and prevent stray fields entering into the center thereof. Normally the housings **24** and **26** are fabricated of a light weight material such as by die casting.

The first connector **24** includes a plurality of pin contacts **38**. These are normally mounted in an electrical non-conductive block or insert **40** so as to be electrically isolated from each other. A small radial flange **42** on the end of the housing **24** engages the end of the block **40** and prevents it moving out of the connector **24**.

Each pin contact **38** includes an enlarged head **44** which is seated on the back side of the insert **40**. Each contact **38** also includes a shank **46** which projects outwardly beyond the exposed face of the insulating insert **40**. The exposed portions of the shanks **46** are surrounded by the collar **34** so as to be protected thereby.

The mating connector **14** also includes an electrically non-conductive block or insert **50**. The insert **50** is mounted so that its exposed face is closed to the exposed face of the insert **40** when the connector **10** and **12** are mated. A plurality of socket contacts **52** are positioned in the insert **50**. Each socket **52** includes an enlarged head **54** that is anchored in the back surface of the insert **50**. They also includes a recess **56** in substantial alignment with the pin contacts **38**. When the two connectors **10** and **12** are coupled together the exposed faces of the two inserts **40** and **52** will mate and the shanks **46** of the pin contacts **38** will be in electrical contact with the recesses **56** in the socket contacts **52**. The gasket **36** may also be compressed between these faces to hermetically seal the junction.

The wire **18** in each conductor **16** is coupled to one of the pin or socket contacts **38** or **52**. In order to accomplish this the insulating layer **20** and the braided shielding **22** are first stripped back from the end of the conductor **16**. This provides a short section of exposed wire **18**. The exposed end of the wire **18** is then inserted into the head **44** or **54** of the appropriate contact **38** or **52**. It is then secured in position by soldering, crimping, etc.

After all of the wires **18** have been attached to the contacts **38** and **52** the contacts are mounted on the inserts **40** and **50**, the inserts are placed within the housings **24** or **26**. Following this a layer **58** of encapsulating or potting material may be poured into the recessed end of the connector. This layer **58** is normally electrically non-conductive and is just sufficiently deep to cover the exposed portions of the wire **18** and part of the insulation **20** remaining on the wires. This will be effective to cover all of the exposed electrical conductive materials, i.e. the wire **18** and heads **44** and **46** of the contacts **38** and **52**. As a consequence the various contacts **38** and **52**, conductors **16** etc. will be retained in position and electrically isolated from each other and from the housing **24** or **26**.

After the foregoing layer **58** of insulating encapsulating material has been provided a second layer **60** of encapsulating material may be formed thereover. The second layer **60** is formed of an electrically conductive potting material. Normally this layer **60** is sufficiently thick to completely fill or substantially fill any space remaining in the passage **28** or **30**. The material in this layer **60** completely surrounds the braided shielding **22** on the conductors **16** and is in intimate contact with the braiding and the housing **24** and **26**. Since this layer **60** of potting material is electrically conductive it forms a conductive path between the various shields and the interior of the housing.

Although a wide variety of electrically conductive potting compounds may be employed it has been found desirable to include electrically conductive particles **62** within the compound whereby its conductivity is increased. If such particles **62** are included the potting compound may be electrically non-conductive and, in fact, may be the same material used in the first layer **58**.

It has been found the contacting of the conductive particles **62** is of a random nature. As a consequence the resistance is also random and on some occasions may be relatively large. In order to eliminate this effect the particles **62** may be of a magnetic nature. By way of examples the particles may be iron filings, copper slivers coated with a magnetic material such as nickel, etc.

After a layer **60** of the potting compound with the magnetic particles **62** has been flowed around the conductors **16** and before it has an opportunity to set up, a magnetic field may be applied to the potting compound. This may be provided by magnetic poles **64** and **66** on the opposite sides of the housing. This field will act upon the particles **62** and cause them to become aligned with the field and each other. Moreover if the magnetic field is sufficiently strong the various particles **62** will not only align themselves but will also become attached to each other and thereby form a large number of parallel low resistance paths. After the layer **60** of potting compound has cured, the field may be removed. However, since the layer **60** is now stiff the magnetic particles **62** are no longer free to move relative to each other and they will remain coupled to each other. Accordingly a large number of electrically conductive paths will be maintained across this portion of the encapsulating material whereby the metal shielding **22** on the conductors **16** will be grounded to the housing **24** or **26**. In order to insure a positive contact with the shielding **22**, the shielding **22** may be made of a magnetic material or else the end portions thereof may be coated with a magnetic material, for example by nickel plating.

In the event there are any stray magnetic or electromagnetic fields in the vicinity of the conductors **16**, they may still produce electrical currents in the braided shielding **22**. However, any such currents will be coupled through the layer **60** of electrical conductive encapsulating material and into the housing **24** or **26** of the connector **10** or **14**. As a consequence all of the electrical currents will be shunted to ground and prevented from entering into any of the electrical wires **16** or contact pins **38** or sockets **52**, etc. It will thus be seen that a highly effective moisture seal is formed and a highly effective grounding is provided.

While only a single embodiment of the present invention is disclosed herein it will be readily apparent to persons skilled in the art that numerous changes may be made thereto without departing from the spirit of the invention. More particularly the structures of the connectors, i.e. the housings, contacts, inserts, etc. may be modified to suit any particular application. Moreover the various encapsulating materials and particularly the electrically conductive layer and the manner of their formation may be modified to suit any particular application. If the conductive particles are employed the manner in which they are aligned may also be varied as required. It should also be noted that this technique is not necessarily limited to connectors of the type shown but may be utilized in connection with any type of electrical insulation where any form of shielded connection is used. Accordingly the foregoing disclosure and description thereof are for illustraitve purposes only and do not in any way limit the invention which is defined only by the claims which follow.

I claim:

1. The method of assembling an electrical connector including the steps of

providing an electrically conductive connector housing having a plurality of separate electrical contacts therein,

interconnecting a plurality of shielded electrical conductors with the contacts and forming an open space around the shield on the conductors and inside of the housing,

preparing a mixture which includes electrically conductive magnetic particles and a fluid that permanently hardens into a substantially rigid mass, said

magnetic particles being mobile within said mixture before said fluid hardens.

at least partially filling said space with said mixture and allowing said fluid to harden into a substantially rigid mass at least partilly filling the space whereby the particles become immobile within said mass,

maintaining a magnetic field in said space and in said mixture whereby the magnetic particles are attracted to each other, to the shielding and to the housing so as to form electrically conductive paths grounding said shielding to said housing, and

maintaining said field in said mixture until after the fluid has hardened into said rigid mass whereby the particles are rigidly maintained in said conductive paths.

2. An electrical connector of the class described including the combination of

an electrically conductive outer housing having a passage extending inwardly from one end thereof,

an electrically non-conductive insert disposed in said passage,

a plurality of electrical contacts mounted in said insert and maintained electrically insulated from each other by said insert,

a plurality of conductors extending through said passage and electrically joined to the contacts in the insert,

electrically conductive shielding surrounding the conductors and terminating inside of said passage adjacent said insert, and

a conductive layer in said housing and surrounding the shielding on the conductors, said layer including a substantially rigid material containing a large number of magnetic particles, said particles being magnetically attracted to each other and permanently retained in fixed immobile positions to form a large number of electrically conductive paths, said paths being effective to electrically interconnect said shielding and said housing whereby the shielding is electrically grounded to the housing.

3. The connector of claim **2** including

an electrdically non-conductive layer in said housing between the insert and the condutive layer, said non-conductive layer being effective to insulate the joined conductors and contacts from the others.

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