Aug. 4, 1970 J. E. WATSON ET AL 3,522,575

HERMETICALLY SEALED ELECTRICAL CONNECTOR

Filed Dec. 11, 1967 4 Sheets-Sheet 1

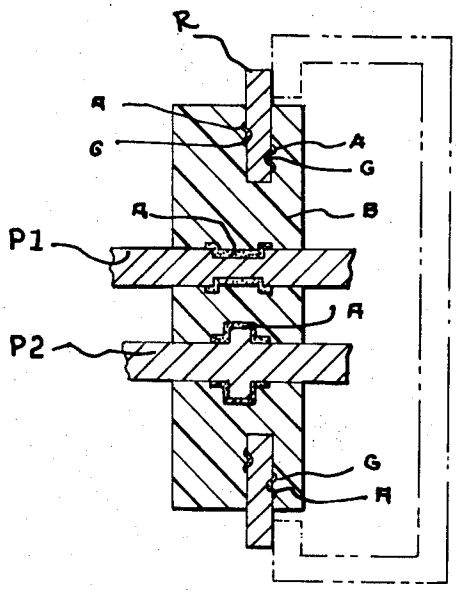

FIG. 1A

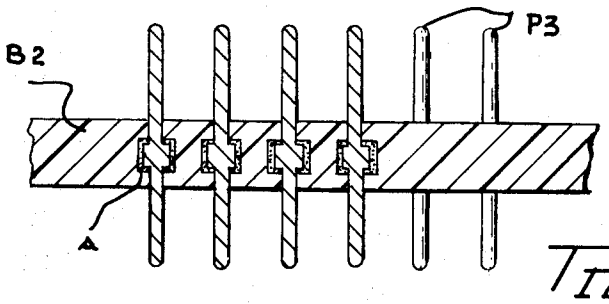

FIG. 1B

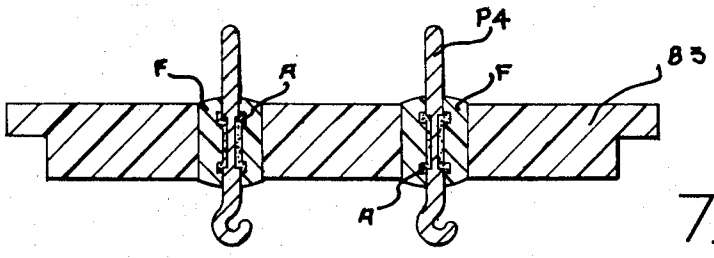

FIG. 1C

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Fig. 2.

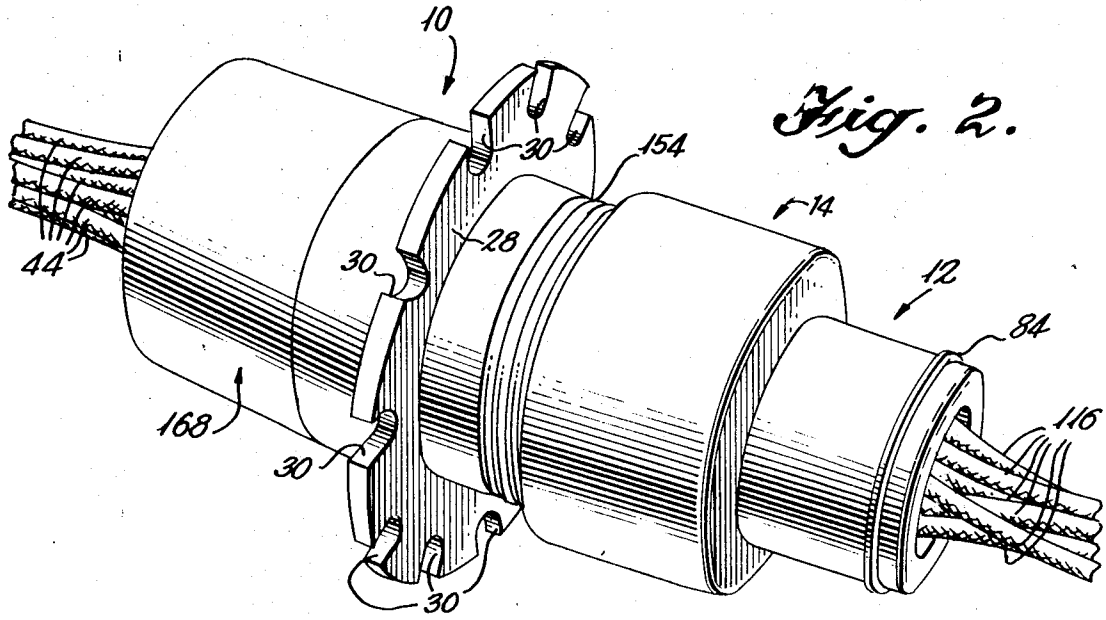

Fig. 3.

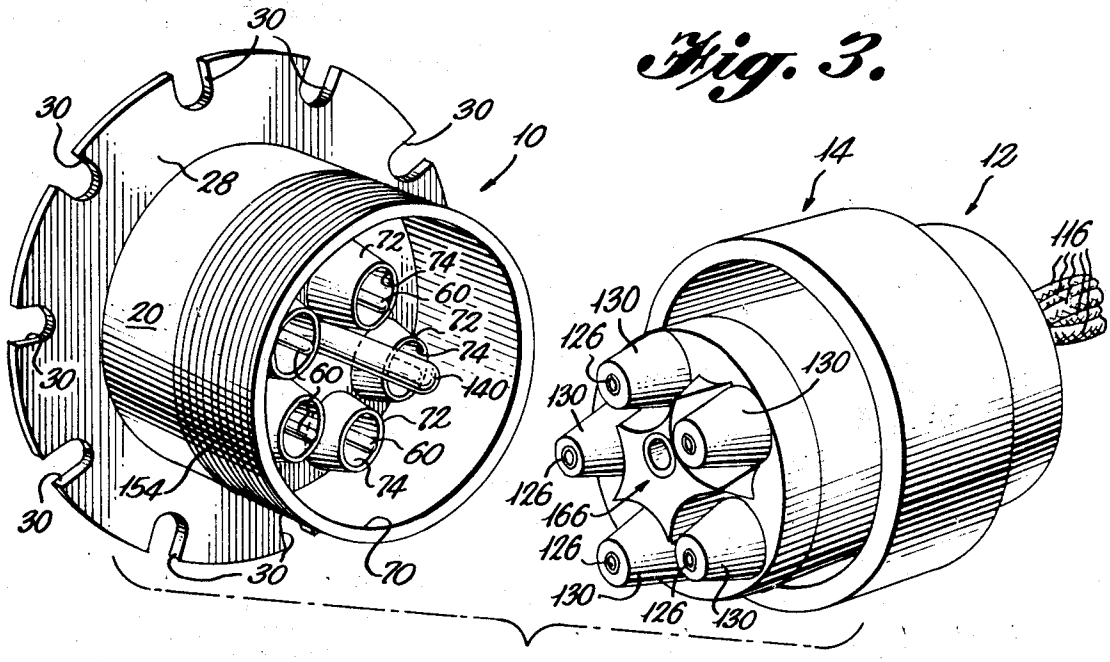

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Fig. 4.

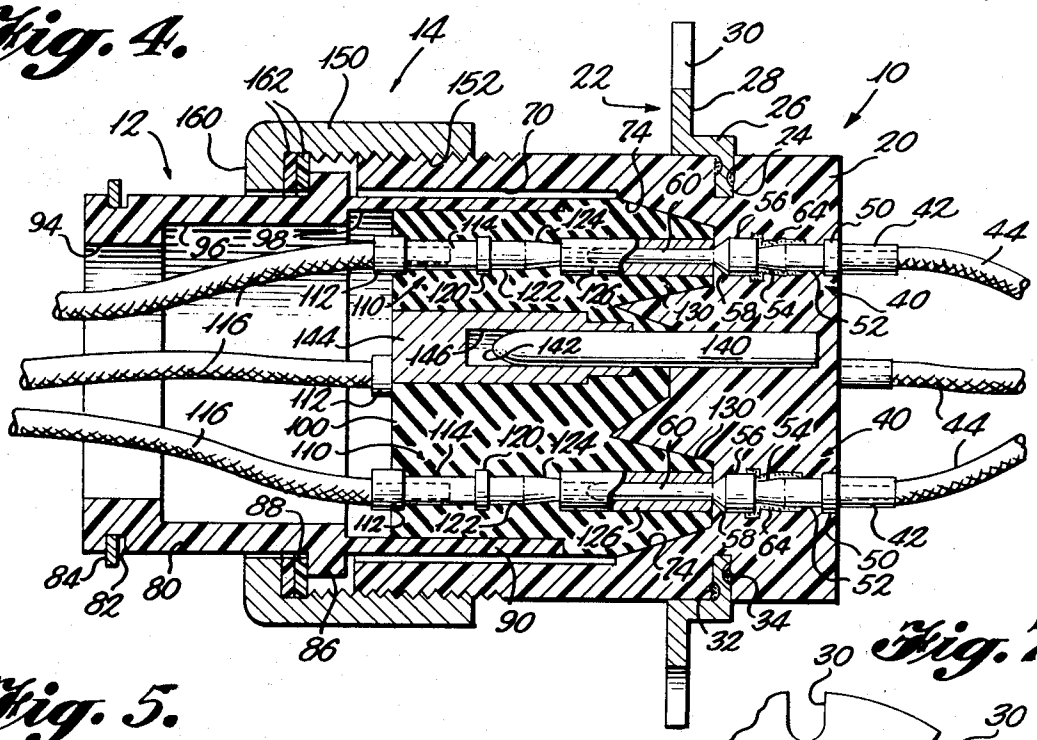

Fig. 7.

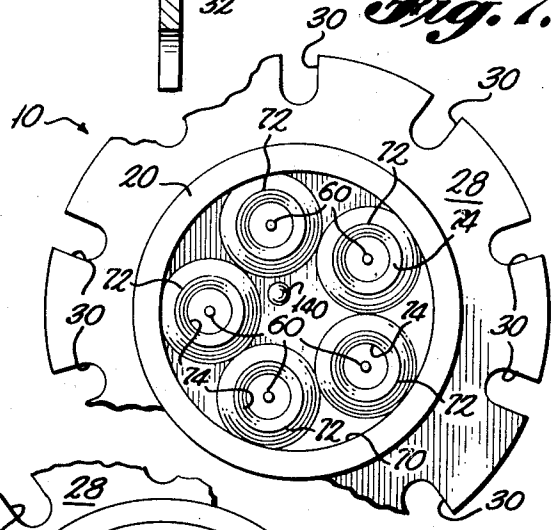

Fig. 5.

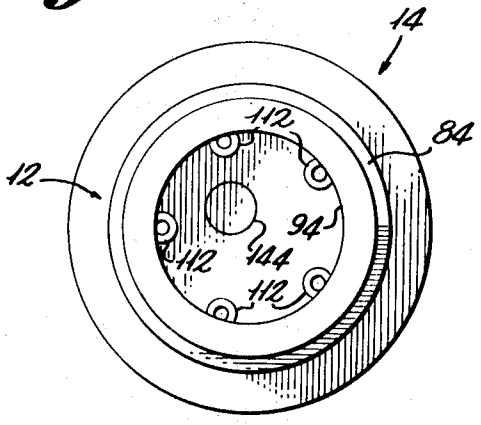

Fig. 6.

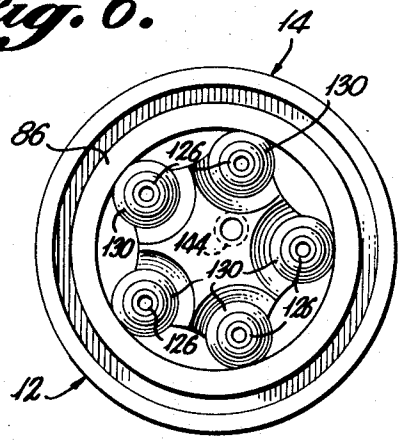

Fig. 8.

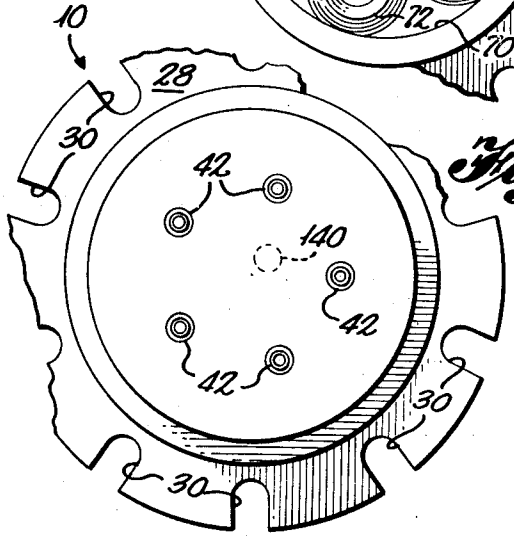

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Fig. 9.

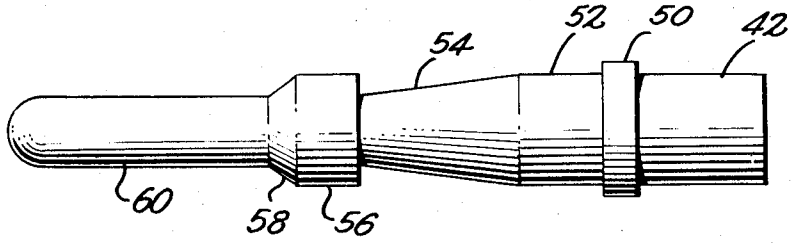


Fig. 10.

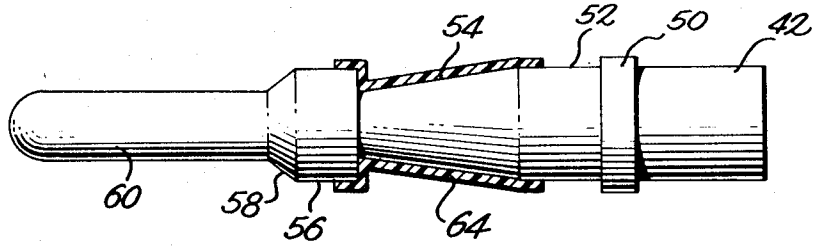
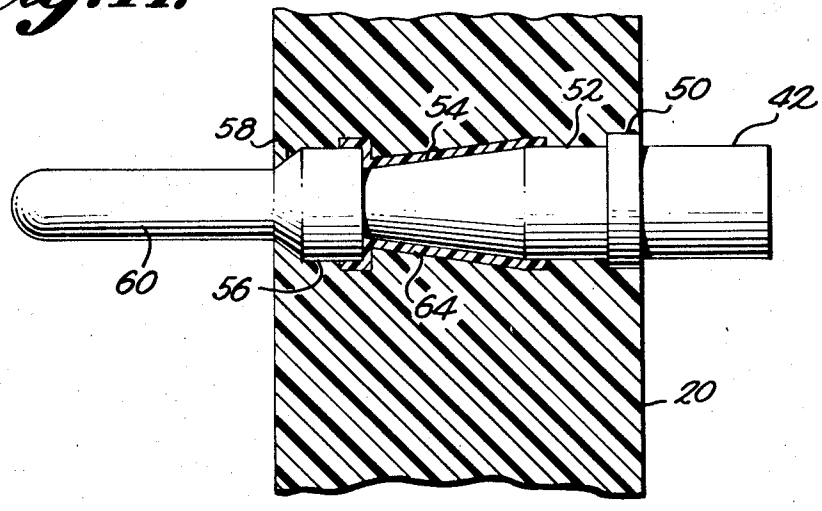


Fig. 11.



United States Patent Office 3,522,575 Patented Aug. 4, 1970

3,522,575

HERMETICALLY SEALED ELECTRICAL CONNECTOR

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Continuation-in-part of application Ser. No. 646,400, June 15, 1967. This application Dec. 11, 1967, Ser. No. 689,650

Int. Cl. H01r 23/58, 23/52, 13/64

U.S. Cl. 339—89 1 Claim

ABSTRACT OF THE DISCLOSURE

A hermetic sealing technique is disclosed featuring one or more conductive metallic members molded within an insulating thermosetting plastic body. A sealing interface between metal and plastic materials is provided through a coating applied to a portion of the surface of the conductive member which has characteristics of adhesion to metal and to plastic and a degree of resiliency sufficient to prevent part separation due to dimensional changes caused by different coefficients of expansion and contraction for the dissimilar materials. A multiple electrical connector featuring the improved sealing technique is taught.

This application is a continuation-in-part of application Ser. No. 646,400, filed June 15, 1967, and now abandoned.

BACKGROUND OF THE INVENTION

One typical specification defines a hermetic seal as being capable of showing no leakage when tested with a helium mass spectrometer having a sensitivity ranging from 10^{-7} 10^{-9} (atmosphere cubic centimeters per second) atmcc./sec. when the seal is cycled from −55° to +125° C. This same specification would qualify any seal having a greater leakage rate as a resilient seal. For this reason plastic and rubber or composition seal structures in general use have not heretofore been considered as acceptable for hermetically sealed units.

A variety of electrical devices require hermetic sealing including switches, headers, connectors and terminals. Prior art efforts generally provide conductive members mounted in glass or ceramic material and fused thereto with the glass or ceramic material fused to some metallic housing in the form of a ring, flange or the like. One problem with the use of glass or ceramic is that the metallic members used therewith must be steel or a special alloy, such as Kovar. Both materials are less than ideal as electrical conductors and the use of glass and ceramic imposes a very substantial design restriction on device configurations. The use of steel or Kovar metallic members also places a design restriction on circuit applications.

It is generally known in the prior art to mold an insulating body about conductive pin members to provide a connector, terminal or the like. U.S. Pat. No. 2,275,762 shows a multiple connector wherein contact members are molded into thermosetting and thermoplastic material. The requirements for sealing against entry of contaminants in general or for waterproofing are, however, far less stringent than those calling for a hermetic seal. The prior art approach to a hermetic seal other than the use of glass or ceramic, usually involves some kind of composite structure wherein a sealing material is entrapped and deformed within a hard thermosetting plastic material. The resilient material is caused to bear against the members to be sealed by a deforming structure. U.S. Pat. No. 2,700,140 shows a multiple waterproof connector

having this kind of seal. While adequate for waterproofing, seals of this type are not good enough to pass the type of specification heretofore mentioned.

One of the problems with a molded plastic structure is that dissimilar materials, insulating plastic and metal, have different coefficients of thermal expansion and when a device is initially made the heating and cooling cycle of the molding operation causes the material to expand and contract at different rates to produce voids and leakage paths in the finished product. With a use specification extending between −55° C. to 125° C. expansion and/or contraction during use of the part can also cause voids which result in leakage paths.

SUMMARY OF THE INVENTION

The present invention relates to method and means for providing a hermetic seal for devices having an insulating plastic body through which is extended one or more conductive metallic members.

The invention is contemplated as having a utility with switches, connectors, terminals, headers and electrical feed-through devices wherein there is a need to provide a conductive path which is hermetically sealed. The conductive path is typically an electrical lead, contact pin or the like, of brass or copper with a suitable plating thereon mounted in and extended through a thermosetting plastic body member. In accordance with the invention a portion of the conductive member is coated with an adhesive prior to molding of the plastic body member with a coating which adheres to both metal and plastic and which maintains a thin resilient interface between the dissimilar materials during the molding operation and thereafter during use of the device. Illustrative embodiments include body members of various thickness with or without a surrounding metallic ring or flange. If a ring is used a portion of it is also coated with the same adhesive. In one embodiment the invention contemplates a structure wherein a portion of the body member is formed prior to the addition of conductive members which are molded into apertures within the preformed body member.

As a detailed illustrative embodiment a multiple electrical connector capable of providing hermetic sealing and capable of use in higher altitudes and at high voltages is described. The connector includes a plurality of mating conical projections and recesses bearing male and female contact members in a spaced array with the projecting portion of a configuration to fit within and engage portions of the conical projections to eliminate air therewithin. One half of the connector includes an outer metallic flange which may serve as a mounting flange. The contact pins and the mounting flange of this connector half are coated with a thermosetting resin which is flexible and has characteristics to readily adhere to both metal and the plastic material of the body of the connector half.

An object of the present invention is to provide a new and improved hermetic seal for electrical devices. A further object of the invention is to provide a hermetically sealed electrical device wherein the insulating material thereof need not be glass or ceramic. Another object is to provide hermetically sealed device capable of using conductive members which are of a low resistance material. Still another object of the invention is to provide a novel method of bonding or sealing metallic members in an insulating plastic body. Yet a further object of the invention is to provide a hermetically sealed high voltage connector for high altitude use.

In the drawings:

FIG. 1*a* is a sectional view, somewhat enlarged from actual size, depicting an embodiment of the invention wherein conductive members are extended through a

mounting block of insulating material held in a metallic ring;

FIG. 1*b* is a sectional view, considerably enlarged from actual size, depicting the invention in an embodiment wherein a plurality of conductive terminal posts closely spaced together are secured in a relatively thin plastic board member;

FIG. 1*c* is a sectional view, considerably enlarged, of another embodiment of the invention wherein terminals are secured in apertures in a preformed board member having a further insulating and plastic material molded into the apertures of the board locking and sealing the terminals therein;

FIG. 2 is a top perspective view illustrating the assembled connector in accordance with the present invention;

FIG. 3 is a top perspective view illustrating the pin portion and socket portion separated from one another;

FIG. 4 is a longitudinal section through the assembled connector;

FIG. 5 is a rear view of the socket portion of the connector;

FIG. 6 is a front view of the socket portion of the connector;

FIG. 7 is a front view, partly broken away, of the pin portion of the connector;

FIG. 8 is a rear view, partly broken away, of the pin portion of the connector;

FIG. 9 is a view illustrating on an enlarged scale a pin connector as used in the present invention;

FIG. 10 illustrates a first step in the method of the present invention; and

FIG. 11 illustrates the completed article according to the method of the present invention.

Referring generally to FIGS. 1*a*–1*c*, the invention is depicted in three configurations of use wherein conductive members P are anchored in a plastic and insulating material in the form of a block or board B with an interface between metallic and plastic materials defined by an adhesive coating A. In each embodiment the conductive members are mechanically locked into the plastic block or board member and a hermetic seal is provided between the different sides of the block or board members.

In the embodiment of FIG. 1*a* there is included an outer supporting ring R which may be attached to a bulkhead or part of a housing in which equipment served by the conductive paths such as P1 and P2, is contained. In one example of use the structure shown in FIG. 1*a* may be considered as a feed-through into a metal can, dotted in, having an aperture receiving a portion of the block B with vertical portions of R extending around the aperture to be brazed or soldered to the can. The can may contain electrical or electronic components or a mechanical switch structure or the like. In another example the ring R may be brazed or soldered to the edge of an aperture in a glass or ceramic envelope which contains vacuum tube elements or the like. The members P1 and P2 may be considered as electrical leads for use in supplying components within a housing which may be to the right of the block B from some supply attached to portions P1 and P2 to the left of B. As another example, the structure in FIG. 1*a* may be considered as part of a connector with portions of the members P1 and P2 on either side serving as contact surfaces mateable with other contact surfaces. As a still further example the structure of FIG. 1*a* may be considered as simply a feed-through for a bulkhead wherein pressure differentials are experienced on either side thereof.

In accordance with the invention in one aspect the structure of FIG. 1*a* is formed by placing the inner portions of ring R within the cavity of a mold with the members P1 and P2 positioned in the mold to extend as shown in FIG. 1*a*. Thereafter plastic material of suitable characteristics is made to fill the cavity with heat and/or pressure applied to result in a molded block of the configuration shown. As can be discerned from FIG. 1*a*, the member R includes a groove on each side shown as G which would extend around the periphery of the ring on opposite surfaces thereof. In accordance with the invention the groove and the surfaces of the ring adjacent to the groove as shown in FIG. 1*a* are coated with an adhesive compound which serves as an interface between the metallic material of the ring and the plastic material of B. The same coating A is also applied to members P1 and P2 extending around the periphery thereof for a portion of the member length as shown. This material has characteristics of adhesion compatible to both metallic and plastic material and additionally characteristics of resiliency so as to ccommodate expansion or contraction of B, R and P during molding and thereafter in use without permitting a seam to develop between the metallic and plastic interface which could result in leaks. The adhesive A is shown to be a little thicker than actually utilized for clarity, but is understood to be a coating. In an application involving the forming of a thermosetting plastic body like B by transfer molding techniques with the members R, P1 and P2 being formed of metals such as brass, the adhesive A was applied in the manner indicated in FIG. 1*a* by coating the parts prior to filling of the mold cavity with the material for B. The coating applied was on the order of .005 of an inch in thickness and was made up of a thermosetting resin including a phenolic resin base having a content of about six percent polyvinyl chloride. In general a coating on the order of between 0.006 and 0.008 of an inch is recommended dependent upon the size or diameter of the metallic members used. For average usage, 0.005 or 0.006 of an inch is preferred. Theremoset resins selected from a group having a phenolic base with approximately 2 to 10 percent adhesives such as polyvinyl chloride, polyvinyl butryl, polyvinyl formal or epoxy varnish are preferred. For a typical application, 6 percent of one of the foregoing is recommended.

In an actual embodiment the material for B was epoxy resin which was glass filled. After application of A the mold cavity was then filled with the material for B and allowed to begin to cure. It was found that the particular material for the adhesive A above-mentioned prevents the coating from being scrubbed from the metallic surfaces during loading of the mold. Preferably the metal parts to be coated are grooved as indicated with respect to R and P1 or are flanged as indicated with respect to P2 to increase the path length over which the coating is applied and through which a path must be opened up to develop leaks, without increasing the size of the members. The use of flanges or grooves also tends to preclude removal of the coating during loading of the mold, and serves to provide a better mechanical locking of the various elements together.

A device made with the system above-mentioned was tested in accordance with the specification for hermetic seals heretofore mentioned and was found to meet such specification.

The requirement for an adhesive which has the desired characteristics of being flexible and also providing adhesion may be found with other material systems. For high temperature systems useful with the invention silicone plastics identified as Dow Corning 301G, or 302G, both having a glass fill or Dow Corning M91084 having a mineral fill, were used to form blocks or boards of various configurations with the adhesive coating employed being a fluorinated elastomer such as Viton rubber or Fluroal. The block material mentioned is good for up to approximately 650° F. and the adhesive is good to approximately 500° F. and the overall system is good for 600° F. intermittent use. With regard to high temperature system, the coating may be made on the order of approximately 0.005 to 0.006 of an inch in thickness as applied with a preferred range of from 0.002 to 0.008 of an inch depending on the size of the members employed.

FIG. 1*b* shows an alternative embodiment of the invention wherein the mounting member is in the form of a

thin sheet B2 and the conductive members are in the form of relatively small diameter terminal pins P3 spaced closely together. Each of the pins includes an enlarged portion around which an adhesive coating A is applied. With prior art devices utilizing glass or ceramic and a metallic support it is difficult to achieve close spacing of small parts. The invention lends itself to this type of assembly.

FIG. 1*c* depicts a further embodiment of the invention wherein the board shown as B3 may be considered as a premolded member of thermosetting material such as phenolic resin or diallyl phthalate having a series of relatively large apertures molded or drilled therein. The invention is utilized by positioning the molded part B3 in a jig holding terminal pins such as P4 coated as indicated, and then loading the larger apertures with a fill such as F of thermosetting material which is then cured. It is contemplated that a member like B3 may even be of a metallic construction in the form of a header or like device. A particular advantage of the invention in such application is that it permits the use of conductive pin members of plated or unplated brass or copper material rather than steel or Kovar.

The foregoing should indicate the general applicability of the invention in a variety of configurations and uses wherein a hermetic seal of conductive members and a standard conductive material is provided.

Referring now to a detailed embodiment of the invention, a connector is shown including a pin portion indicated generally by reference numeral **10**, and a socket portion indicated generally by reference numeral **12**, the pin and socket portions being connected together to provide a hermetic seal therebetween by a cap indicated generally by reference numeral **14**.

As seen most clearly in FIG. 3, the pin portion includes a body means **20** formed of a suitable plastic material such as glass filled epoxy resin. An attaching means indicated generally by reference numeral **22** takes the form of an attaching plate having an annular portion **24** thereof embedded within the body means **20**. Portion **24** of the attaching plate joins with a generally cylindrical portion **26** which in turn joins with a radially outwardly directed annular portion **28** having a plurality of spaced notches **30** formed in the outer periphery thereof. It is apparent that suitable attaching members may be inserted through the notches **30** for securing the attaching plate in operative position upon a suitable support means.

Annular grooves **32** and **34** of generally semicircular cross sectional configuration are formed in opposite faces of the annular portion **24** of the attaching plate. A thin layer of a suitable coating material such as a thermoset resin as hereinafter described is disposed within each of the grooves **32** and **34** to obtain a better and more effective bond between the plate and the material of the body means **20**. The plate may be formed of a suitable metallic substance such as brass or the like.

As seen most clearly in FIGS. 3 and 7, the pin portion body means **20** has a plurality of pin connectors indicated generally by reference numeral **40** embedded therewithin, the pin connectors including tubular portions **42** extending from the rear face of body means **20**, these tubular portions **42** receiving the bared ends of electrical leads **44** and being suitably secured thereto as by soldering or crimping whereby a good electrical connection is provided between the leads **44** and the pin connectors.

The construction of the individual pin connectors may be most clearly understood from an inspection of FIGS. 3 and 8 of the drawings. The tubular portion **42** joins with a solid portion defining an annular collar **50** which in turn joins with a portion having a substantially cylindrical outer surface **52**. Portion **52** inturn joins with a tapered or undercut portion **54** which further joins with a cylindrical collar portion **56**. This portion **56** tapers along a substantially frusto-conical surface **58** to an elongated generally cylindrical prong portion **60**.

As seen most clearly in FIG. 10, in the completed article, wherein the metallic pin connector which is formed of copper or the like is embedded within the plastic body means **20**, a layer of material **64** surrounds the undercut portion of the pin connectors, this layer of material comprising a thermoset resin as hereinafter more fully discussed.

As seen most clearly in FIGS. 2 and 6, the pin portion body means **20** has a generally cylindrical cavity **70** formed therewithin, and a plurality of tubular portions **72**, five in number, are provided, each of these tubular portions defining therewithin a tapered or substantially frusto-conical recess **74**. The prong portions **60** of each of the pin connectors extend centrally within one of said tapered recesses, and as seen most clearly in FIGS. 2 and 3, the outer ends of these prong portions **60** extend beyond the outer ends of the tubular portions **72** and the associated recesses **74**.

The socket portion **12** includes a nonmetallic sleeve **80** having a circumferentially extending groove **82** formed in the outer surface thereof. A snap retainer ring **84** is disposed within groove **82** and serves to hold the cap **14** in position so that it does not become displaced from the socket portion.

Sleeve portion **80** of the socket portion includes an annular radially outwardly extending portion **86** defining a shoulder **68** for a purpose hereinafter described. A portion **90** of the sleeve extends forwardly and receives the remaining part of the socket portion as hereinafter described.

A first bore portion **94** is formed through one end of sleeve **80**, bore portion **94** joining with an enlarged bore portion **96**, which in turn joins with a still further enlarged bore portion **98**.

The socket portion body means **100** may be formed of rubber or the like, body means **100** being suitably secured as by cement within portion **90** of sleeve **80** so that the components will be retained in the operative relationship shown in FIG. 3.

The socket portion body means has embedded therein a plurality of electrical socket connectors indicated generally by reference numeral **110**, these socket connectors being five in number and corresponding in relative relationship to one another with the pin connectors of the pin portion as will hereinafter more clearly appear.

Each of the socket connectors **110** includes an enlarged end portion **112** extending beyond the rear face of body means **100**, portion **112** joining with a portion **114** of reduced dimension, portions **112** and **114** being of tubular construction for receiving the bared ends of electrical leads **116**, these leads being suitably secured in place as by soldering.

Each of socket connectors **110** includes an intermediate peripherally extending collar portion **120** which joins with a portion **122** having a generally cylindrical outer surface which further joins with a tapered or under-cut surface **124**. Surface **124** in turn joins with a generally cylindrical tubular portion **126** which opens at the right-hand end thereof as seen in FIG. 3, each of tubular portions **126** comprising a socket portion for receiving one of the prong portions **60** and being embedded within a projection **130** formed integral with body means **100**.

As seen most clearly in FIGS. 2 and 3, each of projections **130** is tapered so as to provide a substantially frusto-conical outer surface complementary to the correspondingly tapered recesses formed in the pin portion so that each of these projections is adapted to be snugly received within one of the recesses, it being understood that the recesses and projections are correspondingly angularly spaced about the respective pin portion and socket portion.

It will be noted as seen in FIG. 3 that when the pin portion and socket portion are moved into operative relationship with respect to one another, each of the projections formed on the socket portion is received within one of the recesses formed in the pin portion, and

each of the prong portions **60** of the pin connectors is snugly received within the bore formed in the tubular portion **126** of a cooperating socket connector to provide an effective electrical connection therebetween. It will, of course, be understood that each of the socket connectors is formed of a suitable electrically conductive substance such as copper or the like similar to the material of the pin connectors.

Cooperating guide means is provided on the pin portion and the socket portion to ensure proper polarization when the two portions of the connector are moved into operative relationship with respect to one another. An elongated guide pin **140** is embedded within body means **20** of the pin portion and extends within the cavity thereof a substantial distance beyond the tubular portions **72**. This guide pin has a tapered outer end portion **142**.

A guide sleeve **144** is embedded within the body means **100** of the socket portion, this guide sleeve having a bore **146** formed therein which is open at the right-hand end thereof as seen in FIG. 3, the open end of the bore **146** being aligned with a corresponding bore formed through body means **100** whereby the guide pin **140** may enter into the bore of the guide sleeve as shown in FIG. 3.

As seen most clearly in FIGS. 5 and 6, the guide pin and the guide sleeve are offset with respect to the symmetric axes of the pin portion and socket portion respectively so that the two portions can only be assembled in a particular relationship with respect to one another.

As seen most clearly in FIG. 3, cap **14** includes a substantially cylindrical portion **150** having internal threads **152** formed therewithin, these threads being adapted to be threaded upon external threads **154** provided on the outer surface of body means **20** of the pin portion.

The cap also includes an annular radially inwardly extending flange portion **160**. Washer means in the form of a pair of washers **162** formed of a suitable plastic material such as Teflon are interposed between the forwardly facing surface of flange **160** and the shoulder **88** formed on portion **80** of the socket portion.

It is apparent that when the cap **14** is threaded onto the externally threaded portion of the body means **20** as seen in FIG. 3, the washers **162** will be compressed between the cap and the shoulder **88**, and the pin portion and socket portion will be drawn together so as to provide a hermetic seal between these two portions.

As seen most clearly in FIG. 2, the body means of the socket portion includes a raised central area **166** of such configuration as to fit snugly within the projections extending from the body means of the pin portion whereby when the pin portion and socket portion are disposed in operative relationship with respect to one another, these nesting and interfitting portions serve to fill in the space to eliminate the presence of air, to reduce corona effects and to increase the voltage breakdown path length.

As seen in FIG. 1, the portions of the leads **44** extending from the pin connectors have been embedded in a body **168** of a suitable potting compound. In a similar manner, the portions of the leads **116** disposed within the portion **80** of the socket portion may be embedded within a suitable potting compound to hold the leads in desired relationship. The leads extending from the pin portion and the socket portion may be surrounded by a suitable tubing to protect the leads.

Turning now to FIGS. 8–10 inclusive, the steps in the method for bonding the metallic electrical connector in a plastic material is illustrated. The connector illustrated is the pin connector previously described.

In carrying out the method according to the present invention, a coating **64** is applied to the connector as illustrated in FIG. 9. It will be noted that the coating is applied to the undercut area **54** of the connector and overlaps the portion **52** as well as the portion **56** disposed at opposite sides of the undercut area.

The coating for an actual unit was on the order of approximately 5 to 6 thousands of an inch in thickness and comprised a thermoset resin. The thermoset resin used was comprised of a phenolic resin having a 6 percent content of polyvinyl chloride.

After the coating has been applied to the connector as shown in FIG. 9, the connector pins are placed in a transfer-type mold and a body of plastic material is molded thereabout in the conventional manner. As mentioned hereinbefore, the preferred plastic material according to the present invention comprises a glass filled epoxy resin.

Since the coating **64** is of a flexible nature, it has the ability to adhere to both the metallic substance of the electrical connector as well as the plastic substance of the body means **20**. The coating takes up the difference in thermal expansion of the two dissimilar materials until equilibrium is reached.

FIG. 10 illustrates the completed article after carrying out the method of the present invention with the connector embedded within the plastic body means.

It is apparent from the foregoing that there is provided according to the present invention a new and novel hermetically sealed electrical connector which is quite simple and compact in construction, which may be readily assembled and wherein the electrical connecting components are fixed with respect to the portions within which they are mounted and are adapted to interfit snugly and firmly in place. The present invention also provides a novel method of bonding a metallic electrical connector in a plastic material.

As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive.

What is claimed is:

1. A hermetically sealed electrical connector comprising a pin portion and a complementary socket portion and having means for connecting said pin portion and said socket portion together and providing a hermetic seal therebetween, said pin portion including a body means having a cavity formed therein, a plurality of tapered recesses being defined by said body means and being in communication with said cavity, a plurality of pin connectors each of which extends within one of said tapered recesses, a guide pin mounted in said pin portion body means extending parallel to the axes of, and axially beyond, said pin connectors, said socket portion comprising a body means including a portion extending within the cavity in said pin portion, the body means of said socket portion defining a plurality of tapered projections each of which is adapted to fit relatively snugly within one of said tapered recesses in the pin portion body means, an electrical socket connector positioned within each of said projections, each of said socket connectors receiving one of said pin connectors, a guide sleeve in said body means of said socket portion in alignment with said guide pin, said guide sleeve receiving said guide pin, said guide pin and guide sleeve functioning to guide said pin portion and said socket portion together upon engagement of said parts with each other, said guide pin preventing cross contacting of said pin connectors with said socket connectors during engagement, attaching means embedded within said pin portion body means and extending outwardly thereof for supporting the pin portion body means in operative position on a suitable support means, said socket portion body means having an annular shoulder formed thereon and extending outwardly thereof, said means for connecting the pin portion and socket portion together including a cap having threads formed thereon, the outer surface of said pin portion body means having threads thereon cooperating with the threads on said cap, and washer means disposed within said cap and being

engageable with said shoulder on the socket portion body means.

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