

Feb. 1, 1966

J. C. KYLE

3,233,202

MULTIPLE CONTACT CONNECTOR

Original Filed March 30, 1962

2 Sheets-Sheet 1

Fig. 1

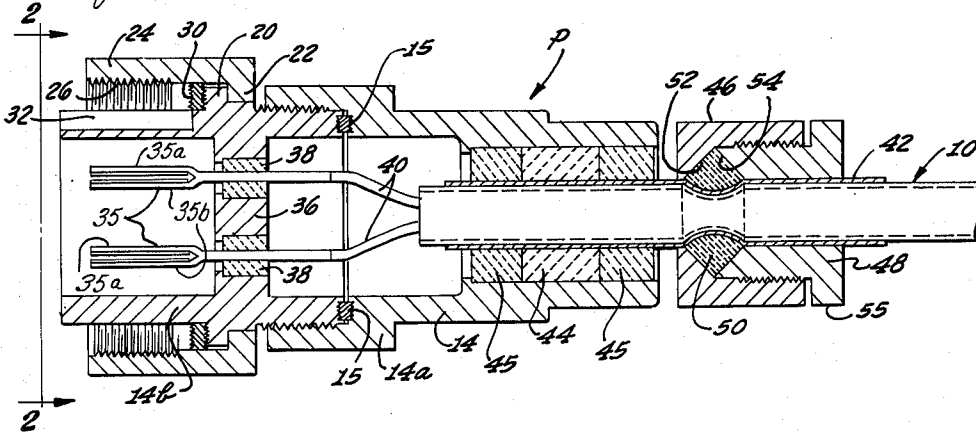


Fig. 2

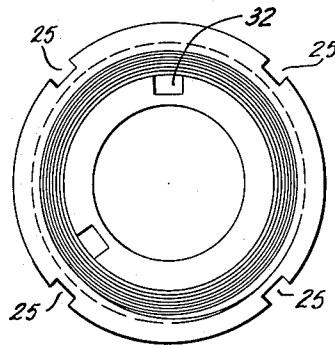
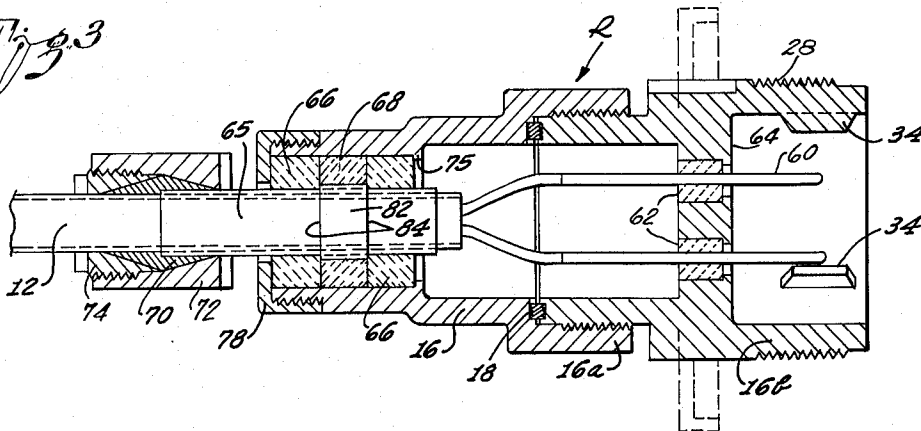


Fig. 3



INVENTOR:
James C. Kyle
By *Ameyth, Rooten & Parvix*
Attorneys

Feb. 1, 1966

J. C. KYLE

3,233,202

MULTIPLE CONTACT CONNECTOR

Original Filed March 30, 1962

2 Sheets-Sheet 2

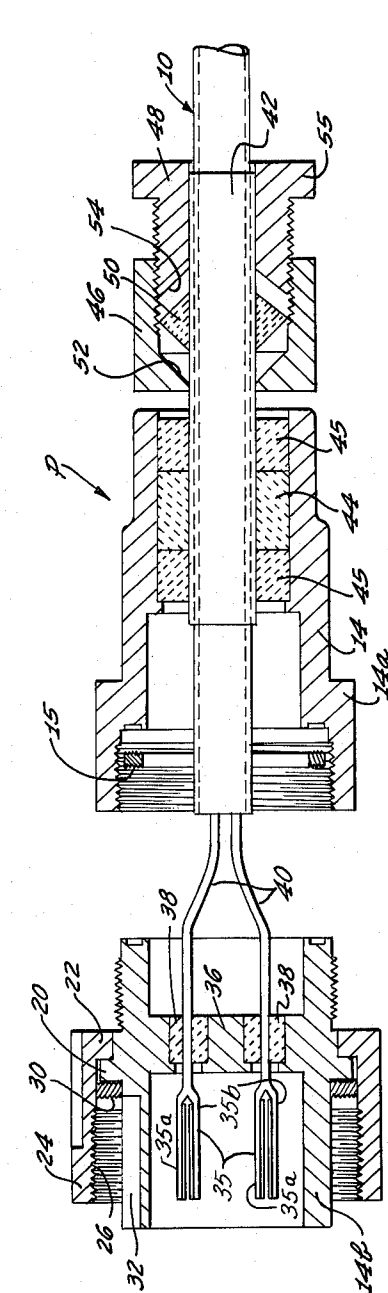


Fig. 7

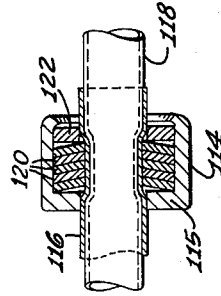


Fig. 6

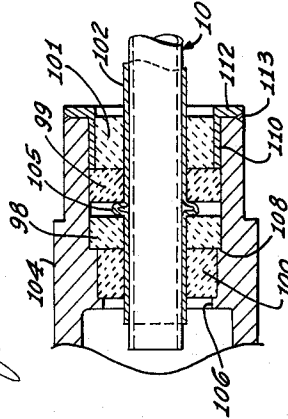
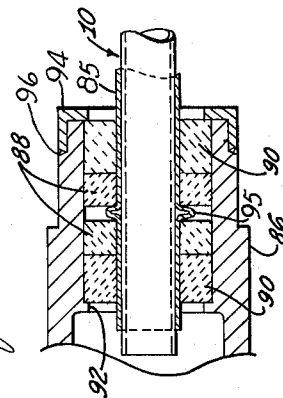


Fig. 5



INVENTOR:
James C. Kyle

By Amyth, Rooten & Paritt
Attorneys

1

2

3,233,202

MULTIPLE CONTACT CONNECTOR

James C. Kyle, Glendora, Calif., assignor to Physical Sciences Corporation, Pasadena, Calif., a corporation of California

Continuation of application Ser. No. 183,838, Mar. 30, 1962. This application Mar. 1, 1965, Ser. No. 440,666 16 Claims. (Cl. 339—30)

This application is a continuation of my co-pending application, Serial No. 183,838, filed March 30, 1962.

This invention is directed to the solution of certain troublesome problems that must be met in the construction of hermetically sealed releasable electrical connections for high temperature services. The invention has special utility for the construction of a multiple contact electrical connector of the general type wherein a multiple contact plug assembly is releasably engageable with a complementary multiple contact receptacle assembly to make a hermetically sealed releasable joint between two metal clad multiple conductor cables. Such a connector constructed for service at 1800° F. has been selected by way of example for the present disclosure and will provide adequate guidance for those skilled in the art who may have occasion to apply the same principles to other specific purposes. It will be apparent that various features of the connector construction have utility in devices other than multiple contact connectors.

One of the problems is to mount the multiple contacts of a connector and the conductors of the cable inside the metal shell or housing of the connector in an insulated manner for high temperature use. This problem is met by mounting the multiple contacts of the connector in ceramic bushings in such manner that the adjoining portions of the cable conductors are effectively maintained in adequately spaced relation to each other and to the metal housing. Thus the adjoining conductor ends of the cable are insulated by air instead of solid dielectric.

Another problem is to seal the releasable joint between the plug assembly and the receptacle assembly in a manner to withstand the high temperature. This second problem is solved by designing the housing bodies of the two assemblies with screw threads for mutual engagement and by employing a captive shear seal ring of ductile metal at the joint.

The most difficult problem is to construct a connector housing which at the time of installation may be quickly, conveniently and effectively mechanically engaged with the end of a metal clad cable in a sealed manner for high temperature use. This problem is met by incorporating into the connector construction a metal tube to embrace the entering cable end. This approach presents the two problems, of first, connecting the metal tube to the connector housing in a sealed manner and, second, connecting the metal clad cable to the metal tube. With these two problems solved, this approach has the important advantage of making it possible to assemble the tube to the housing body at the factory, leaving only the engagement of the metal tube with the metal clad cable to be carried out at the time of installation.

Since the metal housing for a multiple contact connector must be substantially larger in diameter than the cable to which it is connected, the cable-receiving metal tube must be mounted in the metal housing by insulating spacer means of relatively large radial dimension and the spacer means must not only form a hermetic seal at high temperatures but must also provide a mechanical connection capable of withstanding any axial separation force that may be anticipated at the high temperature. For a number of reasons, it is desirable to use ceramic spacer means for this purpose, but the ceramics that are imper-

vious for effective sealing action at high temperature have been found to lack the mechanical strength that is required to withstand the separation forces, and, conversely, ceramics of adequate mechanical strength at high temperatures have been found to be permeable and incapable of sealing action.

The invention meets this dilemma by using a combination of two ceramics. One of the ceramics which will hereafter be termed the sealing ceramic is specialized for sealing action at high temperatures; the other ceramic which will hereafter be termed the high strength ceramic has the important property of high mechanical strength at the high temperature. The preferred practice of the invention includes the further concept of mechanically interlocking the high strength ceramic with both the ceramic housing and the inner metal tube. As will be explained, various methods of mechanical interlock may be used.

The problem of connecting the metal tube with the metal clad cable again involves the two concurrent considerations of sealing effectiveness and mechanical strength. The invention meets this problem by using a metal tube that is made of deformable metal and by contracting a portion of the metal tube radially into sealing contact with the enclosed metal clad cable. To insure that the seal between the metal clad cable and the surrounding metal tube endures under high temperature conditions, the metal tube is constricted radially by mechanical means that encircles the metal tube and remains permanently in constricting position on the tube to sustain the required radial pressure throughout the service life of the connector. Since the permanently installed constricting means exerts radially inward pressure of high magnitude both the metal tube and the encircled metal clad cable are locally deformed and are thus mechanically interlocked effectively for positive prevention of relative axial movement between the tube and the cable. Thus the invention efficiently connects the connector housing with the cable by the two provisions of employing ceramic to mechanically interlock the housing with the metal tube and of mechanically interlocking the metal tube with the enclosed metal clad cable.

A final problem arises from the fact that the interior of the connector housing must be open at the time of installation to permit connecting the multiple cable conductors to the multiple contact elements of the connector. Full access is required so that the joints may be welded to insure joints that will endure at high temperatures. This problem is solved by a novel installation procedure, which, as will be explained, requires that the housing be made in two separable screw-threaded sections with one of the two sections carrying the deformable metal tube and with the deformable metal tube dimensioned to slide along the metal clad cable.

A further feature of the invention is the concept of employing socket contacts that tend to grip the cooperative pin contacts with increasing pressure in response to increasing temperature. For this purpose, each socket contact has two bi-metallic halves which flex towards each other at high temperatures.

The features and advantages of the invention may be understood from the following detailed description and the accompanying drawings.

In the drawings, which are to be regarded as merely illustrative:

FIG. 1 is a longitudinal sectional view of a multiple contact plug assembly constructed in accord with the presently preferred practice of the invention;

FIG. 2 is an elevation of the open end of the plug assembly;

FIG. 3 is a longitudinal sectional view of a comple-

mentary multiple contact receptacle assembly that cooperates with the plug assembly of FIG. 1 to make a complete multiple contact connector;

FIG. 4 is a longitudinal sectional view of separated parts of the plug assembly illustrating the procedure for installing the plug assembly on the end of a metal clad cable;

FIG. 5 is a fragmentary longitudinal sectional view illustrating a modification of the construction shown in FIG. 1;

FIG. 6 is a similar view illustrating a second modification; and

FIG. 7 is a longitudinal sectional view of a tube-restricting means that may be employed in another practice of the invention.

FIG. 1 shows a plug connector assembly, generally designated P, which is mounted on the end of a metal clad cable 10 for releasable connection with a receptacle connector assembly, generally designated R in FIG. 3, which is mounted on the end of a second metal clad cable 12, the two connector assemblies constituting a connector for two cables 10 and 12. The two connector assemblies are multiple contact assemblies since the two cables are multiple conductor cables. In this particular embodiment of the invention, each of the two cables has two conductors and therefore each of the two connector assemblies has two contact elements.

The plug connector P has a cylindrical body or housing 14 which is made in two sections 14a and 14b which screw together with the joint sealed by a shear seal ring 15. The shear seal ring is of a well known serrated type and may be made of gold or other suitable ductile metal. It like manner the receptacle connector assembly R has a cylindrical body or housing 16 which is made in two sections 16a and 16b which screw together and are sealed by a shear seal ring 18.

The cylindrical body 14 of the plug connector assembly P is formed with a radial flange 20 which is engageable by an inner circumferential flange 22 of a collar 24. The collar 24, which is formed with longitudinal peripheral grooves 25 for engagement by a spanner, is dimensioned to telescope over the open end of the receptacle connector assembly R, the collar having an internal screw thread 26 to engage an external screw thread 28 of the connector body 16. When the two connector assemblies are interconnected by the collar 24 the joint is sealed by a shear seal ring 30.

Suitable provision is made for polarizing or indexing the two connector assemblies P and R to make sure that only these two connector assemblies are interconnected by the collar 24. For this purpose the body 14 of the plug connector assembly P is provided with two circumferentially spaced outer longitudinal grooves 32 as indicated in FIG. 2 and the cylindrical body 16 of the receptacle connector assembly R is provided with two corresponding inner radial projections or keys 34 of the same circumferential spacing.

The housing section 14b of the plug connector assembly P is provided with a pair of contact elements in the form of socket contacts 35 which are mounted in a transverse wall 36 of the housing by means of ceramic bushings 38. As heretofore noted, the invention is characterized by the use of two kinds of ceramics, namely, a high strength ceramic and a sealing ceramic. The composition of a suitable high strength ceramic and the composition of a suitable sealing ceramic will be set forth later. Since the bushings 38 are not subjected to high stress they may be made of the sealing ceramic.

The socket portion of each of the socket connectors 35 is longitudinally split into two halves 35a and 35b and the two halves are bi-metal elements that curve inward towards each other in response to rising temperature. Thus the two socket contacts 35 grip a cooperating pin contact with increasing pressure in response to rising temperature.

The shanks of the two socket contacts 35 are welded since the socket contacts are rigidly held by the ceramic bushings 38 they rigidly hold the two wires 40 spaced from each other and from the surrounding housing section 14a. Thus the dielectric inside the connector housing that insulates the two wires is air.

A metal tube 42 that is dimensioned to slide onto the metal clad cable is mounted concentrically in the connector housing section 14a by a high strength ceramic bushing 44 and by two sealing ceramic bushings 45 that are positioned on the opposite sides of the bushing 44. The three ceramic bushings 44 and 45 are fused to both the tube 42 and the surrounding housing section 14a with the high strength ceramic bushing 44 keeping the two sealing ceramic bushings 45 from being stressed to any damaging degree.

The jacket of a metal clad cable for high temperature use is commonly made of the alloy Inconel. Both the connector housing 14 and the metal tube 42 may be made of the same metal.

To complete the installation of the connector assembly on the end of the metal clad cable 10 the metal tube 42 is mechanically engaged with the cable to resist longitudinal movement of the of the tube relative to the cable and the annular space around the cable is sealed. A feature of the invention is the concept of providing means to constrict the tube 42 radially for the dual purpose of mechanically interlocking the tube and the cable and of forming a seal around the cable.

The constricting means shown in FIG. 1 comprises a bushing 46, a gland 48 threaded into the bushing and a contractible ring-shaped mass 50 that is confined between an inner tapered surface 52 of the bushing and a similar inner tapered surface 54 of the gland. The ring-shaped mass 50 may be, for example, a crushable ceramic ring. For convenient manipulation by a wrench, the bushing 46 may be of hexagonal outside configuration and the gland 48 may have a hexagonal radial flange 55. When the bushing 44 and the gland 48 are tightened together the ring-shaped mass 50 is constricted or displaced radially inward with consequent constrictive deformation of both the metal tube 42 and the metal clad cable, both being held permanently under constricting pressure.

The described construction of the multiple contact assembly shown in FIG. 1 makes possible a highly advantageous method of fabrication which may be understood by reference to FIG. 4. In preparation for the final assembly, the contact elements 35 are mounted in a sealed manner in the housing section 14b by means of the sealing ceramic bushing 38. For this purpose the ceramic bushings 38 may be molded in place and then fused to the contact elements and the housing section or the bushings may be premolded, installed and then the assembly may be heated to fuse the bushings to the contact elements and the housing section. Also in preparation for the final assembly procedure the metal tube 42 is permanently assembled to the housing section 14a by means of the ceramic bushings 44 and 45. Here again the assembly of three ceramic bushings may be molded in place and then fused or may be premolded, assembled and fused.

The first step in the final assembly procedure is to loosely mount on the outer end of the tube 42 the constricting means comprising the bushing 46, the gland 48 and the enclosed ring-shaped mass 50. The housing section 14a with the tube 42 assembled thereto is then slidably telescoped over the end of the metal clad cable 10 and retracted on the cable in the manner shown in FIG. 4 to make the ends of the two cable wires 40 fully accessible. The metal sealing ring 15 is passed over the end of the cable and then the exposed wires 40 are butt welded to the corresponding contact elements 35.

The next step is to slide the housing section 14a and the parts united therewith including the tube 42 forward and to screw the two housing sections 14a and 14b to-

gether into tight relationship for effective sealing by the interposed ring 15. The final step is to tighten the gland 48 into the bushing 46 to cause the ring-shaped mass 50 to contract the tube 42 into engagement with the metal clad cable 10 with consequent permanent deformation of both the tube and the cable.

The receptacle connector assembly R shown in FIG. 3 is of the same general construction and is assembled to the cable 12 by the same procedure. A pair of contact elements in the form of pin contacts 60 is mounted by a pair of sealing ceramic bushings 62 in a transverse wall 64 of the housing section 16b. A metal tube 65 is permanently assembled to the other housing section 16a by means of two high strength ceramic bushings 66 and an interposed sealing ceramic bushing 68. The bushings 66 are fused to the housing 16 and the tube 65 to seal the housing and the tube.

The assembly for constricting the metal tube 65 into engagement with the metal clad cable 12 includes a contractible ring-shaped mass 70 enclosing the outer end of the metal tube 65 as well as an adjacent portion of the peripheral surface of the metal clad cable 12. In this instance the ring-shaped mass 70 is a body of relatively soft metal such as copper or brass. The metal ring 70 may be performed with an inner bore of stepped configuration conforming to the stepped configuration of the juncture of the outer end of the tube 65 and the cable 12. An internally tapered metal bushing 72 and an internally tapered gland 74 cooperate by screwing together to contract the soft metal ring 70 into sealing engagement with both the cable 12 and the tube 65 with consequent mechanical interlocking of the tube and cable as well as sealing of the juncture between the cable and the tube.

The invention further teaches various ways in which high strength ceramic bushings and sealing ceramic bushings may be connected to a metal tube and to a surrounding connector housing to form a unitary and structurally efficient assembly in which the high strength ceramic keeps the sealing ceramic from being unduly stressed. Examples are shown in FIGS. 3, 5 and 6.

In FIG. 3 where a sealing ceramic bushing 68 is interposed between two high strength ceramic bushings 66, the assembly of three bushings is engaged with the connector housing 16 by confinement between a shoulder formed by an inner radial flange 75 of the housing and a second shoulder formed by the inner radial flange of a bushing 78 that threads onto the housing. It is apparent that the three bushings 66 and 68 may be inserted into the end of the housing section 16a into abutment with the radial flange 75 and may then be tightly confined by screwing the bushing 78 onto the housing section.

A feature of the construction shown in FIG. 3 is that a metal band 82 fixedly embraces the metal tube 65 to form two oppositely facing outer circumferential shoulders 84. The sealing ceramic bushing 68 conforms to the axial dimension of the metal band 82 and is fused thereto. The two high strength ceramic bushings 66 abut the opposite shoulders 84. Thus the assembly of three ceramic bushings is interlocked with the housing 16 by engaging oppositely facing internal shoulders of the housing and is interlocked with the metal tube 65 by engaging oppositely facing outer shoulders of the metal tube.

FIG. 5 shows how a metal tube 85 may be assembled to a connector housing 86 by means of an inner pair of high strength ceramic bushings 88 and an outer pair of sealing bushings 90. The bushings 90 are fused to the housing 86 and the tube 85 to seal the housing and the tube. The assembly of four ceramic bushings is confined between a first inner shoulder formed by an inner radial flange 92 of the housing 86 and a second inner shoulder formed by an inwardly flanged metal ring 94. To provide interlocking engagement between the ceramic bushings and the tube 85 the tube is crimped radially outwardly to form a circumferential bead 95 which presents

two oppositely facing shoulders. The two high strength bushings 88 snugly straddle the bead 95 in tight engagement with the opposite sides of the bead. It is apparent that in this construction as in the construction shown in FIG. 3 the assembly of ceramic bushings is positively mechanically interlocked both with the surrounding housing and with the axial metal tube. It is apparent that with the four ceramic bushings mounted on the tube 85 the assembly may be inserted into the end of the housing 86 against the inner radial flange 92 and then the metal ring 94 may be secured by welding 96 to complete the assembly.

In FIG. 6, an inner pair of high strength ceramic bushings 98 and 99 and an outer pair of sealing ceramic bushings 100 and 101 are employed to assemble a metal tube 102 to a surrounding connector housing 104. The bushings 100 and 101 are fused to the tube 102 and the housing 104 to seal the tube and the housing. Here again the metal tube 102 is formed with a circumferential crimped bead 105 which is snugly engaged from opposite sides by the two high strength ceramic bushings 98 and 99. The sealing ceramic bushing 100 abuts an inner circumferential shoulder of the housing formed by a radially inward flange 106 and the high strength ceramic bushing 98 that abuts this sealing bushing engages a second inner circumferential shoulder 108 which is formed by slightly enlarging the internal diameter of the housing. The other high strength ceramic bushing 99 abuts an inner shoulder formed by the inner end of a thin walled metal bushing 110 which bushing has a radially outward flange 112 and is secured by welding 113. The second sealing ceramic bushing 101 is mounted inside the thin walled metal bushing 110 as shown. An important advantage of the construction shown in FIG. 6 is that the two high strength bushings 98 and 99 are directly interlocked with both the connector housing 104 and the metal tube 102 in a manner that keeps the two ceramic bushings 100 and 101 from being subjected to axial compression.

FIG. 7 shows another example of an assembly for constricting a metal tube into engagement with a metal clad cable, which assembly may be substituted for either of the constricting assemblies shown in FIGS. 1 and 3. The constricting assembly shown in FIG. 7 comprises a cylinder 114 with a radial wall 115 at one end that is centrally apertured to clear a metal tube 116 that is telescoped over a metal clad cable 118. The annular space inside the metal cylinder 114 is occupied by a pack of Belleville washers 120 and a heavy metal ring 122. The Belleville washers 120 are dimensioned to freely slide along the tube 116 at the unstressed configuration of the washers.

The constricting of the metal tube 116 is accomplished by using suitable means to compress the Belleville washers 120 axially. For this purpose one jaw of a tool may engage the outer surface of the radial wall 115 and the second jaw of the tool may engage the heavy metal ring 122 to force the metal ring towards the radial wall. The axial compression of the Belleville washers 120 contracts the inner diameter of the washers with consequent radial compression of the tube 116 and the metal clad cable 118. While the Belleville washers are held under the effective axial compression by the two jaws of the tool, the open end of the cylinder 114 is swaged radially inwardly to form an annular lip that permanently engages the ring 122 to maintain the Belleville washers under permanent axial compression.

A high strength ceramic suitable for the purpose of the invention may be produced by employing the following mixture in parts by weight:

CaCO ₃	35.50
MgO	4.80
Al ₂ O ₃	4.80
H ₃ BO ₃	14.00
SiO ₂	21.70
TiO ₂	19.20

Another mixture for the same purpose comprises:

CaO	25.4
MgO	6.1
Al ₂ O ₃	6.1
B ₂ O ₃	10.1
SiO ₂	27.7
TiO ₂	24.6

To process one of these mixtures, first the materials are intimately mixed in finely divided form and are then heated to a sufficiently high temperature to mix the ingredients and produce a homogenous mass. The heated mass is quenched in water and is then wet ground to a particle size to pass through a 400 mesh screen. The powered product may be moistened and molded to whatever shape is desired. The molded product is reheated until it is sintered or melted. When melted the material fuses readily to metal surfaces. Since the melted ceramic will not adhere to carbon, carbon molds may be used to form the ceramic to desired configurations or carbon may be used to confine the ceramic in a metal cavity during a heating operation for the purpose of causing the ceramic to fuse the metal surfaces of the cavity.

A sealing ceramic suitable for the purpose of the invention is produced by first processing two separate mixtures A and B. Mixture A may comprise the following in parts by weight:

Pb ₃ O ₄	56.8
MgO	3.0
Al ₂ O ₃	1.5
Bi ₂ O ₃	10.2
SiO ₂	28.5

After these ingredients are thoroughly intermixed the mixture is heated to at least 1900° F. to melt and form a homogeneous mass. The mass is then wet ground to fine particle size.

Mixture B may comprise the following parts by weight:

Pb ₃ O ₄	83.0
BiO ₃	6.0
SiO ₂	10.0
CeO ₂	2.0
Al ₂ O ₃	0.7

These ingredients are thoroughly intermixed and heated to at least 1200° F. to melt and form a homogeneous mass, which is then ground to small particle size.

The final mixture comprises 40 parts by weight of the powdered product of mixture A, 20 parts by weight of the powdered product of mixture B, 5 parts by weight of Pb₃O₄ and 35 parts by weight of MgTiO₃. This final mixture is heated and fused to a homogeneous mass which is then ground to finely divided form. This final powder may be molded by sintering or melting.

My description in specific detail of the preferred practices of the invention will suggest various changes, substitutions and other departures from my disclosure within the spirit and scope of the appended claims.

I claim:

1. In a device for service at high temperatures considerably greater than ambient room temperature, means structurally uniting in a fluid-tight manner two metal members spaced in a first direction, including:

at least a first ceramic body having impervious properties at the high temperatures and interposed between the two metal members in the first direction and bonded to both members to seal the space between the two members; and

at least a second ceramic body having properties of high structural strength at the high temperatures and interposed between the two members in the first direction and in engagement with the members and disposed in adjacent relationship to the first ceramic body in a second direction transverse to the first direction to bear the loads between the two members

and thus prevent destructive stressing of the first ceramic body at the high temperatures.

2. In a device for service at high temperatures considerably greater than ambient room temperature, means structurally uniting in a fluid-tight manner two metal members spaced in a first direction, including:

first and second ceramic bodies having impervious properties at the high temperatures and interposed between the two members in the first direction and bonded to both members to seal the space between the two members; and

at least a third ceramic body having properties of high structural strength at the high temperatures and interposed between the two members in the first direction and in engagement with the members to bear the loads between the two members and thus prevent destructive stressing of said two impervious bodies at high temperatures, said first and second ceramic bodies being on opposite sides of said third ceramic body to seal said third ceramic body from fluid permeation.

3. In a connector assembly for mating in a sealed manner with a complementary connector device to connect a cable having at least one conductor with the complementary device in a sealed manner for service at high temperatures above 1000° F., wherein the complementary connector device is provided with a contact element for establishing electrical continuity with the conductor of the cable, the combination of:

a tube dimensioned to telescope over the cable in a slidable manner;

a connector housing constructed at its forward end for sealing connection with said complementary connector device, the connector housing surrounding a forward portion of the tube with an annular space between the housing and the tube;

a contact element mounted in the housing for permanent connection with the conductor of the cable and releasable connection with the contact element of the complementary connector device; and

ceramic means spanning the annular space in a sealed manner and structurally uniting the housing with the tube,

the tube being made of pliable deformable material,

a portion of the tube extending rearwardly from the ceramic means and from the housing for free access to the rearwardly extending portion to permit a manual operation of deforming the tube into fixed engagement with the cable after the conductor of the cable is connected to the contact element in the connector housing and after the housing is placed in a desired installed position longitudinally of the cable.

4. A combination as set forth in claim 3 in which the housing is made in two separable sections for access to the interior thereof to permit the conductor of the cable to be connected to the contact element.

5. A combination as set forth in claim 3 in which said ceramic means comprises at least a first ceramic body having properties of being impervious even at the high temperatures and at least a second ceramic body having properties of high strength even at the high temperatures to protect the first ceramic body from destructive stresses, the first and second ceramic bodies being disposed in a contiguous and compressed relationship to each other.

6. In a connector assembly for mating in a sealed manner with a complementary connector device to connect a cable having at least one conductor with the complementary device in a sealed manner for service at high temperatures above 1000° F., wherein the complementary connector device is provided with a contact element for establishing electrical continuity with the conductor of the cable, the combination of:

a tube dimensioned to telescope over the cable in a slidable manner;

a connector housing constructed at its forward end for

sealing connection with said complementary connector device, the connector housing surrounding a forward portion of the tube with an annular space between the housing and the tube;

a contact element mounted in the housing for permanent connection with the conductor of the cable and releasable connection with the contact element of the complementary connector device;

ceramic means spanning the annular space in a sealed manner and structurally uniting the housing with the tube,

the tube being made of pliable deformable material, a portion of the tube extending rearwardly from the ceramic means and from the housing; and

means surrounding the rearward portion of the tube, the surrounding means being contractible to deform the rearward portion of the tube by radial compression into permanent engagement with the cable after the housing has been placed in a desired installed position longitudinally of the cable.

7. A combination as set forth in claim 6 in which said surrounding means comprises:

a deformable ring encompassing the tube; and

a pair of members enveloping said tube and said ring, said members having tapered interior surfaces and being interconnected for movement toward each other to obtain a deformation of said ring by said tapered surfaces of said members in a direction for obtaining a sealing engagement between said ring and said cable.

8. A combination as set forth in claim 6 in which said surrounding means comprises:

at least one Belleville washer embracing the tube, the Belleville washer being deformable to compress the tube radially into permanent engagement with the cable; and

means enveloping the Belleville washer to maintain the Belleville washer in deformed state.

9. In a connector assembly for mating in a sealed manner with a complementary connector device to connect a cable having at least one conductor with the complementary device in a sealed manner for service at high temperatures above 1000° F. wherein the complementary connector device is provided with a contact element for establishing electrical continuity with the conductor of the cable, the combination of:

a connector housing constructed at its forward end for sealing connection with said complementary connector device, the connector housing surrounding a forward portion of the tube with an annular space between the housing and the tube;

a socket element mounted in the housing for permanent connection with the conductor of the cable and to releasably engage said conductor element of the complementary connector device, said socket element comprising a pair of spaced bi-metallic members that move towards each other with increasing temperature to grip the contact element of the complementary connecting device with increased pressure; and

ceramic means spanning the annular space in a sealed manner and structurally uniting the housing with the tube,

the tube being made of pliable deformable material, a portion of the tube extending rearwardly from the housing and from the ceramic means to permit the rearwardly extending portion of the tube to be deformed into fixed engagement with the cable to anchor the housing against axial movement relative to the cable.

10. In a connector assembly for mating in a sealed manner with a complementary connector device to connect a cable having at least one conductor with the complementary device in a sealed manner for service at high temperatures above 1000° F., wherein the complementary connector device is provided with a contact element for

establishing electrical continuity with the conductor of the cable, the combination of:

a tube dimensioned to telescope over the cable in a slidable manner;

a connector housing constructed at its forward end for sealing connection with said complementary connector device, the connector housing surrounding a forward portion of the tube with an annular space between the housing and the tube;

a contact element mounted in the housing for permanent connection with the conductor of the cable and releasable connection with the contact element of the complementary connector device;

a lease a first ceramic body impervious at the high temperatures encompassing the tube inside said housing and bonded both to the tube and the housing to seal the space between the tube and the housing;

at least a second ceramic body of high structural strength at the high temperatures encompassing the tube inside the housing in engagement with the tube and the housing and in adjacent relationship to the first ceramic body to bear loads between the tube and the housing and thus prevent destructive stressing of the first ceramic body at the high temperatures, the tube being made of pliable deformable material and a portion of the tube extending rearwardly from the housing and from the ceramic bodies; and means enveloping the rearwardly extending portion of the tube, said enveloping means being radially contractible to deform the rearwardly extending portion of the tube into permanent sealing engagement with the cable.

11. In a connector assembly for mating in a sealed manner with a complementary connector device to connect a cable having at least one conductor with the complementary device in a sealed manner for service at high temperatures considerably above ambient room temperature, wherein the complementary connector device is provided with a pin contact for establishing electrical continuity with the conductor of the cable, the combination of:

a deformable tube dimensioned to telescope over the cable in a slidable manner;

a connector housing constructed at its forward end for sealing connection with said complementary connector device, the connector housing surrounding a forward portion of the tube with an annular space between the housing and the tube;

a contact element mounted in the housing for permanent connection with the conductor of the cable and for releasable connection with the pin contact of the complementary connector device;

two ceramic bodies impervious at the high temperatures encompassing said tube inside said housing and bonded both to the tube and the housing to seal the annular space between the tube and the housing;

at least a third ceramic body of high structural strength at the high temperatures encompassing said tube in said annular space and engaging both the tube and the housing to bear the load between the tube and the housing and to prevent destructive stressing of the two ceramic bodies at the high temperatures, said two impervious ceramic bodies being on opposite sides of the third ceramic body to seal the third ceramic body from fluid permeation,

a portion of the tube extending rearward from the three ceramic bodies and from the rear end of the housing for free access to the rearward portion of the tube to permit the tube to be manually deformed into engagement with the cable after the conductor of the cable is connected to the contact element in the housing.

12. In a connector assembly for mating in a sealed manner with a complementary connector device to connect a cable having at least one conductor with the comple-

mentary device in a sealed manner for service at high temperatures considerably above ambient room temperature, wherein the complementary connector device is provided with a contact element for establishing electrical continuity with the conductor of the cable, the combination of:

- a deformable tube of a diameter to telescope over the cable in a snug but slidable manner, said tube having two oppositely facing outer shoulders at an intermediate position along the length of the tube;
- a connector housing constructed at its forward end for sealing connection with said complementary connector device, the connector housing surrounding a portion of the tube that includes the two oppositely facing shoulders of the tube;
- a contact element mounted in the housing for permanent connection with the conductor of the cable and for releasable connection with the contact element of the complementary connector device;
- first and second ceramic means encompassing said tube inside said housing and in engagement with said housing and said shoulders of the tube, the first ceramic means being disposed in engagement with one of the shoulders on the tube and the second ceramic means being disposed in engagement with the other shoulder on the tube,
- a portion of the tube extending rearward from the ceramic means and from the rear end of the housing to permit said portion of the tube to be deformed into engagement with the cable after the conductor of the cable is connected to the contact element in the housing.

13. A combination as set forth in claim 12 wherein the tube is outwardly crimped to form the two oppositely facing outer shoulders.

14. A combination as set forth in claim 12 wherein the connector housing has a pair of axially spaced oppositely facing inner shoulders and wherein said first and second ceramic means respectively engage individual ones of said inner shoulders at the ends opposite to the outer shoulders of the tube.

15. A method of fabricating a sealed connection for high temperature service between a cable having at least one conductor and a cable housing, which method of fabrication is largely carried out at a manufacturing plant with only simple operations of the fabrication process carried out on the job, said method including the steps of:

- at the manufacturing plant, making the cable housing in two separate sections comprising a forward section and a rearward section with an axial passage through the rearward section and with the two sections constructed for mutual engagement in a sealed manner;
- at the manufacturing plant, mounting at least one contact element in the forward housing section;
- at the manufacturing plant, positioning in the axial passage of the rearward housing section a pliable tube of smaller outside diameter than the inside diameter of the housing and of an inside diameter to telescope slidably over the cable;
- at the manufacturing plant, bonding the tube to the rearward housing section by ceramic material surrounding the tube inside the housing with the ceramic material fused to the housing and to the tube and with a portion of the tube extending rearwardly from the ceramic material and from the rearward housing section;
- on the job, telescoping the tube over the cable with the rearward housing section carried by the tube to expose the conductor of the cable forward of the rearward housing section;
- on the job, bonding the conductor of the cable to the contact element carried by the forward housing section;
- on the job, sliding the tube and the rearward housing section carried thereby forward on the cable to bring

the two housing sections together and then engaging the two housing sections with each other in a sealed manner; and

on the job, deforming said rearward portion of the tube into sealed engagement with the cable.

16. A method of fabricating a sealed connection for high temperature service between a cable having at least one conductor and a cable housing, which method of fabrication is largely carried out at a manufacturing plant with only simple operations of the fabrication process carried out on the job, said method including the steps of:

- at the manufacturing plant, making the housing in two separate sections comprising a forward section and a rearward section with an axial passage through the rearward section and with the two sections constructed for mutual engagement in a sealed manner;
- at the manufacturing plant, mounting at least one contact element in the forward housing section;
- at the manufacturing plant, positioning in the axial passage of the rearward housing section a pliable tube of smaller outside diameter than the inside diameter of the housing and of an inside diameter to telescope slidably over the cable;
- at the manufacturing plant, bonding the tube to the rearward housing section by ceramic material surrounding the tube inside the housing with the ceramic material fused to the housing and to the tube and with a portion of the tube extending rearwardly from the ceramic material and from the rearward housing section;
- at the manufacturing plant, fabricating annular means to fit loosely over said rearward portion of the tube, said annular means being radially contractible by manual force;
- on the job, sliding the annular means and the tube onto the cable with the rearward housing section carried by the tube to expose the conductor of the cable forwardly of the tube;
- on the job, connecting the exposed conductor to the contact element in the forward housing section;
- on the job, sliding the tube and the rearward housing section carried thereby forward on the cable to bring the two housing sections together and then engaging the two housing sections with each other in a sealed manner;
- on the job, positioning the annular means on said rearward portion of the tube; and
- on the job, applying manual force to contract the annular means permanently to deform said rearward portion of the tube into permanent engagement with the cable.

References Cited by the Examiner

UNITED STATES PATENTS

1,635,830	7/1927	Gagnon	339—30
1,797,581	3/1931	Kuhn et al.	339—30
1,857,614	5/1932	Backer	174—77
2,126,002	8/1938	Gardner	174—77 X
2,138,660	11/1938	Mann	29—155.55
2,167,494	7/1939	Sykes et al.	29—155.69 X
2,352,159	6/1944	Brodie	174—77
2,503,429	4/1950	Ziegler	174—50.52 X
2,591,442	4/1952	Lacy-Hulbert et al.	29—155.69 X
2,678,366	5/1954	Hebenstreit	174—77 X
2,873,342	2/1959	Drugmand	338—274 X
2,888,656	5/1959	Bremer	174—77 X
2,982,937	5/1961	Gregoire et al.	339—30 X

FOREIGN PATENTS

144,769	2/1936	Austria.
510,738	3/1955	Canada.
776,904	11/1934	France.