ABSTRACT
An electrical connector means for use in an adverse hostile fluid environment such as a subsea installation, and comprising electrical contact members embedded in and normally covered by a dielectric material having a relatively soft deformable resilient surface means having raised portions which under pressure engagement are adapted to be penetrated by one of the contact members which includes a hard contact point while the other contact member includes a relatively soft contact portion to make full electrical contact under pressure. Shims between housing portions are also provided to limit and control the depth of penetration thereby permitting repeated use of the connector means with full electrical contact.

8 Claims, 9 Drawing Figures
SELF-HEALING ELECTRICAL CONNECTOR MEANS

BACKGROUND OF THE INVENTION

In subsea well operations electrical power is frequently used for operation of certain well equipment and it is necessary to provide releasable electrical connections in the adverse environment or climate of sea water. It is desirable to minimize or eliminate exposure of electrical contact members to the deleterious and corrosive action of the salt water.

Prior proposed connector means for minimizing the deleterious effect of salt water on electrical connections have included self-sealing convexly curved discs placed between connector housing portions, the convex surfaces upon assembly of the connector parts serving to extrude outwardly any salt water therebetween and to prevent entrainment of small quantities of salt water in the electrical connector. In Minto U.S. Pat. 2,703,870 connector pins were advanced under pressure to penetrate the self-sealing discs and to be received in contact receptacles on the opposite side of the discs. In application Ser. No. 828,831 filed May 29, 1969, now U.S. Pat. No. 3,657,681 (owned by a common assignee) electrical contact elements were provided with contact faces exposed on convex resilient surfaces which under pressure engagement expelled outwardly foreign fluid material between the surfaces.

Another type of subsea electrical connector in which means are provided for expelling fluid away from the contact-making members is shown in Nelson U.S. Pat. No. 3,478,298.

SUMMARY OF THE INVENTION

The present invention relates to a self-sealing multi-contact electrical connector means constructed for use in an adverse hostile environment wherein exposure of electrical contact elements to such hostile fluid environment is virtually eliminated and a full effective electrical contact may be repeatedly made during prolonged use of the electrical connector means.

An object of the present invention is to provide an electrical connector means of novel construction which may be exposed to a hostile fluid environment for long periods of time without deterioration of its electrical properties.

Another object of the present invention is to provide a novel construction of the electrical contact members and covering deformable resilient dielectric material whereby improved pressure distribution at electrical contact-making portions is enhanced.

Another object of the present invention is to provide an electrical connector means for subsea use wherein electrical contact members are virtually sealed against intrusion of sea water at all times.

A further object of the present invention is to provide an electrical connector means wherein means are provided for adjusting, controlling, and regulating the pressure contact of one contact member with an opposed contact member.

A further object of the present invention is to provide an electrical connector means wherein contact-making faces of electrical contact members are covered with a deformable resilient dielectric material and wherein one of the contact members is provided with means for penetrating the covering resilient material for embedment in pressure electrical contact relation in the opposed electrical contact member.

A still further object of the present invention is to provide electrical connector means wherein pressure engagement surfaces of deformable resilient dielectric material are configured in the form of raised portions at electrical contact members to provide improved uniform pressure engagement upon making electrical contact.

Generally speaking the present invention comprises an electrical connector means including a housing having separable housing portions, each having a chamber provided with dielectric material in which electrical contact members are embedded and covered by a relatively soft deformable resilient dielectric material portion, one of said contact members having a hard pointed means for penetrating said deformable dielectric portions for embedment in electrical contact in a relatively soft contact member, said resilient dielectric material portions being self-sealing. The ends of the contact members and covering resilient material are located with respect to housing portion positioning surfaces whereby removable shim means between said positioning surfaces may be utilized to regulate depth of penetration of the electrical contact member having said pointed penetrating means.

Various other objects and advantages of the present invention will be readily apparent from the following description of the drawings in which exemplary embodiments of the invention are shown.

IN THE DRAWINGS

FIG. 1 is an exploded elevational view partly in section of separable housing portions of a connector means embodying this invention, the section being taken in a longitudinal plane passing through the axis of the connector means. FIG. 2 is an enlarged fragmentary sectional view taken in the same plane as the section in FIG. 1 illustrating the housing portions in one of the assembled positions. FIG. 3 is a view similar to FIG. 2 and shows another closed position of the housing portions to illustrate control of depth of penetration of an electrical contact member.

FIGS. 4a and 4b are schematic end face views of the resilient contact surfaces of the two housing portions, FIG. 4a showing the male portion and FIG. 4b the female portion. FIGS. 5a and 5b are similar to FIGS. 4a and 4b and schematically illustrate a different arrangement of contact portions, FIG. 5a showing the male portion and FIG. 5b the female portion.

FIGS. 6a and 6b are similar to FIGS. 4a and 4b and schematically show a different modification of the contact members, FIG. 6a showing the male portion and FIG. 6b the female portion.

In FIG. 1 is shown an exploded view of an electrical connector means indicated at 10 embodying the present invention, said connector means 10 generally comprising a connector housing means 11 including separable housing portions 12 and 14, each housing portion 12 and 14 providing a suitable connection for ends 15 and 16 of cable or electrical wire to be electrically connected by the connector means 10. It will be understood that the cable 15 and 16 may be of any construction and that the entrance of the cable ends to the hous-
ing portions may be of suitable water-resistant and waterproof construction.

Housing portion 12 forms a receptacle for housing portion 14 by the provision of an enlarged outer hollow chamber 18. Interiorly of outer chamber 18 housing portion 12 is provided with an inner chamber 19 having a reduced diameter or size as compared to chamber 18 to thereby define an annular limiting and positioning face 20. Interiorly of chamber 19 housing portion 12 may be provided with a hollow cable terminating chamber 21 having an opening 22 for entry of cable end 15.

To provide a watertight entrance for cable end 15 opening 22 may be threaded for threaded connection as at 23 with a fitting 24 having internal threads for threaded connection at 25 to an insert bushing 26 through which cable end 15 is passed. Bushing 26 and fitting 24 provide a cooperable wedge or pressure surfaces for a resilient seal member 27 adapted to contract about cable end 15 in sealing pressure engagement therewith as insert bushing 26 is turned relative to fitting 24.

In this example, housing portion 12 is shown mounted on a bulkhead or wall 29 by a plurality of spaced screw bolts 30 having threaded engagement at 31 with threaded bores in the body of housing portion 12.

Interior hollow chamber 19 defines with cable end chamber 21 an annular seat or shoulder 34 for dielectric means 35 snugly fitted in chamber 19. Dielectric means 35 may include a relatively hard non-deformable base portion 36 of water-resistant dielectric material such as a hard neoprene material. Non-deformable base portion 36 may be provided with one or more bores 37 through which may extend electrical connector pins 38 having a head 39 constructed to secure one end 40 of conductor element 41 from cable end 15 to the conductor pin 38. On the opposite face of dielectric base portion 36, which may be of cylindrical disk-like form, may be bonded a cylindrical disk-like portion 43 of deformable, relatively soft resilient dielectric material such as a soft neoprene. Connector pin 38 is provided with an electrical contact member 44 which snugly fits in an enlarged rearwardly facing opening 45 provided in soft dielectric portion 43, said enlarged contact member 44 being seated as at 46 upon the hard base dielectric portion 36.

The deformable soft resilient dielectric portion 43 of the dielectric means 35 may include end surface means 48 comprising a plurality of raised portions 49 covering and sealing the end face of contact member 44. Thus end surface means 48 comprises a plurality of raised portions 49 and non-raised portions 50 lying between said raised portions in a suitable selected pattern depending upon the arrangement of the contact members 44 in the dielectric means 35. Several arrangements of such raised portions and contact members are shown in FIGS. 4–6 inclusive and will be described hereafter.

In this example of the invention, the receptacle housing portion 12 includes contact member 44 provided with a pointed hard contact point 52, normally adapted to be surrounded and covered by the resilient material of raised portion 49. Each of raised portions 49 cover the end face of a contact member and each raised portion 49 preferably includes a flat planar face 53 which extends above the plane of the non-raised surfaces 50 which may lie approximately in the transverse plane which includes the annular positioning faces 20.

Connector housing portion 14 may be constructed internally generally similar to housing portion 12 and includes a hollow chamber 60 having a depth approximately the same as chamber 19 and having an interior cable end chamber 61 adapted to receive the end of cable 16 for similar connection of wire lead 62 to a connector pin 63 having an enlarged electrical connector member 64, said pin and member 63, 64 respectively being embedded in dielectric means 65. Similar to the construction of dielectric means 35, means 65 includes a hard rigid non-deformable base portion 66 of suitable dielectric materials such as a hard neoprene and seated on an annular seat 67 defined by chambers 60 and 61. Dielectric means 65 also includes a soft deformable resilient portion 68 of dielectric material in which connector member 64 is embedded and covered by end surface means 69 provided with a plurality of correlated raised portions 70 and non-raised portions 71. Non-raised surface portions 71 lie in the plane of limiting or positioning annular end face 72 having a diameter similar to positioning face 20.

In this example, housing portion 14 includes a cable socket 74 of tapered or frusto-conical form through which cable end 16 passes and which may be attached to the body of housing portion 14 by suitable headed bolts 75.

Electrical contact member 64 in housing portion 14 includes a planar end face 77 of relatively soft electrical conducting material. The plane of the face 77 of connector member 64 may lie at least as far forward as the plane of positioning face 72 and in this example in FIGS. 1 and 2, the plane of the end face lies forwardly of the plane of positioning face 72.

It will be noted that the assembly of the dielectric means 35 and 65 with their respective contact members 44 and 64 is similar and both hard and soft composite dielectric disk portions occupy substantially the entire chambers 19 and 60 respectively. To facilitate alignment and registration of the contact members 44 and 64, the bodies of housing portions 12 and 14 may be provided with registration pins 80 and 81 respectively which extend into the hard dielectric base portions 36 and 66 to provide registration of the contact members 44 and 66 relative to their respective housing portions 12 and 14. In assembly, housing portions 12 and 14 may be suitably notched with respect to such registration pins so that the covered contact members and the raised portions thereof may be suitably identified in numerical sequence and in desired opposition for electrical contact.

Means for urging housing portions 12 and 14 toward each other to make electrical contact and to pressure engage the raised dielectric portions may comprise an annular V-shaped groove 84 in the external surface of the body of housing portion 14 slightly rearwardly of the plane defined by the annular seating face 67. The housing portion 12 may be provided at selected spaced intervals about its external circumference and at outer chamfer 18 with threaded openings 85 which threadedly receive lock bolts 88 having a polygonal outer head 89 and a conical wedge surface 80 on its inner end. When housing portion 14 is inserted into outer chamber 18 with the lock bolts 88 retracted, positioning face 72 will be disposed opposite positioning face 20 in housing portion 12.

In the initial make-up of the connector means, shim means comprising a maximum number of shim ele-
ments 92 may be seated on face 20 for selectively spacing the end faces of contact members 44 and 64 to provide selected initial depth penetration of point 52 into contact member 64.

Upon assembly, as best shown in FIG. 2, lock bolt 88 may be urged inwardly to pressure engage as at 94 the conical wedge face 90 of the bolt with the inclined surface 95 of the V-shaped groove 84 on housing portion 14. Tightening of bolts 88 about the circumference of housing portion 12 will urge the housing portion 14 inwardly and before positioning face 72 engages shim means or elements 92, the planar faces of the raised portions 49 and 70 will abut in pressure engagement as at 96 and upon radial outward flow of the raised portions into the unscrewed sections of the end surface means, the hard point 52 of contact member 44 will penetrate the soft resilient covering of its dielectric material 43 and also the soft resilient covering of the opposed raised portion of dielectric material 68 for penetration and embedment at 97 of the hard point 52 in the soft face contact member 64. Upon pressure contact of face 72 with shim elements 92, point 52 will be embedded a preselected initial depth in the soft metal of contact member 64.

Upon entry of housing portion 14 into chamber 18 of housing portion 12, a seal ring 98 such as an O-ring carried in an annular channel 99 adjacent the annular face 72 engages an annular sealing surface 100 provided adjacent the interior end of chamber 18 and of slightly reduced diameter to provide a close seal fit as at 101 with seal ring 98. Since a small amount of salt water may become entrapped between the end face of housing portion 14 and the opposed end surface means 48 of the dielectric means 35, a small weep hole 103 may be provided in housing portion 12 adjacent shim elements 92.

Thus when the lock bolts 88 are successively and uniformly tightened around the circumference of housing portion 12 and the end surface means 69 and 48 are urged towards each other for pressure engagement of the raised portions 53 and 77, the resilient character of the raised portions will squeeze and extrude any foreign fluids or particles from between said surfaces and into the space provided by the non-raised portions of the end surface means. The provision of the raised portions in pressure tight engagement provides uniform pressure engagement of the raised portions under conditions of high contact pressure so that the covering surface portions are readily penetrated by the hard point 52 for making an effective electrical contact with contact member 64. It will be apparent that under these conditions of electrical contact made in a pressure-tight sealed environment about the contact members that the contacting surfaces of the contact members at which electrical contact occurs is effectively protected against the inclusion or the continued presence of foreign fluids or matter such as salt water.

Since there may be frequent occasions when the electrical contacts must be broken or disconnected in some types of electrical underwater service, shim means 92 provide for controlled or regulated depth of contact of hard point 52 with soft contact member 64 by successively removing a shim element upon disassembly of the housing portions 12 and 14 so that when the housing portions are reassembled and urged into pressure engagement, the hard point 52 will make a slightly deeper and increased pressure contact with the electrical contact member 64. Thus the connector means be employed over a prolonged period of time during which an electrical connection has been repeatedly made and broken as required by the maintenance service. FIG. 3 shows such a condition in which two of the exemplary shim elements have been already withdrawn and the hard point 52 is embedded slightly deeper in contact member 54.

It will be understood that the arrangement of the contact members 44 and 64 may vary for different types of electrical installation. In FIGS. 5A and 5B, housing portion 12 may include a similar arrangement of hard contact members 44' as described with respect to the prior embodiment. However, in this example in FIG. 5B, which shows housing portion 14 and end surface means 69, the raised portions providing the contact members 64' may be shaped in the form of arcuate segments so that relative rotational movement of housing portion 14 with respect to housing portion 12 will be less critical and electrical contact may be made in several different relative angular displacements of housing portion 14 with respect to housing 12. The contact members 64' are covered by the resilient soft material of the disk portion 68 as in the previous embodiment.

In FIGS. 6A and 6B, a slightly different arrangement of contact members is shown in which housing portion 12 includes contact members 44'' spaced angularly at 120° with respect to the axis of housing portion 12 and at different radii as indicated by A, B, and C. In FIG. 6B, the mating housing portion 14 includes contact members of annular or ring form such as contact members 64A, 64B and 64C. The annular contact members 64A, B, and C are concentrically arranged at the radii indicated by A, B and C respectively in FIG. 6A and thereby afford electrical contact with the hard contact member 52 of each of the contact members 44'' in any relative angular displacement of housing portion 14 with respect to housing portion 12. As in the prior embodiments, the contact faces of annular rings 64A, 64B and 64C are covered by the resilient material of the end surface means of the dielectric means of the housings.

The dielectric means 35 and 65 provide hard base portions 36 and 66 respectively which permit the imposition of relatively high pressure engagement of the contact members since it will be noted that contact members 44 and 64 respectively are enlarged and are seated on the interface surface of hard base portions 36 and 66. The relatively soft resilient material of the disk portions 43 and 68 respectively assist in tightly and effectively sealing the dielectric means in the housing portions, sealing effectively about the contact members 44 and 64, and after penetration of the end surface means at the raised portions 53 and 77 act to self-seal any opening or penetration made by the hard point 52 when the housing portions are separated.

Various modifications and changes may be made in the examples of the invention described above and which may come within the spirit of the invention and all such changes and modifications coming within the scope of the appended claims are embraced thereby.

1. Electrical connector means for use in a hostile environment, comprising, in combination:
   a connector housing means including separable housing portions provided with hollow chambers and annular positioning faces in opposed relation;
dielectric means in each chamber;  
on one of said housing portions having an enlarged outer cylindrical wall to receive the other housing portion to position said dielectric means and said positioning faces in proximate relation;  
an electrical contact means carried in each chamber and embedded in said dielectric material;  
said dielectric means in each chamber including planar end surface means at about the plane of its respective annular positioning face,  
each end surface means including a raised portion longitudinally aligned with and covering an electrical contact means,  
one of said contact means extending into said raised portion,  
said raised portions of said dielectric means on said separable housing portions having raised self-sealing generally flat faces for pressure contact over a limited area when said housing portions are in assembled operative relation,  
said raised portions being longitudinally compressible and each portion being adapted to flow into non-raised sections of said surface means to reduce the material cross section of said raised portions,  
said raised faces being penetrated by said one of said electrical contact means for making electrical contact between said contact means;  
and means carried by said one housing portion at said outer cylindrical wall to engage the other housing portion for urging said housing portions toward each other to make said electrical contact and to engage under high contact pressures over said limited area said raised self-sealing faces.  

2. In a means as stated in claim 1 wherein said dielectric means includes:  
a a relatively non-deformable dielectric material at the bottom portion of each chamber,  
and a relatively deformable resilient dielectric material at the upper portion of each chamber,  
said deformable resilient material providing said end surface means including said raised portions,  
each of said contact means being embedded in both non-deformable and deformable dielectric material of each dielectric means;  
and each contact means having a shoulder seated on the non-deformable dielectric material.  

3. In a subsea electrical connector construction, the combination of:  
a housing means comprising separable housing portions each having a hollow internal chamber;  
one of said housing portions having an outer enlarged cylindrical wall to receive the other housing portion and its internal chamber;  
dielectric means confined each chamber including a deformable relatively soft resilient dielectric portion adjacent the opening to each internal chamber;  
an electrical contact member embedded in each dielectric means and having a contact surface covered by and adjacent to the surface of said deformable dielectric portion;  
at least one of said deformable portions having a raised portion of selected discrete area covering said contact surface of said electrical contact member embedded therein;  
said electrical contact surface in said raised portion including means to penetrate said resilient dielectric portions;  
and a connecting means at said cylindrical wall to move said housing portions relative to each other to engage said raised dielectric portion of discrete area with the opposed soft dielectric portion to cause penetration of said soft dielectric portions to make an electrical contact between said contact members and to impart localized high pressure contact between said raised portions and said opposed soft dielectric portions to purge said contact surfaces of foreign particles.  

4. In a subsea connector construction as stated in claim 3 including  
means at said deformable portions operable with said housing portions for regulating the depth of penetration of said electrical contact members.  

5. Electrical connector means for use in a hostile environment, comprising, in combination:  
a connector housing means including separable housing portions provided with hollow chambers and annular positioning faces in opposed relation;  
dielectric means in each chamber;  
an electrical contact means carried in each chamber and embedded in said dielectric material;  
said dielectric means in each chamber including an end surface means at about the plane of its respective positioning face,  
said end surface means including a raised portion longitudinally aligned with and covering said electrical contact means,  
said raised portions of dielectric means on said separable housing portions having raised self-sealing faces for pressure contact when said housing portions are in assembled operative relation,  
said raised portions being adapted to flow into non-raised sections of said surface means,  
said raised faces being penetrated by at least one of said electrical contact means for making electrical contact between said contact means;  
means for urging said housing portions toward each other to make said electrical contact and to pressure engage said raised self-sealing faces;  
and means interposed between said annular positioning faces to regulate the depth of penetration of said one of said electrical contact means;  
said depth regulating means including shim elements removably positioned between said positioning faces.  

6. A subsea electrical connector comprising:  
mating connector housing portions each having a hollow chamber with an opening;  
a composite dielectric means in each chamber comprising a hard dielectric portion at the bottom of the chamber and a soft dielectric portion seated therein and facing in the direction of the opening of the chamber;  
each soft dielectric portion having raised portions for pressure sealing engagement with aligned raised portions on the opposed soft dielectric portion in the other housing portion to provide discrete high pressure spaced contact areas for purging said areas of foreign particles;  
an electrical contact member in each composite dielectric means, each contact member including a pin portion extending through said hard dielectric
portion and an enlarged contact portion having a shoulder seated on said hard dielectric portion and immovably embedded in said soft dielectric portion,
said enlarged contact portion having a contact face covered by one of said raised portions;
one of said contact faces having a contact point for penetrating opposed raised portions;
positioning means on said housing portions for regulating the space between opposed contact faces to provide changeable electrical contact engagement;
and means on said housing portions for urging said housing portions toward each other for compressing said soft raised portions to expel fluid therebetween, to electrically engage said contact portions, and to seal said electrically engaged contact portions.

7. Electrical connector means for use in a hostile environment, comprising, in combination:
a connector housing means including separable housing portions provided with hollow chambers and annular positioning faces in opposed relation;
dielectric means in each chamber;
an electrical contact means carried in each chamber and embedded in said dielectric material;
said dielectric means in each chamber including planar end surfaces means at about the plane of its respective annular positioning face,
each end surface means including a raised portion longitudinally aligned with and covering an electrical contact means,
one of said contact means extending into said raised portion,
said raised portions of said dielectric means on said separable housing portions having raised self-sealing generally flat faces for pressure contact when said housing portions are in assembled operative relation,
said raised portions being longitudinally compressible and each portion being adapted to flow into non-raised sections of said surface means to reduce the material cross section of said raised portions, said raised faces being penetrated by said one of said electrical contact means for making electrical contact between said contact means;
means for urging said housing portions toward each other to make said electrical contact and to pressure engage said raised self-sealing faces;
and means interposed between said annular positioning faces to regulate the depth of penetration of said one of said electrical contact means.

8. A subsea electrical connector comprising:
mating connector housing portions each having a hollow chamber with an opening;
a composite dielectric means in each chamber comprising a hard dielectric portion at the bottom of the chamber and a soft deformable dielectric portion facing in the direction of the opening of the chamber;
each soft dielectric portion having raised portions for pressure sealing engagement with aligned raised portions on the opposed soft dielectric portion in the other housing portion;
an electrical contact member in each composite dielectric means, each contact member including a pin portion extending through said hard dielectric portion and an enlarged contact portion having a shoulder seated on said hard dielectric portion and immovably embedded in said soft dielectric portion,
said enlarged contact portion having a contact face covered by one of said raised portions;
one of said contact faces having a contact point for penetrating opposed raised portions;
means for regulating the space between opposed contact faces to provide desired electrical contact engagement;
means for urging said housing portions toward each other for compressing said soft raised portions to expel fluid therebetween, to electrically engage said contact portions, and to seal electrically engaged contact portions; and
said regulating means including opposed positioning faces on said housing portion;
and removable shim means between said positioning faces for modifying the space between opposed contact faces.

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