Aug. 11, 1970 D. B. ROBINSON 3,524,160

UNDERWATER OPERABLE CONNECTOR

Filed Sept. 17, 1968 2 Sheets-Sheet 1

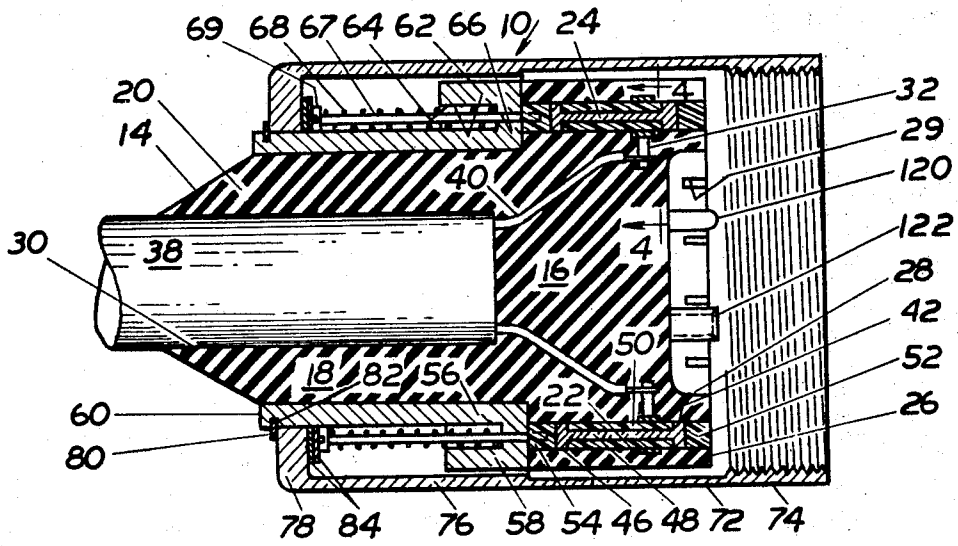


Fig. 1.

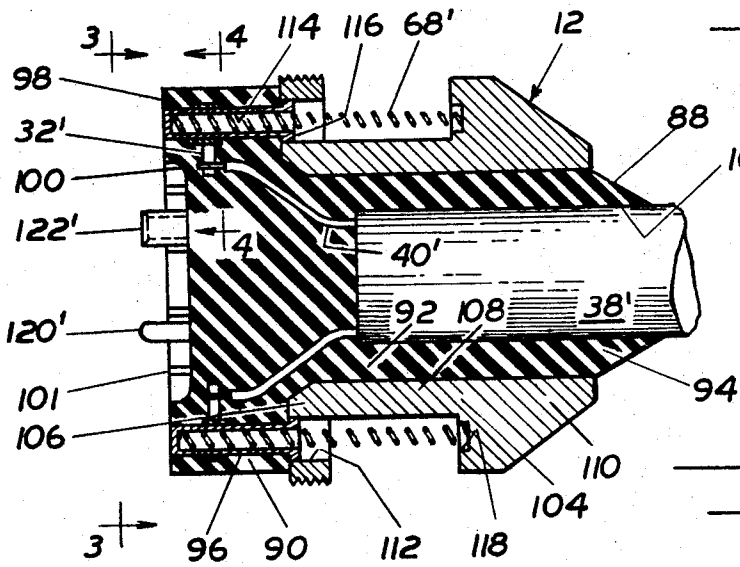


Fig. 2.

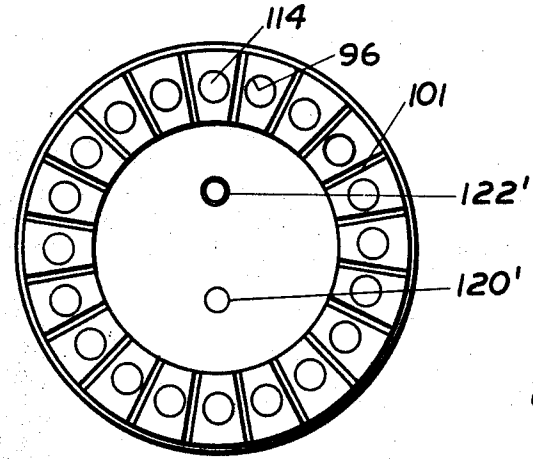


Fig. 3.

Inventor
Donald B. Robinson.

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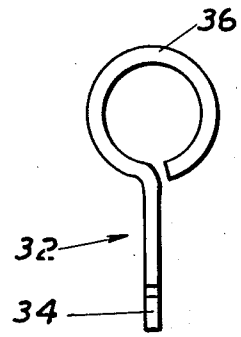


Fig. 4.

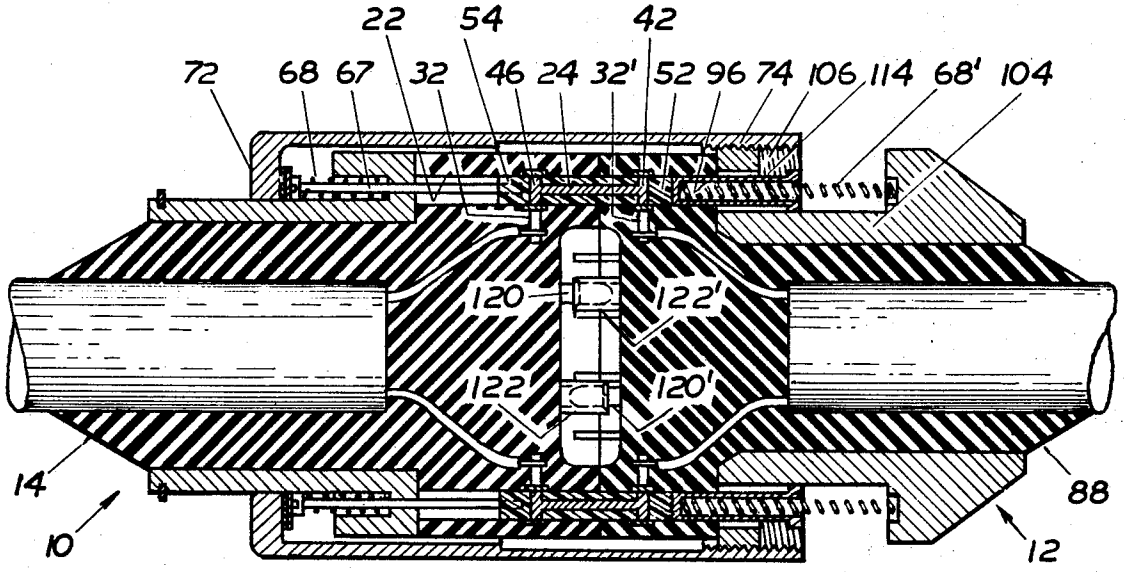


Fig. 5.

Inventor
Donald B. Robinson.

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3,524,160

UNDERWATER OPERABLE CONNECTOR

Donald B. Robinson, 538 Iron Ave.,
Dover, Ohio 44622

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Int. Cl. H01r *13/44, 33/36*
U.S. Cl. 339—34 10 Claims

ABSTRACT OF THE DISCLOSURE

An electrical connector having mating housings formed to establish and/or break an electrical circuit while immersed in an electrolytic fluid.

This invention provides an electrical connector having contacts in the line and load side housings which are sealed off from any outside environment when the housings are either in a mated or unmated position. Additionally, the connector of this invention can be coupled and uncoupled while electrically energized and submerged in any liquid electrolyte, for example water, without causing an electrical short circuit. In other words an underwater operable connector capable of preventing contact between connectors and ambient liquid during coupling and uncoupling operations.

These and other objects and advantages of this invention will become apparent to those skilled in this art upon consideration of the following detailed description and drawings of a referred embodiment of this invention in which:

FIG. 1 is a cross-sectional view of a line side housing embodying the principles of the present invention;

FIG. 2 is a cross-sectional view of a load side housing embodying the principles of the present invention;

FIG. 3 is an end view of the load side housing taken on line 3—3 of FIG. 2;

FIG. 4 is a detail view of an electrical contact; and

FIG. 5 is a cross-sectional view of an assembled electrical connector embodying the present invention.

FIGS. 1 through 5 illustrate one preferred embodiment of an electrical connector of the present invention comprising an elongated line side housing **10** mated with an elongated load side housing **12** each of which have main body portions thereof formed from any suitable resilient insulating material, such as molded neoprene or rubber.

As is shown in FIG. 1 the line side housing **10** has an elongated main body portion **14** which extends rearwardly (to the left in FIG. 1) from a mating face **26** and comprises: a cylindrical forward portion **16**; a cylindrical intermediate portion **18** having an outside diameter thereof smaller than the outside diameter of portion **16**; and a frusto conical rearwardly tapering end portion **20** extending rearwardly from portion **18**. A plurality, as shown **20**, of axially extending circumferentially spaced through bores **22**, are provided in the forward body portion **16** intermediate the outer periphery thereof and the outer periphery of portion **18** for receiving movable contacts **24** therein, in a manner hereinafter described. A rearwardly extending coaxial cylindrically shaped shallow recess **28**, which extends rearwardly from the forward mating face surface **26** of body portion **16**, has an outside diameter thereof approximately equal to the outside diameter of body portion **18**. A plurality of rearwardly extending deforming slots **29**, circumferentially spaced at alternate intervals with bores **22**, are provided on mating face **26** to a depth forwardly adjacent the rearward surface of recess **28** for a purpose hereinafter described. A coaxial cylindrical cable receiving bore **30**, extends axially forwardly from the rear end of body portion **20** with the

forward end thereof located rearwardly adjacent the forward end of body portion **18**.

Referring to FIG. 4, an elongated electrical contact **32** constructed of any suitable material, for example silver plated beryllium copper, comprises an axially extending lower lug strap portion **34** and an upper circular collar or loop portion **36**, the inside diameter of which is equal to the diameter of bore **22**. In forming of body portion **14**, each contact **32** has portion **36** thereof positioned around a respective bore **22**, intermediate the body portion **16** with the lower lug portion **34** thereof extending radially inward therefrom. As shown, one fixed electrical contact **32** is provided for each bore **22**.

A multiple conductor cable **38** is received within bore **30** and at the forwardmost end thereof the cable insulation is stripped away to provide a plurality, as shown **20**, of electrical conductors **40**. Conductors **40** are electrically connected to the lower ends of lug straps **34**, respectively, prior to the forming of body portion **14** and positioning of contacts **32**.

The elongated movable contact **24** is of any suitable electrical conductive material, for example a phosphorous bronze alloy, and comprises identical forward and rearward circular end portions **42** and **46**, respectively, which have a diameter thereof equal to the diameter of bore **22** and an axial length thereof equal to the strip width of the fixed contact **32**, and a relatively long slender intermediate portion **48** having a diameter thereof less than the diameter of the end portions **42** and **46**. An insulating sleeve **50** of a hard insulating material, such as Bakelite or the like, which has an axial length thereof equal to the axial length of portion **48** and an outside diameter thereof slightly greater than the outside diameter of end portions **42** and **46** is provided around portion **48**.

In the position shown in FIG. 1, the movable contact **24** is located within bore **22** intermediate the axial ends thereof so that the inner periphery of portion **36** of fixed contact **32** is in contact with the outer periphery of insulating sleeve **50** intermediate the axial end thereof. At the forward and rearward ends of the movable contacts **24**, identical bore sealing elements or insulating plugs **52** and **54**, respectively, of a hard insulating material, such as Bakelite or the like, which have an outside diameter thereof slightly larger than the diameter of bore **22**, are securely affixed, in any suitable manner, to the axial ends of contacts **24** and slidably and sealably received within bores **22** by deforming the peripheral walls thereof radially outward. The deformation of the walls of bores **22** are facilitated by deforming slots **29**. Plugs **52** and **54** and contact **24** are axially aligned and have a total axial length approximately equal to the axial length of bore **22**.

A hollow elongated rigid sleeve **56**, preferably formed from stainless steel, having an inside diameter and an axial length thereof equal respectively to the outside diameter and axial length of the intermediate body portion **18**, comprises a forward portion **58** which has an outside diameter thereof equal to the outside diameter of body portion **16**, and a rearward portion **60** having a lesser outside diameter thereof than the outside diameter of portion **58**. Sleeve **56** is snugly and non-rotatably received around the outer periphery of body portion **18** having the forwardmost surface of sleeve portion **58** in contact with the rearward surface of body portion **16**.

A plurality, as shown **20**, of axially extending through step bores **62**, coaxial with the respective bores **22** in the main body **14** are provided in the forward sleeve portion **58**, and comprise a rearward portion **64** and a forward portion **66** of a lesser diameter than portion **64**. A cylindrical rigid contact carrier rod **67**, preferably formed from stainless steel, of a diameter approximately equal

to the diameter of bore portion **66**, extends axially forward from a rear end thereof located intermediate sleeve portion **60**, through bore **58** and is firmly secured at the forwardmost end thereof to the rearward insert plug **54**. A contact carrier return spring **68**, of an outside diameter approximately equal to the diameter of bore portion **64**, encompasses a portion of the contact carrier rod **67** which extends from the rearwardmost end of rod **67** to the forwardmost end of bore portion **64**. A retaining head **69** is provided in the rearwardmost end of rod **67** to prevent the spring **68** from sliding off the rod **67**. Thus, when the line side housing **10** is coupled with the load side housing **12**, the contact carrier rod is forced axially forward thereby compressing the contact carrier return spring **68** and moving the movable contact **24** axially forward until the outer periphery of portion **46** comes into contact with the circular portion **36** of the fixed contact **32**, thereby carrying electrical current through the movable contact **24** and completing a circuit with the load side housing **12**. When housings **10** and **12** are uncoupled, the spring bias of the contact carrier spring **68** causes the contact carrier rod **67** to return to the uncoupled position.

An elongated rigid coupling casing **72**, preferably formed from stainless steel, of a generally annular cross section, having a constant outside diameter, comprises: a forward internally threaded portion **74** having an inside diameter thereof slightly larger than the outside diameter of body portion **16**; an intermediate portion **76** with an inside diameter thereof essentially equal to the inside diameter of portion **74**; and a rear housing engaging portion **76** which has an inside diameter thereof equal to the outside diameter of sleeve portion **60**. Casing **72** is axially dimensioned so that when the main body portion **14** is fitted therewithin and the contact carrier return spring **68** is in the unrestrained position thereof, portion **78** of casing **72** has the inner periphery thereof in contact with and is slidably and rotatably received by the outer periphery of sleeve portion **60** forwardly adjacent the rearward end thereof and portion **74** of casing **72** is located axially forward of the mating face **26**. An annular stop bar **80** is rigidly affixed in a groove **82** provided in sleeve portion **60** rearwardly adjacent the rear end of the casing portion **78** to prevent the casing **72** from sliding rearward thereof. A plurality, as shown 2, of annular washers **84** are slidably and rotatably received around the outer periphery of sleeve portion **60** intermediate the forward face of casing portion **78** and the rearward end of the carrier retaining rod heads **69**. Portion **74** of casing **72** threadably engages the load side housing **12** and urges the movable contact **24** axially forward to complete an electrical circuit.

As is shown in FIG. 2 the load side housing **12** has an elongated main body portion **88** which extends rearwardly (to the right in FIG. 2) from a mating face **98** and comprises: a cylindrical forward portion **90** having an outside diameter thereof equal to the outside diameter of portion **16** of main body **14**; a cylindrical intermediate portion **92** which has an outside diameter thereof smaller than the outside diameter of portion **90**; and a frusto-conical rearwardly tapering end portion **94** extending rearwardly from portion **92**. A plurality, as shown **20**, of axially extending circumferentially spaced through bores **96** which have a diameter thereof equal to the diameter of bores **22** of body portion **14**, are provided in body portion **90** intermediate the outer periphery thereof and the outer periphery of portion **92** and are so positioned that when housings **10** and **12** are in a coupled position, bores **96** of housing **12** will be in axial alignment with bores **22** of housing **10**. The mating face **98** of body portion **90** has a rearwardly extending coaxial cylindrically shaped shallow recess **100** therein which has an outside diameter thereof equal to the outside diameter of recess **28** of housing **10**. A plurality of rearwardly extending deforming slots **101**, alternately circumferentially spaced with bores **96**, are provided on mating face **98** to a depth forwardly adjacent the forward surface of recess **100** for a purpose hereinafter described. A coaxial cylindrical cable receiving bore **102** extends axially forwardly from the rearward end of body portion **94** to a forwardmost point thereof located intermediate the length of portion **92**.

As heretofore described with reference to housing **10** and herein designated with like numbers primed, a cable **38'** is received in bore **102** and at the forwardmost end thereof the cable insulation is stripped away to reveal insulated conductors **40'** which are electrically connected to the lug straps **34'** of fixed electrical contacts **32'**. Portion **36'** of contact **32'** is positioned around bore **96** in the forming of body **98** in a manner hereinbefore described.

A hollow elongated cylindrical rigid sleeve **104**, preferably formed from stainless steel and having a constant inside diameter and an axial length thereof equal, respectively, to the outside diameter and axial length of the intermediate body portion **92**, comprises: a forward portion **106**, the outside surface of which is threaded along the entire axial length thereof to cooperate with the threaded portion **74** of casing **72** when housings **10** and **12** are coupled; an intermediate portion **108** which has an outside diameter thereof less than the outside diameter of portion **106**; and a rearward portion **110** having a cylindrical forward end of an outside diameter substantially equal to the outside diameter of body portion **90** and a frusto-conical rearwardly tapering end extending rearwardly therefrom. Sleeve **104** is snugly and non-rotatably received around the outer periphery of body portion **92** having the forwardmost surface of portion **106** in contact with the rearwardmost surface of body portion **90**.

A plurality, as shown **20**, of axially extending through bores **112**, coaxial with bores **96** of the main body **88** are provided in the rearward threaded portion **106**. An elongated cup-shaped rigid spring receiving chamber member **114**, preferably formed from stainless steel, having a radially outwardly extending flange **116** at the open end thereof is slidably received within bore **112** so that the forward surface of flange **116** is in contact with a portion of the rearward surface of portion **106**. As shown, the axial length of member **114** forward of flange **116** equals the axial length of bore **112**. A contact carrier return spring **68'**, having an outside diameter thereof approximately equal to the inside diameter of member **114**, is received within member **114** and in the uncompressed state thereof extends from the forward end of member **114** to the forward face of body portion **94** where a circular depression **118** of a diameter equal to the diameter of spring **68'** snugly receives the forward end of spring **68'** therein.

A polarizing pin **120** and a polarizing pin receiving chamber **122**, of any suitable construction, are firmly fixed to the rearward surface of recess **28** on a common diameter equally intermediate the outer periphery and center thereof and extend axially forward thereof to a point forwardly adjacent the mating face **26**. Pin **120** and chamber **122** cooperate, respectively, in a manner well known in the art with a chamber **122'** and a pin **120'**, which are conjugately mounted at the forward end of housing **12**, when housings **10** and **12** are coupled in a manner hereinafter described.

In assemblying an electrical connector as described, pins **120** and **120'** are respectively inserted into chamber **122'** and **122**, thereby orienting the housing electrical contact into the desired polar relationship. Housing mating faces **26** and **98** are brought into contact where the forwardmost interior thread of coupling casing portion **74** engages the forwardmost exterior thread of sleeve portion **106**. The housing coupling casing **72** is rotated about the central axis thereof, thereby threading casing **72** onto sleeve **104** which causes the contact carrier rod **67** to move axially forward with respect to mating face **26** and the contact carrier return spring **68** to compress axially from the uncoupled position thereof. Bores **22**

and 96 are in axial alignment, therefore, rod 67 forces the forward insulating plug 52 to enter a bore 96, thereby urging the spring receiving chamber 114 axially rearward with respect to mating face 98 and compressing the contact carrier return spring 68' from the unrestrained length thereof. A fluid tight insertion of plug 52 into bore 96 is possible because plug 52 is of a larger diameter than bore 96 and the inner surface of bore 96 deforms radially outward aided by deforming slots 101. Additionally, as plug 52 moves axially forward beyond mating face 98 the insulating sleeve 50, because the diameter thereof is slightly larger than the diameter of bores 22 and 96, continually maintains the fluid seal. The movable contact 24 enters bore 96 and when housings 10 and 12 are completely mated, portion 42 of contact 24 is in electrical and mechanical engagement with the fixed contact 32' and portion 46 is in electrical and mechanical engagement with the fixed contact 32, thereby completing an electrical circuit between line side housing 10 and load side housing 12.

To uncouple the electrical connector of this invention, coupling casing 72 is rotated about the central axis thereof, oppositely the direction of rotation to couple housings 10 and 12, thereby resulting in housing 10 moving axially rearward with respect to housing 12. As the axially forward compressive forces are relieved, the spring bias of return springs 68 and 68', apply axially directed tensile and compressive forces, respectively, on the movable contacts 24 thereby resulting in contacts 24 and insulating plugs 52 and 54 returning to the uncoupled position thereof, that is being fully contained within bores 22.

Although a preferred embodiment of this invention has been described and illustrated herein one skilled in the art can readily embody the principles of this invention in other forms to obtain the same operation and advantages, for example, the return springs 68 and 68' can be replaced by a manual return system of suitable construction. In such a case the housing coupling casing 72 need not have threads at the forward end thereof but could have suitable slots therein to accommodate outwardly extending components of a manual movable contact return system.

A significant feature of this invention is that the electrical components of the line and load side housings are effectively sealed off from outside environment and, additionally, the housings can be uncoupled and coupled while electrically energized and submerged in any liquid electrolyte, for example water, without causing an electrical short circuit. These features can be achieved with structural variations to the preferred embodiment hereinbefore described, for example, a hard, not readily deformed, insulating substance can be substituted for the described material of body portions 14 and 88 if a resilient, easily deformed, substance is substituted for the described material of insulating plugs 52 and 54 and insulating sleeve 50. Additionally some dimensional limitations described can be varied without effecting the features of this invention, for example, the diameter of contact portions 42 and 46 can be slightly larger than the diameter of bore 22 and the axial length thereof can be either larger or smaller than the strip width of contact 32.

The description herein does not limit the structure of this invention and the invention is defined by the scope of the claims set forth hereinafter.

What is claimed is:

1. In an underwater operable electrical connector of the type comprising a pair of first and second matable housings adapted to be secured together in sealed relationship, the improvement comprising: at least one axially extending bore in each housing of said pair of housings; fixed contact means in said housings, respectively communicating with the interior of each of said bores; an elongated movable contact element in said bore of said first housing movable from one location within said first housing bore and out of contact with said fixed contact means to another location partly in said first housing bore and partly in an axially aligned one of said bores of said second housing and located to contact said fixed contacts respectively associated with said first housing bore and said aligned second housing bore when said housings are secured together.

2. In an electrical connector as specified in claim 1 the further improvement wherein each of said housings has a plurality of said bores therein and each of said fixed contacts has a circular loop portion slidably receiving at least an end portion of said movable contact element.

3. In an electrical connector as specified in claim 1 the further improvement wherein said separate housings have conjugate polarizing means to insure correct mating of the respective bores in each of said first and second housings.

4. An electrical connector as specified in claim 1 wherein first and second housings are sealingly mounted on respective multi-conductor cables whereof each conductor is electrically connected to a respective fixed contact means.

5. In an electrical connector as specified in claim 1 the further improvement wherein said movable contact moves from said another location when said housings are secured together back to said one location when said housings are separated one from the other.

6. In an electrical connector as specified in claim 5 wherein spring means is provided for moving said movable contact back to said one location upon separation of said housings.

7. In an electrical connector as specified in claim 1 the further improvement wherein bore sealing elements are located within said bores at each end of each of said movable contact elements some of said sealing elements being movable from a location within given respective ones of said first housing bores to a location within respective ones of said second housing bores mated with said given first housing bores.

8. In an electrical connector as specified in claim 7 the further improvement wherein said sealing elements are secured to the respective ends of said movable contact elements and are movable therewith.

9. In an electrical connector as specified in claim 1 the further improvement wherein each of said matable housings is formed of insulating material at least partially surrounded by respective interfitting threaded metallic shells and wherein said movable contact is moved from said one location to said another at least in part during the interfitting and threaded engagement of said metallic shells.

10. An electrical connector as specified in claim 9 wherein sealing elements are secured to the ends of said movable contacts within said bores and are sealingly mated to said bores but movable therein.

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MARVIN A. CHAMPION, Primary Examiner

J. H. McGLYNN, Assistant Examiner

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