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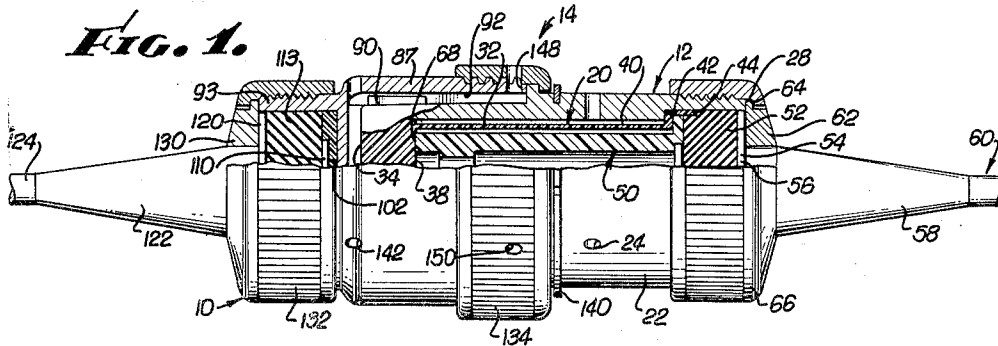
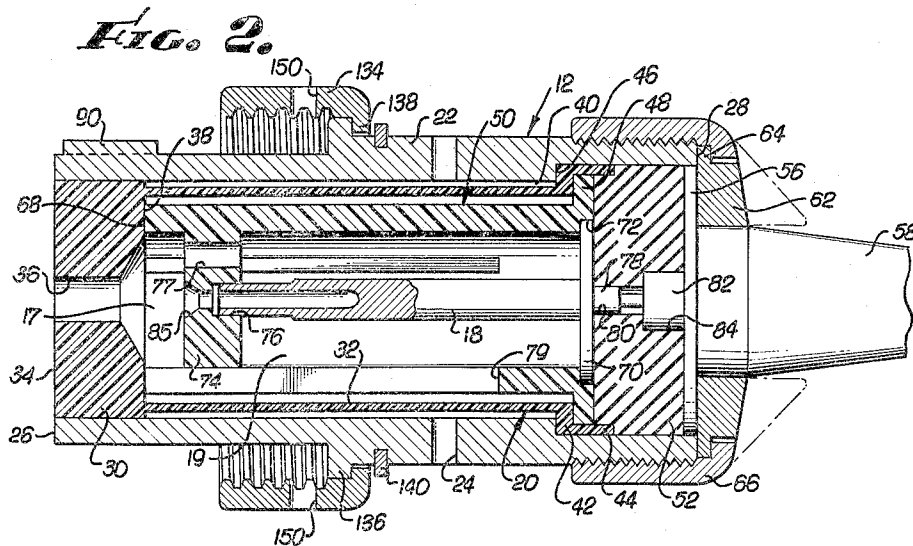
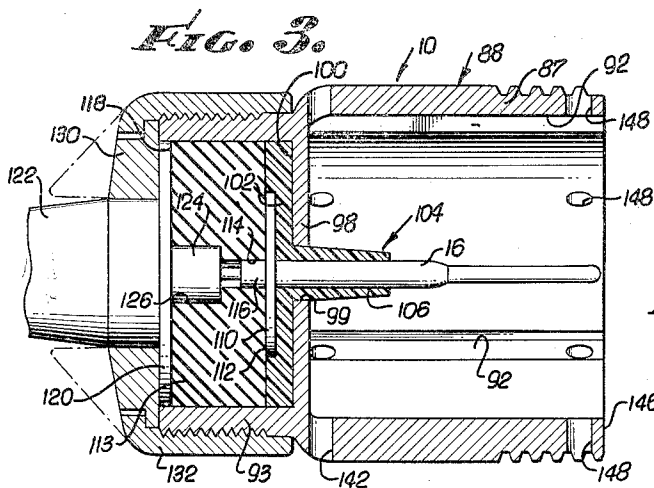
E. W. KUEHL ETAL

3,115,380

HIGH FLUID PRESSURE ELECTRICAL CONNECTOR

Filed June 8, 1962

2 Sheets-Sheet 1



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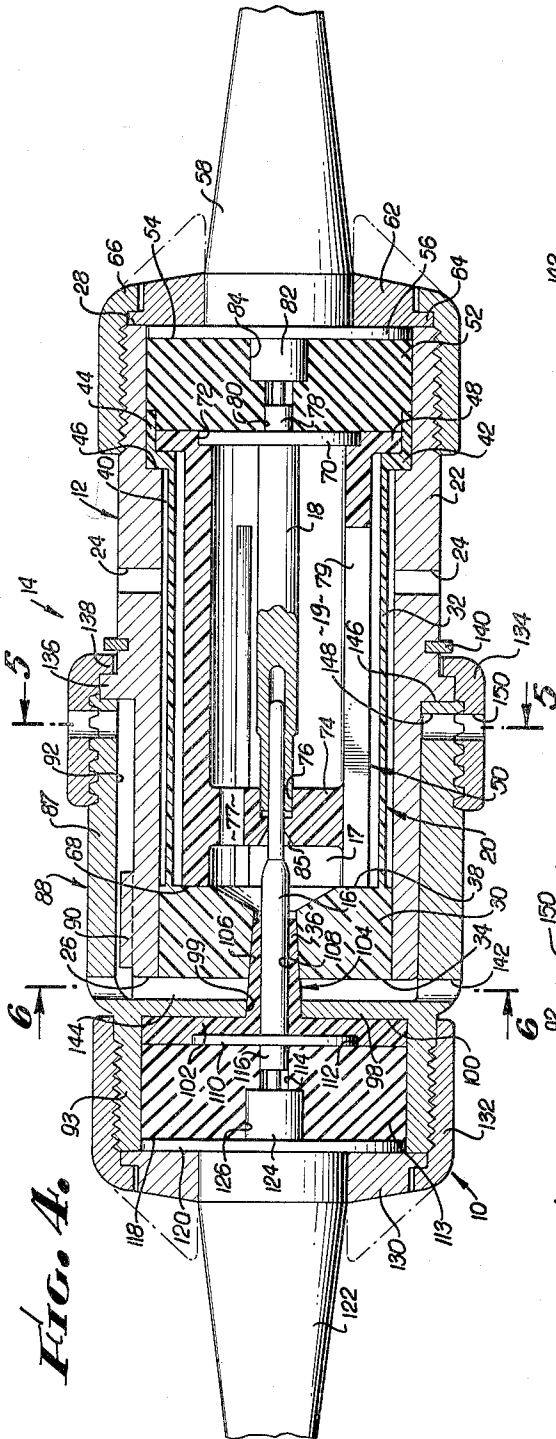
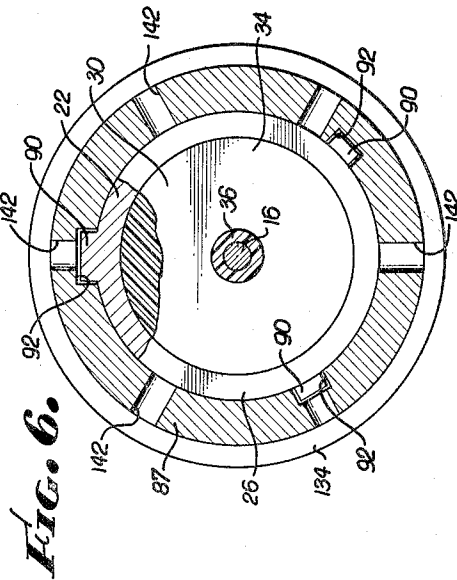
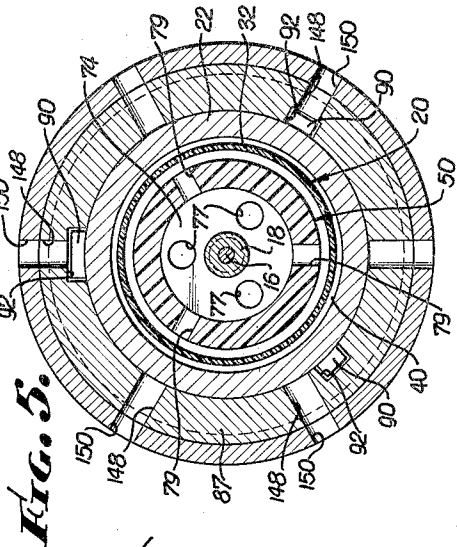
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1

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HIGH FLUID PRESSURE ELECTRICAL CONNECTOR

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This invention relates to electrical apparatus, and more particularly it relates to an electrical connector for use at extremely high environmental fluid pressures such as those which occur in extreme ocean depths.

The relatively recently accelerated interest in exploring the ocean depths has produced a number of problems, one of which is to provide practical electrical connectors which may be submerged to the extreme depths and withstand the extreme pressures and conditions which occur there.

It is thus an object of this invention to provide an electrical connector having a pair of interengageable connector members with mating contact terminals, one of the members having a fluid-filled chamber within which the terminals mate to complete an electrical circuit, the fluid-filled chamber being sealed to the outside when the members are engaged so that the fluid immediately surrounding the terminals is both physically and electrically isolated from fluid external to the chamber, the chamber having movable wall means, such as a flexible diaphragm, bellows or the like, which is accessible to surrounding external fluid pressures so that when and as the external fluid pressure exceeds the internal fluid pressure, to provide a pressure differential, the external fluid pressure bearing on the diaphragm or other movable wall means will result in increasing the internal fluid pressure so that the internal and external pressures will be brought to substantially instantaneous and continuous equilibrium.

Another object of this invention is to provide an electrical connector having the aforesaid characteristics wherein a portion of the wall of the fluid chamber is fabricated of a non-wetting type of material which is constructed so as to admit fluid therein and which is positively wiped by a portion of the opposing connector member when mating engagement of the two connector members occurs to effect isolation of the internal fluid from the external fluid.

A more specific object of this invention is to provide an electrical connector of the aforementioned character wherein the connector member embodying the flexible diaphragm or the like also includes a stabilizing spacer for the diaphragm or the like to prevent unacceptable deforming or collapse thereof when performing mating engagement of the connector members, and during use of the electrical connector.

Another specific object of this invention is to provide an electrical connector of the aforementioned character wherein construction of the connector is such that a voidless condition is maintained in a sealed region of contact mating for achieving the aforesaid pressure equilibrium, so that the ordinary methods of sealing for extremely high pressure differentials are eliminated, and the life of the connector is extended due to the absence of pressure seals.

Further objects and advantages of the invention will appear during the course of the following part of this specification wherein the details of construction and mode of operation of a preferred embodiment are described with reference to the accompanying drawings in which:

FIG. 1 is a perspective view, showing a plug assembly and a receptacle assembly in coupling engagement, parts being broken away to disclose interior details.

2

FIG. 2 is an enlarged sectional view, partially in elevation, illustrating the structure of the plug assembly.

FIG. 3 is an enlarged, sectional view, partially in elevation, illustrating the structure of the receptacle assembly.

FIG. 4 is an enlarged sectional view, partially in elevation, illustrating the coupling engagement of the plug assembly with the receptacle assembly.

FIG. 5 is a vertical sectional view taken on line 5-5 of FIG. 4.

FIG. 6 is a vertical sectional view taken on line 6-6 of FIG. 4.

Referring initially to FIGS. 1 and 4, there is to be seen a receptacle assembly 10 which is coupled to a plug assembly 12 to produce an electrical connector 14. Disposed in the receptacle assembly is a pin contact terminal 16 which is mateable with a socket contact terminal 18 mounted in the plug assembly.

Preliminary to coupling the assemblies together, the plug assembly 12 is filled with a fluid, preferably water, to completely fill or flood the available interior. The preferred manner of filling or flooding the plug assembly is to submerge it in water and while submerged coupling engagement of the assemblies is achieved with the mated contact terminals being immersed in the water and the water being rendered captive within the plug assembly.

A flexible socket insulating diaphragm 20, disposed within plug assembly 12 contributes to rendering the water captive therein. The plug assembly 12 includes a barrel 22 which has a plurality of ports or openings 24 therein which expose diaphragm 20 to external environmental conditions so that when the assembled electrical connector is submerged in the ocean depths the diaphragm 20 is exposed to the extreme external water pressures which occur, and which are generally greater than the internal pressure occurring within the electrical connector.

Since the diaphragm 20 is exposed to the external pressures a constant pressure equilibrium or pressure balance is achieved as the electrical connector is submerged in the ocean depths and withdrawn therefrom.

The construction of the plug assembly 12 and receptacle assembly 10 eliminates the need for sealing against extremely high pressure differentials to thus increase the life and provide greater reliability for the electrical connector 14.

The details of construction of the foregoing enumerated components and the mode of operation of the electrical connector will hereinafter be described in more extensive detail.

Barrel 22 of plug assembly 12 has a forward end 26 and an externally threaded rear end 28, and the aforementioned ports 24 are located intermediate the ends of the barrel, see FIG. 2. Frictionally seated and firmly clamped within barrel 22 is socket insulating diaphragm 20 which has a shape resembling that of a cylindrical cup with a relatively thick-walled bottom 30 and a relatively thin-walled skirt 32 which is exposed to the external environment by ports 24.

Bottom 30 has a forward surface 34 which is flush with the forward edge of barrel 22, and the peripheral edge of bottom 30 is in firm frictional engagement with the adjacent internal surface of barrel 22, to achieve the aforementioned frictional seating of the diaphragm in the barrel.

Centrally located in bottom 30 is an axially extending cylindrical bore 36. When plug assembly 12 is immersed for flooding or when it is filled with water it is through this bore the water passes to the interior of plug assembly 12.

Extending rearwardly from rear surface 38 of bottom 30 is skirt 32 which is spaced from the internal surface

of barrel 22 so as to provide a void 40 which substantially surrounds the skirt and which is filled with the water passing through ports 24 when the electrical connector 14 is submerged for use in the ocean depths.

The rear end of skirt 32 includes a radially outwardly extending annular flange 42 and extending rearwardly from flange 42 is a cylindrical lip 44. Flange 42 is seated against a rearwardly facing shoulder 46 on barrel 22, and forcibly bearing against flange 42 is an annular flange 48 which is integral with the rear end of a forwardly extending cylindrical spacer 50, which will hereinafter be described in greater detail.

Lip 44 is partially disposed between the peripheral edge of flange 48 and the adjacent surface of barrel 22; also a portion of lip 44 is disposed between the adjacent surface of barrel 22 and an elastomer grommet 52 which is in frictional engagement with the adjacent surface of barrel 22.

The foregoing structural arrangement and position of flange 48 of spacer 50 with respect to diaphragm 20, and grommet 52 results in centrally and axially positioning the spacer within plug assembly 12.

Bearing against the rear surface 54 of grommet 52 is a disc bearing washer 56 which is integral with a sleeve 58 that is a component of an electrical conductor cable 60. Circumscribing sleeve 58 is a split bearing washer 62 having a tapered profile, and integral with bearing member 62 is annular flange 64. Annular flange 64 is made to seat against the rear edge of barrel 22 with washer 62 seated against bearing washer 56 by an end bell 66 which is threaded onto the rear end 28 of barrel 22.

When the take-up torque is applied to end bell 66, grommet 52 is compressed between annular flange 48 of spacer 50 and bearing washer 56, and in this way positive frictional seating of grommet 52 within the barrel is achieved and a voidless condition is produced. Also in this way the aforementioned clamping of socket insulating diaphragm 20 is accomplished. Lip 44 is clamped between the internal surface of barrel 22 and the peripheral edge of flange 48 as well as grommet 52, and flange 42 of diaphragm 20 is clamped between flange 48 of spacer 50 and rearwardly facing shoulder 46.

The aforementioned tapered profile of split bearing washer 62 reduces the possibility of snagging the electrical connector on obstructions on the ocean floor. This taper can be increased as shown by the dotted lines which appear in FIGS. 2 and 4.

It is preferred that the socket insulating diaphragm 20 be fabricated of Teflon which is an electrical insulating material that is flexible, substantially chemically inert and exhibits the property of non-wetting, although it is to be understood that other materials having generally similar characteristics may be employed.

In addition to the other functions of grommet 52 heretofore recited, grommet 52 also provides an electrical barrier between electrical conductor cable 60 and barrel 22.

Spacer 50 has the dual purpose of providing structural support for the socket insulating diaphragm 20 and for stabilizing and centrally or axially locating socket contact terminal 18 in plug assembly 12. Spacer 50 is preferably composed of a substantially rigid electrical insulating material. An example of a suitable material, to which the present invention is not necessarily limited, is a fiberglass filled epoxy resin.

The annular flange 48 at the rear end of the spacer 50 is in firm seating engagement against grommet 52, and the forward end 68 of the spacer firmly seats against rear surface 38 of bottom 30 of diaphragm 20 to provide the aforementioned structural support for diaphragm 20.

Seated in a recess 72 in spacer 50 and firmly bearing against grommet 52 is a flange 70 which is on the rear end of socket contact terminal 18. Spaced rearwardly from the forward end 68 of spacer 50 and integral therewith is a perforated transverse web 74 which has an axial

centrally located counterbore 76 therein in which is supported the forward open end of socket contact terminal 18.

The combination of the flange 70 being seated in recess 72 and of the forward end of socket contact terminal 18 being supported in counterbore 76 provides for stabilizing and centrally positioning the socket contact terminal 18 in plug assembly 12.

Circulation of water throughout the available interior of socket insulating diaphragm 20 is provided by openings 77 in web 74 and a plurality of slots 79 in the wall of spacer 50.

Projecting rearwardly from flange 70 of socket contact terminal 18 is a solder well 78 which extends into an axial bore 80 located in grommet 52. Projecting forwardly from washer bearing 56 is a stub end 82 of electrical conductor cable 60 which extends into counterbore 84 disposed in grommet 52. The stub end 82 is stripped of insulation to provide bare wire which extends and is fastened or soldered into solder well 78.

Flange 70 of socket contact terminal 18 provides a sufficient bearing area to resist the tensile loads imposed by conductor cable 60.

When coupling engagement of plug assembly 12 and receptacle assembly 10 is initiated while the assemblies are immersed in water, the pin contact terminal 16 passes through bore 36 and enters cavity 17. To insure mating engagement of pin contact terminal 16 with socket contact terminal 18, even though pin contact terminal 16 may be bent or out of alignment, web 74 of spacer 50 has a contact entry hole 85 therein which is in alignment with counterbore 76, and the contact entry hole incorporates a relatively large, forwardly facing lead-in chamfer which guides pin contact terminal 16 into mating engagement with socket contact terminal 18.

While mating engagement of the contact terminals is being achieved, a forwardly extending, externally threaded skirt portion 87 of receptacle shell 88 is encircling plug barrel 22. To assure proper aligning of receptacle shell 88 with plug barrel 22, the forward end 26 of barrel 22 has on the exterior surface thereof a plurality of equally spaced polarizing pins 90 which align with corresponding elongated polarizing or keyway slots 92 formed on the interior surface of skirt portion 87.

Partitioning skirt portion 87 from externally threaded rear skirt portion 93 of shell 88 is a radially inwardly extending annular flange or partition 98 which has an axial bore 99 extending therethrough. In firm engagement with the rear face 100 of partition 98 is a circular disc portion 102 of a pin contact insulator 104, and integral with disc 102 and projecting forwardly therefrom through bore 99 is a tapered plug 106. Pin contact insulator 104 has an axial bore 108 therethrough and extending through bore 108 is pin contact terminal 16. Therefore, it may be seen that pin contact terminal 16 extends forwardly from partition 98, and thus skirt portion 87 of shell 88 provides a protective shield for a substantial portion of pin contact terminal 16.

When pin contact terminal 16 is brought into mating engagement with socket contact terminal 18 in the aforementioned manner, tapered plug 106 is caused to enter cylindrical bore 36, and because pin contact insulator 104 is fabricated of a flexible, non-wetting material like socket insulating diaphragm 20, preferably Teflon, and the plug 106 tapers to a larger diameter than bore 36, a positive, pressurized wiping action of the bore is achieved with the plug wiping the surface of the bore free of water and displacing the water in bore 36.

The water immediately surrounding contacts 16 and 18 in cavities 17 and 19 will thus be physically and electrically isolated from the surrounding environment. The water displaced by plug 106 will deflect or distend the relatively thin-walled skirt of the socket insulating diaphragm 20 causing an initial low order pressurization of the internally contained water.

5

The structure disposed in rear skirt portion 93 of receptacle shell 88 is substantially identical to the structure located in the rear end of plug barrel 22, performing substantially the same function and producing substantially the same results.

The rear end of pin contact terminal 16 has a relatively large flange 110 thereon which seats in a relatively large counterbore 112 in disc 102. Firmly bearing against flange 110 and disc 102 is an elastomer grommet 113 which is substantially identical to grommet 52, and projecting into axial bore 114 of grommet 113 is a solder well 116 which is integral with flange 110.

In full contacting engagement with rear face 118 of grommet 113 is a bearing plate 120 which is integral with a sleeve 122 comprising a component of electrical conductor cable 124. Projecting forwardly from bearing plate 120 is a stub end 126 of cable 124 which extends into an axial counterbore 126 in grommet 113. A portion of the insulation of the stub end is stripped therefrom to expose bare wire which is fastened to or otherwise soldered in the soldering well 116.

Bearing against bearing plate 120 and circumscribing sleeve 122 is a split bearing plate 130 which is similar to split bearing plate 62 and performs the same function. Bearing plate 130 is held in position by an end bell 132 which is threaded onto rear skirt portion 93.

Like split bearing plate 62, split bearing plate 130 has a taper which reduces the possibility of snagging the electrical connector 14 on obstructions on the ocean floor, and like split bearing plate 62, the taper of split bearing plate 130 may be increased as indicated by the dotted lines which appear in FIGS. 3 and 4.

Take-up torque applied to end bell 132 will compress grommet 113 to produce the same results as are achieved when take-up torque is applied to end bell 66 to compress grommet 52.

When receptacle assembly 10 is in full engagement with plug assembly 12 coupling together of the assemblies is achieved by a coupling nut 134 which encircles plug barrel 22 and which threadably engages skirt portion 87 of shell 88. The threads of skirt portion 87 and coupling nut 134 are matching double lead stub threads which contribute to a quick coupling operation.

Forward removal of coupling nut 134 from plug barrel 22 is prevented by an annular rib 136 which is integral with plug barrel 22 and engageable by an inwardly extending annular flange 138 on coupling nut 134. Rearward removal of coupling nut 134 from plug barrel 22 is prevented by a thrust washer 140 which seats in a groove in the outside of barrel 22. Thrust washer 140 also contributes to the disengagement of plug assembly 12 from receptacle assembly 10.

Immediately forward of annular flange or partition 98 of receptacle shell 88 are a plurality of radial posts or openings 142 which are in communication with a chamber or void 144 which is disposed between the forward end 26 of plug barrel 22 and partition 98. In this way the bottom 30 of socket insulating diaphragm 20 is exposed to the external environment and the pressure occurring in the ocean depths.

Void 144 is produced when receptacle assembly 10 is coupled to plug assembly 12. Skirt portion 87 of shell 88 has a forward end 146 which abuts against annular rib 136 and prevents the forward end 26 of plug barrel 22 abutting against partition 98, so as to provide the void 144.

Adjacent forward end 146 of shell 88 is a plurality of ports 148 certain of which communicate with keyways or polarizing slots 92 as well as void 144. Ports 148 are in alignment with other ports 150 which are in coupling nut 134.

While the instant invention has been shown and described herein in what is conceived to be the most practical and preferred embodiment, it is recognized that de-

6

partures may be made therefrom within the scope of the invention, which is therefore not to be limited to the details disclosed herein, but is to be accorded the full scope of the claims.

We claim:

1. An electrical connector which comprises: a pair of interengageable connector members with mating contact terminals, one of the members having a fluid-filled chamber within which the terminals mate to complete an electrical circuit, the fluid-filled chamber being sealed to the outside when the members are engaged so that the fluid surrounding the terminals is both physically and electrically isolated from fluid external to the chamber, the chamber having movable wall means which is accessible to surrounding external fluid pressures so that the pressure differential may be brought to substantially instantaneous equilibrium when the pressure of the external fluid exceeds that of the fluid in said fluid-filled chamber.

2. An electrical connector according to claim 1 wherein said movable wall means is fabricated of a flexible material.

3. An electrical connector according to claim 1 wherein one of said members embodies a void with a communicating port which is adjacent said movable wall means and by which access to said movable wall means is achieved.

4. An electrical connector which comprises: a pair of assemblies which are engageable with each other, one of which is fluid-filled, and each of which embodies a contact terminal which is mateable with the other contact terminal to complete an electrical circuit, the terminals when mated being substantially entirely immersed in said fluid; a flexible member in said fluid-filled assembly which contributes to containing the fluid therein; and means in said fluid-filled assembly for exposing said flexible member to external fluid so that the pressure differential may be brought to substantially instantaneous equilibrium when the pressure of the external fluid exceeds that of the fluid in said fluid-filled assembly.

5. An electrical connector according to claim 4, wherein said flexible member is a diaphragm.

6. An electrical connector according to claim 5 wherein said diaphragm has an opening therethrough, and the opposing connector assembly has a projection thereon receivable in said opening, said opening and said projection having opposing walls which are engageable in sealed relationship.

7. An electrical connector according to claim 6 wherein at least one of said walls is deformable and wherein one of said walls is of tapered annular shape and the other is generally cylindrical in shape.

8. An electrical connector according to claim 7, wherein the tapered wall is that of the projection.

9. An electrical connector according to claim 6 wherein one of said terminals extends axially through and beyond said projection, and wherein the other terminal is disposed within said diaphragm and axially aligned with said opening.

10. An electrical connector according to claim 4 wherein said means includes a void and ports communicating with said void, the void encircling a portion of said flexible member.

11. An electrical connector which comprises: a pair of assemblies which are engageable with each other, one of which is fluid-filled, and each of which embodies a contact terminal which is mateable with the other contact terminal to complete an electrical circuit, the terminals when mated being substantially entirely immersed in said fluid; a flexible member in said fluid-filled assembly which contributes to containing the fluid therein; means in said fluid-filled assembly for exposing said flexible member to external fluid so that the pressure differential may be brought to substantially instantaneous equilibrium when the pressure of the external fluid exceeds that of the fluid in said one assembly; and sealing means in

said fluid-filled assembly for sealing said fluid-filled assembly to thereby in combination with said flexible member physically and electrically isolate the fluid within said fluid-filled assembly.

12. An electrical connector according to claim 11, wherein said sealing means includes a compressively loaded elastomer member which is in firm engagement with said flexible member to assist in holding said flexible member in an operable position.

13. An electrical connector which comprises: a pair of assemblies which are engageable with each other, one of which is fluid-filled, and each of which embodies a contact terminal which is mateable with the other contact terminal to complete an electrical circuit, the terminals when mated being substantially entirely immersed in said fluid; a flexible member in said fluid-filled assembly which contributes to containing the fluid therein; means in said fluid-filled assembly for exposing said flexible member to external fluid so that the pressure differential may be brought to substantially instantaneous equilibrium when the pressure of the external fluid exceeds that of the fluid in said fluid-filled assembly; and stabilizing means in said fluid-filled assembly which is in firm contacting engagement with said flexible member and contributes to stabilizing said flexible member in an operable position.

14. An electrical connector which comprises: a plug assembly engageable with a receptacle assembly, one of said assemblies being filled with water; a contact terminal in said plug assembly which is mateable with a contact terminal in the receptacle assembly to complete an electrical circuit, the contact terminals when mated being substantially entirely immersed in said water, a stabilized flexible diaphragm in the water-filled assembly which contributes to containing the water therein; and ports in said water-filled assembly for exposing said flexible diaphragm to external water so that the pressure differential may be brought to substantially instantaneous equilibrium when the pressure of the external water exceeds that of the water in said water-filled assembly.

15. An electrical connector according to claim 14, wherein said flexible diaphragm embodies a cylindrical cup shape with the open end portion thereof being firmly fastened in said water-filled assembly so as to maintain said flexible diaphragm in an operable position.

16. An electrical connector according to claim 14, wherein said flexible diaphragm is cylindrical and cup shaped in form with there being a relatively thick-walled bottom and a relatively thin-walled skirt, the skirt being exposed to the external water.

17. An electrical connector according to claim 14, wherein said flexible diaphragm is stabilized with a spacer mounted in said water-filled assembly and in firm engagement with said flexible diaphragm to prevent the collapse of said diaphragm.

18. An electrical connector which comprises: a water-filled plug assembly engageable with a receptacle assembly; a socket contact terminal in said plug assembly which is mateable with a pin contact terminal in the receptacle assembly to complete an electrical circuit, the contact terminals when mated being substantially entirely immersed in said water; a cylindrical cup-shaped socket insulating diaphragm in said plug assembly which contributes to containing the water therein; said diaphragm including a relatively thick-walled bottom and a relatively thin-walled skirt; and ports in said plug assembly, and a void about said skirt in communication with said ports

for exposing the skirt of said flexible diaphragm to external water so that the pressure differential may be brought to substantially instantaneous equilibrium when the pressure of the external water exceeds that of the water in said plug assembly.

19. An electrical connector according to claim 18 wherein said plug assembly includes a diaphragm stabilizing spacer mounted therein, which is in firm engagement with said diaphragm so as to maintain said flexible diaphragm in an operable position.

20. An electrical connector which comprises: a water-filled plug assembly engageable with a receptacle assembly; a socket contact terminal in said plug assembly which is mateable with a pin contact terminal in the receptacle assembly to complete an electrical circuit; the contact terminals when mated being substantially entirely immersed in said water, said plug assembly comprising a substantially cylindrical barrel having a forward and a rear end, and ports intermediate said ends; a cylindrical, cup-shaped socket insulating diaphragm including a relatively thick-walled bottom proximate the forward end of said barrel, and a relatively thin-walled skirt which extends rearwardly in said barrel, said skirt being spaced from said barrel to provide a circumscribing void thereabout which is in communication with said ports for exposing said skirt to external water so that the pressure differential may be brought to substantially instantaneous equilibrium when the pressure of the external water exceeds that of the water in said plug assembly; means in the rear end of said barrel for sealing and rendering the rear end thereof voidless, said socket insulating diaphragm having the open end portion thereof disposed between said means and the wall of said barrel whereby said means contributes to clamping said socket insulating diaphragm in position to provide stability for said diaphragm; and a cylindrical spacer disposed within said socket insulating diaphragm, one end of which seats against said means and one end of which seats against said bottom to contribute to the stability of said diaphragm.

21. An electrical connector according to claim 20 wherein said spacer includes a web having an axial opening therein, and said socket contact terminal includes a bearing plate which seats in a recess in said spacer, the open end of said socket contact being received in said axial opening to thereby centrally position and stabilize said socket contact terminal in said plug assembly.

22. An electrical connector according to claim 20 wherein said means includes an elastomer grommet which seats against said spacer and which has compressive force applied thereto to cause the firm frictional engagement of the grommet with the barrel.

23. An electrical connector according to claim 20 wherein said socket insulating diaphragm is fabricated of a non-wetting material and said diaphragm bottom has an opening therein, and said receptacle assembly includes a projection receivable in said opening, the projection wiping the surface of said opening free of water and displacing such water as is disposed therein to provide a low order pressurization of the water contained in said plug assembly.

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