

[54] **CABLE CONNECTOR**
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[58] **Field of Search** 339/60, 94, 117, 177; 174/19, 21 R

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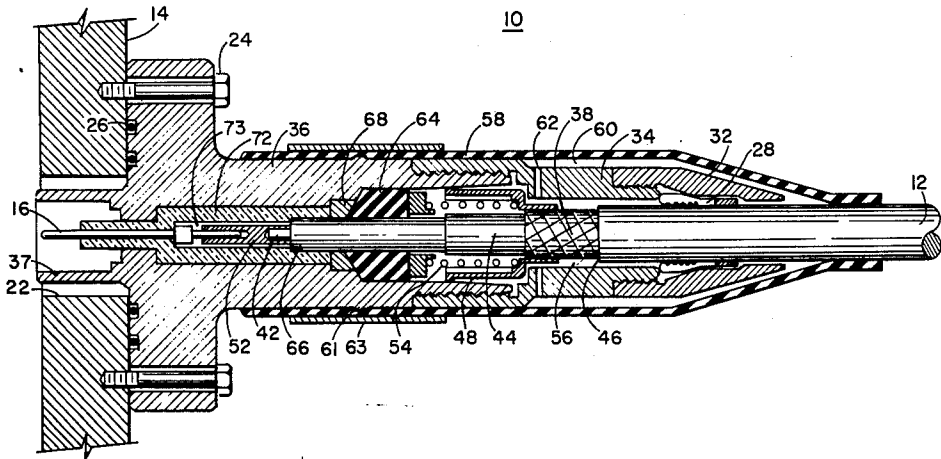
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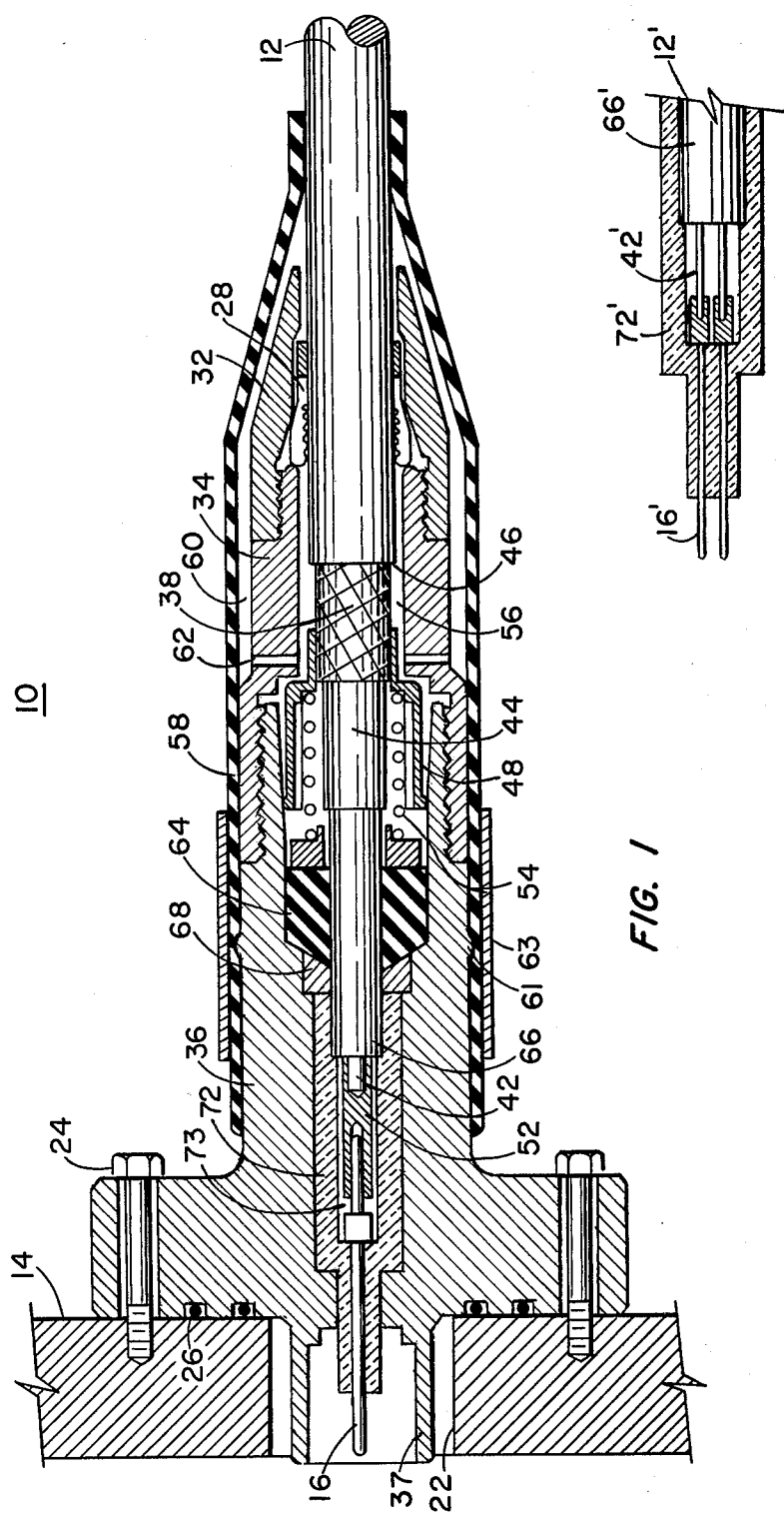
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[57] **ABSTRACT**
A connector for electric cables subjected to high-pressure environments and for making electrical connections across high-pressure, low-pressure interfaces. The connector includes a reservoir of dielectric liquid which fills space between the cable and the inner wall of the connector body. A rubber boot fitted over the connector body contains the reservoir and transmits the environmental pressure to the liquid thereby providing hydrostatic pressure in opposition to the environmental pressure transmitted into the connector through the cable components.

9 Claims, 2 Drawing Figures





CABLE CONNECTOR

BACKGROUND OF THE INVENTION

The invention described herein was made in the course of or under Contract No. W-7405-ENG-48 with the U.S. Atomic Energy Commission.

This invention relates to connections for electric cables and more particularly to connectors for electric cables which are subjected to high-pressures in service and, even more particularly, to connectors for making electrical connections across high-pressure - low-pressure barriers.

The transmission of intelligence via electrical signals through cables is a common practice. There are many instances where the path over which the intelligence is to be transmitted traverses environments which pose difficult problems with respect to making trouble free connections in the cables. One such instance, which has proven particularly troublesome, is where that path traverses a high-pressure - low-pressure interface.

In Plowshare applications, i.e., applications involving utilization of nuclear explosives for peaceful purposes, it is often the case that nuclear explosives are emplaced for detonation in a fluid filled bore hole thousands of feet below the surface of the earth. The nuclear explosive and associated downhole electronics and instrumentation are generally emplaced at the downhole detonation location within a pressure tight container in order to protect them from the downhole environment. Communication between the downhole nuclear explosive package and the surface of the earth is maintained through signals transmitted over electric cables.

Since the nuclear package is maintained at atmospheric, or close to atmospheric, pressure whereas the hydrostatic pressure at the depth of emplacement may be at many thousands of pounds per square inch, the electrical connection passing through the nuclear explosive package container is subjected to very large mechanical forces induced by that pressure differential. Moreover, elevated temperatures exceeding several hundred degrees fahrenheit may also be encountered. The induced mechanical forces frequently exceed the creep strength of the cable materials at the temperature of the downhole emplacement thereby resulting in extrusion of the cable materials into the low pressure region or buckling of those materials within the connector causing distortion and even disruption of the electrical signals.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide an electric cable connector for high pressure service. It is an additional object of the invention to provide a connector for connecting electric cables across a high-pressure - low-pressure interface. Briefly summarized, these and other objects and advantages are accomplished by providing means in an electric cable connector which effectively oppose the forces tending to extrude or buckle the cable within the connector, including means for applying a hydrostatic force through a fluid which is maintained around portions of the cable which are particularly susceptible to such forces.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 of drawing illustrates a preferred embodiment of the invention in section, and

FIG. 2 illustrates an alternative forward end component for the embodiment of FIG. 1 where the cable has a plurality of inner conductors.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to FIG. 1, connector 10 structurally relates cable 12 to barrier wall 14 and brings conductor 16 through passage 22 for connection with another electrical device, not shown, on the other side of wall 14. The end of connector 10 fastened to wall 14 by bolts 24 is considered the forward end while the end into which cable 12 enters the rearward. Connector 10 would be on the high-pressure side of barrier wall 14, the leakage of pressure through the interface of connector 10 and barrier wall 14 being prevented by use of O-rings 26 in accordance with usual practice.

Structurally relating cable 12 to barrier wall 14 is accomplished through collet 28, collet nut 32, adapter 34 and body 36. As shown in FIG. 1, each of these components of connector 10, just identified, has a central opening which together provide a longitudinally extending chamber through the entire length of the connector when the individual components are in their assembled positions. The manner in which the conductors of an electric cable are carried forward through the barrier wall will now be explained.

Cable 12 of FIG. 1 is a coaxial or shielded cable having an outer conductor or shield 38, a single inner conductor 42, a mass of dielectric 44 between the two conductors and a protective outer covering 46. Protective covering 46 and dielectric 44 are trimmed prior to assembly with connector 10 to expose outer conductor 38 and inner conductor 42. Ground strap 48, which is made of a conducting material, is soldered onto outer conductor 38 at its rearward end and expands into contact with the inner surface of body 36, which is also made from a conducting material, at its forward end. This provides the transition for the outer conductor from cable 12 to body 36. Since forwardly extending cylindrical portion 37 of body 36 extends through barrier wall passage 22, electrical connection with the outer conductor of the cable can be made forward of the barrier wall. Loading grommet 64 through compression spring 54 permits the grommet to expand rearwardly thereby compensating for the thermal expansion of the grommet. The function of grommet 64 will be discussed later. Inner conductor 42 of the cable is connected to inner conductor 16, which protrudes into passage 22 of barrier wall 14, through conductive link 52.

Since the interior of the connector 10 must be sealed from the environment in order to preserve the electrical and mechanical integrity of the connection, the pressure of the environment is transmitted into connector 10 through the cable components. The extrusion and/or buckling of the cable components within the connector in response to such high environmental pressures is prevented in the following manner.

The longitudinally extending cavity, or space, 56 between the outer surfaces of the cable components and the inner surfaces of support structure components 32, 34 and 36 is filled with a dielectric liquid, such as silicon oil, which is maintained at the environmental pressure. This is accomplished through application of the environmental pressure through boot 58, which is made from a pressure responsive material such as rubber, onto the dielectric liquid. The boot is dimensioned

in conjunction with the outer surfaces of collet nut 32 and adapter 34 to define a space 60 therebetween which is also filled with the dielectric fluid. Communication between the two spaces 56 and 60 is provided through holes 62 in adaptor 34. Accordingly, the forces transmitted into connector 10 through the cable components are balanced by equal and opposite hydrostatic forces transmitted through the reservoir of dielectric liquid maintained in spaces 56 and 60 in response to the application of the environmental pressure to the outer surface of boot 58. Protuberance 61 and retaining ring 63 cooperate to secure boot 58 on the connector and maintain the reservoir of liquid therein.

The leakage of dielectric liquid in the forward direction is prevented by dimensioning grommet 64, made of rubber or other resilient material, forward portion 66 of cable dielectric 44 and the chamber of body 36 within which the grommet fits to provide seals therebetween. Grommet 64, metal seat 68 and ceramic seal 72 fit within chambers of body 36 designed to receive them and establish their positions in the forward direction. The potential leakage path between ceramic seal 72 and body 36 can be blocked such as by brazing these parts together.

The complementary dimensioning of dielectric portion 66 with grommet 64, metal seat 68 and ceramic seal 72 to provide a snug fit therebetween provides opposition to radially outward and, to a limited extent, forward creepage of the dielectric. A dielectric liquid can be maintained in space 73, with or without communication with the liquid in space 56, if extrusion of dielectric 44 and/or buckling of conductor 52 within space 73 is a problem in any particular application. A liquid seal at the forward end of space 73 can be provided by brazing conductor 16 to ceramic seal 72.

Where several cables of the same nominal size but differing particular dimensions are used with the same connector 10, the holes through grommet 64, metal seat 68 and ceramic seal 72 may be made the same size as the smallest dielectric to be used therewith. Portion 66 of the dielectric cables having a dielectric of larger diameter than that would be trimmed to fit prior to assembly with connector 10.

In instances where connector 10 is to be used with a cable having a plurality of inner conductors, modifications can be readily made to the components at the forward end. FIG. 2 illustrates one such modification to accommodate a cable 12 having a plurality of inner conductors 16, which protrude forward of barrier 14 in the manner of conductor 16 of FIG. 1. Ceramic seal 72 and dielectric portion 66 would be complementarily dimensioned as explained in connection with the embodiment of FIG. 1.

While the foregoing description of preferred embodiments illustrates the invention in electric cable connectors suitable for use in high pressure environments and for interfaces between high pressure and low pressure regions, it will be appreciated by those skilled in the art that various omissions and substitutions and changes may be made within the principle and scope of the invention as expressed in the appended claims.

What we claim is:

1. In a connector for making an electrical connection in a high-pressure environment with an electric cable of the type having at least one inner conductor and a mass of solid dielectric around the inner conductor, or

conductors, the combination comprising:

a. a longitudinally extending support having a chamber extending longitudinally therethrough for the admission at its rearward end of said electrical cable therewithin, said chamber being larger than said dielectric in the transverse directions at at least one location,

b. means for structurally relating said cable to said support,

c. an elastomer boot one end of which is sealably fastened onto the outer surface of said support and the other end of which extends rearwardly thereof sealably engaging the outer surface of said cable, said boot and at least a portion of said outer surface being dimensioned to provide a reservoir for a liquid therebetween,

d. means for transmitting the pressure of the environment which is applied to said reservoir through said boot to a liquid maintained in said chamber, and said support being of a conducting material and said cable having an outer conductor around said solid dielectric and including means within said chamber for providing a transition between said outer conductor and said support.

2. The combination of claim 1 wherein said transition means includes a ground strap of a conducting material which is fastened at its rearward end onto said outer conductor and expands radially outwardly across said chamber to make conductive contact with said support at its forward end.

3. The combination of claim 2 including an elastomer grommet in said chamber forward of said transition means for sealing said chamber in the forward direction.

4. The combination of claim 3 including means for loading said grommet in the forward direction which provide compensation for the relative thermal expansion and contraction of said grommet toward and away from said transition means.

5. The combination of claim 4 wherein said means for loading said grommet and compensating for thermal expansion and contraction includes a compression spring.

6. The connector of claim 5 including means forward of said grommet for structurally relating an internal conductor of said cable to said support and connecting said internal conductor to a conductor which extends in the forward direction in a manner to facilitate connection thereof with another connection device.

7. The connector of claim 6 wherein said means forward of said grommet includes a ceramic seal which fits snugly within said chamber and is fastened to said support.

8. The connector of claim 7 wherein the connection between said internal conductor and said forward extending conductor is made within a longitudinally extending chamber in said ceramic seal.

9. The connector of claim 8 wherein said longitudinally extending chamber in said seal is sufficiently large in the transverse directions to leave a space around the internal conductor members making said connection between said internal conductor and said forwardly extending conductor and including liquid filling said space in said seal.

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