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ELECTRICAL CONNECTOR PLUG AND CONNECTOR ASSEMBLY

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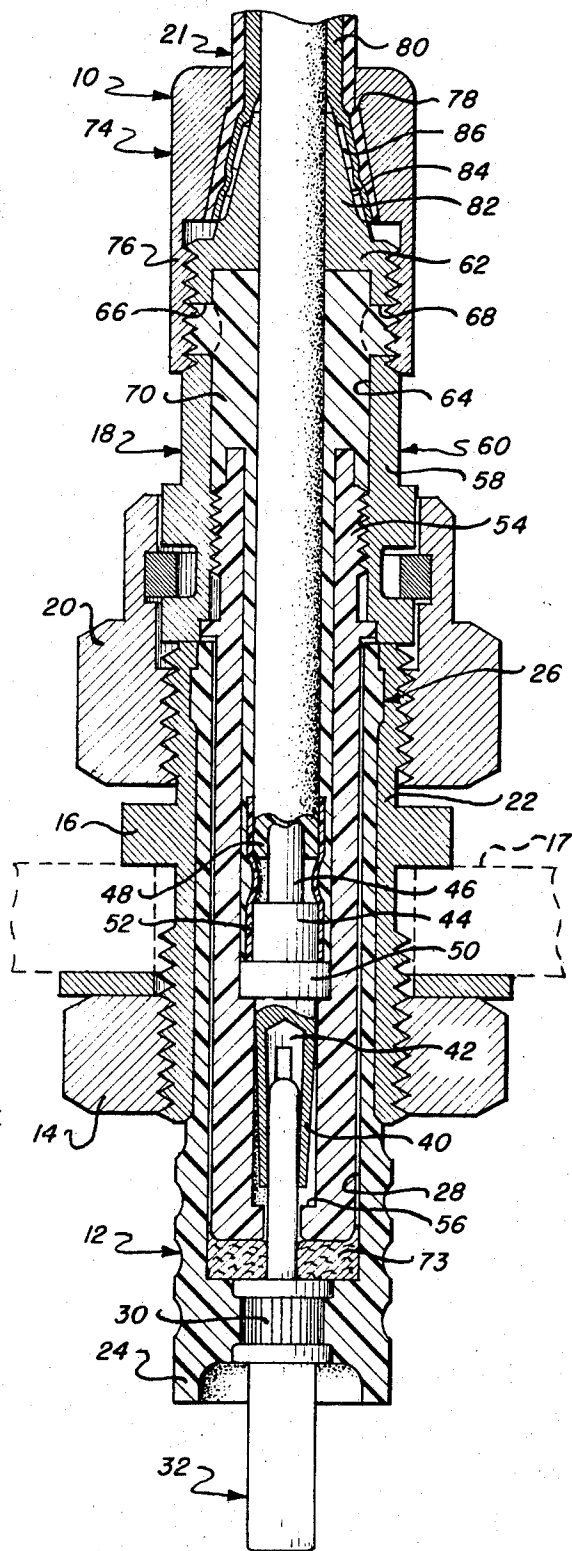


Fig. 1

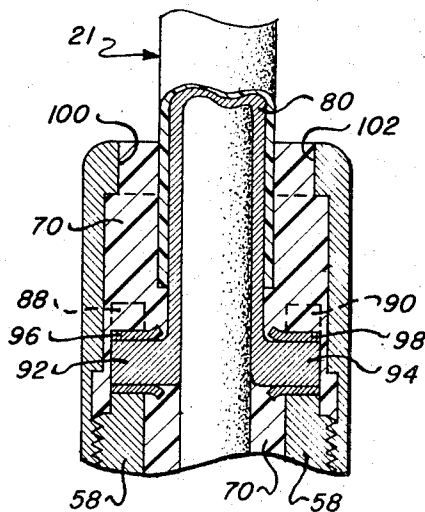


Fig. 3

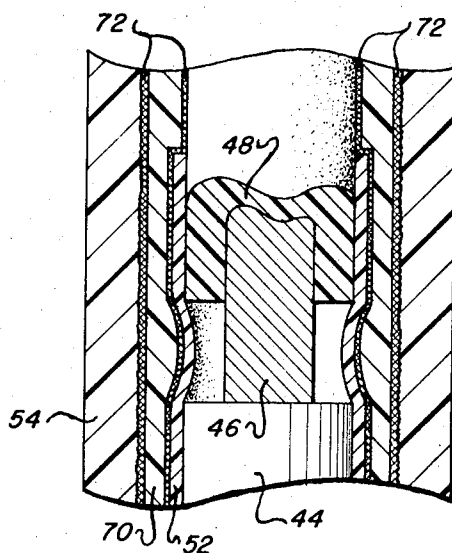


Fig. 2

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ELECTRICAL CONNECTOR PLUG AND CONNECTOR ASSEMBLY

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10 Claims

ABSTRACT OF THE DISCLOSURE

An ultraminiaturized, high-voltage coaxial cable con-
nector including a connector plug assembly having long
electrical discharge paths from its socket formed from
an elongated projecting insulative member, heat shrunk
insulative sleeve, and an insulative sealant injected into
a chamber formed by the insulative member, insulative
sleeve, cable insulator and plug housing to effectively form
a unitary insulative structure within and projecting from
the housing. The insulative member, insulative sleeve and
cable insulator have roughened and/or primed surfaces
facing the chamber for adhesive gripping by the insula-
tive sealant. A connector receptacle assembly for mating
with the plug assembly includes an elongated insulative
receptacle member for receiving the projecting socket
insulative structure and a contact pin to engage the plug
assembly socket, the insulative receptacle member having
extended external and internal electrical creepage paths to
its housing.

BACKGROUND OF INVENTION

Present space, aero space and related technologies are
increasingly requiring the development of ultraminiatur-
ized electronic equipment and parts with consequently
increased electrical strains or withstand (holdoff) strengths
per unit size or dimension. One area where such require-
ments of minimum size with maximum withstand are par-
ticularly difficult to obtain is in electrical connectors and
connector components. It is desirable that electrical con-
nectors, such as for coaxial cables, have a high-voltage
withstand strength between connector pin and metal hous-
ing, possibly for thousands of volts, in a connector having
a very small overall size, such as about 1 to 1.5 inches
long.

These demands may be particularly difficult to meet with
connectors which may be used at high altitude; e.g. alti-
tudes including those above 30,000 feet. In accordance
with the well known relationship commonly referred to as
Paschen's Law or Curve, the breakdown potential be-
tween points at different potentials in air decreases almost
linearly as altitude increases to about 140,000 to 160,000
feet and then increases at a relatively rapid rate as alti-
tude continues to increase. For example, between about
30,000 feet and 160,000 feet, the breakdown voltage
may decrease about 95% or more (from sea level about
97.5%), the most rapid decrease occurring between about
sea level and 50,000 feet. Thus, an ultraminiaturized high-
voltage connector designed to operate and withstand
5,000 volts at sea level, may breakdown at about 300 volts
or less at 160,000 feet. A microminiaturized connector
which may withstand high voltages at relatively low
altitudes and which may be used or readily modified to
withstand the same voltage at high altitudes may there-
fore be particularly desirable.

SUMMARY OF INVENTION

It is therefore an object of this invention to provide a
novel ultraminiaturized electrical connector and connector

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components having high voltage withstand capabilities.

It is a further object of this invention to provide an
ultraminiaturized electrical connector and connector
components which are capable of maintaining its high-
voltage withstand capabilities at high altitudes.

Various other objects and advantages will appear from
the following description of one embodiment of the in-
vention, and the most novel features will be particularly
pointed out hereinafter in connection with the appended
claims.

The invention comprises a plug assembly having an
elongated projecting insulative member, heat-shrunk in-
sulative sleeve, and insulative sealant injected into a cham-
ber formed by these insulative parts and the plug assembly
housing surrounding a coaxial cable and conductive
socket, the insulative member, sleeve and cable insula-
tor having roughened and/or primed surfaces facing the
chamber for adhesively gripping the sealant, said plug
assembly being mateable with a connector receptacle as-
sembly having an elongated hollow insulative member,
and a contact pin to engage the plug assembly contact
socket, the hollow insulative member having extended
external and internal electrical creepage paths.

DESCRIPTION OF DRAWING

The invention is illustrated in the accompanying draw-
ing wherein:

FIG. 1 is a cross-sectional plan view of one form of an
electrical connector and connector plug incorporating fea-
tures of this invention;

FIG. 2 is a fragmentary cross-sectional view of a por-
tion of the connector plug shown in FIG. 1; and

FIG. 3 is a segmented cross-sectional view of a modi-
fied embodiment of the connector of FIG. 1.

DETAILED DESCRIPTION

With reference to the embodiment illustrated in FIG. 1,
the connector, generally indicated at 10, comprises a re-
ceptacle assembly or portion 12 which may be attached
by mounting nut 14 and flange 16 to a panel 17 or the
like for electrical feedthrough and a plug assembly or por-
tion 18 which may be adapted to engage and be fastened
to receptacle portion 12 by a coupling nut 20. Plug
portion 18 may be fastened to the end of an appropri-
ate coaxial cable 21, as described in detailed below.

Receptacle portion 12 may include an annular hous-
ing or shell 22 carrying flange 16 and suitably threaded
to provide the desired engagement with mounting nut 14
and coupling nut 20. An elongated insulative receptacle
member 24 may be mounted within and secured by shell
22 by appropriate flange and groove arrangement 26. Re-
ceptacle member 24 may be suitably molded or otherwise
formed with a centrally disposed bore having a first sub-
stantial portion 28 at a diameter adapted to matingly
receive a coating part of plug portion 18 and a second
or remaining portion 30 supporting a contact or connec-
tor pin 32. Connector pin 32 may be gripped by bore
portion 30 with one end projecting into bore portion 28
and the other end adapted to be connected by any suit-
able means to a source or user of electrical energy. The
exterior surface of receptacle member 24 may be pro-
vided with grooves or irregularities in its outer surface as
shown, to increase the external electrical creepage path
between connector pin 32 and shell 22.

Plug portion 18 may include a socket member 40 hav-
ing an expandable opening 42 at one end to receive con-
nector pin 32 and a portion 44 at the other end adapted
to be fastened or connected to the central conductor 46
of coaxial cable 21. Portion 44 may be formed of a di-
ameter corresponding with or about the diameter of cable
central insulator 48 terminating with an outwardly dis-
posed flange or lip 50 intermediate portions 44 and open-

ing 42. Central conductor 46 may be welded, soldered, or otherwise attached to portion 44. A heat-shrinkable insulative sleeve 52 having an initial diameter loosely fitting about an outer seating periphery of portion 44 and insulator 48 may be heat treated to provide a shrink fit and seal between the outer peripheries of portion 44 and insulator 48 and any gap therebetween and increased mechanical support. The amount of shrinkage and sealing pressure may be determined by the materials used and the temperature of heat treatment. Suitable heat shrinkable materials may be irradiated polyolefin, polyvinylidene fluoride, or the like. An elongated insulative plug member 54, suitably molded or otherwise formed, may be disposed about and in contiguous and gripping relationship with the outer exposed periphery of socket member 40 and its flange 50. Plug member 54 may extend in one direction beyond opening 42 of socket member 40 and include an inwardly extending guide lip 56 for connector pin 32, and projecting in the other direction a sufficient distance to be encompassed by the first portion 28 of receptacle member 24 and beyond, overlying entirely sleeve 52 and a portion of the exposed cable insulator 48. Plug member 54 is preferably spaced from sleeve 52 and cable insulator 48 some prescribed distance for purpose to be explained below. The portion of plug member 54 extending beyond receptacle member 24 may be threadedly engaged or otherwise fastened to a hollow, tubular extension 58 of a housing means or shell 60.

Besides tubular extension 58, shell 60 may include a portion 62 rigidly attached to or forming a part of tubular extension 58, which portion may be closely fitting about cable insulator 48 at a location removed from sleeve 52 and plug member 54. Portion 62, tubular extension 58, plug member 54, sleeve 52, and cable insulator 48 cooperate to form a cavity or chamber 64 therebetween having spaced apart ports 66 and 68, such as through tubular extension 58, communicating therewith. A suitable insulative sealant material 70 such as certain silicones like room temperature vulcanizing castable silicone rubber, may be injected within chamber 64 through ports 66 and 68 to completely fill the entire chamber and provide an adhesive seal to each of the insulative members or sleeves bordering the chamber. To insure an adhesive seal, the exposed surfaces of plug member 54, sleeve 52, and cable insulator 48 facing chamber 64 are preferably suitably prepared including exterior and interior surfaces of member 54. This preparation may include a roughening of the surfaces such as by sandblasting or etching, and for high-altitude use, the preparation preferably in addition includes priming of all or a substantial portion of all surfaces with an interface material which bonds to the insulative members or sleeve or cable insulator and with sealant material 70. Such an interface material is shown with exaggerated thickness in the fragmentary view shown in FIG. 2 as material 72 and may include certain silicone primers or adhesion promoters for the silicone adhesive. The surfaces of member 54 covered by material 72 is shown with exaggerated roughness. Interface material 72 may provide a homogeneous bond between parts and an air-tight pressure seal within plug member 54.

Sealant material 70 may be injected into ports 66 and 68 by any suitable pressure injection means such as by use of a hypodermic syringe. The sealant may be injected into one port while blocking the other port until resistance to flow is evident. Then the other port may be unblocked with continued injection of sealant material 70 to flush entrapped air from the chamber 64 and insure a complete chamber fill and the sealant material then cured.

Additional withstand strength at high altitudes is achieved with an annular, deformable gasket 73 disposed between the end of plug member 54 and the end of bore 28 of receptacle member 24. Gasket 73 may be made of any low compression set material, such as certain silicones, which may be pressed against the respective insu-

lative members 24 and 54 and connector pin 32 to provide a seal therewith.

Shell 60 may also include an end cap or collar member 74 having a skirt 76 which may be threadedly attached to portion 62 and tubular extensions 58 so as to cover and seal ports 66 and 68. Any excess sealant material which leaked from ports 66 and 68 may be used to effect a seal with collar 74. Collar 74 may be disposed about the outer periphery of coaxial cable 21 with an inwardly extending lip 78 for wedging and gripping the outer braid 80 and insulation of cable 21 between lip 78 and a conical extension 82 of portion 62 of decreasing diameter and directed opposite to or away from tubular extension 58. Conical extension 82 may be provided with appropriate annular and longitudinal grooves 84 and 86 for additional gripping of the cable. Shell 60 may be suitably attached to receptacle portion 12 by a coupling nut 20 secured in position by a retaining ring and groove arrangement.

Shell 60 may be modified optionally as shown in FIG. 3 to insure good conductivity where welding is required such as when using aluminum conductor cables. In such construction, tubular extension 58 is provided with one or more radially spaced slots or grooves 88 and 90 for receiving and holding suitably shaped wire bundles 92 and 94 formed from cable braid 80. Wire bundles 92 and 94 may be welded or brazed within annular conductive sleeves 96 and 98 of copper or aluminum as compatible which in turn may be secured into grooves 88 and 90. Collar 74 may be modified to include a pair of longitudinal ports 100 and 102 communicating with chamber 64 for filling thereof and complete the enclosure of chamber 64.

Shell 22 and tubular extension 58 may be formed in overlapping relationship and be provided with appropriately shaped and coacting studs and grooves or keyways to aid in alignment of the plug and receptacle and permit selective engagement of two or more connectors mounted in close proximity.

The various conductive parts of the connector, such as shells 22 and 60, may be made of stainless steel or other suitable conductor, and the socket member 40 may be made of beryllium copper, both appropriately plated such as with gold for good conductivity. Insulative plug member 54 and receptacle member 24 may be made of long glass fiber-filled diallyl phthalate or other suitable filled or unfilled insulating materials. Cable insulator 48 for the above noted primer may commonly be made of a material such as irradiated polyolefin, or the like.

A connector made in accordance with this invention having a maximum outside diameter of 0.21 inch for shells 60 and 22 and a maximum connected length between the ends of shell 60 and connector pin 32 of 1.3 inches without gasket 73 and insulating material 70, is capable of withstanding about 5 kilovolts at sea level between the center conductor and the conductive shells. The lengths of the shortest creepage path, both internal and external, for such a connector may be about 0.5 inch. With gasket 73, insulating material 70, and primer 72 in place as described, this connector will withstand 10 kilovolts and is capable of withstanding 25 kilovolts at altitudes through the critical area including the 30,000 to 220,000 feet range.

This connector thus permits connection of cables at very high voltages with ultraminiaturization at both low and high altitudes.

It will be understood that various changes in the details, materials, and arrangements of the parts, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principles and scope of the invention as expressed in the appended claims.

What is claimed is:

1. A high-voltage connector plug for a coaxial cable having a central conductor and outer braid separated by

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an insulator, comprising, a conductive socket member rigidly secured to said cable central conductor having an outer seating periphery adjacent said cable, an insulative sleeve overlapping said seating periphery of the socket member and overlapping an adjacent outer periphery of said cable insulator and having a shrink fit against both said peripheries, an elongated insulative member disposed about and gripping said socket member having one end portion projecting beyond said insulative sleeve and spaced from the cable insulator and a portion of said insulative sleeve and another end portion including an inwardly extending connector pin guiding lip, said projecting end portion of the elongated insulative member having roughened exterior and interior surfaces, housing means for supporting said insulative member and said cable having a portion about said cable at a location spaced from said insulative member with a tubular extension spaced from said cable insulator forming a chamber thereabout and threadedly engaged with said insulative member, said housing means also having a pair of spaced apart ports therethrough communicating with said chamber, and injected insulative sealant filling said chamber and ports and the space intermediate said cable insulator, insulative sleeve and insulative member and gripping the roughened interior and exterior surfaces of said insulative member.

2. The connector of claim 1 including an interface material between the outer surfaces of said cable insulator and insulative sleeve and the roughened surfaces of said insulative member within said chamber for adhesively gripping said insulative sealant.

3. The connector plug of claim 1 wherein said housing means includes a collar member threadedly engaging and overlying a portion of said tubular extension.

4. The connector plug of claim 3 wherein said housing means includes a portion closely fitting about said cable insulator at said location spaced from said insulative member with said ports disposed through said tubular extension, and said collar member includes a skirt overlying and sealing said ports.

5. The connector plug of claim 4 wherein said closely fitting portion of said housing means includes a conical

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extension of decreasing dimension disposed away from said tubular extension and said collar means includes a lip clamping said cable outer braid against said conical extension.

6. The connector plug of claim 5 wherein said conical extension includes longitudinal and annular grooves for gripping said cable outer braid.

7. The connector plug of claim 3 wherein said cable outer braid is separated into a pair of wire bundles and said housing means includes a pair of oppositely disposed slots enclosed within said collar member for receiving and gripping said bundles.

8. The connector plug of claim 7 wherein said ports are disposed in said collar member.

9. The connector plug of claim 1 including a mating receptacle portion comprising an annular shell, an elongated insulative receptacle member including a centrally disposed bore with a substantial portion at a diameter for receiving said plug insulative member, a connector pin projecting into said substantial portion of said bore gripped by the remaining portion of said bore for mating relationship with said guiding lip and socket member of said connector plug, and an annular sealing gasket disposed about said pin between said mating insulative members.

10. The connector of claim 9 wherein said insulative receptacle member includes an extended electrical creepage path along its outer surface between said connector pin and said annular shell.

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