United States Patent [19]

Caro et al.

[11] **Patent Number: 4,698,028**

[45] **Date of Patent: Oct. 6, 1987**

[54] **COAXIAL CABLE CONNECTOR**

[75] Inventors: **Edward R. Caro**, Monterey Park; **Walter J. Bonazza**, La Canada, both of Calif.

[73] Assignee: **The United States of America as represented by the Administrator of the National Aeronautics and Space Administration**, Washington, D.C.

[21] Appl. No.: **904,513**

[22] Filed: **Sep. 8, 1986**

[51] **Int. Cl.**[4] **H01R 13/52**

[52] **U.S. Cl.** **439/271**; 439/578

[58] **Field of Search** ..... 339/59, 60 C, 60 M, 339/61 R, 61 M, 63 R, 63 M, 177 R, 177 E, 89 C, 90 C, 200 R, 201, 213 R

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,969,866	8/1934	Wild et al.	339/60 C
2,883,640	4/1959	Duenke	339/202
2,937,360	1/1960	True	339/177 R
3,106,599	10/1963	Leitner, et al.	174/12
3,322,883	5/1965	Lusk	174/73
3,361,430	8/1965	Reid	277/26
3,413,407	11/1968	Potter	174/89
3,439,294	5/1968	Flanagan et al.	333/33
3,514,741	5/1970	Noren	339/177 R
3,963,297	6/1976	Panek et al.	339/94 M
4,373,767	2/1983	Cairns	339/94 C
4,545,633	10/1985	McGeary	339/42

FOREIGN PATENT DOCUMENTS

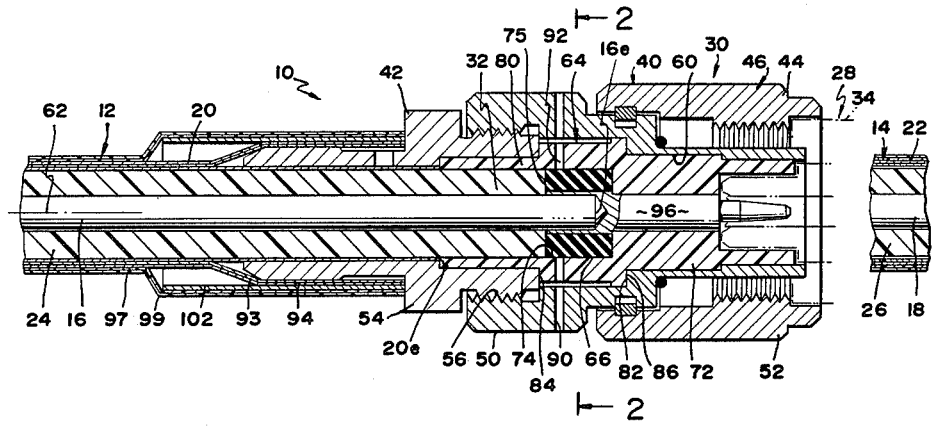
746998	3/1933	France	339/177 R
778781	7/1957	United Kingdom	177 R/

Primary Examiner—John McQuade
Assistant Examiner—David Pirlot
Attorney, Agent, or Firm—Paul F. McCaul; John R. Manning; Thomas H. Jones

[57] **ABSTRACT**

A coaxial cable connector is provided, which resists radio-frequency breakdown in coaxial cables used in the vacuum of outer space. The connector body surrounds an insulator which includes an easily compressible elastomeric portion. An insulated coaxial cable is prepared so its insulation projects beyond the outer conductor and compresses the elastomeric portion of the connector insulator.

6 Claims, 2 Drawing Figures



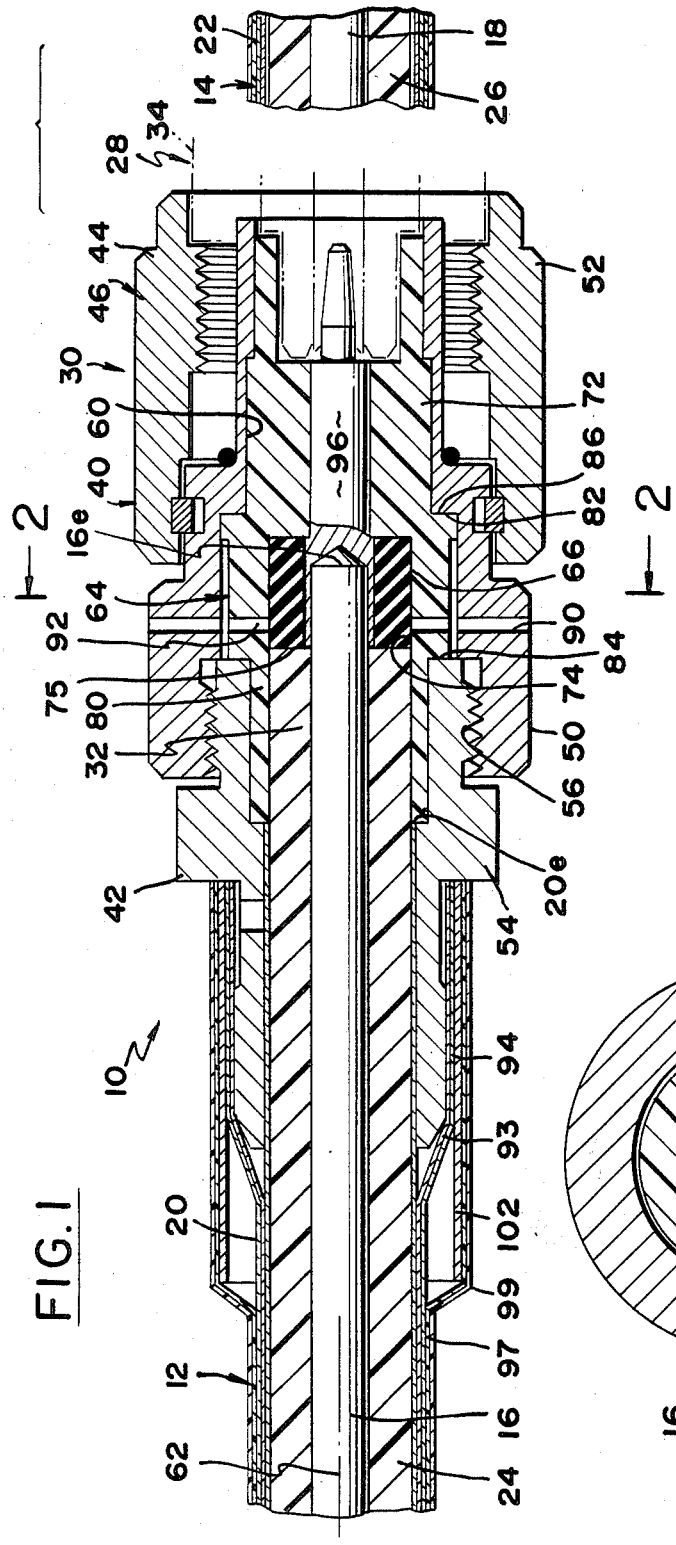

22
18
14
26
34
28
44
46
52
30
72
60
86
40
82
16e
2
2
66
64
90
92
84
74
75
80
50
32
56
20e
42
54
10
94
93
20
102
99
97
12
16
62
24

FIG. 1

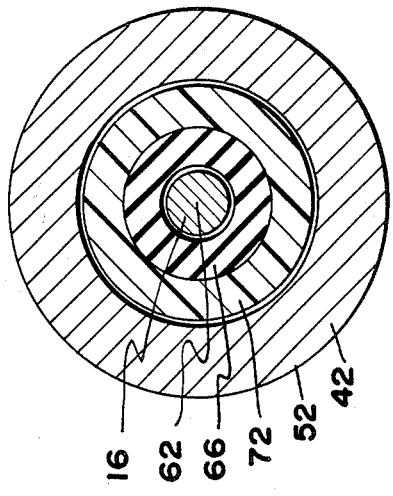

16
62
66
72
52
42

FIG. 2

COAXIAL CABLE CONNECTOR

ORIGIN OF INVENTION

The invention described herein was made in the performance of work under a NASA contract, and is subject to the provisions of Public Law 96-517 (35 USC 202) in which the Contractor has elected not to retain title.

BACKGROUND OF THE INVENTION

Coaxial cable systems used to carry RF (radio-frequency) power in outer space are often provided with an insulation between the outer and center conductors to prevent RF breakdown. Such cable insulation tends to develop gaps or voids at the interfaces between various insulators or dielectric elements, as a result of thermal cycling, aging, and manufacturing tolerances. Wherever a void has developed along such a coaxial system, breakdown can occur when the system is carrying RF power. One cause for breakdown in such a gap, occurs when the pressure of air in the gap has dropped from atmospheric to between 0.01 and 0.1 Torr. At such a pressure range, the radio-frequency voltage between the inner and outer conductors can cause the low pressure air to ionize, become hot, and form a carbon track which feeds on itself and leads to catastrophic failure. If air in the void fully vents to the vacuum of outer space, on the order of 0.001 Torr or lower, then there is the possibility of multipactor breakdown, which is a secondary electron resonance phenomenon which rapidly develops into ionization and catastrophic failure. These problems have been observed in many spaceborn RF systems. A coaxial cable connector or connection system which avoided the development of gaps despite thermal cycling, aging, and manufacturing tolerances, would be valuable in assuring the reliable operation of RF systems, especially those used in the vacuum of outer space.

SUMMARY OF THE INVENTION:

In accordance with one embodiment of the present invention, a connector is provided for connection to the end of an insulated coaxial cable, which resists the formation of gaps in the insulation between the outer and center conductors. The connector includes an electrically-conductive housing with front and rear ends and a passage therewithin. A connector insulator which lies in the passage has an elastomeric rear end portion. The cable is held to the connector housing so the cable insulation projects into the passage and compresses the elastomeric insulation portion. Thus, if the cable insulation shrinks or expands, the elastomeric portion of the connector insulator takes up such shrinkage and expansion, to prevent the formation of a gap between the outer and center conductors where RF (radio-frequency) breakdown can occur.

The novel features of the invention are set forth with particularity in the appended claims. The invention will be best understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a sectional view of a cable and connector assembly constructed in accordance with the present invention.

FIG. **2** is a view taken on the line **2—2** of FIG.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** illustrates a connection system **10** wherein two insulated coaxial cables **12, 14** are connected so their center conductors **16, 18** and outer conductors **20, 22** are in electrical connection. This particular system is designed to carry high frequency power in a high vacuum environment such as in outer space. To prevent breakdown which can occur in that environment, each cable has a cable insulator **24, 26**. The cables are interconnected by a connector system **28** which includes one connector apparatus or connector **30** for connecting to the end **32** of one cable, and also to another connector **34** which connects to the end of the other cable **14**. In order to prevent breakdown, it is important that insulation lie between the inner and outer conductors along the entire interconnection between the cables, with no gap in the insulation through which breakdown can occur. Such gaps can occur because of shrinkage of a cable insulation such as **24** with age, expansion or contraction with temperature changes, and as a result of manufacturing tolerances.

The connector **30** includes an electrically conductive housing **40** with rear and front ends **42, 44**. The housing is formed by a body **46** having a pair of rotatably coupled elements **50, 52**, and a rear fitting **54** which is threadably engaged with a threaded rear end **56** of the body. The housing **40** forms a passage **60** extending along a connector axis **62**. A connector insulator **64** lies in the passage, to insulate the central conductor **96** of the connector from the electrically conductive housing **40**.

In accordance with the present invention, the connector insulator **64** includes an elastomeric portion or part **66** which is normally compressed in a direction along the axis **62** of the connector. As a result, if a cable insulation such as **24** shrinks, as because of aging, so it withdraws from the connector, the elastomeric part **66** expands to avoid the creation of a gap in the insulation through which breakdown can occur. The elastomeric part **66** lies at the rear end of the connector insulation, to bear directly against the cable insulation **24**. If there are manufacturing tolerances which would otherwise cause the end of the cable to not be accurately flat, no gap will open because the elastomeric connector insulation part will fill any indentations at the end of the cable insulation. The elastomeric part **66** can be formed of a plastic foam, silicone rubber (for a higher dielectric constant), or other elastomeric material.

The end of the coaxial cable **12** is prepared for attachment to the connector **30** by removing the outer conductor **20** from around the cable insulation **24** at the end of the cable. The cable insulation includes a projecting end portion or end **32** that projects beyond the end **20***e* of the cable outer conductor. The cable outer conductor is attached to the connector rear fitting **54** to make mechanical and electrical connection with the fitting. The projecting insulation end **32** of the cable insulation projects deeper into the connector than the cable outer conductor, and the projecting insulation end directly abuts the elastomeric part **66** of the connector insulator.

The connector insulator **64** includes not only the elastomeric part **66**, but a second part **72** which extends forward of the elastomeric part. The second part **72** includes a recess **74** which has a width that permits it to closely receive the elastomeric part **66** and also the end of the projecting cable insulation portion **32**. As a result,

the interface **75** between the tip or extreme forward end of the projecting cable insulation portion **32** and the rear end of the elastomeric connector insulator part **66**, is protected against the opening of any gap, by the overlapping walls **80** of the second insulator part at its recess.

The connector housing forms rearwardly and forwardly facing shoulders **82, 84** and the second insulator part **72** forms a pair of corresponding ledges **86** that abut the shoulders to keep the second insulator part in the housing. The distance between the shoulder **82, 84** determines the amount of initial compression of the elastomeric portion **66** of the connector insulator. As the rear fitting **54** is screwed into the threaded rear end **56** of the housing body, it approaches and then abuts the rearmost one of the ledges **86** on the connector insulator, at which point the fitting encounters resistance to further turning. The projecting cable insulation portion **70** has then compressed the elastomeric portion **66** by the desired amount.

The elastomeric connector portion **66** is preferably vented to the outside, to permit the rapid venting of air in the passage when the connector is introduced into a vacuum, and also thereafter permit the escape of vapors that can be produced by the elastomeric connector insulation portion. To enable such escape, the housing and second insulator parts have aligned holes **90, 92** that form a vent extending from the environment outside the housing to the outside of the elastomeric insulation portion **66**, and the recess **74**. Thus, any deep pockets of air, as well as vapors, are vented.

The coaxial cable **12** is prepared for attachment to the connector **30** as by cutting a foil shield **93** and braided shield **94** of the outer conductor **20** and a plastic cable jacket **97** around the outer conductor. The end of the cable insulator is trimmed back to leave the forward end **16***e* of the center conductor projecting forward of the cable insulation to enable its attachment to the connector center conductor **96**. The outer conductor **20** is then mechanically and electrically mounted to the rear fitting **54**. This can be accomplished by inserting the foil and braided shields **93, 94** in the rear fitting and squeezing the shields between a sleeve **102** and the rear of the fitting **54**, and also by soldering the parts together. The cable jacket **97** lies about the sleeve **102** and a heat shrinkable layer **99** is shrunk. Then the fitting **54** with the front end of the trimmed cable thereon is inserted into the connector body **46**, and the body is screwed onto the fitting until the shoulder **84** at the front end of the fitting firmly abuts the rear ledge **86** of the connector insulation.

Thus, the invention provides a connection system for connecting a coaxial cable of the type that includes a cable insulation, to another coaxial conductor such as a connector. Gaps between the insulation of the cable and the connector insulator or the like are avoided by the use of a connector insulator which includes an elastomeric portion that abuts the forward tip of the cable insulation. The connector insulator also preferably includes a part with a recess which receives the compressed elastomeric insulator portion as well as the forward tip of the cable insulation, to protect against the possibility of any gap at their interface. The connection is useful for a connector that mates with another connector, or any other insulated coaxial cable interconnection.

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art, and consequently, it is intended that the claims be interpreted to cover such modifications and equivalents.

What is claimed is:

1. A connector apparatus useful to connect the end of a coaxial cable to another connector apparatus, comprising:

a coaxial cable having center and outer conductors and a cable insulator between them;

an electrically conductive housing having rear and front ends and forming a passage between its ends, said rear end constructed to mechanically and electrically connect to the outer conductor at the end of said coaxial cable;

an electrically conductive center connector conductor having a rear end for connecting to the center conductor of said coaxial cable;

a connector insulator lying within said passage, and having a hole through which said center connector conductor extends at least partially;

said connector insulator including an elastomeric portion positioned to be compressed by the cable insulator of said coaxial cable, whereby to avoid gaps arising from axial shrinkage of said insulator of said coaxial cable;

said cable insulator has an end portion that projects forwardly beyond said cable outer conductor, and said elastomeric insulator portion comprises an elastomeric first insulator part which abuts the projecting end portion of said cable insulator, the rearward portion of said passage having a greater width than the outside of said cable insulator end portion and the outside of said elastomeric insulator part; and

said connector insulator includes a second insulator portion lying in said passage, and having a rear portion that extends around both said elastomeric first insulator part and at least part of the projecting end of said cable insulator.

2. The apparatus described in claim **1** wherein:

the forward end of said coaxial cable extends along a predetermined axis;

said body and second insulator part each has a vent passage, said passages aligned and extending primarily perpendicular to the length of said axis, from the outside of said body to said elastomeric part.

3. A connector apparatus useful to connect the end of a coaxial cable, which includes a cable insulator between the center and outer cable conductors, to another connector apparatus which has center and outer conductors, comprising:

an electrically conductive housing having rear and front ends and forming a passage between its ends, said rear end constructed to mechanically and electrically connect to the outer conductor at the end of said coaxial cable;

an electrically conductive center connector conductor having a rear end for connecting to the center conductor of said coaxial cable;

a connector insulator lying within said passage, and having a hole through which said center connector conductor extends at least partially;

said connector insulator including an elastomeric portion positioned to be compressed by the cable insulator of said coaxial cable, whereby to avoid

gaps arising from axial shrinkage of said insulator of said coaxial cable;

said housing includes a body with a threaded rear portion and also includes a rearwardly-facing internal shoulder, said housing also including a rear fitting threadably engaged with said threaded body portion and forming a forwardly-facing shoulder;

said connector insulator includes a second insulator portion extending between and against said shoulders, said second insulator portion having a recess at its rear end, said recess having a bottom;

said elastomeric portion of said connector insulator lying in said recess and having one end against the bottom of the recess and an opposite end against the cable insulator, whereby the second insulator portion limits how far forward the rear fitting is turned to limit the degree of initial compression of the elastomeric insulator portion.

4. A coaxial connector apparatus for connection to an end of a coaxial cable which has outer and center conductors and a cable insulation between them, comprising:

an electrically conductive connector housing which has front and rear ends and a passage extending into the rear end toward the front end along an axis;

a connector insulator lying in said housing and having forward and rearward ends, and having an elastomeric portion at its rear end, said connector insulator having means for limiting its forward movement within said housing;

said housing including a body with front and rear end portions said body surrounding at least part of said connector insulator, and a fitting which is attachable to the outer cable conductor, said fitting attachable to the rear end portion of said body at a position to hold said cable insulation so it compresses said elastomeric portion of said connector insulator;

said elastomeric portion comprises a first insulator part, and said connector insulator includes a second insulator part which is more rigid than said first part and that has a rear end forming a recess that receives said elastomeric first insulator part, said recess being deeper along said axis than the length of said first elastomeric insulator part therealong, so the recess also receives the end of said coaxial cable insulation.

5. The apparatus described in claim **4** wherein:

said housing body and second insulator part have aligned holes forming a vent extending largely perpendicular to said axis, between the recess in said second insulator part and the outside of said body.

6. The apparatus described in claim **4** including:

said coaxial cable having said outer conductor connected to said fitting and said cable insulation projecting beyond said outer conductor into said recess and compressing said first insulator part.

* * * * *