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LOW LEAKAGE CONNECTOR FOR USE IN HIGH RADIATION FIELDS

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Fig. 1

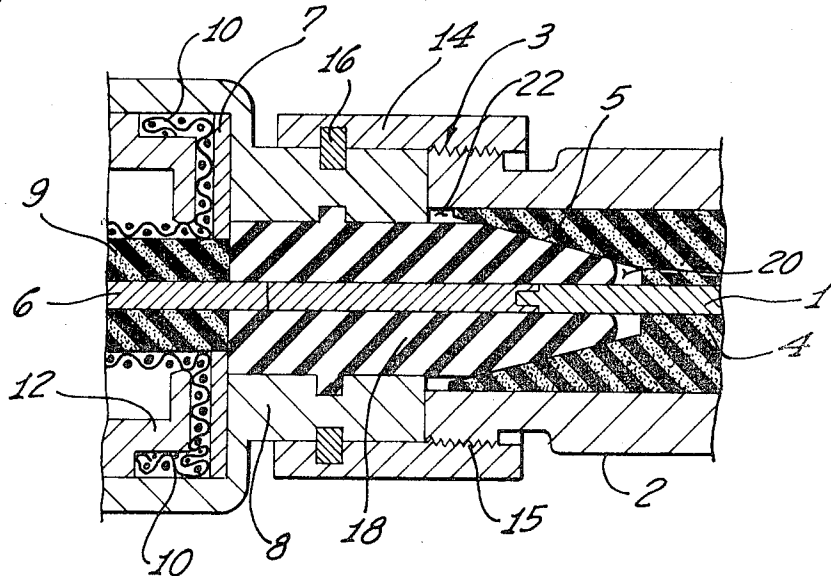
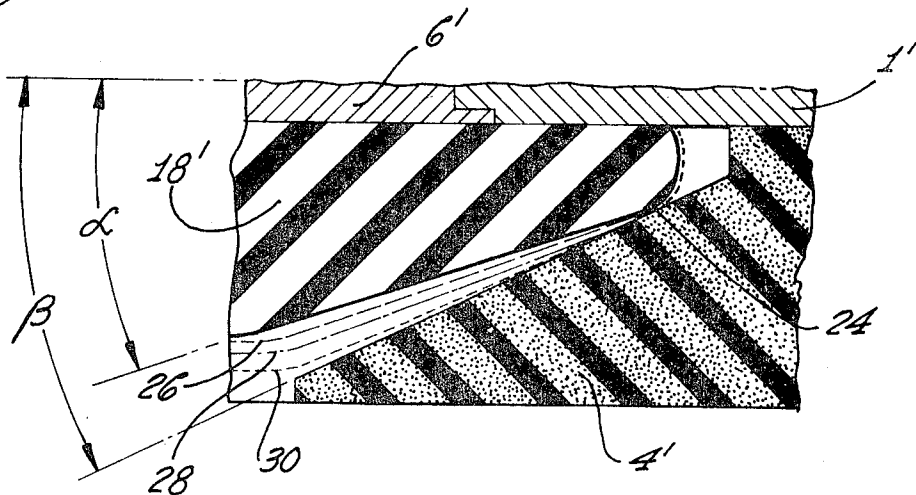


Fig. 2



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LOW LEAKAGE CONNECTOR FOR USE IN HIGH RADIATION FIELDS

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4 Claims

ABSTRACT OF THE DISCLOSURE

The improved electrical connector means of the invention includes the structure of conventional male and female coaxial connectors. That conventional structure is modified so as to avoid the existence of any air path between the center conductor and the outer conductor of the coaxial connector portions after the two portions are fully coupled or joined together. One connector portion, for example, the male connector is modified to include in the space between the center and outer conductor at one end a concavely tapered nonionizable relatively rigid insulating material having an end recessed in the outer wall of the connector portion. The sides of the tapered insulating material are of the form of a truncated cone and form a first angle with respect to the axis of the center conductor. In this embodiment the female connector portion, on the other hand, includes a protruding member of an elastic deformable nonionizable insulating material anchored at the end of the male connector in the space between the center conductor and the outer conductor and which projects from the connector end beyond the outer conductor walls thereof. The protruding insulator has convexly tapered outer sides substantially in the geometry of a truncated cone. The sides of the tapered portion forms a second or cone angle with respect to the axis of said center conductor, and this angle is slightly smaller than the cone angle of the more rigid insulating member, previously cited. In coupling the male and female connector portions together, the protruding elastic insulator fits within the recessed rigid insulator.

The diameter of the front end portion of the elastic insulator is large enough to abut a rearwardly located portion of the wall of the more rigid tapered insulator in the male connector when the two connector portions are first pressed together in the union. Coupling means, suitably a threaded collar, are provided on one of the connector portions, which engages a threaded connector portion on the other connector portion for compressively joining together the two connector portions. As the coupling collar rotates, the compression of the union increases and the deformable insulating material expands or bulges. This bulging commences at the point within the male connector where the deformable projecting insulator first engages or abuts the tapered walls of the more rigid insulator and thereafter, as greater and greater compression is applied, continues and closes sequentially the gap in between the rigid insulator walls and the walls of the projecting elastic insulator from one end toward the other end. In high radiation fields or high voltage fields any path formed by an ionizable gas present between the center and outer conductors breaks down and causes leakage between the cited conductors. This bulging action sweeps out any air initially present between the insulator portions of the male and female connectors and prevents the existence of a direct path of air or gas molecules between the center and outer conductors.

This invention was conceived or reduced to practice during the performance of a contract with the U.S. Atomic Energy Commission.

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This invention relates to low leakage connectors, and more particularly, to electrical connectors for use in environments of high ionization fields caused by atomic energy or high electrical voltages.

Heretofore it has not been possible to provide satisfactory electrical connectors for use in high radiation fields. In high radiation fields gas molecules, such as air, are ionized into positive and negative ions which conduct electrical currents between separated electrical conductors at different electrical potentials. Such ionization creates severe difficulties in providing suitable detachable electrical connections with; for example, neutron detectors used in making measurements of high radiation fields of atomic energy. Conventional connectors contain a dielectric insulating material between the center and concentric outer conductors. At the union where the male and female connector ends join, an air passage is formed between the center and outer conductors. Unfortunately, in high radiation fields this air breaks down or ionizes which results in electrical current flow or "leakage" between the center and outer conductors. In effect, this leakage current "shorts out," electrically, the remainder of the electrical circuit and, hence, with atomic field measurements, the neutron detector. This leakage phenomenon is also observed in connectors used in electrical cables carrying high electrical voltages in high altitude applications.

To avoid this problem in that application, electrical connectors heretofore used were modified so as to permit the insertion of grease or oil in the union between the male and female connector portions. The grease or oil excluded air from between the outer and center conductor at the face of each connector portion. While this method is partially satisfactory, it possesses the obviously undesirable characteristic of being very messy to use in the field.

Therefore, it is an object of this invention to provide an electrical connector for use in high radiation fields;

It is another object of this invention to provide an electrical connector which at the union does not contain an air passage between the center and outer conductors;

It is a further object of the invention to provide electrical connecting means in which the existence of an air path at the union and between the center and outer conductors is precluded without substantial use of grease or oils.

The foregoing and other objects and advantages of the invention, together with modifications thereof and equivalents thereto become more apparent with an understanding of the following detailed description of a preferred embodiment of the invention taken together with the figures of the drawing in which:

FIG. 1 is an illustration in cross section of a novel electrical connecting means embodying the invention; and

FIG. 2 is a graphical illustration of the sweeping action which occurs to remove air and which is illustrative of the principles of the invention.

Briefly stated, the invention encompasses a novel electrical coaxial connecting means having male and female connector portions. Each of the male and female connector portions contains a center and an outer concentrically surrounding cylindrical conductor separated and supported from each other by dielectric material in the annular space between. In accordance with the principles of the invention, a protruding surrounding elastic deformable body of nonionizable insulative material is anchored between the center and outer conductor of the female connector portion and protrudes beyond the outer conductor or shell. The outer sides of this protruding insulator are convexly tapered and comprise the geometry of a truncated cone. The "cone" angle formed between the walls thereof and the axis of the center conductor is a

first angle. The male connector portion includes coaxially the center and outer conductors and an insulator therebetween. The insulator in this connector portion is a relatively rigid material and is recessed from the front or coupling end of the connector portion and concavely tapered from the front to the back so as to have the geometry of a truncated cone, leaving the center conductor exposed and projecting. The "cone" angle formed by the walls of this nonresilient insulator portion and the axis of the center conductor forms a second angle. However, this second angle is slightly larger than the first angle formed by the protruding tapered insulator of the female connector. The outer diameter of a tip of front end portion of the protruding tapered elastic insulator of the female connector is such as to engage and abut a recessed portion of the tapered more rigid insulator walls of the male connector when the two are initially coupled together and the two insulators fit within one another.

Coupling means are provided for compressively uniting the male and female connector portions. In accordance with the principles of the invention, as the coupling member is tightened to increase the compression between the connector portions, the protruding elastic insulator portion increasingly bulges radially from its front to its back causing further and further portions of the walls of the protruding elastic insulator to abut the tapered more rigid insulator wall portions in the male connector portion. Upon full compression, the protruding convexly tapered elastic insulator walls are in full contact with the concavely tapered walls of the nonresilient insulating member of the other connector portion. In accordance with the principles of the invention, the bulging proceeds from the front to the rear of the protruding elastic insulator and a sweeping effect occurs between the insulator walls which pushes out the air from the space previously existing between the protruding tapered elastic insulator and the rigid recessed tapered insulator. In accordance with another aspect of the invention, the first and second angles are acute angles. Moreover, in accordance with still further aspects of the invention, the protruding insulator is an elastomer, suitable silicon rubber; and the recessed insulator is ceramic, suitably aluminum oxide.

FIG. 1 shows in partial cross section the male and female connector portions forming the connector means or connector. Each of the two portions are joined together in the figure to complete the electrical and mechanical union. The male connector includes a center conductor 1, conventionally of copper and an outer conductor or shell 2. The outer conductor is conventionally the shape of a hollow cylinder, consisting of a plated brass threaded end portion 3 on the outer side of outer conductor 2, and a dielectric or insulating material 4 surrounds and supports center conductor 1 within the concentrically surrounding outer conductor 2. Insulating material 4 is a rigid dielectric material, suitably the well known ceramic material, aluminum oxide. Insulator 4 is enclosed within conductor 2 and is tapered concavely from the front end of the connector to a back or recessed position to a distance behind the end of the center conductor 1. Thus, approximately a portion of center conductor 1 protrudes from insulator 4. This portion of the insulating material thus defines the geometry of a truncated cone. The tapered insulator walls form an acute angle with the axis of center conductor 1.

It is noted that ceramic is a material which does not ionize in a field of high atomic radiation. The male connector portion includes conventional elements for clamping or soldering a coaxial cable at the right side of the illustration. Since such elements are old and well known, they are omitted from both the drawings and this description.

The female connector portion includes center conductor 6, suitably copper, concentrically supported within a

hollow outer conductor or shell 8, suitably plated brass. In between center conductor 6 and outer conductor 8 at the left side is an insulating material, insulator 9 of a dielectric material, suitably aluminum oxide. Insulator 9 in this portion of the female connector is supported by a washer shaped conductor 7.

The left portion of the female connector in this embodiment, as is conventional, contains elements for permitting the connector to be electrically connected with a coaxial cable. For purposes of illustration such connection is illustrated in FIG. 1 by showing the wire braid portion 10 of a cable. For this purpose the elements included in the shell includes a clamping member 12, only a portion of which is illustrated, which clamps wire braid 10 in electrical contact with the outer wall 8 of the female connector portion and mechanically holds such cable in place. The clamping member is otherwise of conventional construction and is not described further.

A treated ring collar or coupling member 14 is joined to the outer wall of the shell or outer conductor 8 by a split or snap ring washer 16 which is seated in a groove in both outer conductor 8 and ring collar 14. The treads 15 of the collar engage the treads on outer conductor 2 of the male conductor.

Anchored within the space between center conductor 6 and the front end of outer conductor 8 is a convexly tapered insulator of any nonionizable elastic, deformable, compliant electrical insulating material, such as an elastomer and suitably silicon rubber which protrudes from the end of outer conductor 8.

The front end portion of protruding insulator 18 has conically tapered outer sides or walls and is of the geometry of a truncated cone. In FIG. 1 these sides engage and abut the tapered walls of rigid insulator 4 in the male connector. Although not shown in this figure, when the male and female connectors are separated the taper of the sides of elastic insulator 18 forms an acute angle with the axis of center conductor 9 or 1, which angle is slightly smaller than the acute angle formed by the tapered walls of insulator 4 with the center conductors. However, as illustrated, when the two conductor portions are compressed together, elastic insulator 8 deforms to the same taper as that of the tapered walls of the more rigid insulator 4. The outer diameter at the top end of elastic insulator 18 is the same as the inner diameter of the back recessed portion of tapered insulator 4.

An annular void 20 exists between the top of seal 18 and the back of the opening in insulator 4. Another annular void 22 preferably is present between seal 18 and outer conductor wall 2 in order to permit some type of reservoir for air.

Additionally, it is desirable if the bottom edge of the female connector insulator 9 can be coated with grease to insure the prevention of any air passage between conductor 8 and center conductor 6 at the back of protruding insulator 18. Moreover, the outer sides of insulator 18 may be lightly coated with grease to insure positively that no air space will exist between its tapered walls and the tapered walls of the rigid insulator 4.

It is noted that the diameter of insulator 18 at its tip or front end is substantially the same as the diameter of the tapered walls of insulator 4 at the back end of the conical cavity. This permits an initial engagement between insulator 18 and insulator 4 which fit within one another when the male and female connector halves are initially coupled together. It is further noted that the insulator material used is such as to withstand the radiation fields to which it is exposed.

The construction of most parts of the male and female connector illustrated in this embodiment are well known and conventional. Thus, the support and formation of the ring collar 14, the outer conductor 8, and the coupling therebetween with spinning nut 16 is conventional, as is the construction of clamping member 12, the formation and brazing in place of insulator 9, and the cable con-

nection to wire braid 10. Likewise, the construction of the metal cylinders forming the outer wall 2 and the construction of center conductor 1 with insulating material 4 between them is likewise conventional and is not further discussed. The shape of insulator 4 in the male connector is obtained by forming insulator 4 in a mold to the desired shape and taper before it is inserted, assembled, and brazed in place within hollow cylinder or outer conductor 2.

To construct the protruding insulator 18 a mold, not illustrated, is mounted to the female connector. Such mold is of the desired geometrical configuration. An extension is placed onto the center conductor 6 and a further extension is connected therewith to duplicate the position of male connector center conductor 1. Liquid silicon rubber is then poured into the mold where it flows in between center conductor 6 and outer conductor 8, filling the entire annular space, including the anchoring groove 15, to the desired height. The silicon rubber is then air cured and after the lapse of the necessary time for curing, the mold is removed. This leaves the formed insulator remaining.

Reference is now made to FIG. 2 which more clearly illustrates the principles of the invention. FIG. 2 shows a portion of the center conductors 1' and 6' and the protruding elastic 18' and rigid insulator 4' during the several stages of compression undergone by the connector elements upon fastening of the ring collar 14 in FIG. 1. The taper of the conical segment of insulator 18' is illustrated as an acute angle, α , while the taper of the rigid ceramic insulator 4' is shown as being an acute angle, β , that is slightly larger than α . Upon the initial coupling between the male and female connectors, the two insulators fit within one another and the front edge or tip of the tapered wall of insulator 18' abuts the tapered wall of insulator 4' at the back end at a point 24.

As the ring collar 14 of FIG. 1 is turned to tighten physically the connection between the male and female connector, insulator 18 deforms or bulges and, hence, its outer sides assume in sequence the positions of dotted lines 26, 28, 30 during successive stages of compression until the adjoining walls of both insulators are in full engagement. Since the distance between the tapered sides of insulator 18' and 4' is smallest at the right side in the figure, the bulging initially causes part engagement between a further portion of the outer walls of insulator 18' and insulator 4' at that end. With increased engagement illustrated at 28 and 30 occurring with successive increases of coupling pressure. Thus, as is apparent from the illustration, the manner in which the tapered insulator sides engage sequentially causes a sweeping action from right to left in the figure; and, thus, sweeps out any air initially present between the outer side of insulator 18' and inner walls of insulator 4'.

Reference is again made to FIG. 1. Since a path of air between outer conductor 2 and the center conductor 1 has been excluded, fields of high radiation cannot cause electrical leakage in the connector. The insulators withstand and do not break down during exposure to the atomic radiation. Accordingly, the novel connector of the invention satisfactorily provides a portable connection useful in high radiation or electrical fields.

The elastomer, silicon rubber, used in the preferred embodiment of the invention, has several additional properties useful in the connector combination. One, the silicon rubber tends to cold flow; that is, it expands to fill any slight voids that may be present, while it still retains the ability to restore itself to its original shape. Secondly, the surface of silicon rubber tends to "cling" to other surfaces. In the connector of the invention, the silicon rubber thus clings to the ceramic insulator resulting in a firm seal between the two.

Additionally, it is noted that aluminum oxide is used as the nonionizable insulator of one of the connector portions. In low atomic radiation fields and in high altitude electrical applications, a material such as "Teflon" may

be substituted for ceramic insulator 4. While "Teflon" decomposes in fields of high atomic intensity it is both useful and preferable in more conventional high altitude electrical applications and fields of lower intensity atomic radiation.

It is understood that the foregoing description of an embodiment of the invention has been presented herein to clearly illustrate the invention, and is not intended in any way to limit the invention since numerous other equivalents which do not depart from the spirit and scope of the disclosed invention suggest themselves to those skilled in the art.

For example, the relative location of insulator 18 and insulator 4 may be interchanged between the male and female connectors. Likewise in accordance with the principles of the invention, the shape of the elastic member 18 may be made that of the rigid or nonelastic insulator 4, and vice versa. In addition, the details of the conventional coupling means can be changed so long as they incorporate the relationship set forth herein between the elastic deformable seal 18 and a rigid or nondeformable insulator 4 in the other half of the connection means maintaining the same geometrical relationship so as to effectively cause the air to be swept out of the space between the tapered sides of each member as the male and female connector portions are being fully compressed in engagement.

Accordingly, it is to be expressly understood that the invention is to be broadly construed.

What is claimed is:

1. Electrical connector means for use in high radiation fields comprising: a male connector and a female connector, each of which includes an elongated center conductor and a coaxial outer conductor surrounding said center conductor; said male connector including a relatively rigid substantially nonionizable insulator between its respective center and outer conductors; said rigid insulator being tapered concavely from a front end portion of its respective outer conductor and internal thereof and forming a first angle with respect to the axis of said center conductor; said female connector including a projecting tapered insulator of elastic substantially nonionizable material surrounding the respective center conductor and anchored in place between the respective center and outer conductors; said projecting insulator comprising a convexly tapered projecting portion which extends beyond its respective outer conductor and is adapted to fit within said rigid insulator and having a taper which forms a second angle with respect to the axis of said center conductor; said second angle being slightly smaller than said first angle; and, wherein a front end portion of said projecting insulator is of the same outer dimension as the inner dimension of a rearwardly located recessed portion adjacent an end of said concave taper in said rigid insulator for causing initial engagement between said insulators upon coupling and for leaving a space between an end of said convexly tapered projecting portion and said rigid insulator as a reservoir for air; and, coupling means for coupling together compressively said male and female connectors; whereby with the application of consecutive increases of coupling pressure said elastic insulator increasingly bulges radially and abuts consecutively from one end to the other the walls of said rigid insulator and any air or gas initially existing in the space between said respective insulators is swept out by the sequential mating action.

2. The invention as defined in claim 1 wherein said convexly tapered projecting insulator comprises the geometry of a truncated cone; and, wherein said concavely tapered rigid insulator comprises the geometry of a truncated cone.

3. The invention as defined in claim 2 wherein said tapered protruding insulator protrudes beyond both the inner and outer conductors of said female connector; and,

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wherein said tapered rigid insulator leaves exposed a portion of said respective center conductor.

4. Electrical connector means for use in high radiation fields comprising: a male connector portion and a female connector portion, each of which comprises an elongated center conductor and a coaxial outer conductor surrounding said center conductor; said male connector portion including a relatively rigid substantially nonionizable insulator between the outer and center conductors tapered concavely from the face end and having the geometry of a truncated cone, said insulator portion having a taper which forms a first angle with the axis of said center conductor; said female connector portion including a projecting tapered insulator of elastic substantially nonionizable material surrounding the respective center conductor and anchored in place between its respective center and outer conductors, said projecting insulator comprising a convexly tapered projecting portion having the geometry of a truncated cone which fits within said rigid insulator and has a taper which forms a second angle with the axis of said center conductor; said second angle being slightly less than said first angle; and wherein a front end portion of said projecting insulator is of the same outer dimension as the inner dimension of a rearwardly located recessed portion adjacent an end of said concave taper in said rigid insulator for causing initial engagement between said in-

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ulator while leaving a space between an end of said convexly tapered projecting insulator and said rigid insulator as a reservoir for air; and, coupling means for coupling together, compressively, said male and female connector portions; whereby with the application of consecutive increases of coupling pressure said elastic insulator increasingly bulges radially and abuts consecutively, from one end to the other, the walls of said rigid insulator and air or gas initially existing in the space between the respective insulators is swept out.

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