April 8, 1969 G. W. ZIEGLER, JR 3,437,960

DIELECTRIC BEAD STRUCTURE FOR COAXIAL CONNECTORS

Filed March 30, 1966 Sheet 1 of 6

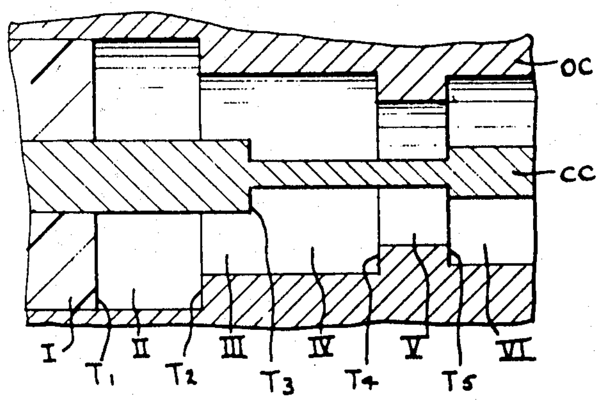


Fig. 1

Fig. 3

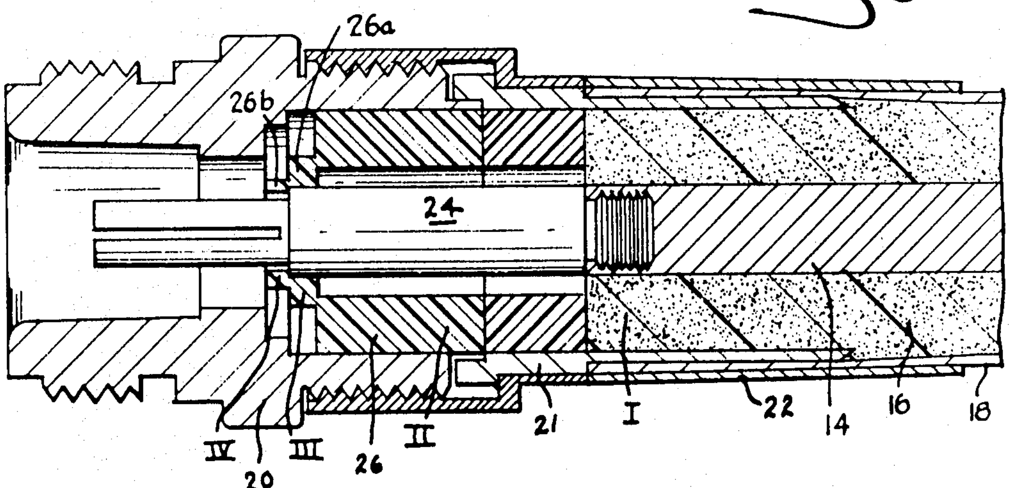
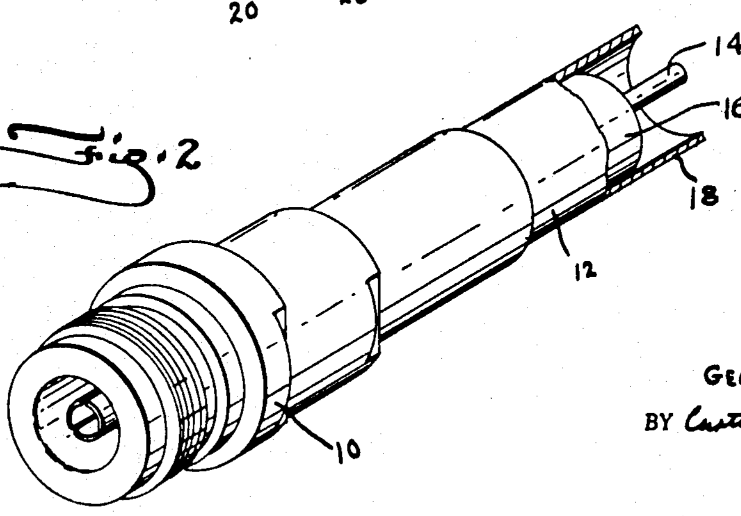


Fig. 2



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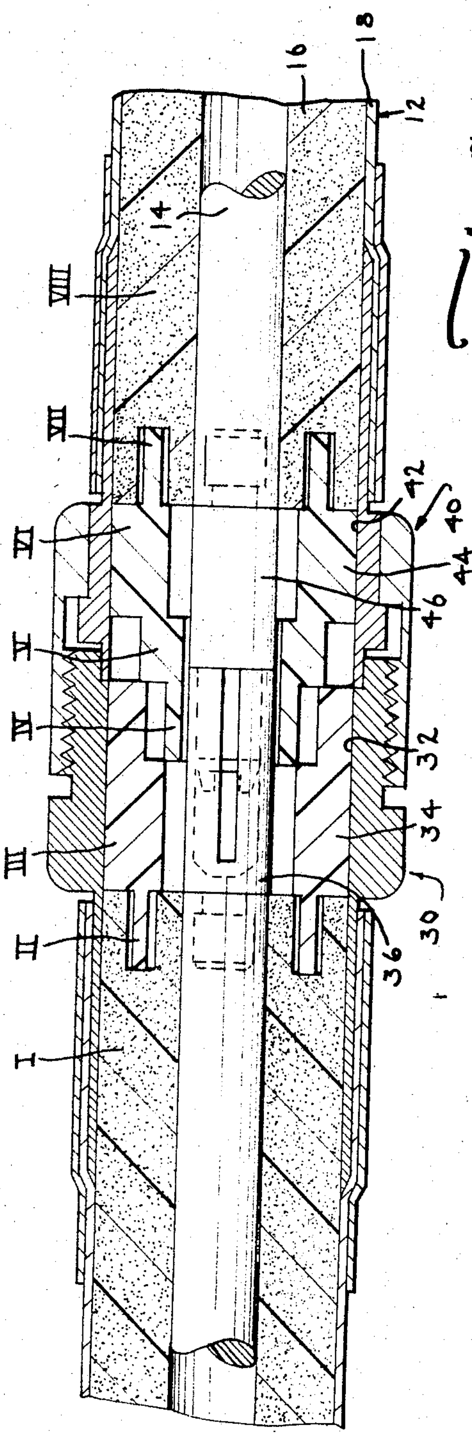

Fig. 5

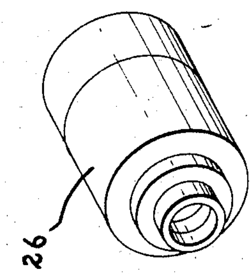

Fig. 4

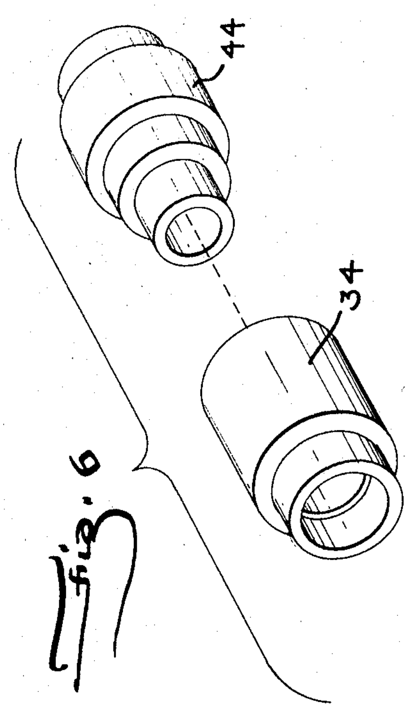

Fig. 6

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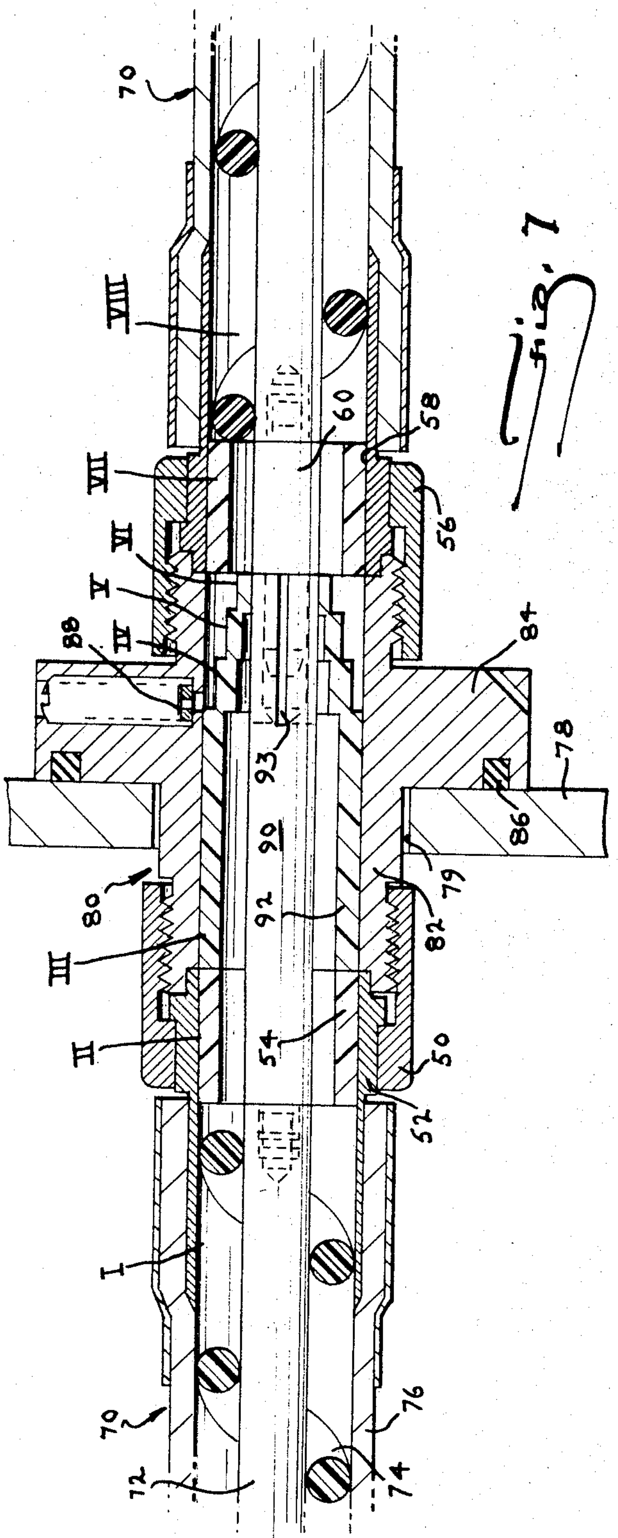

Fig. 7

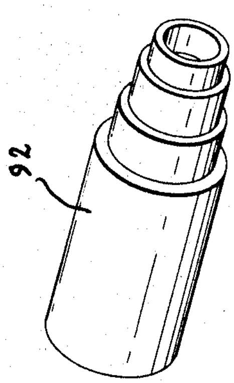

Fig. 8

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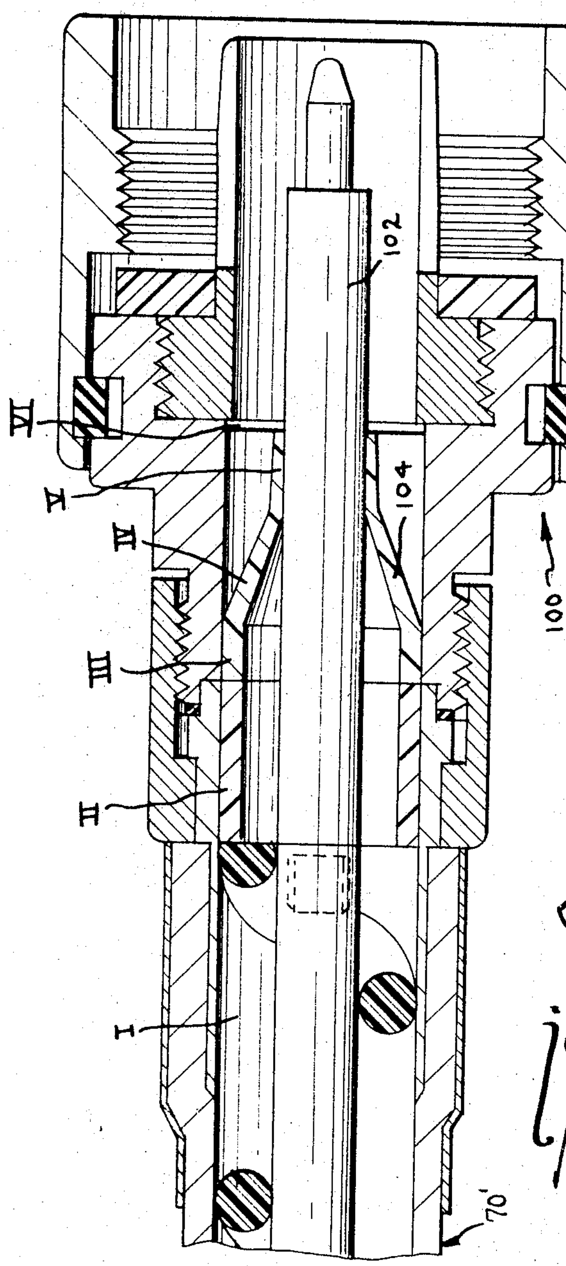

Fig. 9

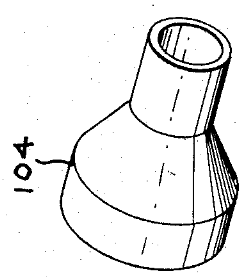

Fig. 10

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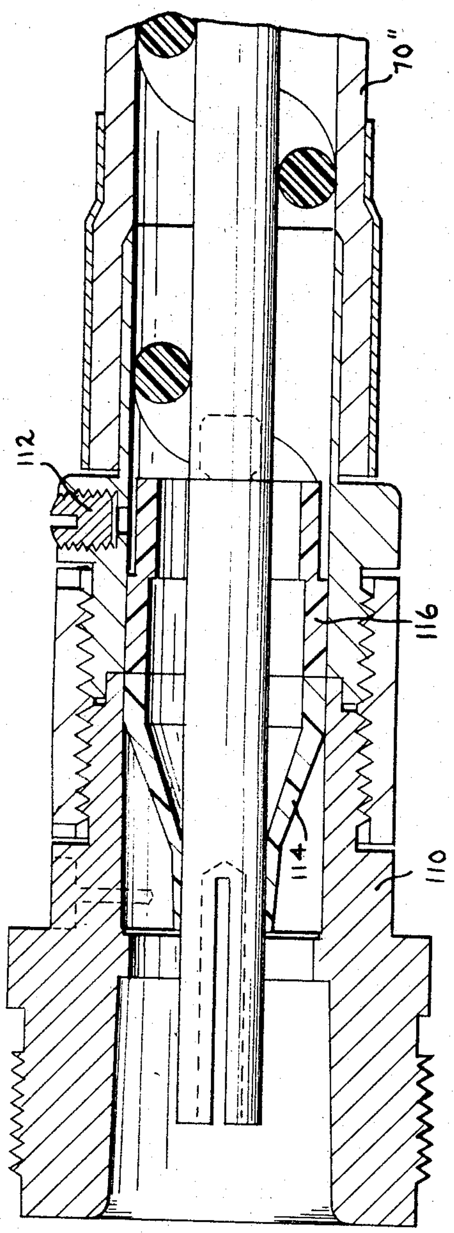

Fig. 11

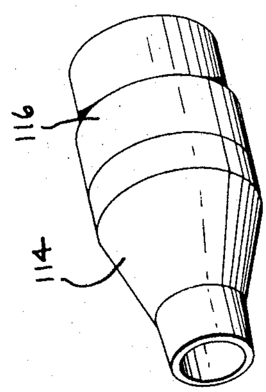

Fig. 12

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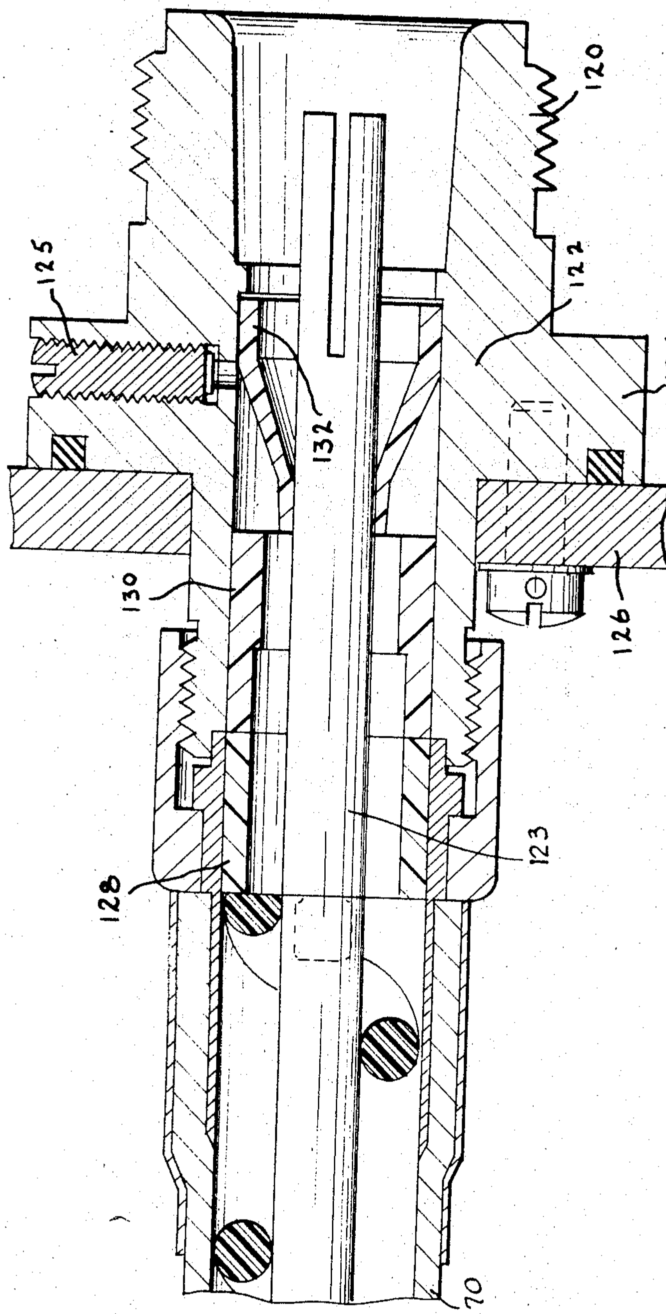
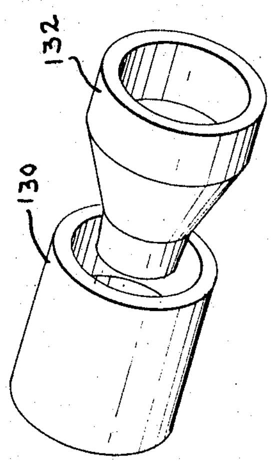


Fig. 13

Fig. 14



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DIELECTRIC BEAD STRUCTURE FOR COAXIAL CONNECTORS

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Int. Cl. H01p 1/04
U.S. Cl. 333—97 19 Claims

ABSTRACT OF THE DISCLOSURE

A dielectric bead structure for coaxial connectors used in high frequency signal transmission as disclosed, featuring a bead of dielectric material shaped to bear against outer and inner conductive portions of a coaxial device in separate segments and to be free of the conductive portions in other segments with structural integrity between segments. The thickness of the different segments, in conjunction with the radial position of the segments in the span between inner and outer coaxial conductive paths, is adjusted to match characteristic impedance or to provide a given characteristic impedance for compensation purposes. The various segments are made integral by providing a radial overlap sufficient for mechanical integrity but of an effective zero axial thickness. Insert segments are thus made to provide center conductor support and/or sealing. Insert segments are also extended and supported free of conductor contact to increase voltage breakdown length while, at the same time, providing compensation or adjustment for characteristic impedance matching.

Background of the invention

In most coaxial cable systems there are a number of transitions from one type and size of cable to another type and size of cable. One example is in communication systems wherein a main supply cable is branched into a number of receiver cables of different construction or size. Another example is that of the transition from a receiver cable into the receiver chassis. In terms of cable construction the main cable may be comprised of a tubular outer conductor and a solid center conductor supported by a spiral dielectric core wound about the center conductor, gas filled and of a relatively large diameter. The receiver cables may be of similar construction, but of a smaller diameter and perhaps with a different dielectric material such as a filling of foamed polyethylene. A receiver chassis receptacle may be of even smaller diameter. Connectors for these and other applications must effect the necessary transition with as little loss or signal degradation as possible.

As will be appreciated by those skilled in the art, the principal cause of signal loss in coaxial application is one of signal reflections caused by mismatch in characteristic impedance from one line segment to another. Mismatch may result from physical changes in conductor spacing or geometry or from changes in the dielectric medium through which most of the energy of high frequency signals is transmitted. Characteristic impedance is in fact expressed as a relationship of conductor diameter spacing and dielectric constant at a given radial section of a coaxial line.

At any transition between cables of different type or of different size the factors which affect characteristic impedance are altered and to minimize loss it is necessary to adjust characteristic impedance or compensate for changes in characteristic impedance. The former is usually accomplishhed by adjusting conductor spacing relative to a dielectric material of a chosen constant. The latter is carried out in accordance with a variety of techniques

such as is taught by Grimsman, Pomerantz and others. In many applications, however, the usual manipulataion of the factors of conductor spacing and choice of dielectric material will not achieve a low loss transition and the present practice of the art finds many instances of expensive quality cable and connectors linked into a system having a substantial mismatch at each cable transition.

One such instance is in a connection between cables having the center conductors thereof supported by spaced dielectric disks where the cable has a characteristic impedance which does not permit the use of a solid dielectric bead to support the cable center conductor. When the cables are severed and then spliced or applied to connector halves the prior art has experienced difficulty due to mismatch conditions caused by center conductor displacement radially with the outer conductor. This happens when the connection is first made. It also occurs later when the dielectric disks nearest the connection become compressed due to supporting too great a span of center conductor.

Summary of the invention

This invention relates to dielectric bead structures for coaxial connectors of the type used in high frequency application.

A related shortcoming of the prior art in the foregoing case is in an application which precludes a solid dielectric bead and yet requires a seal for gas loading of either the cable or through the connector of use.

Another instance of difficulty with prior art devices is one where for mechanical considerations the connector of use has a relatively long center contact span (requiring support) and compensation or adjustment of characteristic impedance requires a non-solid dielectric bead. In this instance the bead must, in adjacent segments, be free of either the center conductor or of the outer conductor and yet still support the center conductor.

Still another example of prior art shortcoming is in a device which requires compensation or adjustment by a bead which cannot be solid in any radial section and yet must be continuous between the outer and inner conductive portions of a connector to provide either sealing, support or adequate path length to increase the voltage breakdown of the device.

The present invention has as its general objective the provision of a coaxial cable dielectric bead structure which provides compensation or adjustment of characteristic impedance and concentric center conductor support and/or sealing.

A further object is to provide a dielectric bead structure for connectors, splices and the like for coaxial cable which prevents signal loss due to mismatch in applications wherein there is a transition between cables of different type or size.

A still further object is to provide a dielectric bead structure which supports connector or splice center conductors in connections between cables having a nonsolid dielectric support of the cable center conductor.

It is another object to provide a bead structure for coaxial cable connectors which permits compensation or adjustment of characteristic impedance through long axial spans wherein it is not possible to provide a radially solid bead segment.

It is yet another object to provide a dielectric bead structure which increases the voltage breakdown rating of a connector or splice and at the same time dielectric impedance compensation or adjustment and center conductor support and sealing.

The foregoing objectives are attained by the present invention through the provision of a dielectric bead which is made to engage the outer conductive portions of a coaxial device in one segment and to be free of the outer conductor in other portions with a structural integrity between segments.

The thickness of the different segments in conjunction with the radial position in the span between coaxial conductive paths is made to provide a match of characteristic impedance for adjustment purposes or a controlled change in characteristic impedance for compensation purposes. Additionally, the various segments of the invention bead are made integral by providing a radial overlap sufficient for mechanical integrity. With this structure certain segments may be made to engage the outer conductor of a coaxial device and other segments made to engage the center conductor thereof. In this way support and/or sealing may be provided in a wide variety of cable and connector, splice applications. In one form the bead of the invention is made to increase the path length for voltage breakdown by providing an overlap of separate bead segments which do not radially fill the span between conductors.

In the drawings:

FIGURE 1 is a sectional view of a coaxial transmission line included to explain the invention;

FIGURE 2 is a perspective of a coaxial connector plug included to explain the use of the invention;

FIGURE 3 is a longitudinal section of the plug of FIGURE 2 including the invention bead in a stepped embodiment which provides center contact support, impedance adjustment and impedance compensation;

FIGURE 4 is a perspective view of the bead employed in FIGURE 3;

FIGURE 5 is a longitudinal section of a coaxial connector joined to cable and including the invention bead in another stepped embodiment adapted to provide center contact support, high voltage breakdown and impedance adjustment.

FIGURE 6 is a perspective of the bead of the embodiment of FIGURE 5;

FIGURE 7 is a longitudinal section of a bulkhead connection of coaxial cable and a further embodiment of the invention bead structure adapted for contact support and impedance adjustment in a particularly long contact span;

FIGURE 8 shows the bead structure of the embodiment of FIGURE 7 in perspective;

FIGURE 9 is a longitudinal section of a connector jack connected to a coaxial cable and employing an alternative tapered embodiment of the bead of the invention adapted for contact support, impedance adjustment and sealing;

FIGURE 10 shows the lead of FIGURE 9 in perspective;

FIGURE 11 is a longitudinal section of a connector plug connected to a cable and having the alternative tapered bead embodiment and a stepped bead positioned for gas loading of a cable at the rear of a connector;

FIGURE 12 shows the modified bead of FIGURE 11 in perspective;

FIGURE 13 represents a bulkhead connector in longitudinal section in a still further embodiment using the tapered bead of the invention positioned to provide gas loading of a cable from the front of a connector; and

FIGURE 14 is a perspective of the bead of FIGURE 13.

Description of the preferred embodiment of the invention

FIGURE 1 shows a number of transitions in a coaxial transmission line having center and outer conductive members CC and OC. These transitions represent the types of changes which occur in interfacing cables or connectors of one kind or type to cables or to connectors of another kind or type. Beginning at the left there is a segment I of relatively larger diameter having a solid dielectric material. Next there is a segment II with a transition at **T1** created by a change in dielectric material to air or another gas. There is then a transition at **T2** with a reduction in the inner diameter of OC, the outer diameter of CC remaining the same. At **T3** the outer diameter of CC is reduced, the inner diameter of OC remaining the same. At **T4** the inner diameter of OC is again reduced relative to the outer diameter of CC. At **T5** there is a change in diameter of both CC and OC and a following segment VI. Looking at FIGURE 1 from right to left reveals a still further case; the enlargement of OC relative to CC.

The foregoing transitions and segments usually result from a variety of design requirements. The transition from I to II usually arises by a design requirement calling for a change in foam filled cable to cable which is exposed and must be pressurized to prevent moisture from entering the cable system. The transition at **T2** occurs when there is a change in cable size as from a supply cable to a branch cable. The changes at **T3**, **T4** and **T5** occur in applications wherein one type of cable is used for long spans while another type is necessary for short spans. These latter transitions occur particularly in the interface of the connectors which join dissimilar cables or join a given cable to an equipment chassis. All of these transitions also occur when there is a requirement that a given cable be interfaced to a standard connector of different size.

The relationship which expresses characteristic impedance Z_0 is related to a quantity existing at a radial section of a line and is:

$$Z_0=\frac{138.05}{K}\frac{D}{d}$$

where K is the effective dielectric constant of a radial path between an outer conductor of inner diameter D and center conductor of outer diameter *d*. As can be seen from FIGURE 1, if the dielectric material in segment II is air it must have a different Z_0 from the Z_0 of segment I, which has a solid dielectric material. If mismatch is to be avoided some kind of compensation will be necessary or if possible a change must be made in the diameters of CC and OC to adjust the characteristic impedance to that of the line. As to Z_0 of segments II and III there will again be a resulting mismatch unless some compensation or adjustment is made. Since the dielectric constant of all practical materials for bead structures is higher than air, it will be apparent that a radially solid bead cannot be used in any of the segments III–V when connected to segment I. The usual practice when going from a solidly filled cable of large diameter to a smaller diameter is to make the radial path between conductors as much as possible of a material of a lower dielectric constant or of air. This creates problems of design if the center conductor CC needs to be supported physically within the OC as in the segments III–VI. If sealing against gas flow between segments is necessary, the requirement of a substantial portion of free space in the radial path between conductors creates yet another problem.

The various discontinuities of FIGURE 1 will be recognized in the specific connector forms to be described relative to the solution of the invention to these problems. In FIGURE 2 a connector plug **10** is shown terminated to a coaxial cable **12** having a center conductor **14** (solid copper rod) a solid dielectric **16** (foamed polyethylene) and an outer conductor **18** (aluminum tubing). The plug **10** is used to mechanically and electrically connect the cable **12** to another cable through a mating jack or to an equipment chassis through a jack receptacle. The plug **10** is shown in section in FIGURE 3 to include an outer conductor structure **20**, which is terminated to the cable outer conductor **18** by an adapter **21**, which includes a ferrule **22** forced over the cable outer conductor on a sleeve extension of **21**.

The forward portion of **20** is of a geometry and design to meet an industry standard for mateability, as for example, that of the type N connector. Within **20** and **21** is a center contact member **24** terminated to the cable center conductor. Its forward end is also made to a particular industry standard (again a type N). As can be seen from FIGURE 3, the connector has smaller coaxial dimensions than that of the cable to thus require some compensation of Z_0 to prevent signal loss. Specifications for standard connectors such as the type N do not permit diameter changes in the forward mating portions of the connector and thus dictate that compensation be provided by some means positioned between the cable and the plug forward end. Additionally, experience has shown that a center contact member like **24** needs to be supported against radial displacement. It has been found that the process of severing and facing a coaxial cable for termination in a connector half so works the center conductor in its surrounding dielectric that it is no longer concentric. If the center contact is attached, as is **24**, it will then lie off center in the connector. This has been found even in cable solidly filled with foamed dielectric and it is especially prevalent in cable wherein the center conductor is supported by a spiral or disk dielectric bead as is to be hereinafter described. The weight of the center contact structure **24** over a period of time will tend to increase the condition of center conductor sag.

The invention solution is evidenced by the bead structure **26** shaped as shown in FIGURES 3 and 4. Bead **26** is made to engage the outer conductor structure **20** in one segment and to engage the center contact **24** in another segment. The bead **26** is made in two pieces to allow the forward part of **20** to be separated from the rear part. The adjacent separate portions of **26** may be considered as identical with respect to character and dielectric material.

Considering the device of FIGURE 3 from the standpoint of characteristic impedance, if the cable employed has a $Z_0=50\Omega$, the segment I is also made to have a $v_0=50\Omega$. The dielectric material for bead **26** is made substantially more rigid than the foamed materials used in cable in order to provide support strength. Because of this and to maintain a characteristic impedance $Z_0=50\Omega$ in segment II, the bead is relieved as indicated to provide air as a portion of the radial path between conductors and thereby obtain an equality of K as compared with that of the cable. The dimensions for the portion of the bead **26** in segment II may be indirectly calculated from the relationship for Z_0 or as described in my copending application Ser. No. 276,714, filed Apr. 30, 1963, now U.S. Patent No. 3,350,666, granted Oct. 31, 1967.

The next segment III is made integral with the adjacent portion of **26** forming part of segment II through a web or overlap portion **26*a***. The web **26*a*** has a radial thickness sufficient to adequately join the adjacent portion of **26**. It is made to have an axial thickness of effectively zero and therefore need not be adjusted with respect to characteristic impedance. The inner diameter of **26** in the segment III is made to receive and support the center contact coaxially of **20** by reason of the structural link with the portion of **26** in segment II. In this way the center contact is radially supported by a bead which does not have a solid radial section. As may be discerned, the steps of the bead also provide a seal between the cable and the connector. This seal may be made adequate for gas loading by providing a wedge fit of the portions against the conductors. A material of substantial shear strength should be used for the bead.

The portion of **26*b*** in segment IV is made to extend from segment III through a web of substantially zero thickness and is of a thickness and is radially placed to provide a characteristic impedance different from that of the preceding segments and of the cable. In the embodiment of FIGURE 3 the characteristic impedance of segment IV is made greater than that of preceding segments for the purpose of providing compensation in accordance with the teachings in my Patent No. 3,350,666. It could, of course, be made less than or equal to the line characteristic impedance if the relative dimensions of the connector and cable were such as to require either no compensation or a different compensation.

In an actual embodiment of FIGURE 1 the bead **26** was made of a Teflon block machined to the configuration shown. Its dimensions in inches were approximately:

Segment	OD	ID
II	0.450	0.235
III	0.311	0.162
IV	0.200	0.142

It was used with a connector having a type N forward part terminated to a cable known in the trade as Foam Flex made by Phelps-Dodge Inc. This cable has a foamed polyethylene dielectric material. The rear portion of the actual sample was made in accordance with my co-pending application Ser. No. 308,265 filed Sept. 21, 1963, now U.S. Patent No. 3,245,027, granted Apr. 5, 1966.

FIGURE 5 shows a connector for a cable like that described above having a plug half **30** and a jack half **40** of the construction described in Patent No. 3,245,027 previously mentioned. The construction of the conductive portions of each half including the outer portions **32** and **42** and center contacts **36** and **46** is made to define a coaxial path of constant diameter. The connector thus may be made of constant characteristic impedance along its entire axial length and eliminate any need for compensation.

With the design of the connector of FIGURE 5 there is still the problem of center contact support and two additional problems. First, the cable dielectric material, being foamed polyethylene, is not suitable for machining so that a solid connector beam may be employed. This means that a different dielectric material must be used. If it is Teflon, as is often specified, then the bead cannot have a solid radial section and still provide a K suitable for impedance matching. In conjunction with this requirement there is a requirement of connector voltage breakdown equal to or better than that of the cable. If some portion of the dielectric radial path must be air, then the prior art approach of separate beads will not be adequate.

The embodiment of FIGURES 5 and 6 solves these problems in the manner shown. The characteristic impedance of the line, segments I and VIII, is $Z_0=50\Omega$ and the characteristic impedance of each of the segments II–VII are also adjusted to 50Ω. To increase voltage break-down in the connector the bead **34** of plug half **30** and the bead **44** of jack half **40** each include in the segments II and VII sleeve extensions fitted into the cable dielectric material **16** as shown. The cable material **16** may be prepared by the means described in co-pending application Ser. No. 524,215 filed Feb. 1, 1966, now U.S Patent No. 3,346,949, granted Oct. 17, 1967. Sufficient cable dielectric material is removed to adjust the radial path so that the composite of polyethylene, air and Teflon yield a characteristic impedance adjusted to 50Ω. The bead segments in II and VII are made integral with adjacent bead segments so that the creepage path for breakdown is made about twice the radial spacing between conductors. The bead segments in III and VI have an outer diameter to wedge fit within the outer conductors **32** and **42** of the connector halves. The bead inner diameters are made to provide a bead thickness yielding the desired characteristic impedance. The adjacent segment IV includes a portion of the bead **34** of plug **30** which has a reduced thickness as shown to permit mating with the bead of jack **40**. The thickness of the bead **44** in segment IV is adjusted relative to the portion of **34** in segment IV to provide a composite radial path to achieve the desired 50Ω characteristic impedance. This portion of **44** is an extension from a bead segment residing in V, which is of a thickness and radial displacement to yield a characteristic impedance of 50Ω and is joined by a web of zero axial thickness. Both portions have an inner diameter to engage the center contacts **36** and **46**. This provides support toward the center of the connector to prevent conductor sag and resulting mismatch due to a lack of concentricity. The inner diameter of the bead **44** in segments IV and V must, of course, permit insertion of the contacts and are for this reason made to lightly engage the contact outer surface. As will be discerned, the overlap of beads in segment IV provides a long breakdown path.

The next portion of bead **44** resides in segment VI and is in engagement with the outer conductor **42**, but relieved from **46** to an extent to yield the desired characteristic impedance. The rest of the bead **44** resides in segment VII, identical to that of bead **34** in segment II. Segment VIII is again the cable of characteristic impedance equal to 50Ω.

The bead of the jack **40** is thus made to support the center contacts of the connector and the beads of both the plug and the jack are such as to provide an adjustment of impedance and high voltage breakdown.

FIGURES 7 and 8 show an embodiment including a pair of jacks **50** and **56** connected to identical cables **70** and joined through a bulkhead connector receptacle or double ended plug **80**. The cable **70** is of a type known in the trade as Spirafil-T made by Phelps-Dodge Inc. It includes a solid center conductor **72**, a dielectric bead **74** formed in a spiral about **72** and of a thickness to support **72** within an outer conductor **76** of metal tubing.

The jacks **50** and **56** are similar to each other and are like the device of Patent No. 3,245,027, previously mentioned, except that the jack **50** does not have a center contact member. Each jack includes a dielectric bead member like **54**, shown relative to **50**, which is relieved interiorly to provide a desired characteristic impedance.

The receptacle **80** has a center conductive sleeve **82** having an interior bore and outer ends of diameters to mate with the jacks **50** and **56**. An integral flange **84** is extended outwardly from the body of **82** to engage the surface of one side of a panel or bulkhead **78**. The bulkhead includes an aperture **79** through which the body of sleeve **82** is fitted.

Flange **84** is made to carry a seal **86** which is compressed into a slot as shown in FIGURE 7 when **84** is forced against **78**. This may be accomplished by screws, not shown, which pass through **84** and into **78**. A gas entry point **88** is provided extending through **84** to the interior of **82**. The receptacle **80** includes a center contact **90** which is fitted into the center conductor **72** at one end and is made to engage a mating contact **60** of jack **56**. In the particular application represented in FIGURE 7 the cable **70** is gas loaded on both sides of **78**. This cable has its center conductor **72** coaxially supported within the outer conductor **76** by a spiral bead **74** which is of a diameter to engage the surface of the conductor. As will be apparent, the effective dielectric constant of the cable is quite low, approaching that of air (or the gas being used which is typically of a K close to air). Support of the center conductor is provided at spaced points along the cable. As will be appreciated, any bead which is of solid cross section would have to have a dielectric constant approaching that of air to avoid mismatch. With known materials any bead of this characteristic would be far too soft to provide lasting contact support in the span shown for the receptacle of FIGURE 8.

As a matter of fact, the effective dielectric constant of cable **70** is too low for use of the invention solution previously described relative to FIGURES 3 and 5. A two step bead of relatively hard material engaging the outer conductor of **80** (the bore of **82**) and the center contact **90** will have to have a wall thickness such that the inner diameter of the larger part of the bead is greater than the outer diameter of the smaller part of the bead. The two parts of the bead could therefore not be joined and could therefore not be made to support the center contact. The invention embodiment to solve this is shown in FIGURES 7 and 8 as a bead **92** comprised of adjacent integral portions of four different diameters. Referring to the characteristic impedance of the various segments, I and VIII are, of course, that of the cable. Segments II and VII are adjusted in impedance to that of the cable and as can be discerned are of relatively thin wall section. The bead **92** is in each of the segments III, IV, V and VI made of a wall thickness and radial position to provide the characteristic impedance of the cable and adjacent connector segments. Each of the portions of the bead is also of relatively thin wall section but a sufficient overlap through a web of zero axial thickness is provided to assure integrity and support for the center contact member **90** and contact **60**. The bead portion in segment III is of an outer diameter to engage the interior of sleeve **82** and the bead portion in segment VI has an interior diameter to engage the outer surface of **92**. Note that the outer diameter of the bead in segment VI is less than the inner diameter of the bead in segment III. Gas transfer is accomplished through the grooves **93** in the center contact member **92** which serve to provide spring members for mating contact of the member with **60**. The bead **92** can be machined from Teflon or some other material which is sufficiently strong to provide center conductor support in the configuration shown.

In the previous embodiments the receiving transition between cables or connectors of different types or sizes has been carried out through a stepped dielectric bead. FIGURES 9 and 10 show an alternative bead construction in a connector plug **100**. The plug **100** is for a standard type N connector and is mateable with the jack **20** of FIGURES 2 and 3 (although drawn a bit larger in scale here). The cable shown as **70'** is like that discussed relative to FIGURE 7 and it is terminated through a similar connector jack to the rear of the type N plug as shown. The center contact member **102** is made common to both the jack and the plug and extends from an attachment with the cable center conductor through the plug to form its center contact member. This construction eliminates several parts from the usual type N transition connector, but as can be seen presents a relatively long span which must be supported to maintain concentricity. In addition, the cable **70** is of the type which is gasable. The cable **12** attached to the type N jack of FIGURES 2 and 3 is of a nongasable type. This means that a seal must be provided between the cables to prevent the system connected through **70'** from degassing through the connection to that part of the system which employs cable like **12**.

The bead of plug **100** shown as **104** is made to have a diameter at one end to engage the inner surface of the connector outer sleeve and at the other end an inner diameter to engage the outer surface of **102**. Both diameters are in this embodiment made to provide a wedge fit and the portions in bearing engagement with the conductive portions of the connector are made sufficiently long to provide a gas seal. Between the end portions of bead **104** is a portion which tapers in both outer diameter and in wall thickness. This tapering portion structurally joins the end portions to provide both center contact support and sealing. Referring to the characteristic impedance of the line formed by the assembly of FIGURE 9, segments I and II are of a characteristic impedance equal to that of the cable. The portion of the connector in segment III is made to be equal to that of segment II by control of the thickness and radial position of **104**. The portion in segment V is also made to have a characteristic impedance equal to that of the cable and segments II and III by the same procedure. The portion of the connection in segment IV can be made to provide the desired characteristic impedance by the reduction of wall thickness shown in the bead as it tapers down from the larger diameter portion to the smaller diameter portion. It has been found that once the correct bead wall thickness for the end portion is calculated a proper taper for the center portion can be provided by calculating the proper wall thickness for a series of bead segments of different diameters in between those of the bead ends.

This will yield a series of bead section calculations from which a composite tapering bead portion can be readily laid out, which is of an axial length proper for the particular connector design involved. With regard to the device and bead of FIGURE 9, the tapering portion is made of an axial length to be easily manufactured and still leave the end portion of an axial length sufficient to provide support and sealing and yet not so long as to make bead insertion difficult. The bead **104** is as shown made to support **102** near its axial center. It is made to end just short of entering into the type N forward portion of **100**, which is controlled as to dimensions and characteristic impedance. At this point a segment VI is provided wherein the characteristic impedance of the connector is made to be greater than that of the cable to provide compensation in the manner described in my application Patent No. 3,350,666 previously mentioned.

In an actual embodiment for a type N plug having a bead like **104** the bead was made of Teflon with dimensions in inches of approximately:

Segment	OD	ID	Axial length
III	0.343	0.252	0.269
IV			0.300
V	0.185	0.136	0.088

FIGURES 11 and 12 show a jack **110** having a type N front end which is mateable with the plug **100** of FIGURE 9. The jack **110** is terminated to cable **70′** like that previously discussed by a mating connector plug which includes a gas port **112** to permit the cable to be gas loaded at the connection. In the connection formed by the device of FIGURES 9 and 11 the cable of the plug **100** would be gas loaded through a port up line from **100**, which seals gas transfer from **110**. An application wherein **100** and **110** must be frequently disconnected requires this construction to prevent loss of gas pressure. The bead **114** is identical to the bead **104** of **100**. The bead **116** is modified to include a first portion wedged in the bore of the jack connecting **110** to the cable **70″** and a second portion of reduced diameter supported by the first portion clear of the gas port. These portions are joined by a web of substantially zero axial thickness. The bead **116** is of a radial thickness and radial displacement to provide a proper match of characteristic impedance. As will be apparent from this, the invention concept has a utility other than conductor support or sealing. It may be used in any application wherein it is necessary to provide adjustment or compensation of characteristic impedance in a coaxial line segment which must have one or more of its conductive surfaces free of solid dielectric material.

FIGURES 13 and 14 relate to another embodiment employing a tapered bead positioned to seal a plug, provide center contact support and permit gas loading. The connector **120** includes a type N front end having a body **122** and a flange **124** secured to a panel or bulkhead **126** in a sealed mounting like that described relative to FIGURE 7. The rear port of **120** includes a plug and jack fitting to a cable **70**. Within this rear port are beads **128** and **130** to provide an adjustment of characteristic impedance to that of the cable. Within an adjacent portion is a bead **132** having end portions of diameters to provide support for the center contact **123**. These portions are joined by a bead portion tapered in the manner previously described. The bead **132** is axially positioned within **120** so that the bead portion of reduced diameter is beneath a gas port **125**. The smaller end of the bead **132** is of a diameter relative to the inner diameter of **130** to permit gas flow from the port, outboard of the panel **126** back down into the cable. This construction is particularly useful in applications wherein the forward plug of **120** is frequently disconnected as is the case with test equipment or auxiliary checkout lines.

In the various embodiments heretofore mentioned emphasis has been given to specific cables and specific connector designs. This is for illustration purposes only and the invention is fully adaptable to uses with other types of cables and connectors, splices, terminals, adaptors and in any coaxial devices wherein the problems mentioned are present. The various beads have been disclosed as of one piece. It is contemplated that the various stepped or tapered portions can be of several pieces bonded together as by suitable adhesive. It is also contemplated that several pieces may be integrated mechanically to form the beads disclosed by providing a flange on one piece made to fit into a recess in an adjacent piece through the web portion.

In each of the disclosed embodiments the supporting bead portions have been of a geometry and material to adjust the characteristic impedance of a segment to that of the line. In the manner disclosed relative to the segment IV in the embodiment of FIGURE 3, the support portions of the bead may be made to provide a different characteristic impedance for compensation.

Having disclosed preferred embodiments of various devices to teach the practice there, I now define what is claimed as invention.

What is claimed is:

1. In a coaxial device having an outer conductor and a center conductor in at least first and second axial segments with the radial spacing between outer and center conductors in the first segment including a dielectric medium having a dielectric constant lower than that of the second segment, a dielectric bead in said second segment comprised of dielectric material defining first and second portions of a given axial length, the first portion being in contact with the outer conductor and the second portion being in contact with the center conductor, said portions being joined through a web of said dielectric material of zero axial thickness but sufficient radial thickness to provide center conductor support, the dielectric material of said bead along said axial length except that of said web being of a thickness and radial position to provide an effective dielectric constant equal to that of the first segment.

2. The device of claim **1** wherein said first and second portions of said bead extend fully around the circumference of said conductors and are of diameters to provide a wedge fit against said conductors to seal said device for gas loading.

3. The device of claim **1** wherein there is provided a fourth portion of dielectric material joined to one of said first and second portions having a radial thickness and radial placement to provide an effective dielectric constant different from that of said first segment for purposes of compensation.

4. The device of claim **1** wherein said first and second portions are of one piece extending fully around the circumference of said conductors and axially along said conductors for a distance at least as great as the radial spacing between conductors to provide a voltage breakdown characteristic approximately equal to that of the first segment.

5. In a coaxial device having an outer conductor and a center conductor in at least first and second segments with the spacing between conductors in the first segment having a dielectric medium including a relatively soft supporting material which yields a given effective dielectric constant for said segment, the spacing between conductors in said second segment having a dielectric medium therebetween including a relatively rigid conductor supporting bead of a dielectric constant higher than that of said first mentioned material, the said bead having a radial wall thickness and radial position along the length thereof to yield an effective dielectric constant equal to that of the first segment and being in bearing contact with the outer and center conductors to provide support of the center conductor.

6. In a coaxial device having an outer conductive path and a center conductive path including at least a first segment of a given characteristic impedance and a second segment wherein the center conductive path requires radial support, a bead of dielectric material of substantial shear strength including a portion in contact with the outer conductive path and free of the center conductive path and a portion in contact with the center conductive path and free of the outer conductive path, said portions being of thickness and radial placement to provide an effective dielectric constant along the length of said second segment to compensate or adjust the characteristic impedance of said second segment relative to said given characteristic impedance and with each portion being joined to support the said center conductive path coaxially in said second segment.

7. In a coaxial connector including mating halves terminated to cable having a center conductor surrounded and supported by a dielectric medium with an outer conductor having a given characteristic impedance, each half including a dielectric bead of a material having a dielectric constant lower than that of the medium of the cable, said bead being comprised of a series of axially-spaced sections each having a different and distinct radial thickness and radial placement along the section length to provide an effective dielectric constant equal to that of the said medium, a center contact means extending within said halves to join the cable center conductors, said means being radially supported by said bead coaxially of said halves.

8. The connector of claim **7** wherein the bead of one half is made to axially overlap the bead of the other half to extend the voltage breakdown path of the connector.

9. The connector of claim **7** wherein at least one of said beads includes an integral cylindrical portion which extends into the dielectric medium of the cable to increase the voltage breakdown characteristic of the connector.

10. The connector of claim **7** wherein at least one of the said beads extends fully around the circumference of the conductive surface in a connector half and extends between said surfaces to provide a gas seal.

11. A dielectric bead for coaxial devices of the type having an outer conductor and a center conductor, the said bead including a first portion of an outer diameter to engage the interior surface of the outer conductor and a further portion of lesser outer diameter having an inner diameter to engage the outer surface of the center conductor to support the center conductor concentrically relative to said outer conductor, the said bead having a radial thickness in each said portion to provide a substantially equal effective dielectric constant along the length of said portions.

12. The bead of claim **11** wherein said first and further portions are separated by at least one other portion of different diameter and wall thickness to extend the length of said bead and the point of radial support of the center conductor.

13. The bead of claim **12** wherein said other portion is tapered along its length.

14. In a coaxial line of a given characteristic impedance a coaxial device having an outer conductor and a center conductor of a radial spacing equal to that of the line, a bead supporting said center conductor coaxially within said outer conductor by engaging the outer and center conductors, said bead being comprised of a series of portions each of a dielectric material of substantial shear strength and each portion being of a wall thickness and radial placement relative to its axial length in said device to maintain the characteristic impedance of said device approximately equal to that of said line.

15. In a coaxial device having an outer conductor and a center conductor in at least first and second segments with the spacing between the conductors in the first segment including a dielectric medium having a dielectric constant lower than that of the second segment, a dielectric bead in said second segment in engagement with the outer conductor in one portion and the center conductor in another portion with said portions being joined through a web of zero axial thickness to provide center conductor support and with each radial section of said bead, except that of said web, being of a thickness and radial position to provide an effective dielectric constant equal to that of the first segment, said bead including at least a further portion of dielectric material between said one and another portions and joining said portions, said further portion being free of contact with said conductors and serving to extend said bead axially to extend the support provided to the center conductor axially from the engagement of the bead with the outer conductor.

16. The device of claim **15** wherein said further portion has a radial thickness and radial placement to provide an effective dielectric constant equal to that of the first segment.

17. The device of claim **16** wherein said further portion and said one and another portions are comprised of a series of cylinders of different diameters.

18. The device of claim **16** wherein said one and another portions are cylinders of different diameters and said further portion is tapered in outer diameter and in wall thickness.

19. A dielectric bead for coaxial connectors of the type having an outer conductor and a center conductor, said bead including a first portion of an outer diameter to engage the interior surface of the outer conductor and a further portion of lesser outer diameter having an inner diameter to engage the outer surface of the center conductors to support the center conductor, said bead having a radial thickness in each said portion to provide a substantially equal dielectric constant along the length of said portions, said further portion being cylindrical and said portions being joined by a web of zero axial thickness.

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