

July 7, 1942.

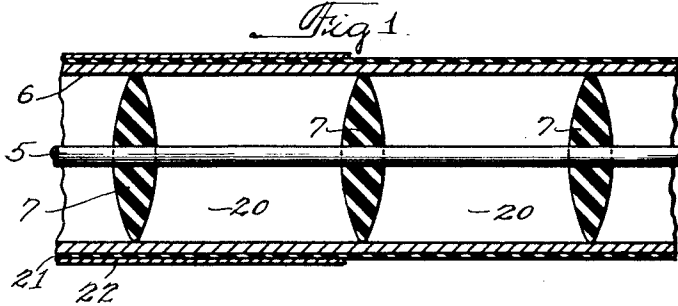
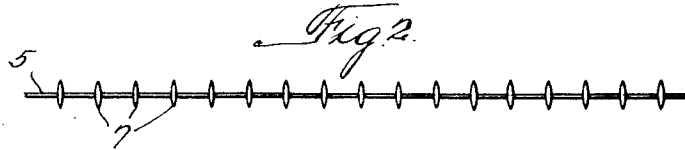
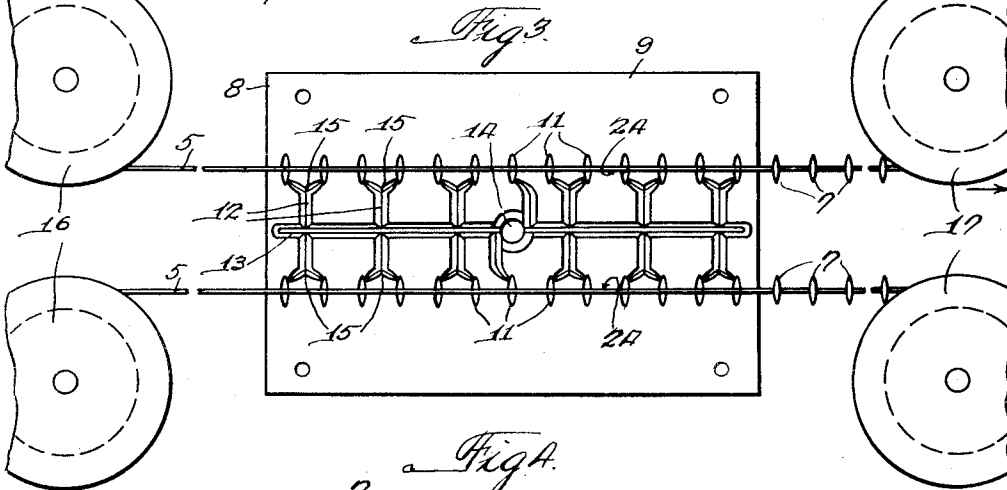
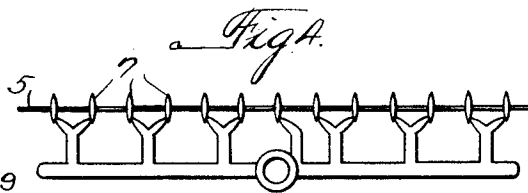
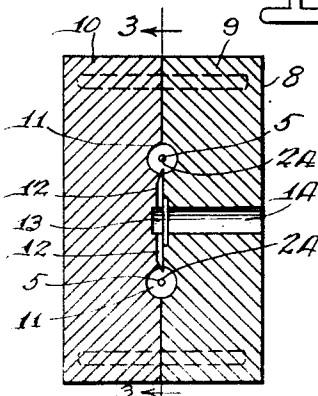
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2,288,899

METHOD OF AND MEANS FOR MAKING COAXIAL CABLES

Filed Jan. 15, 1940

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 6.

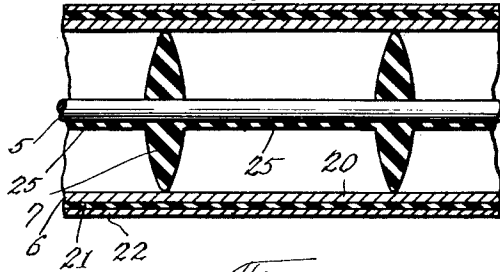


Fig. 7.

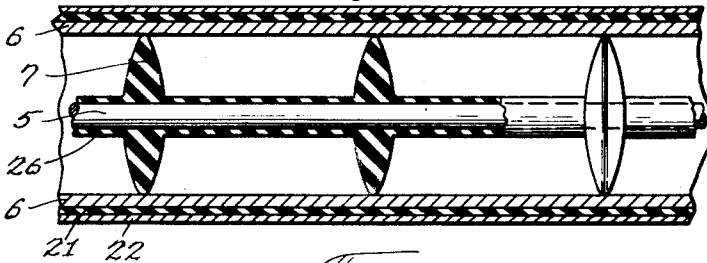


Fig. 8.

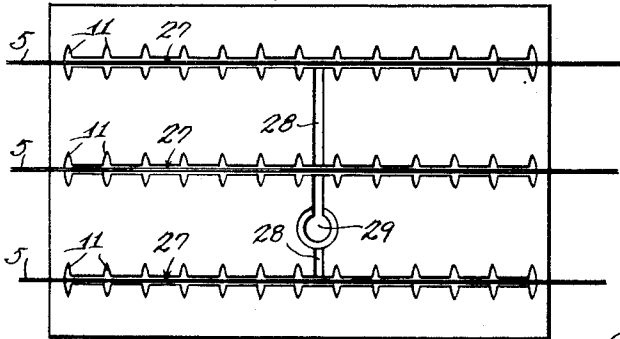


Fig. 9.

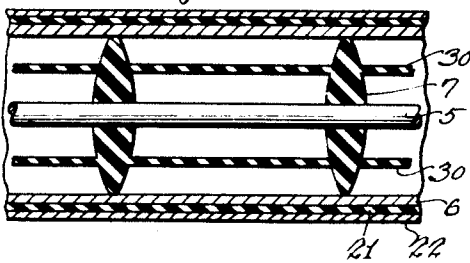
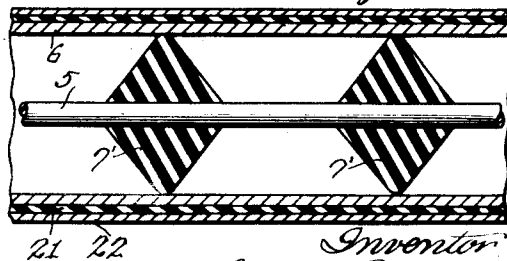


Fig. 10.



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UNITED STATES PATENT OFFICE

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METHOD OF AND MEANS FOR MAKING
COAXIAL CABLES

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9 Claims. (Cl. 18—59)

This invention relates broadly to coaxial cable construction and more particularly to a coaxial cable adapted especially for use as a lead-in of television antennas and the like.

New effects are introduced in the handling of ultra high frequency waves in television transmission and reception. Adequate pick-up at ultra frequencies requires an antenna of a di-pole construction having such dimensions as to be tuned to the incoming signals. Fundamentally, the di-pole consists of a rod one-half wave length long. The rod is cut apart at the center, and usually a twisted pair, with one wire joined to each half of the rod, is brought down to the receiving set. Care must be exercised to locate and mount the antenna in order to secure maximum signal pick-up and avoid interference. To illustrate the difficulties of proper reception, lack of proper signal delivery produces gray and indistinct pictures, while static interference prevents obtaining any picture at all if the antenna is not picking up enough signal. If the signals are weak, enough pick-up might be obtained to form a picture, but the synchronizing impulses may not be strong enough to hold the picture. This will cause drift, no matter how carefully the vertical hold control is adjusted. On the other hand, a slight static impulse might cause each time a slip of one frame of the picture. One common source of interference is from automobile ignition. The di-pole of the antenna must be located quite often at high locations to reduce or to avoid this interference, and to prevent surrounding high buildings from acting as a shield to the antenna. A long lead-in is therefore required but the signal gain may not offset the added resistance of the lead. To overcome this, since the lead may not be shortened, a coaxial cable has been suggested for the twisted pair lead. Inasmuch as the signals are received only by the horizontal di-pole and the only purpose of a lead-in is to connect the di-pole to the receiver, the lead-in should preferably be constructed to prevent pick-up and thus avoid interference to which television apparatus is exceptionally sensitive. A poorly insulated conductor touching a metal object may make a variable resistance contact that gives the effect of static interference, or improper insulation between the conductors of the lead-in connecting each section of the di-pole may cause the same trouble or pick up magnetic or radiation disturbances in the vicinity of the receiver.

Broadly, this invention is directed to an improved type of coaxial cable adapted particu-

larly for use as the lead-in between a television antenna and receiver, or as the concentric tubes in television transmitting aerials, whereby to overcome the difficulties heretofore experienced, and to an improved method of making this coaxial cable whereby a very simple and efficient structure will be provided at minimum cost.

Specifically, the invention relates to a cable structure, and a method of making the same, that includes coaxial or concentric conductors spaced from each other by spaced dielectric members, preferably non-absorptive of moisture, whereby the dielectric members together with the air chambers or pockets formed therebetween provide an efficient type of insulation between the coaxial conductors and an efficient shield against disturbances or pick-ups.

The method herein disclosed novelly includes passing the center conductor through a die block, molding a plurality of spacers thereon and affixing these spacers upon this center conductor by molecular tension resulting from shrinkage or contraction of the thermo-plastic material employed, the spacing of these spacers themselves along the center conductor and the immovable affixation thereof in this spaced relation being advantageously accomplished preferably by a single molding operation. It will be understood that the outer conductor may be a single tubular or laminated member or a fabricated structure that may be spun or otherwise placed about these spacers. The final layer or coating of insulation may thereafter be formed about the outer conductor. If used in high frequency transmission, the outer layer may be a lead sheath or like material.

It will be remembered that the method herein disclosed is noted for its simplicity and low cost of operation, and for its ability rapidly to place these spacer members upon the center conductor in a single operation, the forming operation placing these spacer members along the central conductor at predetermined distances and the rapid cooling thereof causing affixation thereof in this spaced relation without additional labor or other expense. The space between these members may form sealed air pockets between the outer and inner conductors, while these members effectively insulate the concentric conductors from each other, reduce static disturbances therebetween, and prevent absorption of any moisture that will break down this insulation.

Although the cable herein disclosed is described as being particularly useful as a lead-in between the di-poles of a television antenna and

receiver and as the concentric tubes in transmitting aerials, it will be understood that the cable is capable of many uses and is not to be confined to the specific examples given or to a cable necessarily having the outer conductor coaxial with the inner conductor.

Other objects and advantages of the invention will be apparent from the following detail description when taken in connection with the accompanying drawings which form a part hereof.

In the drawings:

Figure 1 is an enlarged cross section of a portion of a coaxial or concentric cable embodying the invention;

Fig. 2 is a view at a smaller scale of the central conductor;

Fig. 3 illustrates the method of forming the insulation spacers upon the central conductor;

Fig. 4 illustrates the central conductor after removal from the die but before the trimming operation;

Fig. 5 is a transverse section through the center of the die block shown in Fig. 3;

Fig. 6 is a view similar to Fig. 1 but illustrating a modification of the structure shown;

Fig. 7 illustrates a further variant embodiment of the invention;

Fig. 8 is a view similar to Fig. 3 and illustrates how the spacing members may be formed by a single operation upon any member of center conductors passing through a die block at one time;

Fig. 9 illustrates a still further variant embodiment of the invention; and

Fig. 10 also illustrates a further embodiment of the invention.

The coaxial cable herein disclosed comprises an inner or central conductor 5, an outer conductor 6 and a plurality of spacing members 7 disposed along the central conductor 5. Spacing members 7 are preferably made of a thermo-plastic material characterized mainly by its insulation qualities and ability to be non-absorptive of moisture. I find polystyrene to be an excellent thermo-plastic material for this purpose. It has excellent insulation properties which approximate those of air and has a dielectric constant of 2.6 at 60 cycles. For all practical purposes, this material is considered non-absorptive of moisture. It will be understood, however, that other materials may be used and that polystyrene is mentioned only as an example.

Spacing members 7 are molded directly upon central conductor 5. They are cooled upon central conductor 5 so that they will contract and thereby be affixed thereto in a predetermined spaced relation by molecular tension. In other words, the material of these spacing members 7 grip the central conductor by molecular tension produced by contraction upon cooling. The term molecular tension to produce the affixation of spacing members 7 upon central conductor 5, as I use it herein, is the result produced, I believe, from injecting the thermoplastic material in molten form in die cavities as distinguished from mere heating and then squeezing. These members 7 thereby become immovably affixed in spaced relation along central conductor 5 without requiring any additional operation or means to keep them spaced at proper distances apart.

As disclosed, the method of making the coaxial cable includes passing central conductor 5 through a die 8 comprising a matrix 9 and a

or cavities 11 cut therein corresponding to the desired shape or configuration of spacing members 7. These recesses 11 are arranged to communicate by pairs with passages 12 that connect with a main passage 13 communicating with a transverse passage 14 leading to a source of supply. Each passage 12 is divided as indicated at 15 and communicates with its pair of recesses 11 by opening into these recesses along one of their faces and not at their peripheral edge. Any number of recesses 11 may be provided in die 8 so that a corresponding number of spacing members 7 may be formed in one molding operation. The arrangement of passages 12, 13 and 14 may also be changed, but I consider it advantageous to communicate with each recess 11 as shown so that the plastic material may be injected at one side and not at the peripheral edge.

Fig. 3 illustrates several central conductors 5 being unrolled from spools 16, passing through die 8 by a predetermined stepped movement and being rolled upon spool 17 with spacing members 7 formed thereon. Fig. 4 illustrates a section of one of the central conductors 5 with spacing members 7 formed thereon as removed from die 8 following a molding operation. The thermo-plastic material has been cooled and spacing members 7 that have been formed are fixed upon central conductor 5 in spaced relation with the usual tailings attached, these tailings representing the material that flows into passages 12, 13 and 14 upon each injection. With the material cooled or set, these are readily removed by being broken or severed at the point where they connect to the sides of spacing members 7, it being noted that the points of connection between each side face and the tailing is small in cross section, and consequently, the material will break at this point without leaving surplus material projecting from the side faces of the spacing members. The cooling of the thermo-plastic material is relatively rapid. Die 8 may be suitably cooled, as by water, so that the material may be sufficiently cool when removed to permit tailings to be severed almost immediately. In this manner, the method is continuous and spacing members may be molded in fixed spaced relation upon their central conductor 5 in one operation without requiring intermediate spacers between the members 7 or the usual tedious manual operation of threading the members 7 upon the central conductor with intermediate spacers interposed or other means employed to hold members 7 properly spaced.

Fig. 3 illustrates how two central conductors may be passed through die 8 at the same time. This permits spacing members on two conductors to be formed in one injection operation and in practically the same time as would be required for one conductor. Die 8 may be constructed so that any number of conductors may be passed therethrough to have spacing members 7 formed thereon in one injection of the thermo-plastic material.

Spacing members 7 are uniform in shape and are uniformly spaced along conductor 5, and, when inserted in outer conductor 6, their periphery will uniformly contact the inner surface of this outer conductor so that a plurality of longitudinally spaced air chambers 20, completely closed off from one another, may be formed between these conductors along the entire length of the coaxial cable.

Outer conductor 6 may be a single tubular or

laminated member through which central conductor 5 is pulled with spacing members 7 formed thereon, or it may be a fabricated structure that may be spun or otherwise formed about the spacing members 7, to provide the structure shown in Fig. 1. One or more final layers or coatings of insulation 21 may thereafter be formed about outer conductor 6. If used on high frequency transmission, the outer layer may be a lead sheath 22 or like material.

From the foregoing description it will be apparent that the method herein disclosed results in forming any number of spacing members 7 at one time along the inner conductor of a coaxial cable in a fixed spaced relation. This eliminates tedious and expensive assemblies that require additional parts which do not always assure a structure uniformly made. Moreover, the molecular tension of the thermo-plastic material holding these members 7 in fixed relation may actually seal these members upon the inner conductor. Air pockets are thereby provided that increase the efficiency of the coaxial cable as a lead-in for a television receiver because it will prevent pick-up of undesirable signal waves and interference disturbances produced from magnetic and radiation effects. It will be also noted that thermo-plastic material has a certain cold flow which may, in time, advantageously form a peripheral seal between the contacting edge of members 7 and outer conductor 6 if this contacting edge should fail to engage the outer conductor tightly. In either event, the contacting engagement will be augmented by the cold flow to assure a tight seal. Hence, moisture will not pass from one air pocket to another, and the pockets will constitute an effective shield against magnetic and radiation disturbances between the dipoles of the antenna and the receiver. The omission of longitudinal spacers between the spacing members 7 increases the efficiency of the cable because the central conductor is thereby exposed to a sealed pocket of air, which acts as a better insulator and shield against the pick-up of undesirable effects along a lead-in between the antenna and receiver.

If the flexibility of central conductor 5 should cause spacing members 7 to turn or twist when the same is inserted in outer conductor 6 or when outer conductor 6 is spun or woven thereabout, edge 24 of one of the die members may be cut away slightly to form a small groove along the groove receiving the conductor. In the ejection operation, this groove will fill with thermo-plastic material, so that, when the wire is removed from the die, a longitudinal rib 25 shown in Fig. 6 is formed along conductor 5 between spacing members 7. In this manner, conductor 5 is reinforced and the spacing members are prevented from twisting or turning. It will be understood, however, that spacing members 7 may be made of greater dimension along conductor 5, if so desired, to secure a surface engagement larger than shown.

The method disclosed is exceedingly simple and inexpensive to practice. The product is likewise simple and inexpensive and may be produced at a fraction of the cost of coaxial cables heretofore constructed.

It will be understood that the method of forming insulated spacing members 7 is not necessarily limited to a central conductor of a coaxial cable but may be used in other types of cables where it is desirable to space one or more inner conductors within an outer tubular conductor.

However, the cable herein disclosed provides a very efficient cable structure for use as the lead-in between a television antenna and receiver. The conductors thereof are effectively insulated from one another to prevent any pick-up of magnetic or radiation disturbances as well as any pick-up of signal waves between the antenna and the receiver.

I wish it to be understood, however, that central conductor 5 may be completely surrounded by a layer 26 of insulating material, as shown in Fig. 7, in order more effectively to reinforce spacing members 7 against twisting if there is any tendency for these spacing members to twist when pulled through outer conductor 6 or when this outer conductor 6 is spun or built-up upon center conductor 5 and about the spacing members. I also find this concentric layer 26 very useful to reinforce center conductor 5 when formed of wire that is not sufficiently stiff to hold its shape or is of such a flexible character that it will tend to bend at or adjacent the point where it enters these spacing members, either through normal handling or when outer conductor 6 is placed about the spacing members.

When concentric layer 26 is used, the construction of the die adapted to be used will be somewhat simpler. As shown in Fig. 8, grooves 27 receiving center conductors 5 will be provided with a larger diameter than the diameter of these conductors so that the molding material will flow about the center conductors lying in these grooves 27 and into recesses 11. Passages 12 and their manner of connecting to the side of recesses 11 may be eliminated. When a number of center conductors are passed through a single die at one time, as shown in Fig. 8, a single communicating passage 28 connected to a transverse passage 29 may extend to each central conductor groove 27. No other passage in the die is necessary unless it is desired.

Fig. 9 illustrates another embodiment giving greater rigidity between spacing members 7 near their peripheries, which I find very effectively prevents any twisting of these members 7 and still permits the use of air as insulation between both conductors 5 and 6. In this connection, spacing members 7 may be provided with strips 30 that may be preferably formed during the same molding operation that forms the spacing members.

Fig. 10 also illustrates accomplishing substantially the same result by enlarging the area of contact between spacing members 7 and center conductor 5. Although this illustration shows spacing members 7 as being of diamond shape and the preceding illustrations show spacing members 7 as being of disk shape, it will be understood that other shapes may be used and are contemplated as being within the scope of the invention.

Without further elaboration, the foregoing will so fully explain the gist of my invention that others may, by applying current knowledge, readily adopt the same for use under varying conditions of service, without eliminating certain features, which may properly be said to constitute the essential items of novelty involved, which items are intended to be defined and secured to me by the following claims.

I claim:

1. A method of making coaxial cable having a central conductor and a tubular conductor coaxial with said central conductor which comprises molding a plurality of insulating spacing

members upon said central conductor by injecting under pressure individual bodies of molten insulating material having greater shrinkage properties upon cooling than said central conductor in die cavities through which said central conductor is passed, and immovably fixing by molecular tension said spacing members holding said central conductor in said cavities until said molten material has cooled and contracted under said pressure upon said central conductor, and placing said central conductor with said spacing members fixed thereon in coaxial relation within said tubular member.

2. A method of making a coaxial cable having a central conductor and a tubular conductor coaxial with said central conductor which comprises forming along said central conductor a plurality of insulating spacing members of thermo-plastic material having greater shrinkage properties upon cooling than said central conductor by molding individual bodies of molten material upon said central conductor in a predetermined spaced relation, immovably affixing by molecular tension said spacing members in said predetermined spaced relation by the contraction of said thermo-plastic material when cooling, and placing said central conductor with said spacing members formed thereon in coaxial relation within said tubular member.

3. A method of making a coaxial cable having a central conductor, an outer tubular conductor and insulating spacing members for holding said conductors in coaxial relation which comprises moving said central conductor by predetermined lengths through a cooled die having a plurality of recesses therein corresponding in shape to said insulating spacing members, injecting under pressure a thermo-plastic insulating material in a molten condition into said recesses as each length of said central conductor is moved into said die to form said spacing members thereon said thermo-plastic material having greater shrinkage properties than said central conductor, and allowing the injected thermo-plastic material to set and thereby become immovably affixed by molecular tension at said recesses upon said central conductor, repeating said operation for successive lengths of said central conductor, and thereafter placing said central conductor with said spacing members formed thereon in coaxial relation within said tubular conductor.

4. A method of making a coaxial cable having a central conductor, an outer tubular conductor and annular insulating spacing members through which said central conductor passes for holding said conductors in coaxial relation which comprises moving said central conductor by predetermined lengths centrally through a passage in a die and centrally through a plurality of recesses formed in said die and corresponding in shape to said spacing members, injecting a thermo-plastic insulating material having greater shrinkage properties upon cooling than said central conductor into said recesses at one side thereof, allowing the injected material to set and thereby become immovably affixed by molecular tension at said recesses upon said central conductor to form said spacing members thereon with a smooth peripheral edge, repeating said oper-

ation for successive lengths of said central conductor, and thereafter placing said central conductor with said spacing members formed thereon in coaxial relation within said outer tubular conductor.

5. A method of forming insulation spacing members upon an inner conductor disposed within an outer conductor of a coaxial cable which comprises moving said inner conductor through a passage within a die having a plurality of spaced recesses formed therein and corresponding in shape to said spacing members, injecting into said recesses a thermo-plastic insulating material characterized by its ability to contract upon cooling and to have greater shrinkage properties than said central conductor, and cooling the injected thermo-plastic material to cause the same to contract and to thereby immovably affix itself by molecular tension at said recesses upon said inner conductor.

6. A method of making coaxial cables which comprises molding a plurality of individual bodies of insulation material on one or more conductors said insulation material having greater shrinkage properties upon cooling than said conductors, and cooling said bodies to immovably affix the same by molecular tension upon said conductor or conductors.

7. A method of making coaxial cables having a plurality of separate gas containing pockets hermetically sealed one from another which comprises forming a plurality of spacing members of insulating material along a central conductor by molding individual bodies of molten insulating material upon said central conductor in predetermined spaced relation, hermetically sealing said bodies of molten material upon said central conductor upon cooling, placing an outer tubular conductor about said central conductor and said spacing members, and bringing the inner surface of said outer tubular conductor and the peripheries of said spacing members into intimate contact with each other to provide a hermetical seal between said outer tubular conductor and said spacing members.

8. A method of making coaxial cables having a plurality of separate gas containing pockets hermetically sealed one from another which comprises forming a plurality of spacing members of insulating material along a central conductor by molding individual bodies of molten insulating material upon said central conductor, hermetically sealing said bodies of molten material when cooling upon said central conductor, and forming an outer tubular conductor about the peripheries of said spacing members so as to bring the same into intimate contact with said peripheries of said spacing members whereby to form a seal between the periphery of each spacing member and said outer tubular conductor.

9. A method of making coaxial cables having a plurality of separate gas containing pockets hermetically sealed one from another which comprises hermetically sealing a plurality of insulation spacing members upon a central conductor, and hermetically sealing the periphery of each spacing member with the inner surface of an outer tubular conductor.

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