July 7, 1942. J. P. GITS 2,288,900

METHOD OF AND MEANS FOR MAKING COAXIAL CABLES

Original Filed Jan. 15, 1940 2 Sheets-Sheet 1

Fig. 1.

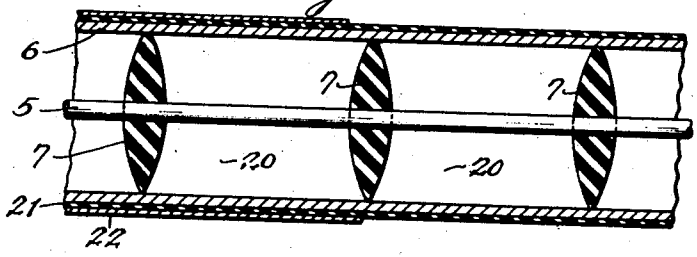


Fig. 2.

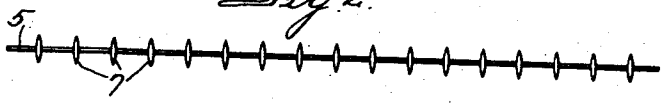


Fig. 3.

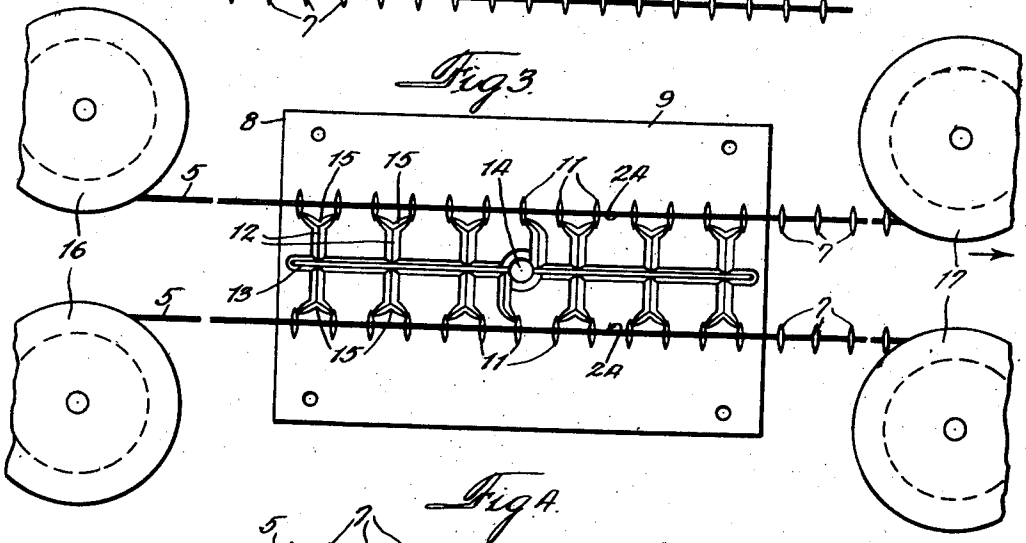
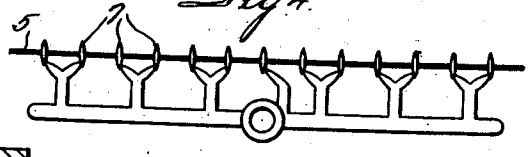


Fig. 4.



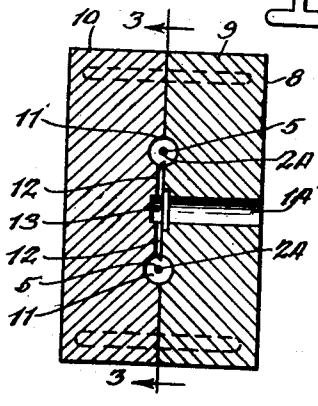


Fig. 5.

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Fig. 6.

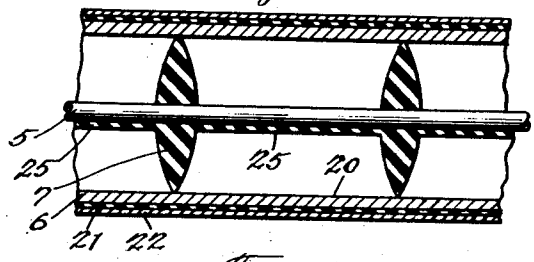


Fig. 7.

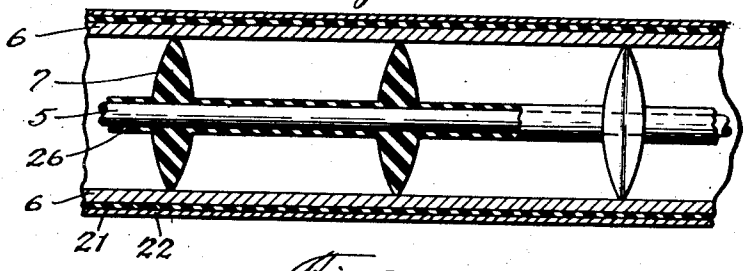


Fig. 8.

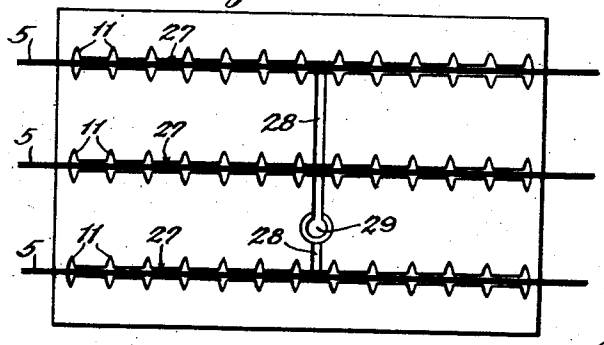


Fig. 9.

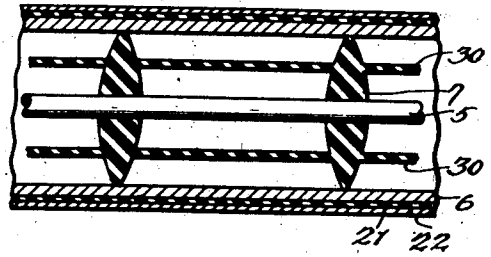
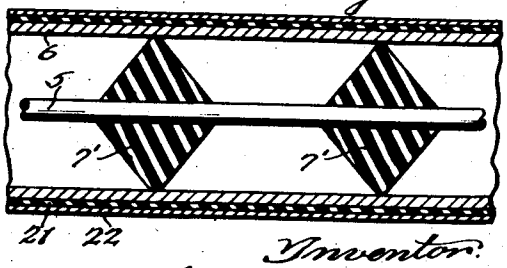


Fig. 10.



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UNITED STATES PATENT OFFICE

2,288,900

METHOD OF AND MEANS FOR MAKING COAXIAL CABLES

Jules P. Gits, Chicago, Ill., assignor to Gits Molding Corporation, Chicago, Ill., a corporation of Illinois

Original application January 15, 1940, Serial No. 313,846. Divided and this application October 17, 1940, Serial No. 361,508

8 Claims. (Cl. 173—28)

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 guildings 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 particularly 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 which method has been disclosed and claimed in my copending application, Serial No. 313,846, filed January 15, 1940, of which this application is a division.

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 forms 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 removed 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 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 patrix **10** (Fig. 5) having a plurality of recesses 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 be-

tween 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 di-poles 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 5 or when outer conductor 5 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 thermoplastic 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 adapt 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 coaxial cable comprising a central con-

ductor, a tubular conductor coaxial with said central conductor, and a plurality of spacing members of a material having greater shrinkage properties upon cooling than said central conductor, said spacing members being molded upon said central conductor and being held thereon by the molecular tension of the material out of which said spacing members are formed.

2. A coaxial cable comprising a central conductor, a tubular conductor coaxial with said central conductor, and a plurality of insulation members for axially spacing said conductors, said insulation members being of a material having greater shrinkage properties upon cooling than said central conductor, said insulation members being molded upon and spaced apart in fixed relation along said central conductor and immovably held by molecular tension of the material out of which said members are formed.

3. A coaxial cable comprising a central conductor, a tubular conductor coaxial with said central conductor, a plurality of molded bodies of insulation material having greater shrinkage properties upon cooling than said central conductor, said bodies of insulation material being molded and held by the molecular tension of said material upon said central conductor at predetermined distances apart to support said central conductor in insulation relation within said tubular conductor, and a layer of insulation disposed about said tubular conductor.

4. In a coaxial cable, an outer tubular conductor, a central conductor, and a plurality of spacing members in the form of molded annular bodies of insulation material between said conductors arranged in spaced relation upon said central conductor, said insulation material between adjacent annular spacing bodies extending along and upon said central conductor in integrally molded relation with said annular spacing bodies, both said bodies and said extensions therebetween being immovably affixed to said central conductor by the molecular tension of said molded insulation material.

5. In a coaxial cable, an outer tubular conductor, a central conductor, a plurality of spacing members in the form of molded annular bodies of insulation material between said conductors arranged in spaced relation upon said central conductor, and an annular sleeve between adjacent annular spacing bodies extending along and upon said central conductor in integrally molded relation with said annular spacing bodies, both said bodies and said sleeves therebetween being immovably affixed to said central conductor by the molecular tension of said molded insulation material hermetically sealing said central conductor therein.

6. A central conductor for a coaxial cable having a plurality of molded spacing bodies of insulation material having greater shrinkage properties upon cooling than said central conductor, said spacing bodies being molded upon said central conductor and being held thereon by the molecular tension of said molded insulation material out of which said spacing bodies are formed.

7. A coaxial cable formed with a plurality of separate gas containing pockets that are hermetically sealed one from another, which comprises an inner conductor, a plurality of spaced bodies of insulated material hermetically sealed upon said inner conductor in fixed position the spacing between said bodies of insulation material constituting said pockets, and an outer tubular conductor about said inner said conductor and said bodies of insulation material, said bodies of insulation material being hermetically sealed about their peripheries with said outer tubular conductor.

8. A coaxial cable formed with a plurality of separate gas containing pockets that are hermetically sealed one from another which comprises an inner conductor, a plurality of spaced annular bodies of insulation material hermetically sealed upon said inner conductor in fixed position, an outer tubular conductor about said inner conductor and said bodies of insulation, said bodies of insulation also being hermetically sealed about their peripheries with said outer tubular conductor to provide thereby hermetically sealed spaces that form said separate gas containing pockets, and means between said annular bodies of insulation material to reinforce said bodies against a tilting or twisting action that will destroy said hermetical seal between their said peripheries and said outer tubular conductor.

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