

# United States Patent

Nevin et al.

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## [54] METHOD OF MAKING COAXIAL CABLE

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### Related U.S. Application Data

[60] Continuation of Ser. No. 790,662, Jan. 13, 1969, abandoned, which is a division of Ser. No. 653,947, July 17, 1967, Pat. No. 3,461,499.

[52] U.S. Cl. .... 29/624, 18/13 RR, 18/13 W, 18/14 RR, 29/474.1, 156/47, 156/51, 174/107, 174/105, 264/173, 264/177

[51] Int. Cl. .... H01b 13/00, H05k 3/00

[58] Field of Search ..... 156/47, 48, 49; 264/47, 173, 264/177; 29/624, 474.1; 174/105, 107; 18/13

[56]

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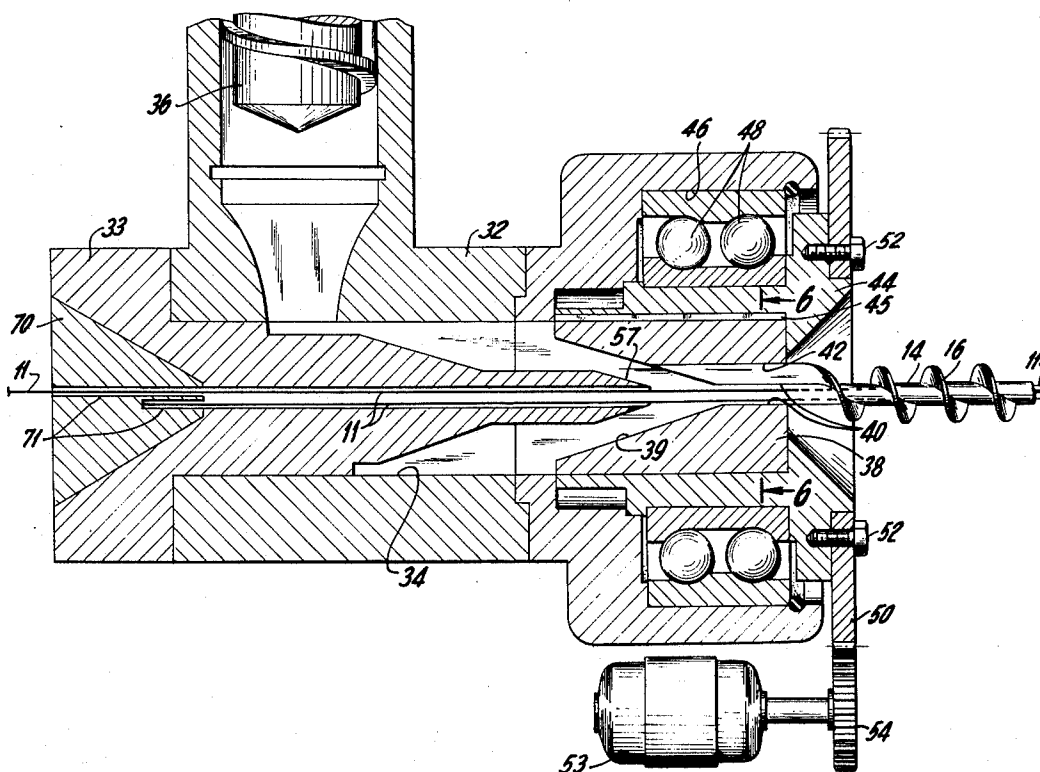
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[57]

### ABSTRACT

An air dielectric coaxial cable includes a thin cylindrical center conductor supported by a concentric plastic insulating layer having a plastic helical web thereabout. In fabricating the cable, a tubular center conductor is formed from a thin metallic foil or tape and is passed continuously from the tube former through a stationary annular confining zone into a rotary die where the requisite insulating layer and web are extruded around this conductor.

2 Claims, 7 Drawing Figures



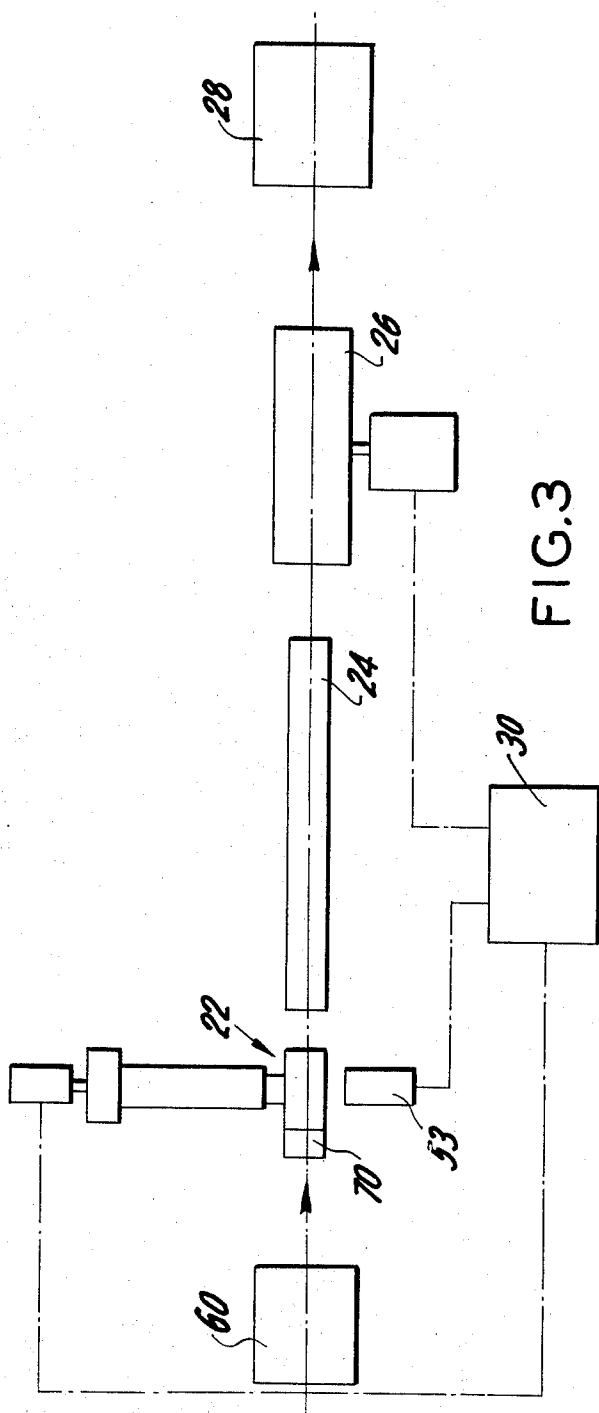


FIG. 3

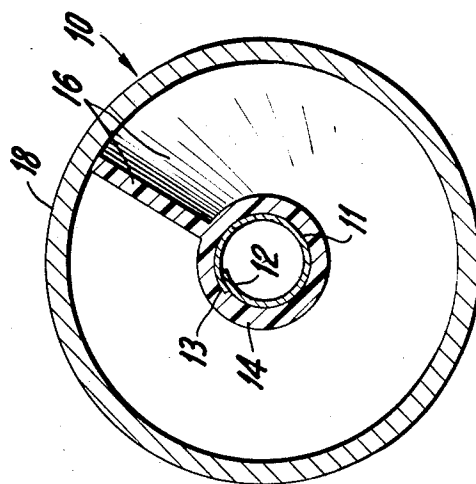


FIG. 2

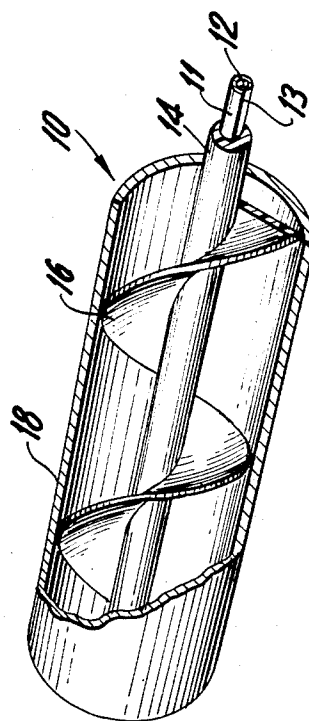


FIG. 1

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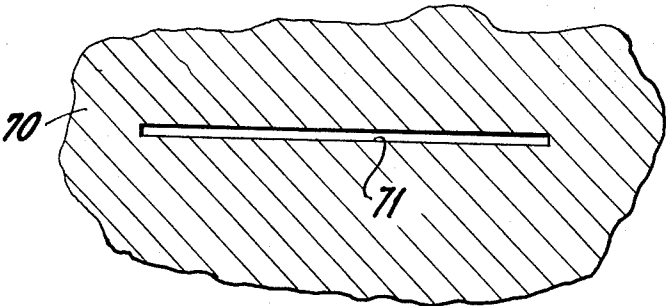


FIG. 5A

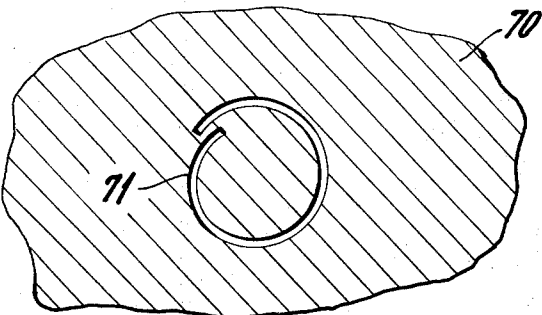


FIG. 5B

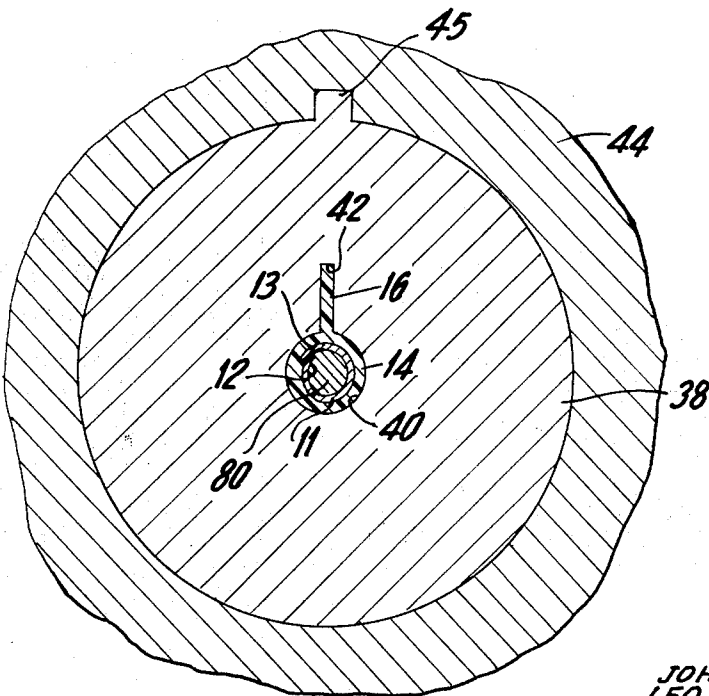


FIG. 6

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# METHOD OF MAKING COAXIAL CABLE

This application is a continuation of our copending application Serial No. 790,662 filed Jan. 13, 1969, and now abandoned, which is a division of our application Serial No. 653,947, filed July 17, 1967 (now U.S. Pat. No. 3,461,499 granted Aug. 19, 1969).

This invention relates to a method for fabricating coaxial cables of the air dielectric type.

Typically, prior art coaxial cables employ relatively rigid, shape-retaining, preformed center conductors of solid tubular cross section. To produce a uniform spacing between the inner and outer cable conductors, insulating material, illustratively of a solid or spiral form, is extruded onto the preformed center conductor. Production of such cables therefore requires the distinct operations of preforming the inner conductor, and adhering the desired insulating material thereto. Further, cables formed in such a manner require a relatively large amount of metallic material to embody the requisite relatively rigid shape-retaining center conductor.

It is an object of the present invention to provide an improved method for fabricating such cable.

In accordance with the principles of the present invention, a feeding arrangement of any conventional type is used for directing a plasticized resinous material under pressure to a rotating extrusion die. The extrusion die is formed with a main orifice adapted to accommodate passage of the tubular center conductor on which a concentric insulating layer and an associated web are to be formed. Flat metallic tape is fed to the main orifice of the extrusion organization via an input forming die adapted to convert the tape to the desired cylindrical geometry, and the tube thus formed is passed from the forming die into the rotating extrusion die while maintaining the tube under confinement between inner and outer concentric stationary members, thereby inhibiting distortion of the tube.

Intersecting this main orifice and extending radially outwardly therefrom is a web-extruding sub-orifice. This sub-orifice, at least where it opens through the exit end of the die, exhibits a shape of the desired cross section of the helical web, preferably rectangular. The outer periphery of the sub-orifice terminates short of the outer extremity of the die, so that both the main and sub-orifices are completely contained within and defined by the extrusion die. The extrusion die is held in a die carrier which is mounted about the tubular center conductor in the main orifice, and a driving mechanism is provided to rotate the die carrier, and hence the extrusion die.

The metallic tape is continuously supplied through the forming and extrusion dies by a transport arrangement. The flat tape converted to tubular form in the input forming die is maintained in that shape as it passes along the inner and outer stationary confining members; and it emerges from the outer confining member into a surrounding flow of the resinous material which is extruded through the sub-orifice and the area in the main orifice surrounding the tubular conductor to respectively form the concentric insulating layer and its attendant helical web about the tubular conductor. The helix form is imparted to the web by rotation of the extrusion die during this lengthwise movement of the newly formed tubular conductor.

The pitch of the resulting helical web is determined by the rotary speed of the extrusion die relative to the linear speed at which the transport arrangement conducts the tubular tape (center conductor) through the main extrusion orifice. Accordingly, the pitch of the helix can be varied as desired by varying the ratio of these two speeds.

The above and other objects and features of the present invention will be apparent from the following detailed description of an illustrative embodiment thereof presented hereinbelow in conjunction with the accompanying drawing in which:

FIG. 1 is a partially cutaway perspective view of an electrical coaxial cable produced in accordance with the principles of the present invention;

FIG. 2 is a cross sectional view of the coaxial cable shown in FIG. 1;

FIG. 3 is a schematic illustration of an extrusion system, including control apparatus, for practicing the method of the present invention;

FIG. 4 is a vertical, longitudinal, sectional view of the forming and extrusion apparatus schematically shown in FIG. 3;

FIG. 5A and 5B are partial cross sectional views illustrating the extremities of forming apparatus depicted in FIGS. 3 and 4; and

FIG. 6 is a sectional view taken along lines 6-6 in FIG. 4.

Referring now to FIGS 1 and 2, there is illustrated an air dielectric coaxial cable 10 including a thin metallic tubular center conductor 11 having overlapping edges 12 and 13. The conductor 11 is adhered to, and is physically supported by a concentric insulating plastic layer 14 having as an integral portion thereof a helical web 16, with the web 16 spiraling about the layer 14 in the direction of the overlap 13-12. The web 16 serves to further provide mechanical support and rigidity for the thin tape center conductor 11, and also functions to maintain the center conductor 11 in a uniform, concentric relationship with an outer conductor 18.

The term "conductor" as used herein refers to an electrical conductor of any conventional material having high conductivity, such as copper or aluminum.

The system arrangement for fabricating the coaxial cable 10 of FIGS. 1 and 2 is schematically illustrated in FIG. 3 and includes a source 60 for supplying a thin metallic tape e.g., a rotatable reel thereof. The tape 11 is passed through a shaped passage in an input forming die 70 which converts the tape from its initial flat form into a tube having overlapping edges. The tape 11 is pulled by an appropriate transport mechanism described below.

The thin tubular electrical center conductor 11 is pulled through extrusion apparatus 22 wherein the circular insulating layer 14 and the helical web 16 are extruded thereon. The conductor, insulating layer and web combination 11-14-16 is then passed through a conventional cooling apparatus, such as a water trough 24 to impart the final solid state to the insulating layer 14 and the web 16. Removed from the cooling apparatus 24 is a transport mechanism 26 for translating the conductor 11. Any conventional transport mechanism 26, such as a tractor capstan, may be employed. The transport mechanism 26 feeds the insulated composite center conductor to a receptacle 28, e.g., a take-up reel.

So that the helical web 16 will have a uniform pitch, a coordinating speed control 30 is employed to control the relative speeds of the transport mechanism 26 and the extrusion apparatus 22. The control 30 is of any known type which, in response to any increase or decrease in the speed of one such element, results in a corresponding relative change in the speed of the other, so that the relative speeds of the rotary extruder 22 and the transport mechanism 26 are maintained essentially constant. The control 30 may be adapted to provide different ratios for the two speeds to provide a helical web of any desired pitch. This adjustment may be effected automatically according to a predetermined pattern when it is desired to vary the pitch of the helical web from time to time during a continuous run.

FIGS. 4 through 6 illustrate in detail the composite extrusion apparatus 22, including the forming die 70, which were schematically shown in FIG. 3. The die 70 includes a forming passage 71 therethrough which continuously varies from the metallic tape 11 receiving flat slot shown in FIG. 5A to the center conductor tubular forming exitway illustrated in FIG. 5B. Further a rod 80, with a flared end, may advantageously be affixed to the forming die 70. To preserve the clarity of the drawing, the rod 80 is shown only in FIG. 6. Accordingly, when the metallic tape 11 is drawn through the forming die 70 by the transport mechanism 26, the tape is continuously bent by the passage 71 into the requisite overlapping circular form shown in FIG. 2, the transported down the length of the rod 80 and within a stationary confining member 33, which function to retain the tape 11 in such tubular shape and to inhibit such formed tape from collapsing or otherwise distorting. The flared rod end comprises a further aid to retaining the circular form of the center conductor and, as will become more clear from the following, presses the tape against the extruded insulating layer 14 to enhance the adhesion therebetween.

The extrusion apparatus 22 includes therein a block 32 containing the cylindrical member 33 and forming therewith an annular cavity 34 for receiving a plasticized resinous insulating material to be extruded. Any conventional non-conductive thermoplastic or thermosetting material such as any of the polyolefins, crosslinked or not, such as polyethylene, polysulfone, or polytetrafluoroethylene, may be used. The material is supplied by a standard feeding organization, such as a feed screw 36 which forces the material through the cavity 34 and into the adjacent entrance end of an extrusion die 38.

The extrusion die 38 is formed with a center extrusion orifice 40 which receives the center conductor 11, and provides sufficient, uniform spacing therearound to supply the desired thickness of insulating material to form the layer 14. Extending radially outward from the center orifice 40 is a rectangular sub-orifice 42 through which the resinous material for the web 16 is extruded. The dimensions of the apertures 40 and 42 are made slightly larger than the corresponding desired dimensions for the insulating layer 14 and the web 16, respectively, in order to allow for shrinkage when the layer 14 and the web 16 cool and solidify in the bath 24. The extrusion die 38 is supported within a die carrier 44 and is adapted to be rotated with its carrier, as through a key 45. The die carrier 44 is located in a cavity 46 formed in an extension of the block 32 and is supported for

rotation therein by antifriction bearings 48. In order to impart rotary motion to the die carrier 44 and its extrusion die 38, a drive sprocket 50 is secured to the die carrier by any conventional means, such as by bolts 52. The drive sprocket is adapted to be driven by a variable speed motor 53 through a suitable connection 54.

The formed electrical center conductor 11 is drawn along the shape supporting rod 80 and member 33 and passes through the center of the main orifice 40 in the extrusion die 38. The die 38 has a conical cavity 39 therein forming an inlet to the extrusion orifices 40 and 42. The member 33 has a similarly tapering end 57 centrally located in the die cavity 34 so that the extruded plastic material is forced from the annular cavity 34 through the tapering annular passage surrounding the tapered end 57, and thence through the main orifice 40 and, coincidentally therewith, through the sub-orifice 42.

In forming the insulating layer 14 and the helical web 16, the conductor 11 is pulled by the transport mechanism 26 lengthwise through the extrusion die 38. Simultaneously therewith, the resinous material is fed by the screw 36 to the extrusion die 38 and is extruded circumferentially about the center conductor 11 via the main orifice 40. At this time also, the resinous material is extruded through the rotating sub-orifice 42 into the form and a radial helical web having its inner edge at the outer periphery of the layer 14, since this sub-orifice intersects the main orifice 40 through which the conductor translates. The relatively soft plastic insulating material 14-16 adheres to the fragile center conductor tape 11 during and after the extruding operation, imparting mechanical rigidity and shape stability thereto following translation of the tubular center conductor 11 past the supporting rod 80.

The spacing of the convolutions of the helix i.e., the pitch thereof, is determined by the speed at which the conductor 11 passes through the die 38 relative to the speed at which the die is rotated. With a fixed speed of conductor movement, an increase in rotational speed of the die 38 decreases the helix pitch. Conversely, an increase in speed of conductor movement increases the helix pitch. Accordingly, coordinating speed control means 30 can be programmed or manually adjusted to provide any desired pitch by merely varying the relative speeds of the transport mechanism 26 and the die 38 rotating motor 53. It is also necessary to control the rate that the insulating material is fed to the die 38 in order to provide uniform insulation thickness. For example, if the conductor movement or the die rotation decreases to any large extent, it is necessary to similarly decrease the rotational speed of the feed screw 36 in order to avoid feeding the material at an excessive rate to the extrusion orifices 40 and 42. The speed control of the feed screw 36 is coordinated with the operation of the transport mechanism 26 and the variable speed motor 53 by the speed control element 30.

It is noted that any desired web shape can be provided by merely varying the cross-section of the extrusion orifice 42. Similarly, various size conductors can be accommodated by interchanging the forming die 70 with its attached rod 80, and the extrusion die 38.

Also, the drive motor 53 is preferably adjusted to rotate the extrusion die 38 in the direction of the center conductor overlap 13-12 shown in FIG. 2, i.e., in the

direction defined by the upper overlap tape edge 13 (counterclockwise as viewed in FIG. 6). Such a relative direction of rotation assures a fixed amount of overlap between the center conductor ends 12-13, and therefore a fixed diameter for the center conductor 11. These parameters would otherwise be subject to variation when perturbations in the extruding pressure are encountered.

It will be understood that the inner and outer confining members 80 and 33, respectively, being essentially concentric to each other, serve to maintain the tape 11 in its tubular form as it passes from the forming die 70 into the rotating die 38, so that there is no need to adhere the overlapping edges of the tape tube to each other before the tube is encased in the extruded insulating material. The tube 11 emerges from the outer confining member 33 into the tapering stream of insulating material within the rotating die, so that the surrounding insulating material in conjunction with the internal support 80 serves to maintain the desired tubular form of the tape as it passes through the extruding zone.

We claim:

1. In the fabrication of an air dielectric coaxial cable, the method comprising the steps of passing a thin metallic tape through a forming die to render said tape tubular in cross section, continuously passing the tubular tape from said die to an extruding zone while adjacent overlapping edge portions of the tubular tape are detached from each other and while maintaining the tubular tape under confinement between inner and outer concentric stationary members to inhibit distortion of the tape from its tubular form, continuously passing the tubular tape from said outer confinement member into

and through an extruding die in said zone while extruding insulating material around the tubular tape as it emerges from said outer member into the extruding die and while rotating the extruding die in the direction defined by the outermost of said overlapping edge portions, to form said material into a continuous layer and a helical web surrounding the tubular tape, and supporting the tubular tape internally in said extruding zone, whereby the tape emerging from the extruding zone is mechanically supported in tubular form by said layer and helical web.

2. In the fabrication of an air dielectric coaxial cable, the method comprising the steps of passing a thin metallic tape through a forming die to render said tape tubular in cross section, continuously passing the tubular tape from said die to an extruding zone while adjacent overlapping edge portions of the tubular tape are detached from each other and while maintaining the tubular tape under confinement between inner and outer concentric stationary members to inhibit distortion of the tape from its tubular form, continuously passing the tubular tape from said outer confinement member into and through an extruding die in said zone while continuously forcing insulating material into the die in an annular stream surrounding said outer confining member and tapering in the direction in which the tubular tape emerges from said outer member, continuously rotating the die to extrude the material from said stream into a continuous layer and a helical web surrounding the tubular tape, and supporting the tubular tape internally in said extruding zone, whereby the tape emerging from said zone is mechanically supported in tubular form by said layer and helical web.

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