Nov. 19, 1968 J. J. NEVIN 3,411,182

APPARATUS FOR EXTRUDING HELICAL WEBS ON CONDUCTORS

Filed Sept. 28, 1966 2 Sheets-Sheet 1

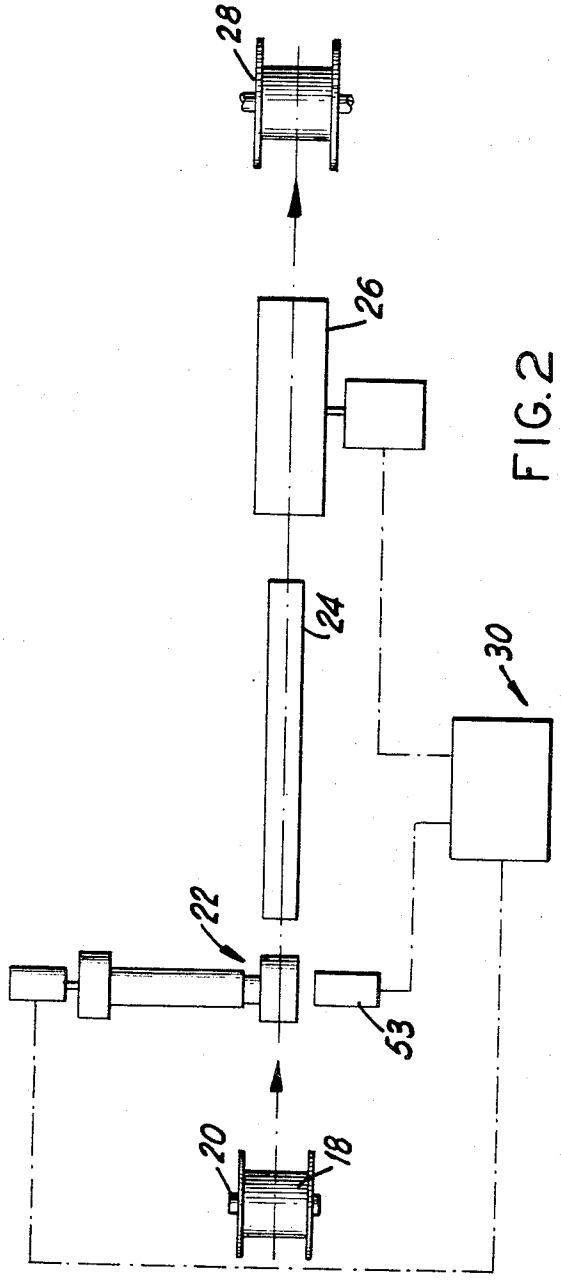

FIG. 2

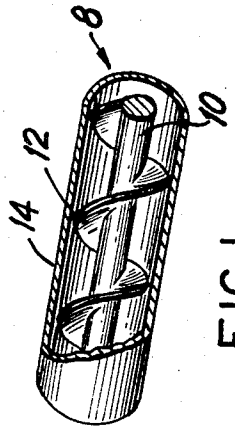

FIG. 1

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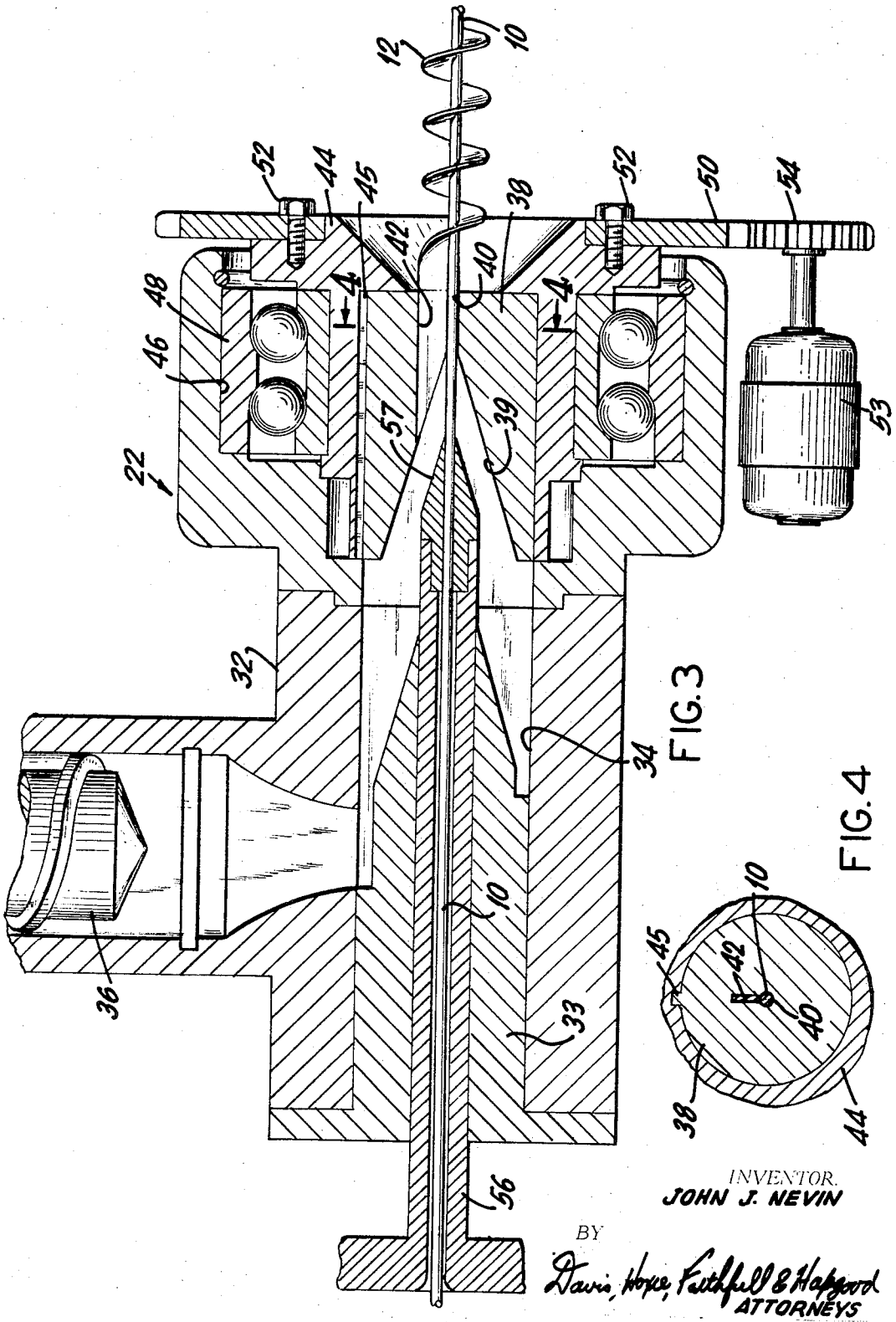

FIG. 3

FIG. 4

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APPARATUS FOR EXTRUDING HELICAL WEBS ON CONDUCTORS

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ABSTRACT OF THE DISCLOSURE

The electrical conductor is passed through the main orifice of an extrusion die having an exit end through which the main orifice opens and also having a sub-orifice intersecting the main orifice and extending generally radially outward therefrom, the sub-orifice opening through the exit end of the die with the radially outer portion of the sub-orifice terminating short of the outer periphery of the die. The die is supported for rotation about the conductor and is provided with an inlet to which a plasticized resinous material is supplied under pressure in all rotational positions of the die, to cause the material to be extruded continuously through the exit opening of the sub-orifice in the form of a generally radial web on the conductor. Driving means are provided to rotate the die so as to spiral the web in a helix about the conductor, the pitch of the helical web being determined by the rotational speed of the die relative to the speed at which the conductor is moved lengthwise through the die by a transport means.

The disclosure

This invention relates to extrusion apparatus and more particularly to apparatus for extruding a helical web around and along the length of an electrical conductor. A conductor having a web formed in accordance with this invention is useful as a component of electrical cable, such as coaxial cable wherein the helical web serves to maintain the conductor in concentrically spaced relation to a surrounding outer conductor.

In the past, such helical webs have been formed on conductors by the use of two structurally independent but functionally cooperating elements, one stationary and the other rotatable, which together form the extrusion die. An example of such an apparatus is seen in United States Patent No. 2,465,482. In order to provide perfect concentricity and uniformity of the web thus formed, perfect alignment of the two die elements must be attained and maintained, which is difficult if not impossible and is time-consuming at best. Modification of the desired web, for example, in width or cross section, requires changing one or both elements and therefore requires a realignment of these elements.

A second known type of apparatus, for forming a helical web about an electrical conductor, comprises a rotatable die having a cavity with the configuration of the helix and through which the electrical conductor passes. In addition to the need for accurately aligning the conductor within the cavity, the uniformity of the resulting helix is dependent upon the accuracy with which the die cavity is machined. Furthermore, it is necessary to provide a different die for each different helix pitch which is desired. An apparatus of this type may be seen in United States Patent No. 2,834,047.

Accordingly it is one object of this invention to provide an improved extrusion apparatus for forming a uniform helical web about a cylindrical element and in which the extrusion die is self centering with respect to the element.

Another object of this invention is to provide an extrusion apparatus having sufficient operation flexibility to permit variation in helix pitch without replacement of the extrusion die.

These and other objects and attendant advantages of the present invention will become apparent and better understood from the following description and accompanying drawings in which

FIGURE 1 is a partially cutaway perspective view of an electrical coaxial cable produced by apparatus in accordance with this invention;

FIGURE 2 is a schematic illustration of an extrusion system, including control circuitry, made in accordance with this invention;

FIGURE 3 is a vertical, longitudinal sectional view of the extrusion apparatus of the system of FIGURE 2, and

FIGURE 4 is a sectional view taken along line **4—4** in FIGURE 3.

Briefly stated, this invention in one form comprises an extrusion apparatus including a feeding means, which may be conventional, for directing a plasticized resinous material under pressure to an extrusion die. The extrusion die is formed with a main orifice adapted to accommodate passage of the conductor on which the web is to be formed. Intersecting this main orifice and extending radially outwardly from it is a sub-orifice through which the resinous material is extruded. This sub-orifice, at least where it opens through the exit end of the die, has the shape of the desired cross-section of the helical web, preferably rectangular, with its radially outermost portion terminating short of the outer periphery of the die, so that the sub-orifice is completely contained within and defined by the die. The extrusion die is held in a die carrier which is mounted for rotation about the conductor in the main orifice, and driving means are provided to rotate the die carrier and hence the extrusion die.

In some instances, it may be desired to extrude the helical web simultaneously with an underlying thin film of the material which completely surrounds the conductor and from which the web protrudes. In such instances, the main orifice of the die is provided with a diameter which exceeds the conductor diameter by twice the desired thickness of the film. Otherwise, the diameter of the main orifice is essentially the diameter of the conductor.

The conductor is fed continuously lengthwise to the extrusion die and through its main orifice by suitable transport means. In order to form the helical web about the conductor, the resinous material is extruded through the sub-orifice and the extrusion die is rotated during this lengthwise movement of the conductor. The pitch of the resulting helical web is determined by the rotational speed of the die relative to the linear speed at which the transport means passes the conductor through the die, and the pitch can be varied as desired by varying the ratio of these two speeds. Because the conductor is supported so that its central axis coincides with that of the main orifice in the die, and because the sub-orifice is completely defined by the die, the helical web will be concentric to the conductor axis and uniform throughout.

Referring now to the drawings, and more particularly FIGURE 1, there is illustrated an air dielectric electrical coaxial cable **8** including an electrical conductor **10** having a helical web **12** extending radially therefrom and formed by the apparatus of this invention. The web serves as a dielectric support to hold the inner conductor **10** concentrically within an outer conductor **14**.

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 as shown in FIGURE 2 includes a payoff reel **18** rotatably supported by any conventional means, such as jackstands **20**, which permits free rotation of the

reel as the conductor is pulled by an appropriate transport mechanism described below.

The electrical conductor **10** is passed through an extrusion apparatus **22** wherein the helical web **12** is extruded onto the conductor **10**. The conductor and web combination is then passed through a conventional cooling apparatus, such as a water trough **24**, wherein the web acquires its final solid state. Downstream from the cooling apparatus is a transport mechanism for pulling the conductor from the payoff reel **18**. Any conventional transport mechanism **26**, such as a tractor capstan, may be employed. The transport mechanism **26** feeds the webbed conductor to a take-up reel **28**.

So that the helical web **12** will have a uniform pitch, a coordinating speed control **30** is provided which controls the speeds of the transport mechanism **26** and the extrusion apparatus **22**. The control **30** is of the known type which, in response to any increase or decrease in the speed of one, results in a corresponding change in the speed of the other, so that the relative speeds are maintained essentially constant. If desired, however, the control **30** may be adjusted to maintain a different ratio of the speeds and thus provide a uniform helical web of different 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.

FIGURES 3 and 4 illustrate in detail the extrusion apparatus which forms the helical web **12**. The apparatus includes a block **32** containing a cylindrical member **33** and forming therewith an annular cavity **34** for receiving a plasticized resinous material to be extruded. Any conventional, nonconductive, thermoplastic or thermosetting material can be used. The material is supplied by a standard feeding means, such as a feed screw **36**, which forces the material through the cavity **34** and into the adjacent entrance end of an extension die **38**.

The die **38** is formed with a central orifice **40** which, as shown, receives the conductor **10** with a close sliding fit. Extending radially outwardly from the central orifice **40** is a rectangular sub-orifice **42** through which the resinous material is extruded. The radial dimension of the sub-orifice **42** is slightly larger than the desired web height in order to allow for shrinkage when the web **12** cools and solidifies. The extrusion die **38** is supported within a die carrier **44** and is adapted to be rotated with this carrier, as through a key **45**. The die carrier **44** is located in a cavity **46** formed in an extension of the stationary block **32** and is supported for rotation therein by bearings **48**.

In order to provide 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 bolts **52**. The drive sprocket is adapted to be driven by a variable speed motor **53** through a suitable connection **54**.

The electrical conductor **10** is fed through a guide **56** centrally located within the cylindrical member **33** and passes from this guide through the central orifice **40** in the extrusion die **38**. The die **38** has a conical cavity **39** tapering from the entrance end of the die toward its exit end and forming an inlet to the orifices **40** and **42**. The guide **56** has a similarly tapered end **57** centrally located in the die cavity **39**, so that the extrusion material is forced from the annular cavity **34** through the tapering annular passage surrounding the guide end **57**, and thence through the sub-orifice **42**.

In forming the helical web **12**, the conductor **10** is pulled lengthwise through the extrusion die **38** by means of the transport mechanism **26**. Simultaneously, the resinous material is fed by a screw **36** to the extrusion die **38** and is extruded through the sub-orifice **42** in the form of a radial web having its inner edge in contact with the conductor, since this sub-orifice intersects the main orifice **40** through which the conductor passes. At the same time, the extrusion die **38** is rotated by the variable speed motor **53**, resulting in the formation of a uniform extruded web **12** spiralling about the conductor **10** along its length. The spacing of the convolutions of the helix, that is, the pitch of the helix, is determined by the speed at which the conductor **10** is moved through the die **38** and the speed at which the die is rotated. With a fixed speed of conductor movement, an increase in rotational speed of the die decreases the helix pitch. Conversely, with a fixed rotational speed of the die, an increase in speed of conductor movement increases the helix pitch. Accordingly, the coordinating speed control means **30** can be programed to provide any desired pitch by merely adjusting the relative speeds of the transport mechanism **26** and motor **53**. It is also necessary to control the rate of material feed in order to insure uniformity in web thickness. For example, if the conductor movement or the die rotation decreases considerably in speed, it is necessary to similarly decrease the rotational speed of feed screw **36** in order to avoid feeding the material at an excessive rate to the extrusion orifice **42**. The speed control of the feed screw **36** is coordinated with the operation of the transport mechanism **26** and variable speed motor **53** by means of the speed control means **30**.

Any desired web shape can be provided by merely varying the cross-sectional shape of the extrusion orifice **42**. Similarly, various size conductors can be accommodated by interchanging the extrusion die **38**. This is accomplished by merely removing the die carrier **44** from the block **32** and replacing the extrusion die **38** with the appropriate die. The die and carrier assembly are then reinserted in the cavity **46**.

As will be observed from FIGURES 3 and 4, the extrusion is effected through an orifice **42** extending radially outward from the main orifice **40** but terminating short of the outer periphery of the die **38**, so that the extrusion orifice **42** is defined entirely by the die and the conductor **10** passing through the main orifice. Consequently, it is unnecessary to center the extrusion die **38** with any other element of the apparatus, in order to form a uniform helical web **12** which is perfectly concentric to the conductor **10**. Such concentricity is assured simply by preventing lateral movement of the conductor relative to the main orifice **40**, which movement is avoided by a close sliding fit of the conductor in the orifice or, when the aforementioned thin film is also to be extruded, by the centering action of the resinous material as it is forced through the annular tapered inlet **39** surrounding the conductor. In other words, the present apparatus is entirely self-centering for the purpose of maintaining the helical web concentric to the conductor. Moreover, the helical web is formed without resort to a helical die cavity, which requires accurate and difficult machining and limits the helix to a predetermined pitch.

The extrusion material supplied by the feed screw **36** may be any of the polyolefins, cross-linked or not, such as polyethylene, polysulfone or Teflon. The cooling apparatus **24** serves to solidify the extruded material before it is engaged by the transport mechanism **26** which pulls the conductor from the extrusion die.

I claim:

1. Apparatus for extruding a helical web along the length of an electrical conductor, said apparatus comprising

(*a*) an extrusion die formed with a main orifice through which said conductor is adapted to pass, the die having an outer periphery and also having an exit end through which said main orifice opens, the die also being formed with a sub-orifice intersecting said main orifice and extending generally radially outward from said main orifice, said sub-orifice opening through said exit end of the die with the radially outer portion of the sub-orifice terminating short of said outer periphery, the die forming an inlet to said sub-orifice,

(*b*) means supporting the die for rotation about said conductor in the main orifice,

(*c*) means for supplying plasticized resinous material under pressure to said inlet in all rotational positions of the die, to cause said material to be extruded continuously through said exit opening of the sub-orifice in the form of a generally radial web on the conductor,

(*d*) transport means for moving said conductor lengthwise through said main orifice, to draw the extruded material from said exit end of the die, and

(*e*) driving means for rotating the die in one direction about said conductor to spiral the web in a helix around the conductor, the pitch of the helical web being determined by the rotational speed of the die relative to the speed at which the conductor is moved lengthwise by said transport means, and the radial dimension of the helical web being determined by said sub-orifice within the die.

2. Apparatus as defined in claim **1**, in which the die has a conical cavity tapering toward said exit end and forming said inlet to the sub-orifice, the apparatus comprising also a stationary guide member having a conical end disposed in said cavity in spaced relation to the die and tapering toward said exit end, said member having a passage for guiding the conductor to the die and opening through said tapered end, said material supplying means forming an annular supply passage surrounding the guide member and opening into said cavity at the end of the die remote from said exit end.

3. Apparatus as defined in claim **1**, comprising also control means operatively connected to said driving means and said transport means for maintaining a predetermined ratio of the rotational speed of the die and said lengthwise speed of the conductor.

4. Apparatus as defined in claim **1**, in which said main orifice is dimensioned to receive the conductor with a close sliding fit.

5. Apparatus as defined in claim **1**, in which said transport means include mechanism for pulling the conductor from the extrusion die, the apparatus comprising also cooling means interposed between the extrusion die and said pulling means and operable to solidify said extruded material on the conductor.

References Cited

UNITED STATES PATENTS

2,446,057	7/1948	Morin	18—13 RXR
2,805,179	9/1957	Burr	18—13 RXR
2,834,047	5/1958	Morin	18—13 R

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