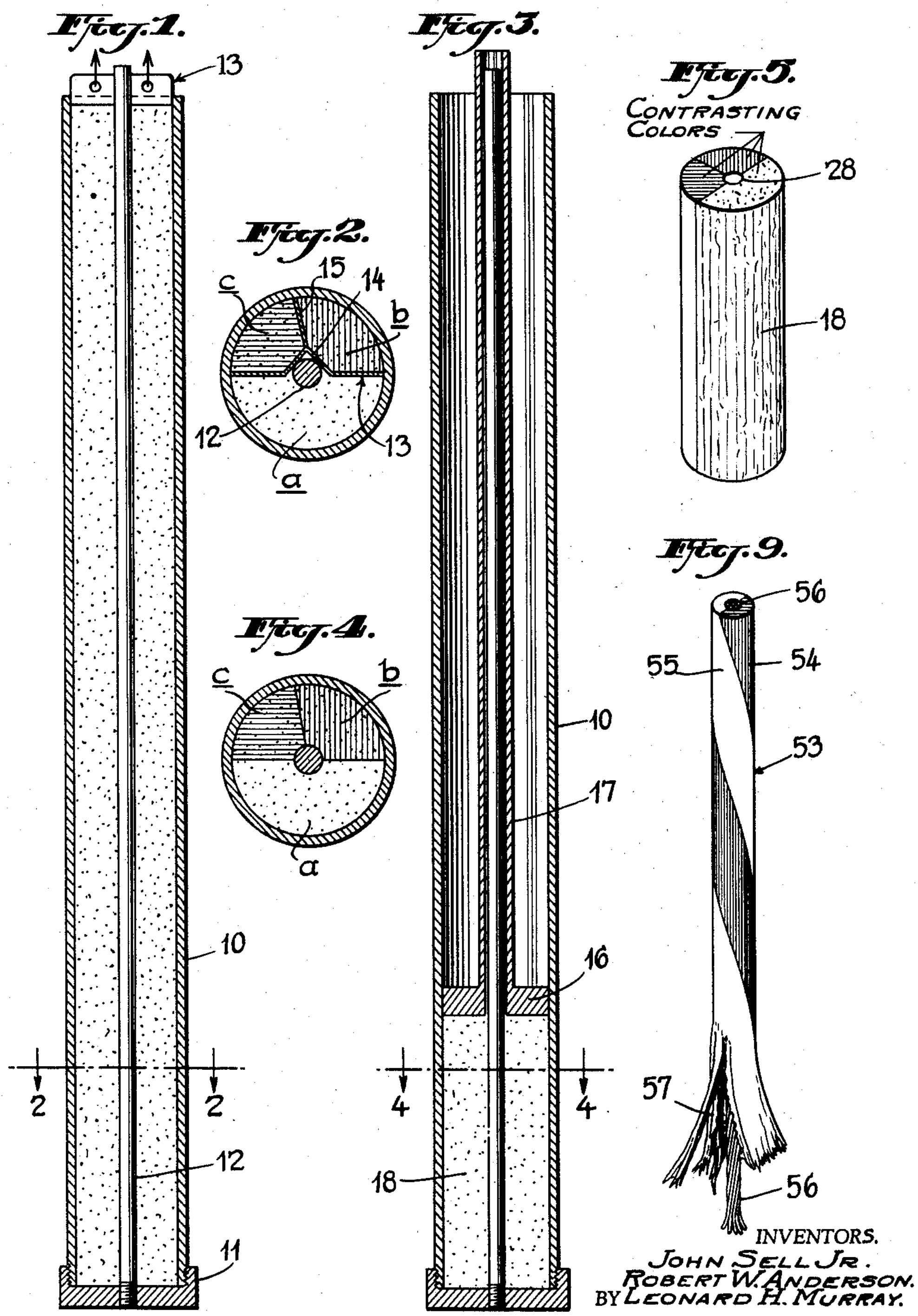
July 19, 1960 J. SELL, JR., ET AL 2,945,265

METHOD FOR MAKING INSULATED WIRE

Filed Feb. 25, 1957 3 Sheets-Sheet 1



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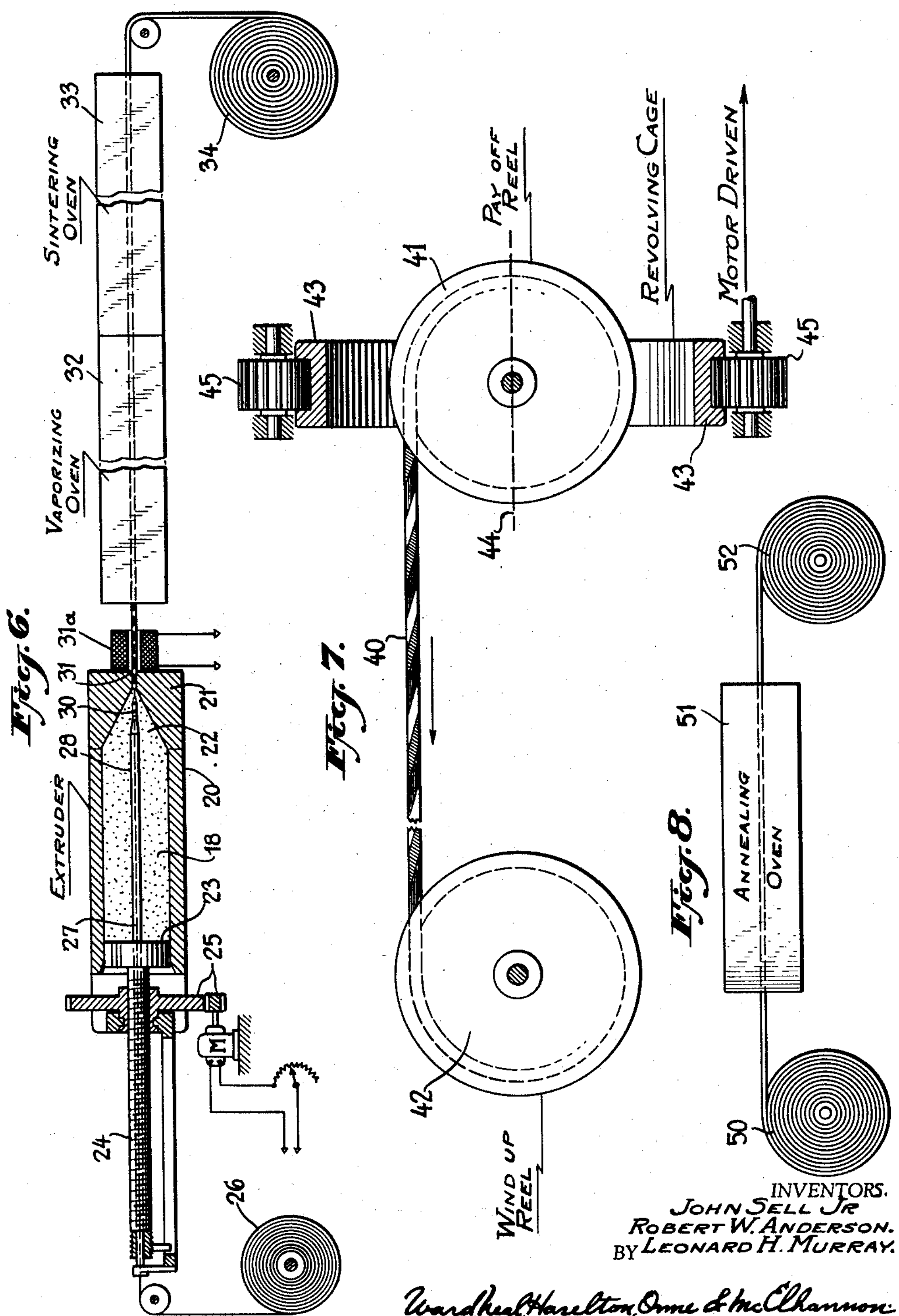

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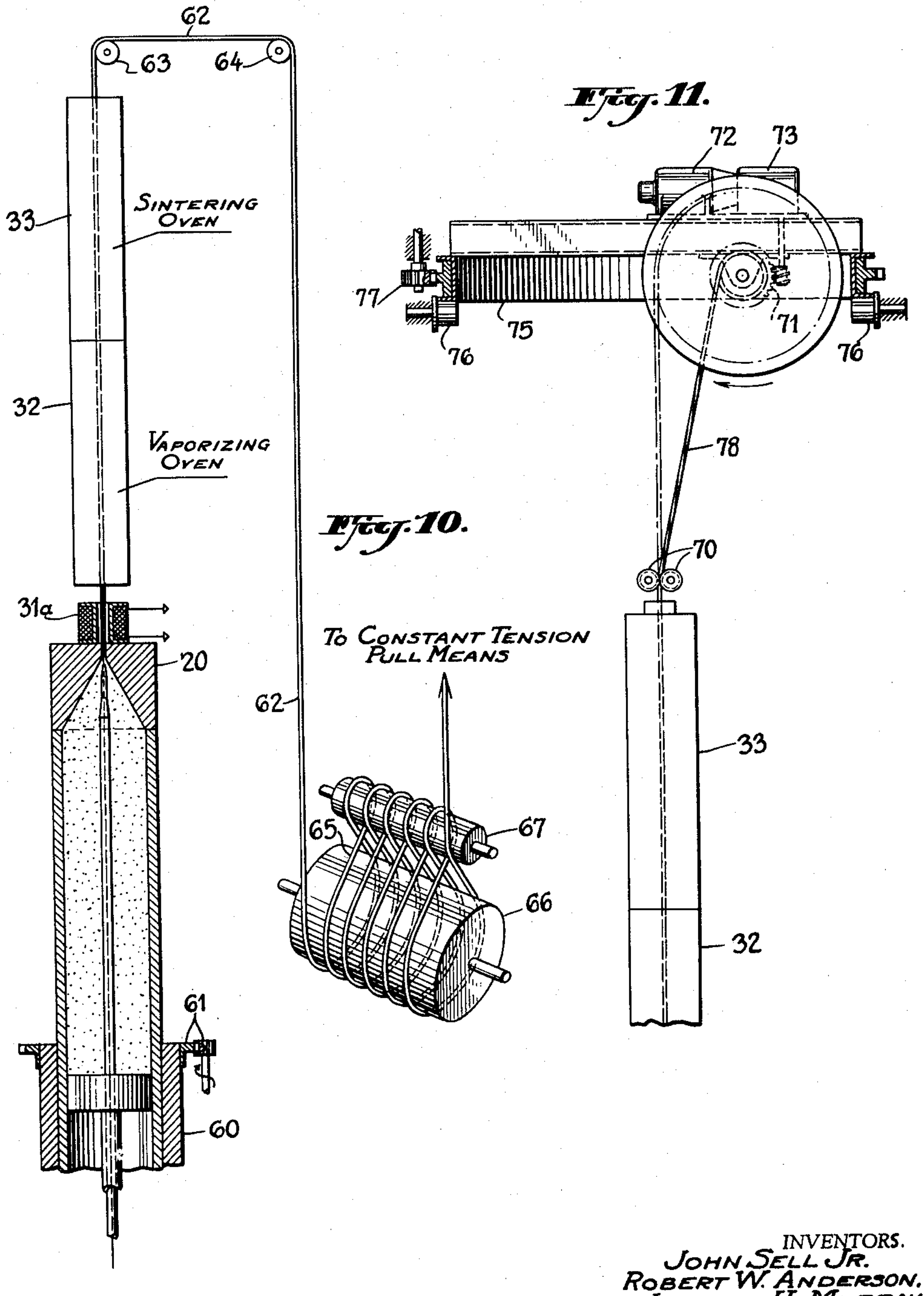

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METHOD FOR MAKING INSULATED WIRE

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Filed Feb. 25, 1957, Ser. No. 642,161

5 Claims. (Cl. 18—59)

This invention relates to vari-colored insulated wire, the insulation being formed of such materials as polytetrafluorethylene, known under the Du Pont trade name "Teflon." The invention as hereinafter claimed comprises novel methods for insulating wire with Teflon or the like as well as for making elongated annular bodies of Teflon as applied to, or as adapted to receive, a wire, among other possible uses. The novel products resulting from the methods hereinafter disclosed are disclosed and claimed in applicants' copending application Serial No. 606,824 filed Aug. 29, 1956 and entitled "Insulated Wire," the present application being a continuation-in-part of said prior application.

When insulated wires are used, as in groups for electrical circuit purposes, it is quite customary to provide insulation of various contrasting colors or patterns on the different wires, to enable ready identification of the various different circuit portions to facilitate compliance with assembly and maintenance instructions without mistaking one wire for another. While this color identification is a simple matter with many types of wire insulation, it has heretofore presented a serious problem in cases where polytetrafluorethylene is used, since colored coatings and the like cannot be made easily and permanently to adhere to such material. Furthermore, it is desirable when using such material as insulation on a wire, to form same into an integral continuous sheath for the wire, and thus separate vari-colored strands cannot be used. While such material may be colored by mixing same with various mineral pigments before it is extruded onto the wire so as to make a wire wholly insulated with material all of one color, yet the different color possiblities which may be achieved in this way are often insufficient in number to permit proper identification of the numerous different wires in complicated electrical circuitry. The problem thus arises of providing two or more permanent contrasting colors on each wire and in a manner whereby same may be easily observed regardless of the position of the wire.

A method heretofore well known for the application of polytetrafluorethylene to wire has involved first making a cylindrical "preform" of such material with a hole extending axially therethrough. That is, the material in powedered form, mixed with a lubricant such as naphtha, is compressed to make such preform. The preform is then placed in an extruding machine, and while the wire is being advanced through such hole, material of the preform is extruded thereon as a coating of annular cross-section. The coated wire is then passed through a vaporizing oven to vaporize and drive off the lubricant, and then through an oven for "sintering" the insulation coating. By mixing mineral pigments with the powdered material used in making the preform, the whole insulating coating on the wire may be made of a desired color by the same general process, yet the task of providing a distinctive identifiable pattern of contrasting colors, still presents serious problems.

If contrasting colors are used for the material of various succeeding layers as pressed together to make the preform, then after the preform has been extruded onto the wire, the color pattern thereon will either be unpredictable, or portions of one color will be so extended out along the wire that the contrasting colors will not appear on each short length of wire; that is, there will be long lengths all of one color, followed by long lengths all another color or colors and too long to permit easy identification of different small wire portions in complicated circuits. And if, for example, the preform is made with one longitudinal side portion of one color and the other of another color, then the resulting insulated wire in use may be so laid that over considerable lengths thereof, still only one color will be visible on its exposed side. To overcome this objection, the wire as insulated may be twisted so as to present a vari-colored helical pattern. Yet it has been found that if such an integral sintered Teflon coating on a wire is twisted, then when it is subjected to the prescribed temperature tests, as for example a temperature of about 250° C. for a period of 96 hours, the Teflon will tend to shrink longitudinally along the wire, sometimes leaving the end portions of the wire bare, or causing irregularities or curling of the wire along its length. It has been found, however, that in accordance with the present invention, this last objection may be overcome by subjecting the insulation coating to an annealing treatment following the twisting thereof, whereupon it may be subjected to the final temperature test at 250° C. for 96 hours without causing any appreciable shrinkage. In fact the coated wire may be repeatedly subjected to such temperature for prolonged intervals without causing shrinkage or buckling of the insulation. Such annealing step involves heating the coated wire substantially to the sintering temperature used. As an alternative method, instead of annealing the twisted insulated wire to prevent shrinkage of the insulation under higher temperatures, it is possible to so control the extrusion of the insulation on the wire as to avoid such shrinkage. That is, to this end, the polytetrafluoroethylene as it emerges from the extrusion die onto the wire, is maintained at a predetermined temperature while it is being caused to emerge from the die at a speed determinable by trial and which will usually be a trifle faster than the speed of travel of the wire, for example 0.1–0.2% faster. Also in some cases, the stability against shrinkage of the helically-formed, vari-colored insulation on the wire may be improved by either rotating the extrusion apparatus or by rotating the wind-up reel for the insulated wire, whereby in either case the insulated wire becomes twisted in the course of its travel from the extrusion die to the wind-up reel through the vaporizing and sintering stages, instead of being twisted later.

In these ways, according to the invention, polytetrafluorethylene and materials which act in a generally similar way may be used to form a novel insulated wire with an integral continuous coating which is vari-colored according to a predetermined helical pattern and which is substantially non-shrinking at the maximum temperatures under which such insulated wire is designed to be tested and used.

Further and more specific objects, features and advantages of the invention hereof will appear from the detailed description given below, taken in connection with the accompanying drawings which form a part of this specification.

In the drawings:

Fig. 1 is a vertical sectional view showing an elongated cylindrical container with longitudinal partition means therein and in which preforms such as above referred to are adapted to be made;

Fig. 2 is a horizontal cross-sectional view taken at line 2—2 of Fig. 1;

Fig. 3 is a vertical sectional view of the container of Fig. 1 after the partition means for separating the different colored materials has been removed and a plunger has been introduced for compressing the preform;

Fig. 4 is a cross-sectional view taken substantially along line 4—4 of Fig. 3;

Fig. 5 is a perspective view of one of the preforms of the insulation material after removal from the container of Fig. 3;

Fig. 6 is a somewhat schematic diagram showing one form of equipment for extruding Teflon from a preform onto a wire to form an integral sheath or coating thereon;

Fig. 7 is a view also somewhat schematic showing one form of arrangement which may be used for twisting the coated wire as made with the apparatus of Fig. 6 and so that if the coating has been formed with longitudinal portions of contrasting colors, the wire after twisting will present a vari-colored helical pattern;

Fig. 8 is a schematic diagram showing the manner in which the coated twisted wire from the apparatus of Fig. 7 may have its coating annealed;

Fig. 9 is a perspective view of a piece of the finished insulated wire;

Fig. 10 is a view similar to Fig. 1, but partly broken away and showing an alternative arrangement of apparatus for carrying out the invention; and

Fig. 11 is another similar view, but showing still a further embodiment of the apparatus.

It will be understood that the various pieces of equipment, as somewhat schematically shown in the drawings, represent merely examples of the types of devices which may be used in carrying out the invention and that same are shown merely by way of example.

Referring now more specifically to Fig. 1, an elongated cylindrical metal container **10** is provided, having a suitably removable bottom piece **11** and containing a metal rod **12** running from the bottom to the top. A partition member **13** is provided in the container, formed for example of sheet metal and shaped so as to separate the space in the container into longitudinally extended cavities extending throughout the height of the container. Two, three or more such cavities may be provided, depending upon how many colors are desired for the insulation on the finished wire. For example, if only the natural color of Teflon and one other color are desired, then this partition member may extend diametrically across the cylinder, except for a portion of angularly shaped cross-section as at **14**, which allows the rod **12** to be centrally positioned. On the other hand, if for example three colors are desired, then the partition member will be formed with an additional wing portion as at **15**, welded for example along the portion **14**, and thereby the arrangement will provide for three compartments as at *a*, *b* and *c* for containing insulation material of three different colors.

The powdered Teflon is first mixed in the usual way with a desired amount of lubricant such as naphtha, together with the desired amount of colored material in the form of powdered mineral pigment. There are various known powdered mineral pigments of different colors, suitable for mixing with powdered Teflon for coloring the final product. The following are typical examples:

Black—Carbon black.
Blue—Aluminum oxide and cobaltic oxide.
White—Titanium dioxide.

The pigment, lubricant and powdered Teflon may be uniformly mixed by tumbling the same together in a container. Thus such mixtures of three desired colors, for example, may then be poured into the cavities *a*, *b* and *c* of the device of Figs. 1 and 2.

Thereupon the partition member **13** may be removed by pulling same upwardly out of the container **10**. This will leave in the container a plurality of vertically extending bodies of the different colored mixtures, each body conforming to the shape and size of the cavity *a*, *b* or *c* into which same was poured, and as best indicated in Fig. 4.

Thereupon, as indicated in Fig. 3, a plunger **16**, operated by a hollow piston rod **17**, is forced down into the container **10** to compress the powdered bodies of colored mixtures into an integral solid preform **18**, the different side portions of which, as shown in Fig. 5, being of contrasting colors. That is, portions of sector-shaped cross-section are sharply defined and of the desired contrasting colors, but except for the color difference, the preform comprises one integral uniform solid piece.

The preforms as at **18** are then placed in a known form of extruder, for example such as shown in Fig. 6. Such extruder equipment may comprise a cylinder **20** for receiving the preform and having a suitably removable cap piece **21** formed with an internal conical cavity **22** into which one end of the preform is compressed as by a plunger **23**, the plunger being advanced in the cylinder as by a worm gear **24** and motor-driven gearing **25**. The bare wire to be coated is suitably unwound from a reel **26** and passes through the hollow central portion of the worm **24** and through a quill member **27** which extends through the longitudinal hole **28** which was formed by the rod **12** in the preform **18**. The wire proceeds from the hollow tip **30** of the quill, through an extruder orifice or die portion at **31**, and in so doing, the Teflon of the preform is extruded as an integral annular coating surrounding the wire as it emerges from the die. In order to insure maintenance of the insulation material at the region of the die portion **31** at a temperature insuring good extruding conditions, the insulated wire as it emerges from the die may be surrounded by a suitable electrical resistance heating coil as indicated at **31***a*, and thereby, through adjustment of the heating current by trial, the most desirable temperature conditions may be maintained. If a preform is formed with vari-colored sector portions as shown in Fig. 5, then the coating on the wire as it emerges from the die, will be in like manner formed with vari-colored portions of sector-shaped cross-section. Despite the great reduction in diameter of the body of Teflon as it is extruded from the preform into the form of a coating on the wire, it has been found that the distribution of the different colors angularly about the wire will remain the same as in the preform.

The insulated wire, after it emerges from the die, is conducted in known manner first through a vaporizing oven as at **32** for expelling the lubricant from the insulation at a temperature for example of about 450° F., and then through a sintering oven as at **33**, wherein the Teflon is sintered by subjecting it successively to temperatures for example of about 650°, then about 800° and finally about 650° F., in known manner. Finally the insulated wire may be wound onto a reel as at **34**.

It will be understood that if the insulated wire as thus formed has for example a cross-section one-half of which is one color and the other half another color, then in use, such wire might be so placed that when observed from one side, it will appear all to be of one color, or if more than two colors have been used, one or more of the colors may not appear when observing the wire from one side thereof.

Accordingly, in order to make certain that however the wire is placed in use, all of the colors will be noted when observing the wire from one side, the coated wire, in accordance with this invention, is twisted either at spaced intervals, or preferably continuously as by the use of apparatus such as schematically indicated in Fig. 7. Here the wire **40** is shown being unwounded from a reel **41** onto a reel **42**. One or the other of these reels, for example the reel **41**, is meanwhile rotated about in a plane perpendicular to the axis of the wire **40**, as shown. For example, the reel **41** may be journalled in a circular cage or frame **43** which is suitably journalled for rotation about an axis indicated by the dash line **44**. For example, the frame **43** may be formed with gear teeth on its periphery for engaging suitable motor-driven pinion gears or the like as indicated at **45**. In the case of a typical example of Teflon insulation wire having an over-all diameter for example of 1/16", same may be twisted to have about twelve helical convolutions per foot, which will be ample to assure that all of the pluralities of colors will be revealed at intervals sufficiently close to insure ready identification of the desired wire when same is being used or connected in a circuit.

Before such Teflon-insulated wire is shipped from the factory, it is customary to subject same to a temperature test. One more or less standardized test of that nature comprises subjecting the product to a temperature of about 250° C. for a period of 96 hours. When such insulated wire untwisted is subjected to such a test, a 12" length thereof should withstand the test without shrinkage of the insulation longitudinally by more than a small amount, such as 1/8" or less. However, it is found that after twisting such wire, if the insulation has been applied in the manner thus far described, usch a test may in some cases cause the insulation on a one-foot length, for example, to shrink by an objectionable amount, say from 3/8" to 3/4".

To overcome this difficulty, the insulated wire may, as indicated in Fig. 8, be unwound from a reel as at **50** and passed through an annealing oven **51** onto a wind-up reel **52**. In this annealing oven, the insulation is subjected preferably to a temperature of about 700–800° F., or as outer limits, about 650°–850° F., the duration of the annealing period extending from about one-half minute to about two minutes.

After such annealing, it has been found that insulation which otherwise would tend to shrink, will readily withstand the above-mentioned 250° C. test without any noticeable shrinking, and in fact the wire may be subjected to such a temperature for repeated and prolonged intervals without shrinkage.

The time and temperature factors above given have been found to be suitable and appropriate when practicing the method using Teflon of the grades now readily commercially available, but it will be understood that the invention in various of its aspects, when applied to the use of insulation materials of other grades or of other types, may be carried out, using other suitable temperature and time factors which may be properly determined by trial.

It will be understood that the terms "vari-colored" and "contrasting colors" as used herein may, if desired, comprehend a white or whitish appearance as one of the "colors." In a typical case, one-half of the cross-section of the insulation coating for example may be of a natural white or wax-like appearance of the polytetrafluorethylene, whereas the other half may be colored with a pigment which is red or some other distinctive color.

A portion of the finished insulated wire is shown at **53** (Fig. 9), this example being one of which one-half of the insulation comprises a distinctively colored portion **54** and the other half **55**, which is of natural color, both halves extending along the wire helically and being integrally formed as one uniform piece of insulation, except for the color in the portion **54**. Such insulation as applied in the manner above described, firmly grips the central conductor **56**. When the insulation is torn, which requires a powerful force, it will be noted that the content thereof has a fiber-like orientation, as indicated at **57**, extending in a direction helically about the wire. Such insulation has great strength in the direction of such orientation, and since the fiber-like content is in effect helically wrapped about the wire, this gives the coating great strength, not only longitudinally, but against any possibility of being split from the wire.

Preferably, as indicated in Fig. 9, the contrasting colored portion or portions should have a considerable segmental cross-section and extend either to the conductor or to a considerable depth from the surface of the insulation so that the color will still appear even after wear or abrasion, although if the insulation coating is quite thick or on an insulated wire of which the over-all diameter is quite substantial, then it may not be important to have the colored portion extend entirely through the insulation. But for small wires, the colored portions may preferably and usually be of a "substantially sector-shaped" cross-section. The "sector" may extend over an arc of either more or less than 100°. The partition means **13** as used in the container **10** may, of course, assume various shapes, depending upon the preferred segmental or sector-shaped cross-section of the desired colored portions. The term "segmental" as used herein is intended to comprehend sector-shaped portions as well as other segmental portions.

While the annealing step as above described in connection with Fig. 8, has been found satisfactory for insuring against shrinkage of the insulation at higher temperatures, even in cases where the extrustion of the insulation may have been such as to leave serious tensions therein, yet in many cases, at least for insulated wire of relatively small diameter, it has been found that this annealing step may be dispensed with by properly regulating the extruding conditions in such manner as to avoid and tendency for the insulation or portions thereof to be applied to the wire under longitudinal tension. This may be accomplished by regulating the speed of the wire as it advances through the extruding die in relation to the speed of the annular mass of insulation material emanating from the die orifice onto the wire and at the same time by controlling the temperature through the use of the heating coil **31***a*. The speed of the wire may, of course, be varied or regulated by adjusting the speed of the drive means (not shown) for the wind-up coil **34**. And the longitudinal speed of emanation of the insulation from the die may be adjusted or varied by varying the speed of the motor M for the drive gears **25** which act to advance the plunger **23**. This may for example be accomplished by the use of a rheostat for the motor M as indicated. In typical cases, it has been found that satisfactory results are obtainable if the insulation is caused to emanate from the die at a speed about 0.1% up to about 0.2% faster than the speed of the wire, the wire speed in a typical case being about 20 feet per minute. Under these conditions, satisfactory results will be obtained by maintaining a temperature within the heating coil **31***a* of about 100° F. With the insulation extruded under these conditions, it has been found possible safely to dispense with the subsequent annealing step and still provide an insulation coating which will withstand the above-described temperature tests without shrinkage.

As above indicated, it is also possible to dispense with the performance of the twisting operation as a separate step, viz. the operations above described in connection with Fig. 7. This may be done by either rotating the whole extruding equipment with respect to the wind-up coil, or by rotating the wind-up coil with respect to the extruding equipment. The former possibility is illustrated somewhat schematically in Fig. 10, whereas the apparatus for carrying out the latter alternative is illustrated in Fig. 11. As indicated in Fig. 10, the entire extruder may be mounted upon suitable frame means as at **60**, which frame means is adapted to be rotated about the axis of the extruder orifice as by a suitable motor-driven gearing **61**. Thus the insulated wire during its passage from the die orifice through the vaporizing oven **32** and sintering oven **33**, may be twisted at a rate sufficient so that the color bands will become helical, the speed of rotation of the extruder being varied or adjusted to provide a helical pattern of the desired pitch.

In properly carrying out the process so that the speed of travel of the wire will be regulated at the desired constant rate, means for pulling the wire to advance it should preferably be provided in a form which will insure against slippage of the pulling means with respect to the insulation. In the case of polytetrafluorethylene insulation, this presents somewhat of a problem due to the exceedingly slippery nature of such material. One arrangement for overcoming this problem is indicated in Fig. 10, wherein the insulated wire **62**, after passing over suitable pulleys as at **63**, **64**, is wound in "figure 8" loops as at **65**, over suitably driven rollers as at **66**, **67**, the wire then being pulled by some suitable known form of constant tension pull means as indicated. This arrangement as shown in Fig. 10 may, of course, also be used with the equipment as shown in Fig. 6.

With the alternative arrangement shown in Fig. 11, the extruder is stationary and the insulated wire passes up through the sintering oven **33** straight and untwisted and thence may pass between a pair of suitable grooved guide rollers as at **70** to a wind-up reel means **71**, the latter being driven as by a motor **72**, connected through suitable known clutch and gear means indicated generally at **73** of a type adapted to so control the winding as to pull the wire up at the desired constant speed. As further shown in Fig. 11, the whole wind-up arrangement may be mounted upon a frame as at **75**, rotatably supported as on rollers **76**, the frame being adapted to be constantly rotated by suitable motor-driven gear means, as indicated at **77**. Thus the entire wind-up mechanism may be rotated at a suitable speed to cause twisting of the wire at **78** after it leaves the sintering oven and before it is wound up. The frame **75** may be rotated at varying speeds depending upon the desired pitch of the helical color bands on the wire.

The arrangement shown in Fig. 10, which provides for the twisting of the insulated wire during its passage through the ovens, may be preferable to the arrangement of Fig. 11 in cases where the insulation material is of a kind and quality such that it will not become injured by reason of twisting during heating, but such that the twisting during heating may tend to more effectively "set" the twist. However, in cases where it is desired to avoid the twisting during the heating of the insulation in the ovens, the arrangement of Fig. 11 may be preferred. This arrangement has advantages over that of Fig. 7 in that it avoids the inconvenience of a separate operation.

Although certain particular embodiments of the invention are herein disclosed for purposes of explanation, various further modifications thereof, after study of this specification, will be apparent to those skilled in the art to which the invention pertains. Reference should accordingly be had to the appended claims in determining the scope of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. Method for applying to wire insulating coatings of polytetrafluoroethylene material and the like which is integral and vari-colored according to a helical pattern and which is substantially non-shrinking at temperatures up to about 250° C., which method comprises: preforming a solid integral body of such material with a central opening therethrough by compressing masses of such material which are of contrasting colors and are initially in finely divided form, and are located to extend in contact with each other longitudinally along said opening and respectively at different angular positions about said integral opening; advancing an integral wire to be insulated through said opening while progressively extruding material from said body onto the wire to form the insulating coating thereon with portions of the contrasting colors extending longitudinally of the wire; sintering the thus-applied coating; then twisted the wire whereby the contrasting colored portions of the insulation thereon assume a helical shape, and in which the insulating material is extruded at a rate to apply a coating on the wire which at the region of extrusion advances at a speed slightly greater than the speed of advance of the wire.

2. Method for applying to wire, vari-colored coatings of polytetrafluorethylene, comprising separately preparing at least two quantities of such material in substantially powdered form, at least one of said quantities being mixed with a distinguishing coloring substance, depositing said quantities in powdered form as masses thereof in a containing means and initially with a separating means therebetween, and with a centrally extending member therein, causing relative movement of the deposited masses and such separating means whereby such masses come together and in positions surrounding said member, applying pressure to compact the masses, thereby forming an integral compact body thereof of generally annular cross-section with segmental portions of contrasting colors, progressively extruding the material of such compact annular body axially through a restricted orifice while advancing therein the wire to be coated, the extruded material being caused to emanate from the orifice at a speed faster than the speed of the wire, but no more than about 0.2% faster, sintering the extruded material and twisting the wire as coated thereby, thereby forming an integral coating on the wire having helical portions of its cross-section of contrasting colors and such coating being substantially non-shrinking at temperatures up to about 250° C.

3. Method for applying to wire vari-colored insulating coating of polytetrafluorethylene material and the like which comprises: preforming an integral body of such material with a central opening therethrough by compressing masses of such material which are of contrasting colors and are initially in finely divided form, and are located in contact with each other respectively at different angular positions about said opening; advancing the wire to be insulated through said opening while progressively extruding material from said integral body onto the wire to form an integral insulating coating thereon with body portions of the contrasting colors which extend along on the wire; sintering said coating and also twisting such insulating coating relative to the axis of the wire whereby the contrasting colored portions of the insulation assume a helical formation, and in which the wire is advanced at a predetermined speed and the insulating material is extruded at a rate to apply a coating on the wire which at the points of extrusion advances at a speed slighly greater than the speed of advance of the wire.

4. Method for applying to wire vari-colored insulating coating of polytetrafluorethylene material and the like which comprises: preforming an integral body of such material with a central opening therethrough by compressing masses of such material which are of contrasting colors and are initially in finely divided form and are located in contact with each other respectively at different angular positions about said opening; advancing the wire to be insulated through said opening while progressively extruding material from said integral body onto the wire to form an integral insulating coating thereon with body portions of the contrasting colors which extend along on the wire; sintering said coating; also twisting such insulating coating relative to the axis of the wire whereby the contrasting colored portions of the insulation assume a helical formation; said wire being advanced at a predetermined speed and the insulating material being extruded at a rate to apply a coating on the wire which at the points of extrusion advances at a speed slightly greater than the speed of advance of the wire and not more than about 0.2% faster than the speed of the wire.

5. Method for applying to wire vari-colored insulating coating of polytetrafluorethylene material and the like which comprises: preforming an integral body of such material with a central opening therethrough by compressing masses of such material which are of contrasting colors and are initially in finely divided form and are located in contact with each other respectively at different angular positions about said opening; advancing the wire

to be insulated through said opening while progressively extruding material from said integral body onto the wire to form an integral insulating coating thereon with body portions of contrasting colors which extend along on the wire; sintering said coating; also twisting such insulating coating relative to the axis of the wire whereby the contrasting colored portions of the insulation assume a helical formation; said wire being advanced at a predetermined speed and the insulating material being extruded at a rate to apply a coating on the wire which at the points of extrusion advances at a speed which is from about 0.1% to about 0.2% faster than the speed of advance of the wire.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,945,265 July 19, 1960

John Sell, Jr., et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 27, for "and" read -- any --; column 7, line 65, for "integral opening; advancing an integral wire" read -- opening; advancing the wire --; line 67, after "said" insert -- integral --; same line 67, for "the", second occurrence, read -- an integral --; same column 7, line 70, for "twisted" read -- twisting --.

Signed and sealed this 20th day of December 1960.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON

Commissioner of Patents

UNITED STATES PATENT OFFICE

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