

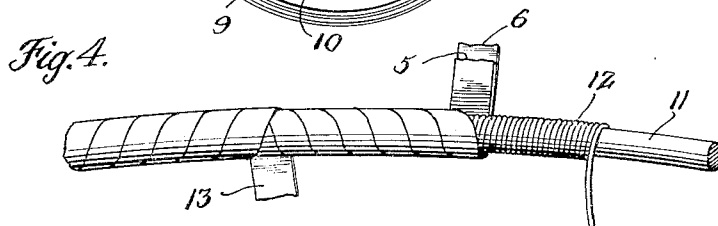
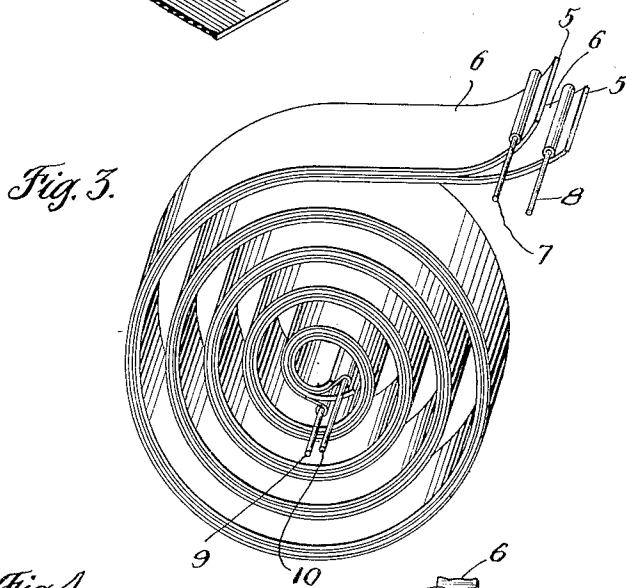
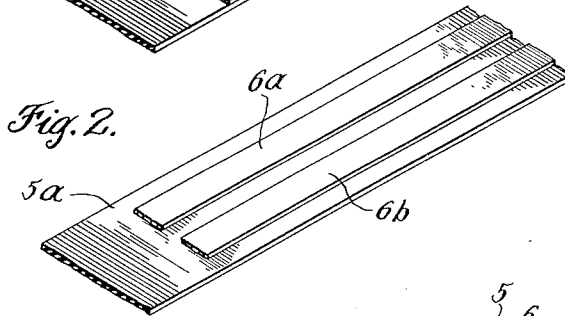
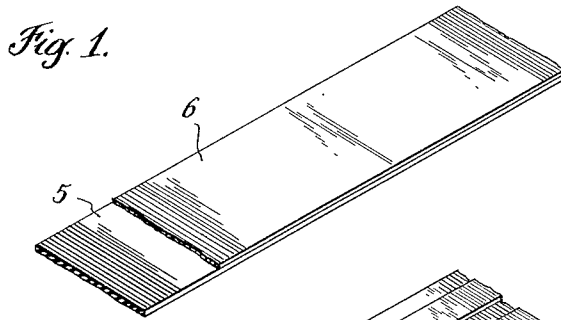
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W. J. DAVIS

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LAMINATED STRIP PRODUCT FOR ELECTRICAL PURPOSES

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INVENTOR
William J. Davis
BY
Spencer Street & Co.
ATTORNEYS

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2,998,840 LAMINATED STRIP PRODUCT FOR ELECTRICAL PURPOSES

William J. Davis, West Reading, Pa., assignor to The Polymer Corporation, Reading, Pa., a corporation of Pennsylvania

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This invention relates to a composite or laminated strip or tape-like product for use in electrical devices and equipment. The invention is especially concerned with a composite strip or tape structure as a stock product which is adapted for a variety of uses in the electrical and electronic arts, as will further appear.

One of the principal objects of the present invention is the provision of a composite strip stock product having both electrical and magnetic properties or characteristics.

A further object of the invention is the provision of a stock product of the kind above mentioned and further having specially advantageous physical characteristics including a high degree of flexibility, the product, in fact, having a striking limpness which makes it very easy to wind upon other elements or upon itself. Moreover, the product may even be sharply bent or creased without impairing either the electrical or magnetic properties thereof.

Other objects of the invention and other advantageous characteristics of the product can be explained more readily after more detailed consideration of the structure of the product, for which purpose reference is made to the accompanying drawing, in which—

FIGURE 1 is a perspective view of a portion of strip stock made up according to the present invention;

FIGURE 2 is a view similar to FIGURE 1 but illustrating a modification;

FIGURE 3 is a somewhat diagrammatic illustration of one type of electrical device made up by use of the product of the present invention; and

FIGURE 4 is a view of another device for which the product of the invention is well adapted.

Before describing the features illustrated in the drawing, it is here first pointed out that the present invention contemplates employment of finely divided ferromagnetic material as a magnetic constituent of the product. Use of finely divided ferromagnetic materials for various magnetic purposes, especially where high frequency currents are involved, is already known. In accordance with the present invention, however, such material is employed in a new way and in a special relationship to other components of the composite structure.

As seen in FIGURE 1, a strip stock product is made up of two strip or tape-like elements shown at 5 and 6. Element 5 comprises polytetrafluoroethylene having finely divided particles of ferromagnetic material dispersed therein. Preferably, according to the invention, the ferromagnetic materials have both magnetic and electrically conductive properties or characteristics, for instance, carbonyl iron. Moreover, for some special uses a strip product constructed according to the invention may be made up with tape 5 containing dispersed particles of electrically conductive substantially nonmagnetic material.

For most purposes it is advantageous to employ relatively high percentages of the ferromagnetic material, preferably upward of 50% by volume of the total material of which the strip 5 is formed. Especially desirable characteristics are obtained for many purposes where the strip 5 comprises upwards of about 85% ferromagnetic material, the balance being polytetrafluoro-

ethylene. A method for preparing an intimate intermixture of ferromagnetic material and polytetrafluoroethylene in percentages running up even to about 98% or 99% by volume of the ferromagnetic material is disclosed in my copending application Serial No. 495,456, filed March 21, 1955. The details of that method need not be considered herein, although it is here mentioned that the intimate admixture of the ferromagnetic material and the polytetrafluoroethylene in fine particle form obtainable according to the method of the application above identified may be formed under pressure into various shape-retaining structures. For example it may be extruded under pressure in the form of a rod. It may also be calendered to form thin strips, such as that illustrated at 5 in FIGURE 1. In an alternative procedure for producing a tape or strip, a rod may first be extruded, and then the rod rolled to flat shape.

Strip stock according to the invention may be made up either of sintered or unsintered tape.

Filled polytetrafluoroethylene strip or tape prepared as above mentioned has considerable strength even in the green state, but the strength is extensively increased by sintering the strip, for instance by heating, preferably in an inert atmosphere at a temperature of from about 627° F. to about 800° F.

The other component of the composite structure as shown in FIGURE 1, i.e., the strip 6 comprises an electrically conductive element bonded to one side of the strip 5. The element 6 is advantageously of thin or foil-type metal and is desirably highly flexible, so that the laminated structure retains a high degree of flexibility. The conductive element 6 may for example comprise a separately formed aluminum or other metal foil adhesively bonded to one face of the strip 5. As an alternative, a conductive type of aluminum paint or coating composition may be applied to one face of the strip 5 in order to provide a thin conductive element bonded to the strip 5. Still another effective technique in providing the conductive element bonded to the strip 5 is the use of vacuum metalizing methods of well-known types. It will be appreciated that in the illustration of FIGURE 1, although the width of the strip stock there shown is suitable in preparing a strip stock product according to the invention, ordinarily the conductive element 6 would be much thinner than shown, the thickness being exaggerated purely for the sake of illustration. Similarly, for most purposes the strip 5 would be thinner than appears in FIGURE 1, although in some cases relatively thick tape or strip may be used.

The strip stock of FIGURE 1 may be produced in any length desired, or continuously, and pieces may thereafter be cut from a stock roll in order to fill desired specific needs in fabricating electrical devices or other equipment therefrom.

When the filled polytetrafluoroethylene strip is to be sintered, it is preferred that the conductive element or elements be applied or bonded to the polytetrafluoroethylene strip subsequent to the sintering operation, which operation requires relatively high temperatures, as already mentioned, which in many cases would adversely influence the bonding of the conductive strip.

In a composite structure such as shown in FIGURE 1, the strip 5 contributes magnetic properties by virtue of the ferromagnetic particles dispersed therein. In addition, strip 5 further contributes dielectric properties, by virtue of the presence of the polytetrafluoroethylene, and this strip constitutes a nonconductive element which, in use, for instance when the composite strip is wound upon itself, acts to insulate one turn from another. When employing electrically conductive ferromagnetic material as the filler in the strip 5, as is preferred, it is also preferred to insulatively coat the individual particles of the filler

prior to incorporation thereof in the strip. This may be accomplished by applying a phosphate coating, as is mentioned in my copending application above identified. The use of conductive particles with insulating coatings further enhances the dielectric properties of strip 5.

Although the conductive strip 6 may be of width different from that of strip 5, either narrower or wider, the embodiment as illustrated in FIGURE 1 wherein the strips 5 and 6 are of the same width is preferred for some purposes. However it is preferred for most purposes that the conductive strip should be at least slightly narrower than the strip 5.

In FIGURE 2 there is illustrated a modification in which a strip 5a is identical with strip 5 described above in connection with FIGURE 1. In FIGURE 2, however, instead of a single conductive strip, two conductive strips 6a and 6b are bonded to strip 5a. Strips 6a and 6b extend throughout the length of strip 5a but are transversely spaced from each other. More than two conductive strips could also be used for specific purposes. An example of a special use for the embodiment of FIGURE 2 is mentioned hereinafter.

In FIGURE 3 there is illustrated a device made up of strip stock of the type shown in FIGURE 1. Here two pieces of the composite strip material are superimposed upon one another and the assembly is then spirally wound end-wise thereof. Electrical connections 7 and 8 are associated with the outer ends of the conductive elements 6 of the two strips, and connections 9 and 10 are associated with the inner ends of the two conductive strips. With a device formed in this way, and with appropriate coupling of the connections 7, 8, 9 and 10, both capacitance and inductance may be introduced into a circuit. The high degree of flexibility of the strip stock of the invention is an important characteristic in enabling the production of a unit such as shown in FIGURE 3. In this connection, a device of the kind illustrated in FIGURE 3 would for most purposes desirably be wound much more tightly than indicated in the figure. Indeed, the device may readily be wound or wrapped so that all of the turns directly contact each other, the showing of spacing between the turns in FIGURE 3 being merely for convenience and clarity of illustration. With a device made up in this manner, the capacitance of the unit and also the inductance of the unit are increased at least several times as compared with a similar unit made up of conductive strips and interleaved dielectric layers in which the latter do not incorporate the ferromagnetic material.

A strip stock product of the kind shown in FIGURE 2 may be used in forming a device similar to that shown in FIGURE 3. In this case two adjacent ends of each of the pairs of conductive strips 6a and 6b may be interconnected, the electrical connections being made at the opposite ends, in this way providing for doubling the conductor path through the unit. Also, the strips 6a and 6b may be maintained in electrically separated circuits or interconnected in various other ways for the accomplishment of different electrical or electro-magnetic effects.

Another illustrative use of the strip stock product of the present invention is shown in FIGURE 4. This shows a delay line incorporating a central dielectric core 11 with a spirally wound conductor 12 thereon. This is covered by strip stock of the kind shown in FIGURE 1 spirally wound about the spiral conductor 12, with the ferromagnetic strip 5 of the composite tape adjacent to the conductor 12. When wound in this way the conductive ele-

ment 6 of the composite tape forms a shield or second conductor which is both inductively and capacitatively coupled with the conductor 12. By simple winding of the composite tape in spiral fashion about the conductor 12, the turns of the conductor 6 while effectively shielding the entire cable structure, are at the same time insulated from each other, so that the conductor 6 has an extended spiral path around the cable. The entire assembly may be covered with a simple type of electrical insulating tape such as indicated at 13, or other similar flexible covering which affords mechanical protection.

When a delay line of this type or a similar structure is made up of a core of flexible material, for instance of polytetrafluoroethylene, with or without ferromagnetic particles dispersed therein, the structure is characterized by a high degree of flexibility, so that it may readily be coiled or even bent upon itself without adversely influencing either electrical or magnetic properties.

It is to be understood that the foregoing description and the accompanying drawings are illustrative of the invention and are not to be taken as limiting the scope of the appended claims.

I claim:

1. As a strip stock product, a laminated structure comprising an electrically conductive flexible metallic foil-type strip extended lengthwise of and bonded to one side of a flexible non-conductive tape composed of polytetrafluoroethylene having finely divided particles of magnetic material dispersed therein.

2. As a strip stock product, a laminated structure comprising an electrically conductive flexible metallic foil-type strip extended lengthwise of and bonded to one side of a flexible non-conductive tape composed of polytetrafluoroethylene having finely divided particles of an electrically conductive ferromagnetic material dispersed therein.

3. As a strip stock product, a laminated structure comprising a flexible non-conductive tape composed of polytetrafluoroethylene having finely divided particles of magnetic material dispersed therein, and a plurality of electrically conductive flexible metallic foil-type strips bonded to one side of said tape in spaced parallel relation running lengthwise of said tape.

4. As a strip stock product, a laminated structure comprising an electrically conductive flexible metallic foil-type strip extended lengthwise of and bonded to one side of a flexible non-conductive tape composed of sintered polytetrafluoroethylene having finely divided particles of magnetic material dispersed therein.

5. A method for making a strip stock product for use in electrical equipment, which method comprises pressure compacting in the form of a tape intermixed particles of polytetrafluoroethylene and a finely divided filler comprising a magnetic material, sintering the tape, and thereafter bonding to one side of the tape an electrically conductive flexible metallic foil-type strip in position to extend lengthwise of the tape.

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