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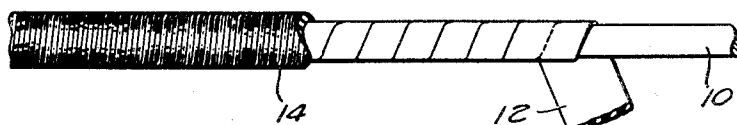
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2,459,653

INSULATED CONDUCTOR

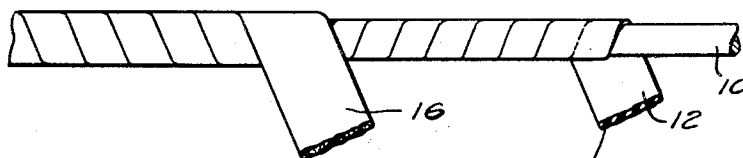
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Fig. 1.



Polymerized Tetrafluoroethylene

Fig. 2.



Polymerized Tetrafluoroethylene

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INSULATED CONDUCTOR

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2 Claims. (Cl. 174—120)

1

This invention relates to insulated conductors and more particularly to conductors carrying insulation capable of withstanding elevated temperatures and heavy loads.

It has been proposed heretofore to employ various organic compositions as an insulating covering or coating for electrical conductors. Many organic compositions have served satisfactorily in these applications at moderate temperatures. However, the great proportion of organic compositions employed for this purpose are characterized by a short life at temperatures of about 150° C. and higher. The standards of the electrical societies do not recommend the use of conductors carrying organic insulation at temperatures of above 105° C. continuously. At elevated temperatures the rate of deterioration of organic resins becomes more rapid and the life of the insulation is reduced approximately logarithmically.

It has been discovered that unexpected insulating benefits may be attained by the use of polymerized tetrafluoroethylene which is an exceptional organic material. It will withstand extremely high temperatures without deterioration. In fact, polymerized tetrafluoroethylene may be heated to a red heat without any significant decomposition or other breakdown. No brittleness or other adverse effects are observed at sub-zero.

Polymerized tetrafluoroethylene unfortunately is characterized by an exaggerated degree of cold flow even under moderate pressures. No successful insulation has been prepared from the polymer alone where the insulation was subjected to pressures.

The object of this invention is to provide a conductor insulated with an organic resinous coating capable of withstanding extreme temperatures and heavy loads.

A further object of the invention is to provide for insulating a conductor with a layer of a solid polymerized tetrafluoroethylene in combination with a layer of inorganic fibrous material to provide for mechanical strength.

Other objects of the invention will in part appear hereinafter and will in part be obvious. For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description and drawing, in which:

Figure 1 is a schematic view in elevation of a conductor, and

Fig. 2 is a schematic view in elevation of a modified form of the invention.

Solid tetrafluoroethylene polymers may be pre-

2

pared by compressing tetrafluoroethylene gas at high pressures in the presence of various catalysts, such, for example, as silver nitrate. The polymers so produced are generally in the form of a powder which is insoluble in practically all known solvents. To prepare solid members therefrom, according to an accepted method, the powder is compressed under high pressure into predetermined shape and the compacts so prepared are then sintered in a furnace at a temperature sufficient to cause the polymer to form a solid body. The solidified bodies have a waxy appearance and feel unctuous when rubbed with the fingers. The solid bodies produced by the sintering operation may be readily machined to any predetermined shape with ordinary wood or steel working tools. For example, the polymers may be drilled, cut with a saw, milled, sanded, and otherwise formed into any shape and desired surface condition.

The solid polymerized tetrafluoroethylene cannot be applied satisfactorily from solution to conductors due to its relative insolubility in practically all known solvents. However, it is possible to prepare a sintered body, such as a cylinder of the polymer, which can be cut or shaved into a continuous strip, tape or sheet. The tape so produced may be readily wrapped about a conductor thereby providing an insulating covering. However, the solid tetrafluoroethylene polymer is incapable of withstanding any heavy pressures or loads. The cold flow of the polymer is high even at moderate loads. Either the tetrafluoroethylene is cut rapidly when two wires are crossed under pressure, which may occur when a coil is being wound, or under a continuous application of moderate pressures, such as may occur in service, metallic conductors will press through the polymer by causing it to flow and thereby a short-circuit may occur. Coils prepared from wire wrapped with the polymerized tetrafluoroethylene alone were found to be grounded in a few hours after being put into slots of motors.

According to this invention, highly satisfactory insulation suitable for use at high voltages and at extreme elevated temperatures under heavy loads has been prepared from polytetrafluoroethylene. Referring to Fig. 1 of the drawing, the electrical conductor 10 is wrapped initially with a layer 12 of the tape composed of polymerized tetrafluoroethylene. The conductor 10 may be prepared from solid or stranded conducting material. Copper wire, silver wire, carbon and graphite bars, nickel, iron and other metallic strips may constitute the conductor. As shown, the

3

tape is applied half-lapped. A layer 14 of an inorganic fibrous material, for example, glass fibers or asbestos fibers, is applied tightly about the tape 12. The fibers 14 may be continuous filament or staple fiber glass or glass sliver in which the average diameter of the fibers is less than 0.002 inch. For best results, particularly in wrapping fine wire, the glass fibers should have a diameter of about 0.00025 inch and less. The wrapping of inorganic fibers compacts and confines the tape 12 of polymerized ethylene fluoride and thereby prevents the resin from flowing unduly under load. Furthermore, the fibers enable a better distribution of pressures and thereby enable the conductor to more satisfactorily withstand conditions of service.

A copper wire having a diameter of 0.064 inch was first wrapped with half-lapped polytetrafluoroethylene tape $\frac{1}{8}$ inch wide and 0.003 inch thick and thereafter wrapped with glass fibers. The total thickness of the insulation was approximately fifty mills. The conductor withstood 7000 volts before puncturing.

For certain applications the layer 14 of inorganic fibrous material may be treated with a silicone resin in order to improve the dielectric strength, to impart better mechanical strength, and to prevent the fibrous covering 14 from gaping or opening when bent. Suitable silicone resins are the phenyl ethyl silicones, methyl silicones, phenyl methyl silicones and the like. The conductor shown in Fig. 1, after being covered with the fibrous inorganic layer 14, may be treated by applying thereto a solution of a partially polymerized silicone and subjecting it to a heat treatment first to remove the solvent and then to advance the polymerization of the silicone to a solid resinous state.

Referring to Fig. 2 of the drawing, there is shown a modified form of the invention in which the conductor 10 wrapped with the tape 12 of polymerized tetrafluoroethylene is then wrapped with a tape 16 of glass or asbestos fibers. The fibrous tape 16 may be half-lapped as illustrated or partly overlapped or it may be butted. It will be noted in both Figs. 1 and 2 that the fibrous material is lapped in a direction opposite to the tape 12. This enables the conductor to hold up better on being bent. The tape covering, as shown in Fig. 2, may be treated with the silicone resins, as above mentioned, in order to improve its properties.

The conductors shown in Figs. 1 and 2 are particularly desirable for switchboard wiring, rheostat wiring, as well as wiring for electric ranges, ovens, irons, and similar heating devices. Wiring to electrically heated drying devices such as enamelling ovens and the like may be prepared from the insulated conductors. Coils prepared from the insulated conductors may be applied to motors and generators as well as to transformers and reactors. By reason of their extraordi-

4

nary thermal resistance, the insulated conductors may be subjected to temperatures of over 200° C. continuously. It is believed that the conductors shown may be subjected for long periods of time to temperatures of 400 and 500° C. without any substantial deterioration.

In preparing the conductors in Figs. 1 and 2, the tape 12 of polymerized tetrafluoroethylene may be polished or burnished by means of rollers or dies in order to produce a smooth compact covering. Two or more layers of the polymer in tape form may be applied.

In some applications, the conductor 10 may be covered with only the tape of polymerized tetrafluoroethylene provided the mechanical loads are low and exposure to wear and tear is negligible. For example, a conductor with the polymerized tetrafluoroethylene tape alone may be used for simple lead wires and for wiring or connections, for instance on switchboards, where it does not come into a pressure or wear contact with other members. A conductor with a half-lapped tape providing a wall thickness of 0.009 inch of the tetrafluoroethylene alone has a breakdown value of 6200 volts between two adjacent wires. Its use as switchboard wiring is accordingly suggested.

Since certain changes may be made in the above description, and different embodiments can be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. An insulated conductor comprising, in combination, a conductor, polymerized tetrafluoroethylene applied to the conductor, an exterior layer of an inorganic fibrous material applied about the polymerized tetrafluoroethylene, and a silicone resin applied to the fibrous material to impregnate and bond the whole.

2. An insulated conductor comprising, in combination, a metallic conductor, a tape composed of a polymerized tetrafluoroethylene wrapped about the metallic conductor, a wrapping of glass fibers of an average diameter of less than 0.002 inch applied about the tape, and a silicone resin applied to the wrapping of glass fibers.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,234,560	Keyes	Mar. 11, 1941
2,243,560	Hall et al.	May 27, 1941
2,258,218	Rochow	Oct. 7, 1941
2,392,388	Joyce	Jan. 8, 1946
2,397,568	Seaman	Apr. 2, 1946