

March 28, 1944.

B. J. BARMACK

2,345,229

INSULATION FOR ELECTRICAL CONDUCTORS

Filed June 3, 1941

2 Sheets-Sheet 1

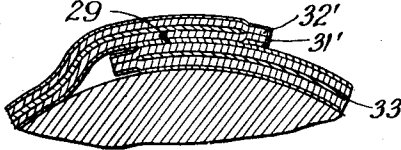
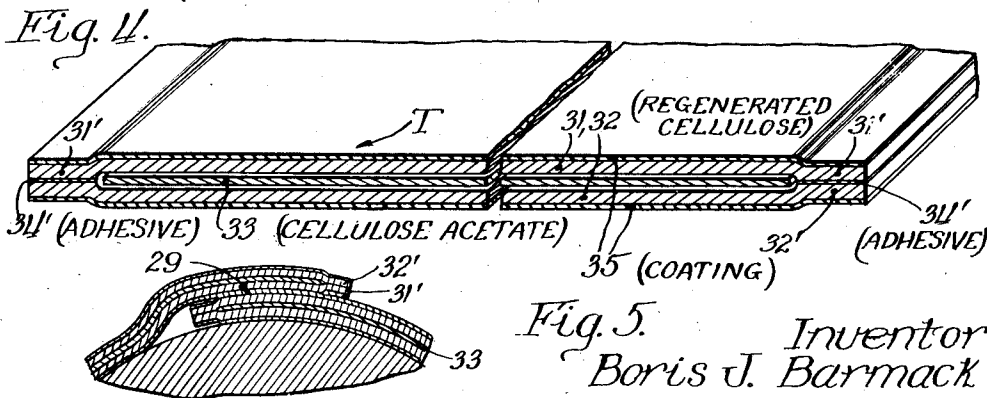
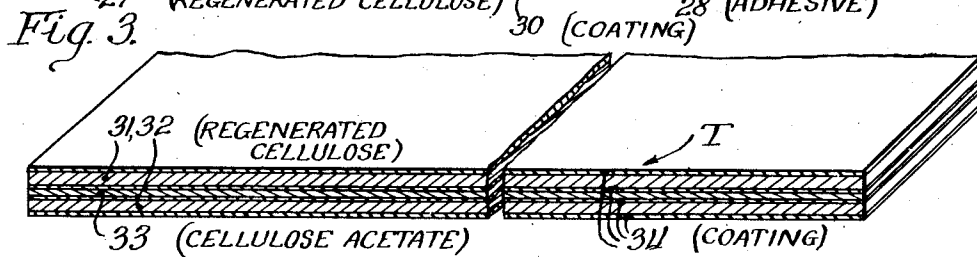
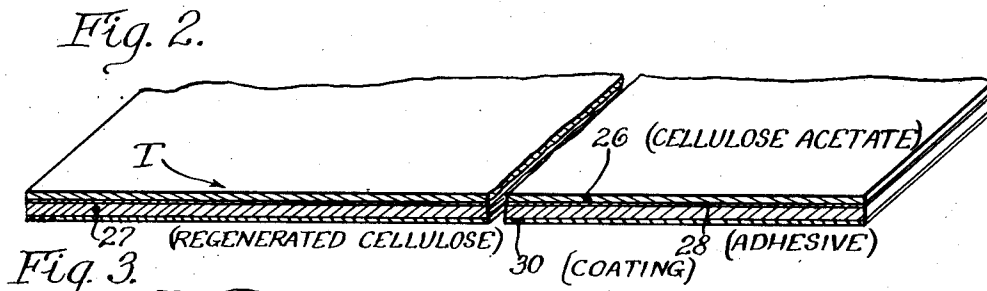
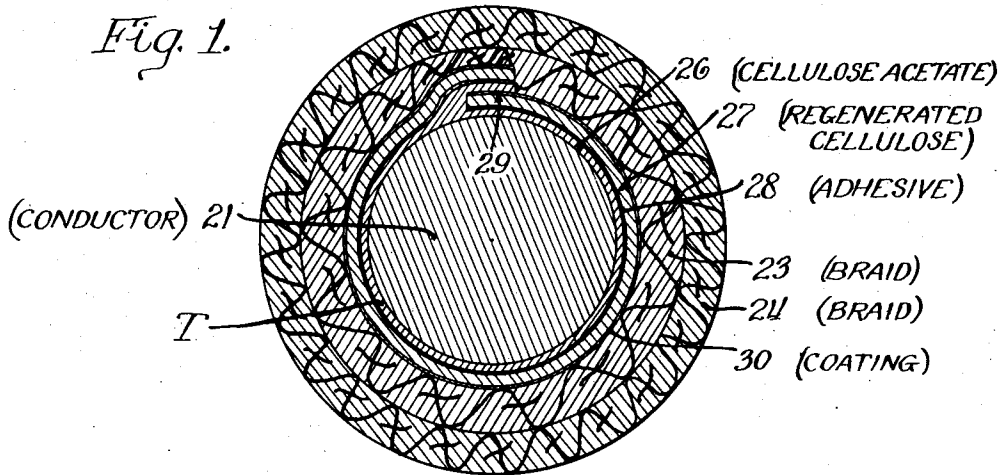


Fig. 5.

Inventor:

Boris J. Barmack

By *Curran, Jackson, Cottrell & O'Connell*
Att'ys

March 28, 1944.

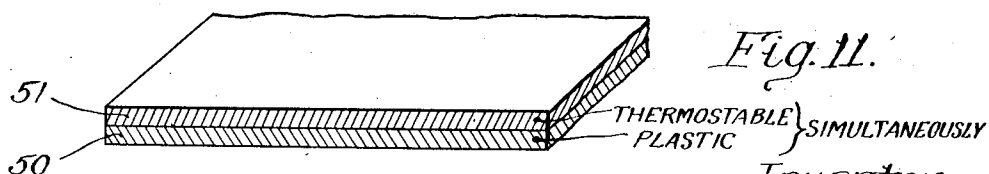
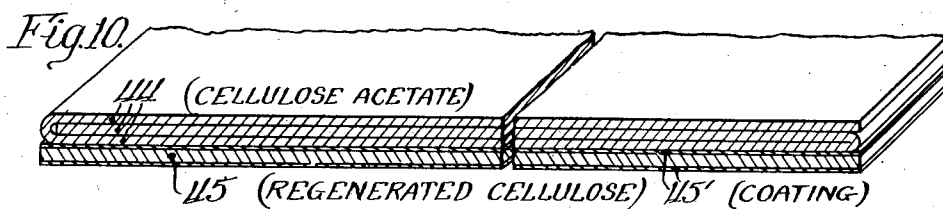
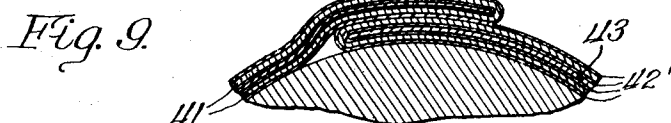
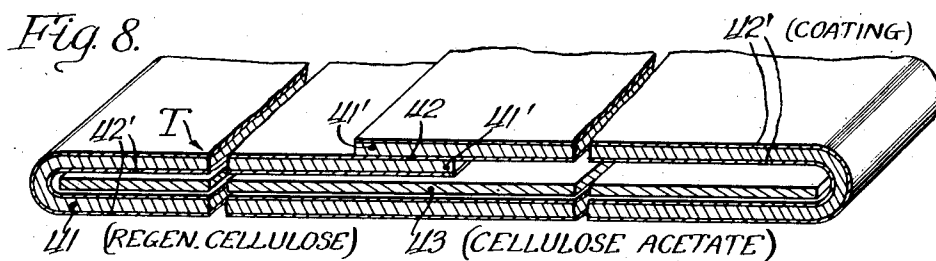
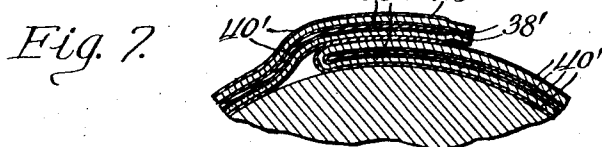
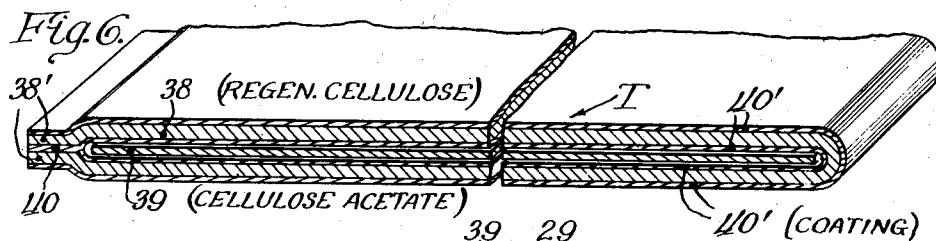
B. J. BARMACK

2,345,229

INSULATION FOR ELECTRICAL CONDUCTORS

Filed June 3, 1941

2 Sheets-Sheet 2



Inventor:
Boris J. Barmack

By *Brown, Jackson, Butcher & Dixon*
Attys.

UNITED STATES PATENT OFFICE

2,345,229

INSULATION FOR ELECTRICAL CONDUCTORS

Boris J. Barmack, Chicago, Ill.

Application June 3, 1941, Serial No. 396,442

32 Claims. (Cl. 174-120)

The present invention relates generally to insulated electrical conductors. This application is a continuation-in-part of my copending application Serial No. 238,969, filed November 5, 1938.

The problem of applying continuous sealing coverings over conductors has been met by processes such as extrusion and application of coating compositions. These are relatively slow, expensive, or difficult, compared to processes of mechanically applying a covering to a conductor.

Also, where certain covering material has, as an incident to its selection, a plasticity, especially when warm or heated, the pressure of braid or thread coverings over such a plastic covering causes the material to flow, and the threads cut in and approach the conductor.

The present invention has for one object the provision of a process quickly and at low cost to apply insulating material to a conductor.

Another object of the invention is to provide for the production of a tape-covered wire having a seam by overlap of the tape, and to seal the seam by application of heat.

Still another object of the invention is to produce a covered conductor entirely sealed by a seamless continuous body of insulating material.

Still another object of the invention is to protect a plastic insulating material on a conductor by a film or sheet covering outside of it.

Another object of the invention is the production at low cost of highly efficient high-tension weather-resisting cable suitable for electric service lines.

Various other and ancillary objects and advantages of the invention will become apparent from the following description and explanation, to be read in conjunction with the drawings in which:

Figure 1 is a cross sectional view on an enlarged scale through a conductor, diagrammatically illustrating one embodiment of a cellulosic covering applied thereto;

Figure 2 is a cross sectional view, also on an enlarged scale, diagrammatically illustrating the embodiment of cellulosic tape shown applied in Figure 1;

Figure 3 is a similar view diagrammatically illustrating another laminated embodiment of cellulosic tape;

Figure 4 is a similar view diagrammatically illustrating an envelope embodiment of cellulosic tape, and Figure 5 is a fragmentary sec-

tional view showing the lapped seam of such tape in its application to the conductor;

Figures 6 and 7 are similar views illustrating another envelope embodiment of cellulosic tape and its application to the conductor;

Figures 8 and 9 are similar views illustrating still another envelope embodiment of cellulosic tape and its application to the conductor;

Figure 10 illustrates another multi-ply embodiment of my improved tape; and

Figure 11 illustrates more generically the combination, in a tape, of insulating materials which are simultaneously plastic and thermostable.

In carrying out the invention, a heat-sealing material is applied to a conductor in one of numerous possible ways, so as to be covered with a wrapper of sheet material applied mechanically by a method which produces an overlapping relationship between edges of the sheet material. The sheet wrapper may be applied to provide a longitudinal seam or a spiral seam. Beneath this wrapper, the presence of heat-sealing material between the conductor and the wrapper produces an insulated conductor which is then capable of subjection to heat for activating the heat-sealing material to an adhesive condition. The adhesive condition effects a complete union of the material with itself, and according to its specific character it may also become united to the material on either or both sides of it. For example, when the heat-sealing material is in direct contact with the conductor and in direct contact with the wrapping sheet, it may become united to the conductor and to the wrapping sheet, and may also effectively seal the seam of the wrapped sheet.

The heat-sealing material may be of several types. It may be synthetic resin substance of the type which is activated by heat and then set to hardened thermostable form. It may be thermoplastic, whereby it softens and hardens with heating and cooling without being thermostable as are some synthetic resins. Suitable synthetic resin heat-sealing materials are rigid and flexible forms of phenol-aldehyde resins, vinyl resins, polystyrenes, rubber condensation products and others. The preferred ones are those which are available commercially in sheet form, such as polyvinyl chloride, copolymers of vinyl acetate and vinyl chloride, vinylidene chloride and flexible phenol-aldehyde resins. Suitable thermoplastic heat-sealing materials are cellulose acetate, cellulose acetate butyrate, ethyl cellulose and its isomeric forms, bitumens, and

many single materials and mixtures well known to those skilled in the art.

The wrapping sheet must be one which is thermostable at the temperature required to effect heat-sealing of the inner material, so that the wrapper maintains its strength and form to provide a tubular sheath to confine the heat-sealing material. Suitable wrapping materials are Cellophane, coated Cellophane, glassine paper, ordinary paper, filled paper and fabrics, for example tracing cloth and vellums, and like materials which are continuous in character and thermostable as described.

It is not necessary that the wrapping material be nonthermoplastic, for it may be thermoplastic at a temperature much higher than that employed to activate the heat-sealing material.

It is possible to make separate applications of the heat-sealing material and of the wrapping material, but it is preferred to combine the materials into a composite sheet material, to wrap that sheet about the conductor in one operation, and then to heat to activate the heat-sealing material.

Where separated applications of inner and outer layers are used, the outer layer may be so placed as to locate its seam remote from the seam of the inner layer. In the case of two longitudinal tapes, the seams are preferably 180 degrees apart.

For many types of conductors, it is desirable to have insulation which is permanently thermoplastic, even to a disadvantage, not for a function of thermoplasticity, but only as an incident to choice of thermoplastic material for some other function. An example is the use of cellulose acetate for its high dielectric strength. This is commonly applied as a solution in a solvent to deposit a coat of cellulose acetate. Such conductors are also commonly covered with a "braid" of cotton or other thread, and sometimes the braid is impregnated with hot asphalt. In placing a simple braid over a cellulose acetate insulating layer, it has been found that the braid cuts into the plastic cellulose acetate by reason of mechanical pressure in the apparatus. This is especially true where the cellulose acetate is uncushioned against the metal conductor. The cutting of the braid into the cellulose acetate is accentuated in the later life of the conductor by heat or pressure, or both. The above action reduces the insulation thickness and dielectric property, and it may go to the point where braid contacts the conductor. Thus easy contact with water to the metal is effected on wetting the braid. Also, in the case of a braid impregnated with asphalt, pitch, wax, or other material in a process requiring heat, the braid more easily cuts into the cellulose acetate at a stage in the production of the insulated wire.

The present invention overcomes this defect in such a use of cellulose acetate or other thermoplastic covering by reason of the thermostable wrapping sheet layer being interposed as a protection over the thermoplastic material, to prevent the cutting in by threads of the braid. Whereas the use of heat to impregnate the braid is disadvantageous in the circumstances above stated, it is made advantageous in one phase of the present invention. The heat is employed to soften the cellulose acetate or other heat-sealing material, so that it may be applied by a method leaving a seam in the applied layer to be closed by the effect of heat. The heat also may effect bond of the heat-sealing mate-

rial to the base beneath it, such as the conductor itself, thus permitting a loose application initially and an anchored layer eventually, thereby dispensing with the use of coating compositions to secure an anchored coat.

In another aspect of the present invention, where the heat-sealing substance and the heat employed are such that the heat-sealing substance becomes quite fluid, the wrapping sheet provides a tubular sheath to contain it, thus acting as the walls of a mold for the fluid material. This is the case where a thermo-setting resin may go through a plastic stage before it hardens.

Accordingly, it can be appreciated that the present invention is largely mechanical in character, depending upon physical properties of materials selected for both electrical and physical characteristics. In the instance of a permanently thermoplastic material, it is only the physical state in response to temperature that is involved. In the instance where the heat-sealing material is a thermo-setting resin, the physical state desired may depend upon both physical and chemical properties of the potentially reactive resin-substance employed.

The heat-sealing material may be selected for dielectric strength, resistance to water, permanence, insulating characteristics, flexibility, toughness, and many other qualities according to the use of the conductor. The essential requirements are insulating and heat-sealing properties.

The wrapping sheet material may likewise be selected for many qualities. It may present the exposed surface of the finished conductor, or it may be an intermediate covering, as in the case where a braid is applied. Its essential qualities are permanence and strength under conditions of heat to be employed to activate the heat-sealing material. Other properties may influence the choice of material. A preferred property is ability to unite with the heat-sealing material in its activated stage, whereby the two materials may become in whole or in part integrated by the heat treatment.

Where the desired sheet material is resistant to adhesion with the heat-sealing material, it may be surfaced with a layer which has the desired property. Thus, for example, where regenerated cellulose (uncoated Cellophane) is used as the sheet wrapper, over cellulose acetate, it has been found that the activated cellulose acetate does not adhere well to the cellulosic surface. However, where the commercial heat-sealing Cellophane, which has an applied coating, is used, it has been found that the activated cellulose acetate adheres well to it.

One of the great advantages of the invention is the ability to produce the insulated conductor rapidly by mechanical operations, to be followed only by a heat treatment. The latter need not slow the permissible rapidity of the mechanical action. The preferred mechanical action is to apply a tape to a conductor, either spirally wound, or longitudinally applied to provide a seam of overlapping edges of the tape. Machines for such operations are well known and need no special description. One improved form of such a machine or guide apparatus for applying the tape longitudinally is disclosed in my aforementioned prior application Serial No. 238,969, filed November 5, 1938. The heat-sealing material may be applied as a tape or as a component of a tape. The thermostable sheet may be applied as a tape

over the applied heat-sealing material, or as a tape of composite material including some or all of the heat-sealing material. Depending upon the use of the double or single wrapping action, and upon the structure of the tape, the seam of the wrapping sheet may be with or without heat-sealing material at the inter-face. These differences in resulting structure will become apparent from the detailed references to the drawings.

In the drawings, it is to be understood that the materials referred to specifically therein as present, are merely illustrative of useful materials for the functions desired, and that the invention is not to be considered as limited to them or by the use of them. One of the most difficult problems in insulation is the production of inexpensive primary distribution wires (2000 to 7500 v.) for out-of-doors exposures. These are subjected to heat and cold, rain and sun, snow and ice, friction with tree limbs and the like, accidental crossing of companion wires, and ground contacts, with the result that any pinholes in the insulation in the presence of moisture may make a short circuit. High dielectric strength is required also to prevent breakdown and the formation of pinholes where high electric stress is present across the insulation from some abnormal disturbance.

Since cellulose acetate is one heat-sealing material of high dielectric strength, and since regenerated cellulose is a suitable wrapping material easily secured in water-proof form, in moisture-transmission-resistant form, and in a heat-sealing coated form, these basic materials are used in the illustrations to indicate how the invention is employed to produce such primary distribution wires.

In Figure 1 the numeral 21 represents conductor material, such as a single strand of copper wire. Upon this is wrapped a tape, such as shown in Figure 2. The cross-section of Figure 1 is such as that exhibited by a wrapping with a longitudinal or a spiral seam. The tape of Figure 2 is shown in cross-section and it may be longitudinally or spirally applied to conductor 21.

The tape of Figure 2 is represented by the letter T, and consists of a layer of cellulose acetate 26 and a sheet of regenerated cellulose 27 of the commercial form having a coating 28 thereon. The coating 28 is such as provides a bond for the cellulose acetate 26 to the regenerated cellulose sheet 27, as an adhesive. Commonly, the layer 28 is a modified nitrocellulose coating. Other suitable adhesives are natural gums, natural and synthetic resins, and "Paraplex" (a product of The Resinous Products and Chemical Co.—see U. S. Patent No. 1,761,816). Layer 30 is a coating which is heat-sealing, as provided by the "MST" Cellophane of E. I. du Pont de Nemours & Company of Wilmington, Delaware, the layer 28 being a corresponding coat. In this "MST" Cellophane the letters denote the following properties: M=moisture-vapor-proof; S=sealing; T=transparent. The aforesaid coating on this Cellophane greatly increases the moisture-vapor resistivity of the Cellophane. Such coating is also capable of making a heat-sealing bond when brought up to a temperature of approximately 190° to 200° F. These temperatures are well within the range of temperatures ordinarily employed in the impregnating operation. The layer of acetate 26 may be a sheet entity adhesively

secured to the Cellophane, or it may be a layer deposited thereon from solution or otherwise.

In Figure 1 the tape T is shown with a seam 29 in which the interface includes the cellulose acetate inherently as a result of overlapping tape T of Figure 2. Over the seamed tape T is a layer of braid 23, and over that a second layer of braid 24. The braided cable is impregnated with a material like air-blown asphalt heated at a temperature of about 300 to 350 degrees F. The heat affects the cellulose acetate and, as shown in the region of the seam 29, it flows to fill in the gap which would normally appear at the inner edge in the seam. The heat thus seals the normal seam between its wrapped edges, and provides a continuous layer of cellulose acetate around the conductor. As wrapped about a copper wire, the tape T may slip. But after heat is applied, the layer 26 unites with the conductor adhesively, and prevents slippage of the tape. Because the Cellophane layer 27 has two coats 28 and 30, which are heat-sealing, and also adhesive to the cellulose acetate, the heat also seals the seam 29 of the tape T at the inter-face.

In Figure 3 a modified tape is shown in which cellulose acetate is used primarily for its dielectric function, and but slightly for its thermoplasticity. The major portion of the heat-sealing material is that supplied by the heat-sealing coats on "MST" Cellophane. These are also used in creating the tape of Figure 3, to unite the cellulose acetate between two layers of "MST" Cellophane. The tape of Figure 3 consists of two sheets of regenerated cellulose 31 and 32, and a sheet of cellulose acetate 33. The sheets 31 and 32 each have two surfaces with heat-sealing coats 34 thereon, which are also employed as adhesive to unite with the sheet 33. In using this tape for a conductor, and applying heat, the layers 34 unite with themselves, and with the conductor. Pressure on the seam will cause heat-plastic cellulose acetate 33 to exude thus to fill up the gap in the seam and add to the circuit of heat-sealing material 34 about the conductor. The overlapping of the cellulose acetate gives the desired dielectric properties, and the sealing of the seam keeps moisture out.

Figure 4 is a modified form of the tape of Figure 3, in which the cellulose acetate is confined to function only as dielectric, by being enclosed in an envelope form of two sheets of regenerated cellulose. The cellulose sheets are shown at 31 and 32, and a cellulose acetate sheet is shown between them at 33. As illustrated, the sheet 33 need not be adhesively united to the sheets 31 and 32. Adhesive 34' is shown combining the edges of the Cellophane sheets into an envelope. This may be the same material as described above for adhesive 28 in Figure 2. The layers 35 represent the coating found on "MST" Cellophane, or other heat-sealing coating on Cellophane, such as a mixture of "Paraplex" and nitrocellulose. Thus, on wrapping this tape on a conductor, the structure shown in Figure 5 results. The coatings 35, and not the cellulose acetate 33, serve to provide the heat-sealing material.

Figure 6 is a modified form of the tape of Figure 4, in which one sheet of Cellophane 38 is folded to include a sheet of cellulose acetate 39. Adhesive 40 is employed to secure together the edges 38' of the Cellophane. Layers 40' represent the coating material which is heat-sealing. Thus, where the sheet 38 is "MST" Cellophane,

the cellulose acetate sheet will be bonded to the cellulose sheet, and the adhesive designated 40 will be the same material as layers 40', provided as a part of "MST" Cellophane. The seam formed on a conductor is shown in Figure 7.

Figures 8 and 9 illustrate use of a modified Cellophane envelope 41 including cellulose acetate only as a dielectric sheet 43. The seam formed by the lapped edges 41', 41' of the envelope is on a face of the tape, and is closed by adhesive 42, which is shown as an extension of "MST" coats 42' on both faces of the Cellophane. The coats 42' are the heat-sealing material.

In these various forms of Figures 4, 6, and 8, the Cellophane acts as a protecting film over the cellulose acetate to keep any later applied braid from cutting into the cellulose acetate. For the purpose of heat-sealing and closing the seam, the normal coating on "MST" Cellophane is effective. When high dielectric strength is not desired, the cellulose acetate may be omitted, without in any way departing from the use of heat-sealing material.

In Figure 10, a modification of the tape of Figure 2 is shown. Where a relatively thicker layer of cellulose acetate or other heat-sealing material is used, it need not be supplied by use of a thicker single sheet or coat, but it may be supplied by several plies 44 of thinner sheets. As illustrated, a single sheet is made into several plies by folding, by lap or envelope folding, or by zig-zag or "S" folding. An "MST" Cellophane strip is shown at 45 to which the bottom ply 44 is secured. Layers 45' represent the heat-sealing layers of "MST" Cellophane. Such a tape is more flexible to handle than one with a single thick sheet of the same amount of cellulose acetate. The plies 44 may be heat-tacked together and to the sheet 45 at numerous spots, or otherwise secured to provide a unitary tape for application to a conductor.

Figure 11 represents a laminated tape having a layer 50 which is plastic at some elevated temperature, and 51 represents a wrapping sheet which is thermostable at the same temperature, the word "Simultaneously" in the drawings being bracketed against both properties to indicate the simultaneous existence of these conditions. Cellulose acetate is one example of the thermoplastic material, and regenerated cellulose is one example of the thermostable material.

The above embodiments having regenerated cellulose and cellulose acetate in a braid-covered asphalt-impregnated wire are representative of the idea of employing a partitioning sheet (the cellulose) which is impervious to the impregnating material on one side and to the thermoplastic or heat-sealing material on the other side at the elevated temperatures where the materials soften or flow.

According to the preferred practice of my invention, the cellulosic covering is in the form of a tape applied longitudinally on the conductor. That is to say, the tape thus applied embraces the conductor as a sheath, with the seam extending substantially longitudinally of the conductor. Distinct advantages accrue to this longitudinal application of the cellulosic tape. For example, where it is desired to maintain high dielectric and moisture excluding characteristics, it is necessary to overlap the material at the seam or meeting edges of the tape, and the longitudinal seam results in a smaller amount of seam area than in the case of a spiral seam following from a spiral application of a tape covering. Thus, the longi-

tudinal method of application results in a decided saving of material. Also, the possibility of leakage through the seam is reduced proportionately to the reduction of seam area.

A further advantage of the longitudinal application of the cellulosic tape is the greater rapidity and facility with which it can be applied to the conductor. The cellulosic tape can be applied directly in the braiding machine, preliminary to the application of the first braid on the conductor, and the tape can be applied as rapidly as the braids are applied, so that the step of applying the cellulosic material need not slow up the operation of applying the braids.

While I have illustrated and described what I regard to be the preferred forms of my improved insulated conductor, and the preferred methods and apparatus for carrying it into effect, nevertheless it will be understood that such are merely exemplary and that numerous modifications and rearrangements may be made therein without departing from the essence of the invention.

I claim:

1. In combination, an electrical conductor, a cellulose tape extending lengthwise of the conductor and embracing the latter in the form of an insulating sheath, said sheath having a lapped seam extending longitudinally of the conductor, and an outer thread covering over said sheath impregnated with a saturant applied in a heated condition, said cellulose tape comprising a heat-sealing coating which establishes a heat-seal at said lapped seam from the temperature of the heated saturant.
2. An electrical conductor insulated by a longitudinally extending tape comprising a strip of cellulose acetate folded upon itself to provide a plurality of laminations, and an outer strip of regenerated cellulose.
3. An electrical conductor wire insulated by a tape extending lengthwise of the wire so as to form a sheath with its seam extending longitudinally of the wire, said tape comprising an inner lamination of cellulose acetate base material and an outer lamination of regenerated cellulose coated with an adhesive, said cellulose acetate lamination constituting an insulating medium of high dielectric strength, and said regenerated cellulose lamination constituting a backing of relatively high heat-resistance and mechanical strength.
4. An electrical conductor wire insulated by a multi-ply tape surrounding said wire in the form of a sheath with a sealed overlapping seam extending axially of the wire, said sheath comprising at least one ply of cellulose acetate and a backing of regenerated cellulose surrounding the cellulose acetate, and a thread covering over said sheath, the said backing protecting the cellulose acetate from the thread covering.
5. An electrical conductor wire insulated by a tape surrounding said wire in the form of a sheath with its seam extending longitudinally of the wire, said tape comprising a composite strip of regenerated cellulose and thermoplastic cellulosic insulating sheet material, this sheet material being folded upon itself to provide a plurality of laminations, the regenerated cellulose being in the form of a backing strip on the outside of the sheet material.
6. An electrical conductor insulated by a longitudinally extending composite tape comprising an inner strip of cellulose acetate sheet material folded upon itself to provide a plurality of laminations, and an outer backing strip of cellulose sheet

material, the cellulose acetate material of said inner strip being of higher dielectric strength than the cellulose material of said outer strip, and the cellulose material of said outer strip being of higher mechanical strength at an elevated temperature than the cellulose acetate material of said inner strip and enveloping said cellulose acetate material.

7. An insulated electrical conductor comprising a conductor wire, an insulating composite tape comprising inner and outer cellulosic strips applied lengthwise of the conductor wire to have the seam of said composite tape extend longitudinally of the conductor wire, one of said strips being composed of cellulose acetate and the other of said strips being composed of regenerated cellulose, said inner strip being folded upon itself to provide a plurality of laminations, said outer strip substantially enveloping said inner strip, and an asphalt-impregnated thread covering outside of said inner and outer cellulosic strips, said inner cellulosic strip being thermoplastic at the temperatures to which the conductor is subjected in the asphalt impregnating operation, and said outer cellulosic strip remaining in substantially its original physical state at said temperature, whereby said outer strip serves to confine said inner strip while the latter is in a plastic state.

8. An insulated electrical conductor comprising a conductor wire, an insulating tape applied lengthwise of the wire so as to form a sheath with its seam extending longitudinally of the wire, said tape comprising an inner strip of thermoplastic insulating material and an outer strip of regenerated cellulose, said inner strip being folded upon itself to provide a plurality of laminations, the material of said outer strip being of greater mechanical strength than that of said inner strip at an elevated temperature and being arranged to substantially envelop said inner strip, and an asphalt-impregnated thread covering outside of said inner and outer cellulosic strips, said inner strip being thermoplastic at the temperatures to which the conductor is subjected in the asphalt impregnating operation, and said strip of regenerated cellulose remaining substantially in its original solid state at said temperatures, whereby said outer strip serves to confine said inner strip while the latter is plastic.

9. An insulated electrical conductor comprising a conductor wire, an inner layer of insulating material of relatively high dielectric strength surrounding said wire, an outer covering comprising a wrapping of thread, and an intermediate medium serving to partition said thread covering from said inner layer, said thread covering being impregnated with a relatively high temperature saturant, said inner layer being composed of a material which is thermo-sealing at the impregnating temperature of said saturant, whereby to fuse into a continuous sheath about the conductor and said intermediate partitioning medium being composed of a material which is thermostable at the impregnating temperature of said saturant and which is also impervious to the plastic state of said inner layer and to said relatively high temperature saturant.

10. An insulated electrical conductor comprising a conductor wire, an inner ply of insulating material of relatively high dielectric strength applied lengthwise of the wire in direct contact therewith so as to form an inner insulating sheath with its seam extending longitudinally of the wire, an outer covering comprising a wrapping of thread, and an intermediate medium serv-

ing to partition said thread covering from said inner ply, said thread covering being impregnated with a relatively high temperature saturant, said inner ply being composed of a material which is thermoplastic at least to the extent to permit thermo-sealing upon attaining the impregnating temperature of said saturant, and said intermediate partitioning medium being composed of a material which is thermostable at the impregnating temperature of said saturant and which is also impervious to the plastic state of said inner ply and to said relatively high temperature saturant, and being resistant to water which may enter the conductor through a break in said thread covering.

11. An electrical conductor having multi-ply insulation thereon, said insulation comprising a protecting layer of thermostable sheet material applied to form a seam in which such material overlaps itself, adhesive material sealing said seam, and inside said layer and adjacent thereto a layer of heat-sealing material, said heat-sealing material being continuous about the conductor by union in its heat-activated stage.

12. An electrical conductor having multi-ply insulation thereon, said insulation comprising a thread covering, a protecting layer of thermostable sheet material within said thread covering applied to form a seam in which such material overlaps itself, and inside said layer, adjacent thereto and between the adjacent faces of said seam a layer of heat-sealing material, said heat-sealing material being continuous about the conductor by union in its heat-activated stage, and being a sealing body at the interface in the seam of the protecting layer.

13. An electrical conductor having multi-ply insulation thereon, said insulation comprising a protective layer of thermostable sheet material applied to form a seam in which such material overlaps itself, adhesive material sealing said seam, and inside said layer and adjacent thereto a layer of heat-sealing material, said heat-sealing material being continuous about and in union with the conductor by union in its heat-activated stage.

14. The method of insulating an electrical conductor which comprises forming about the conductor at least two layers of strip material, an inner layer being of heat-sealing material and an outer layer being sheet material which is thermostable at a temperature at which the heat-sealing material is active and unites with itself, and heating the wrapped conductor to activate said heat-sealing layer to unite with itself, whereby upon cooling it seals the conductor within a sheath of the inner layer.

15. The method of insulating an electrical conductor which comprises wrapping about the conductor a covering of sheet material, locating between said covering and in contact with said conductor a discontinuous layer of heat-sealing material, the said sheet material being thermostable at a temperature at which the heat-sealing material is active and unites with itself, and heating the wrapped conductor to activate said heat-sealing material to unite with itself and with the conductor, and thereby seal over the conductor with a continuous layer within the protecting sheath formed by the thermostable wrapping.

16. An electrical conductor having multi-ply insulation thereon, said insulation comprising a layer of thermoplastic material encircling the conductor, an overlapping wrapped layer of sheet

material over said layer, a thread covering over said wrapped layer, and adhesive material in the seam of the overlapping portion of said material to seal the seam, said sheet material being thermostable at a temperature at which the under layer is plastic.

17. An electrical conductor wire having multiply insulation thereon, said insulation comprising a layer of material which is subject to flow with heat, an overlapping strip of sheet material enveloping said layer with its seam extending axially of the wire, said strip being sealed to itself in the seam at the overlapping whereby to form a continuous sheath, said sheet material being thermostable at a temperature at which the underlayer flows, and a thread covering over said strip.

18. An electrical conductor having multiply insulation thereon, said insulation comprising a layer of material which is subject to flow with heat, an overlapping wrapped strip of sheet material over said layer, said strip being sealed to itself in the seam at the overlapping whereby to form a continuous sheath, said sheet material being thermostable at a temperature at which the under layer flows, and a thread covering over the said wrapped sheet, whereby on heating the structure the wrapped sheet prevents the thread covering from cutting into the flowable layer.

19. An electrical conductor wire having multiply insulation thereon, said insulation comprising a layer of material which is subject to flow with heat, a layer of sheet material in strip form surrounding said layer with the strip length extending axially of the wire, said sheet material being thermostable at a temperature at which the under layer flows, a thread covering over and in contact with the said overlapping tape, whereby on heating the structure the overlapping tape prevents the thread covering from cutting into the flowable layer, and solidified impregnating asphalt in said thread covering, the heat flowable layer being such that it flows at any temperature at which said asphalt is heated to a non-solid condition.

20. Electric cable comprising a conductor, a continuous layer of cellulose acetate about said conductor, an overlapping wrapped layer of sheet material over said cellulose acetate, the said sheet being thermostable at a temperature at which the cellulose acetate softens, and a thread covering over and in contact with said wrapped layer, the sheet preventing the thread covering from cutting into the cellulose acetate under the influence of heat.

21. Electric cable comprising a conductor, a continuous layer of cellulose acetate about said conductor, an overlapping wrapped layer of sheet material about said cellulose acetate, the said sheet being thermostable at a temperature at which the cellulose acetate softens, a thread covering over and in contact with said wrapped layer, the sheet preventing the thread covering from cutting into the cellulose acetate under the influence of heat, and solidified asphalt impregnating said thread covering.

22. Electric cable comprising a conductor, a continuous layer of cellulose acetate about said conductor, and an overlapping wrapped layer of regenerated cellulose about said cellulose acetate.

23. Electric cable comprising a conductor, a continuous layer of cellulose acetate about said conductor, an overlapping wrapped sheet layer of regenerated cellulose about said cellulose ace-

tate, and a thread covering over and in contact with said sheet layer, the latter serving to prevent the thread covering from cutting into the cellulose acetate at an elevated temperature.

24. Electric cable comprising a conductor, a continuous layer of cellulose acetate about said conductor, an overlapping wrapped sheet layer of regenerated cellulose about said cellulose acetate, a thread covering over and in contact with said sheet layer, and solidified asphalt impregnating said thread covering.

25. The method of insulating an electrical conductor which comprises placing about the conductor a layer of material which flows when heated, placing over said layer a wrapped overlapping sheet of material which is stable at a temperature at which said flow takes place, said sheet material being provided with heat activated sealing material at least in a portion which overlaps another portion to provide a complete seal for the same, whereby said sheet layer acts to contain the under layer when heated, and heating to effect at least a sealing of the seam, each of said three named materials being electrical insulating material.

26. The method of insulating an electrical conductor which comprises wrapping onto said conductor in overlapping relation a tape of composite sheet material to provide an overlapping seam, said tape comprising a layer of material which flows when heated and a layer of material thermostable at a temperature at which the other layer flows, said tape being wrapped to place the thermostable layer outside the flowable layer, whereby to provide a protecting sheath therefor.

27. The method of claim 26 in which the flowable layer is heat-sealing, and in which the wrapped structure is heated to self-seal said material to provide a continuous layer thereof about the conductor.

28. The process of claim 26 followed by placing a thread covering about and in contact with the wrapped tape, and then by subjecting the thread covered conductor to the impregnating action of a hot fused insulating material.

29. An electrical conductor having multiply insulation thereon, said insulation comprising a layer of heat-sealing material encircling the conductor, an overlapping layer of wrapped sheet material providing an overlap seam lengthwise of the conductor, said seam being sealed by heat-sealing material, said wrapped layer of sheet material being thermostable at a temperature at which the heat-sealing material is active to seal, and a thread covering over said wrapped layer.

30. An insulated electrical conductor comprising a conductor wire, a strip of tenuous water-proof cellulosic material applied lengthwise of the wire to form a tubular sleeve tightly adjacent the wire with its seam extending axially of the wire, a heat-sealing adhesive of water-proof character to close the seam of said strip, whereby the wire is housed in a water-proof cellulosic sleeve, and a relatively heavier insulation of asphalt-impregnated thread covering outside of and adherent to said sleeve, said water-proof cellulosic sleeve being impermeable to the heated asphalt with which said thread covering is impregnated, whereby perforations and cracks present in or resulting from aging of the asphalt and opening inwardly toward the wire are insulated electrically from the wire by said sleeve.

31. An insulated electrical conductor comprising a conductor wire, a tenuous water-proof tape composed of a plurality of plies applied longitudinally

dinally of the wire to form a tubular sheath tightly adjacent the wire and with the side edges overlapped in a longitudinal seam, at least one of said plies being a thermo-sealing waterproof material in position in the tape providing a sealing adhesive of water-proof character to close said seam, whereby the wire is enclosed in a continuous waterproof sheath, and a relatively heavier insulation of asphalt-impregnated thread covering outside of and adherent to said sheath, whereby perforations and cracks present in or resulting from aging of the asphalt and extending inwardly toward the wire are insulated electrically from the wire by said sheath.

32. The method of insulating an electrical conductor, which comprises applying a complete insulating covering of sheet material which is heat-sealing, placing over said covering additional insulating material which is thermally stable at a temperature at which the first-mentioned covering is heat-sealing, and then heating the so covered conductor at least to said heat-sealing temperature whereby to effect heat-sealing of said first mentioned covering.

BORIS J. BARMACK.