

UNITED STATES PATENT OFFICE

2,147,824

ELECTRICAL INSULATING MATERIAL

John Krauss Webb, London, England, assignor to
International Standard Electric Corporation,
New York, N. Y.

No Drawing. Application January 11, 1936, Se-
rial No. 58,783. In Great Britain March 8,
1935

13 Claims. (Cl. 154-2.6)

This invention relates to improvements in elec-
trical insulating materials and to the manufac-
ture thereof and has for its main object to
provide an improved process of treating fibrous
materials such as paper, tape, fabric, silk, arti-
ficial silk, yarn, string or the like with styrene
to render such materials suitable for a variety
of uses in electrical insulation and particularly
in the manufacture of condensers and cables and
the jointing of cables.

The present invention provides as a new ar-
ticle of manufacture an electrical insulating ma-
terial comprising a base of fibrous material such
as indicated above, impregnated with liquid
styrene which is polymerised.

According to the present invention there is
provided a process of manufacturing electrical
insulating material comprising a base of fibrous
material for example paper which is character-
ised in this that the fibrous base is impregnated
with styrene or styrene mixture so as to fill the
pores and interstices thereof and the styrene is
subsequently converted into polystyrene without
loss by volatilisation. To this end the polymer-
isation may be effected in a bath of liquid styrene
or styrene mixture. Preferably the styrene mix-
ture comprises styrene and a plasticiser such as
diphenyl or its derivatives.

An important feature of the invention consists
in treating the surface of the impregnated ma-
terial after polymerisation for the removal of
surplus polystyrene so as to restore the fibrous
texture of the surface. Suitable materials for
such treatment are solvents of polystyrene such
as liquid styrene, chlorinated diphenyl or benzene.

In the manufacture of such insulating mate-
rial in roll form a difficulty is experienced in
that the polymerisation of the styrene impreg-
nating the roll of material results in a solid
polymerised mass which cannot be unwound, but
according to a feature of the present invention
this difficulty is overcome by a process of treat-
ment which includes impregnating the material
with a mixture of styrene and a plasticiser (e. g.
styrene 60% diphenyl or its derivatives 40%)
polymerising the mixture in a closed vessel, un-
winding the material whilst the polymerised mix-
ture is soft, either at the temperature of poly-
merisation, or at a raised temperature, subject-
ing the material to treatment for the removal
of surplus styrene to restore the fibrous texture
of the surface and calendering and rewinding
the material, preferably with a suitable lubricant
whereby the material may be readily unwound in
subsequent use.

The nature and uses of the invention will be
better understood from the following description
thereof in which it has to be assumed that the
paper or fabric may first have been esterified for
example partially acetylated and so rendered less
hygroscopic. It must also be assumed that the
term "styrene" refers to styrene or a mixture of
styrene with a suitable plasticiser introduced to
increase the flexibility.

The roll of paper or fabric is impregnated in
any suitable manner as by the vacuum impreg-
nation process, with a suitable mixture of styrene
and plasticiser (e. g. styrene 60% chlorinated
diphenyl 40%) which is polymerised under ex-
cess of the mixture in a closed vessel. The roll
on removal is a solid mass, but if the polymerisa-
tion has been carried out gradually at 120° C.
the plasticised styrene will become sufficiently
soft and sticky at 120° C. to permit unwinding.
When unwound the tape or sheet may be
smoothed by passing through rolls (which may
be heated). If required it may then be wound
while still sticky direct into position for insu-
lating purposes. If, however, it is required to
be stored for work in the field or on a machine
it should be cooled and treated to remove the
surplus styrene and restore the fibrous nature
of the material as by being passed through a
bath of lubricant. Suitable lubricants are styrene
(liquid) chlorinated diphenyl, benzene, or, in gen-
eral, solvents of polystyrene. The choice of the
lubricating liquid depends upon the purpose for
which the tape or sheet is being prepared. After
the tape or sheet has been passed through the
lubricant it may be wound again in a roll. It
will then be in a state in which it may easily
be unwound and rewound as required without
further treatment. It may, in fact, be handled
similarly to ordinary impregnated or unimpreg-
nated paper or fabric.

Metal foil may be attached to the paper or
fabric after the styrene has been polymerised and
while it is hot and sticky and before the material
passes through the smoothing rolls.

The invention is however not restricted to the
manufacture of insulation in roll form as it may
be applied to insulating sheets or panels in which
case plasticisers may not be required. The base
material of paper, cardboard, fabric, wood, or
the like would be impregnated with styrene and
polymerised in a closed mould, and to effect re-
moval after polymerisation the mould could be
chilled whereby the contraction is sufficient to
break the contact between the product and the
mould.

Moreover it is quite practicable to polymerise at a temperature at which the resultant product is soft, and therefore, in a state for immediate unwinding or separation. As an example the styrene impregnated material could be polymerised at 135° C. and unwound or separated immediately at this temperature without further heating.

The softening temperature of pure styrene after polymerisation is of the order of 100° C. This is a starting point and it would probably be necessary to reach 130 to 140° C. in order to get efficient winding. The addition of plasticizers would reduce this temperature.

The primary uses of polymerised styrenated paper or fabric according to this invention are in connection with cable joints and terminations as described in my copending applications Ser. No. 745,931, filed September 28, 1934, and Ser. No. 35,960, filed August 13, 1935, the material replacing the paper impregnated with styrene which is thereafter polymerised in situ.

There are, however, as mentioned above certain additional and special applications of this new material. The material may, for example, be employed in constructing joints of the ordinary oil-impregnated type or in insulating coils in oil-filled transformers or similar electrical apparatus. In such applications the material provides greater security against electrical breakdown, compared with the ordinary oil-impregnated tape or fabric used. It also provides a certain measure of imperviousness to the oil or compound used and may restrict the movement of such insulating fluid. This effect of imperviousness may be enhanced in a simple way. If the material is heated during or after its application to the apparatus it can be rendered sticky and adherent. If, therefore, it is applied with an overlap a wrapping of an impervious nature is obtained.

An application of this nature is the use of pre-polymerised styrenated paper or fabric as an impervious covering to a lead covered cable to inhibit the passage of moisture or corrosive fluids and acting in a manner similar to wrappings of bitumenised paper or fabric or to wrappings of self-vulcanising rubberised materials.

Another application is the insulation of low tension cables in a manner similar to that achieved by applying varnished cambric tapes.

In laminated paper insulation which is impregnated with a fluid (or with a fluid which is afterwards solidified either by cooling or by polymerisation) it is realised that the main dielectric weakness lies in the films of free impregnating medium existing between consecutive laminations of paper. It would be an advantage if such films could be relieved of part of the electrical stress imposed in service. The impregnated paper could easily withstand greater electrical stresses. It is known that stress could be transferred from the films to the laminations of impregnated paper if the specific inductive capacity or the dielectric loss of the films could be increased. If, however, these films are fluid during any considerable portion of service life the fluid diffuses and permeates the laminations and eventually the grading effect disappears. If, however, the laminations are made of polymerised styrenated paper or fabric of relatively low specific inductive capacity and dielectric loss, and if after winding or wrapping the apparatus is impregnated with a mixture containing components of high specific inductive capacity or dielectric loss then the solid laminations of low specific inductive capacity

and loss are separated by thin films of material of high specific inductive capacity and/or loss, and the overall resistance to electrical breakdown is greatly increased. This mixture may be a styrene mixture which is subsequently polymerised in situ.

In the special case of condensers high specific inductive capacity throughout is of particular importance since given values of capacity can be obtained with greatly reduced dimensions. In this case the following procedure can be followed. The prepolymerised styrenated paper or fabric can be made of increased specific inductive capacity value by incorporation in the styrene mixture of components of high specific inductive capacity. The impregnating compound which may be polymerised in situ can be made of even higher specific inductive capacity so that the overall specific inductive capacity is increased and the desired grading of electrical stress is simultaneously obtained.

A suitable material for admixture with the impregnating compound to raise the specific inductive capacity is nitrobenzene. A suitable material for admixture to raise the dielectric loss is an alcohol such as β phenyl ethyl alcohol.

In forming polymerised styrenated paper or fabric the first step is evacuation and impregnation with unpolymerised liquid styrene. Since styrene has a high vapour pressure arrangements can be made whereby after the initial drying and evacuation the paper or fabric passes on its way to the impregnating bath through an atmosphere of styrene vapour which is being continuously pumped off and condensed. In this stage vapour impregnation will occur and the pores of the fibres will be penetrated. Owing to the low viscosity of the liquid styrene impregnation will be very rapid even at low temperatures. The paper may therefore be very thoroughly impregnated by passing into the impregnating bath at a speed consistent with that of the initial capillary rise in the paper. The paper may be then wound in a pad or roll under styrene and subsequently polymerised.

The methods described above are applicable to the formation of polymerised styrenated yarn or string which may be used for various purposes in connection with telephone cables and wires, but it is clear that the invention is not limited in its scope to the particulars given above. For example, the invention may be applied to textile insulated wire which may be impregnated with styrene and polymerised after the manner described for paper tapes. Such wire may be used for example for the manufacture of coils by winding the coil in a heated condition which on cooling becomes solid and need not be taped or mechanically supported for use.

What is claimed is:

1. A process of manufacturing tapes, sheets or the like, of electrical insulating material which comprises impregnating tapes, sheets or the like, of fibrous material with styrene or styrene mixture so as to fill the pores and interstices thereof, subsequently converting the styrene into polymerised styrene at an elevated temperature while the fibrous material is immersed in a bath of liquid styrene or styrene mixture whereby loss of styrene by volatilization during polymerization is inhibited, thereafter removing the fibrous material from said bath and subsequently treating the fibrous material to remove any surplus of polymerised styrene.

2. A process of manufacturing tapes, sheets or the like, of electrical insulating material which

comprises impregnating tapes, sheets or the like, of fibrous material with styrene or styrene mixture by vapor impregnation in an atmosphere of styrene vapor so as to fill the pores and interstices thereof, thereafter passing said tapes, sheets or the like of fibrous material into a bath of liquid or styrene mixture, subsequently converting the styrene into polystyrene by the application of heat while the fibrous material is immersed in a bath of liquid styrene or styrene mixture whereby loss of styrene by volatilization during polymerization is inhibited, and thereafter removing the fibrous material from said bath.

3. A process according to claim 1, in which the fibrous material is esterified so as to render it less hygroscopic before impregnation.

4. A process according to claim 1, in which after polymerization of the impregnated fibrous material so much of the polymerized styrene is removed from the surface of the fibrous material as to restore the fibrous texture of said surface, thereafter said material is calendered, and then said material is wound into rolls with a lubricant whereby it can be readily unwound for subsequent use.

5. A process of manufacturing tapes, sheets or the like, of electrical insulating material which comprises impregnating tapes, sheets or the like, of fibrous material with styrene or styrene mixture so as to fill the pores and interstices thereof, subsequently converting the styrene into polystyrene at a temperature of at least approximately 120° C. while the fibrous material is immersed in a bath of liquid styrene or styrene mixture whereby loss of styrene by volatilization during polymerization is inhibited, thereafter removing the fibrous material from said bath and subsequently treating the fibrous material to remove any surplus of polystyrene.

6. A process according to claim 1 wherein the fibrous base is impregnated with a mixture comprising approximately 60% styrene and approximately 40% chlorinated diphenyl.

7. A process according to claim 1 wherein the surface of the impregnated material after polymerization is treated with a solvent of polystyrene such as liquid styrene, chlorinated diphenyl or benzene for the removal of polystyrene to restore the fibrous texture of the surface.

8. A process according to claim 1 in which the impregnated material is polymerized in roll form and the said roll is unwound while the polymerised mixture is soft either at the temperature of polymerisation or at a raised temperature, and after treatment for the removal of surplus styrene the material is rewound in a condition in which it can be readily unwound for subsequent use.

9. A process of manufacturing electrical insulating material which comprises impregnating a base of fibrous material with styrene or styrene mixture so as to fill the pores and interstices thereof, subsequently converting the styrene into polystyrene at an elevated temperature while the fibrous material is immersed in a bath of liquid styrene or styrene mixture whereby loss of styrene by volatilization during polymerization is inhibited, thereafter removing the fibrous material from said bath, subsequently treating the fibrous material to remove any surplus of polystyrene, and thereafter calendering the fibrous material.

10. A sheet, tape or the like, of electrical insulating material which comprises a sheet, tape or the like, of esterified fibrous material intimately impregnated with polymerized styrene or styrene mixture which fills the pores and interstices thereof, the said polymerized styrene or styrene mixture being integrally united in and among said fibrous material by polymerization in situ and the said material being free from voids resulting from loss of styrene by volatilization during polymerization.

11. A process according to claim 1, in which the impregnated material is rolled up and then polymerised in roll form beneath the surface of a bath of styrene and the said roll is subsequently unwound and subjected to a treatment for the removal of surplus polystyrene.

12. A process according to claim 1, in which metal foil is attached to the material preferably after the styrene has been polymerised and while it is hot and sticky, for example by passing the material and metal foil between smoothing rollers.

13. A process according to claim 1, wherein components of high specific inductive capacity, for example nitrobenzene, are incorporated in the impregnating mixture.

JOHN KRAUS WEBB.