

Aug. 1, 1967

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3,334,037

ELECTRICAL SURFACE TREATMENT OF POLYMERIC WIRE INSULATIONS

Filed May 22, 1964

FIG. 1

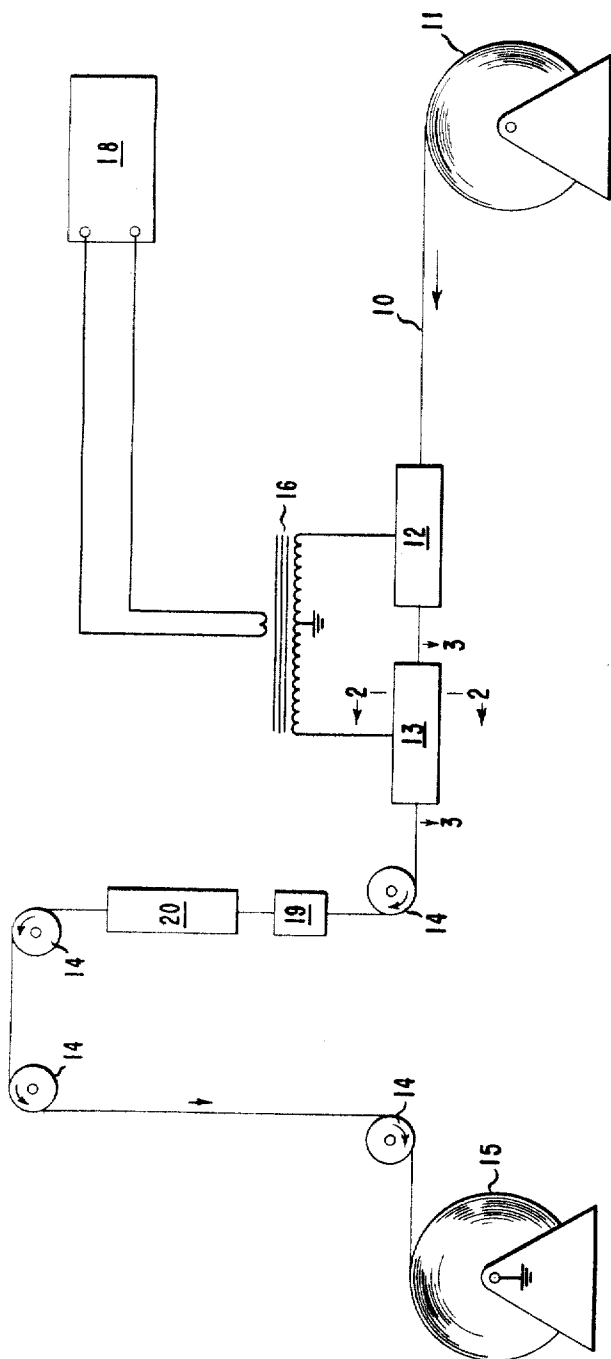


FIG. 3

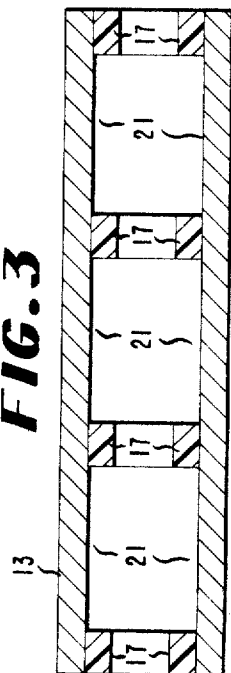
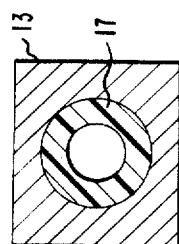


FIG. 2



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ELECTRICAL SURFACE TREATMENT OF POLYMERIC WIRE INSULATIONS

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Filed May 22, 1964, Ser. No. 369,406

3 Claims. (Cl. 204—165)

This invention relates to a process for the electrical surface treatment of polymeric wire insulations and to the apparatus for carrying out this treatment, and, more particularly, to a process and apparatus for rendering polymeric wire insulations adherent to other materials, such as inks, adhesives, coatings and the like.

Heretofore, one of the most widely used methods for treating polymeric wire insulations to render the surface thereof adherent has consisted of applying a source of alternating current at very high frequency to a single electrode. This electrode is fed by an unbalanced line. The other side of the line is grounded to the wire embedded in the wire coating being treated. This process is generally carried out in an inert atmosphere to produce satisfactory results. The coils of wire being processed act as an electrical impedance in series with the load, and because the coils are winding and unwinding during the treatment process, they are a variable impedance between the generator providing the high voltage alternating current and the load. This has a detrimental effect on the tuning of the system and can result in variability in the degree of treatment obtained at various points along the wire.

It is an object of this invention to provide a process and apparatus for rendering polymeric wire coatings suitable for adhesion. It is a further object to provide such coatings having a very high degree of uniformity in surface properties at all points along the length of the wire. These and other objects will be more clearly apparent hereinafter.

The objects of this invention are realized by employing a two electrode system fed by a balanced line connected to a source of alternating current.

The wire embedded within the polymeric coating being treated is maintained at a potential approximately midway between the potentials of the two electrodes. For safety reasons, this is usually ground potential. The source of alternating current is preferably center-tapped, and this is also preferably maintained at ground potential. The electrodes are perforated and the coated wire to be treated is passed through these perforations. A source of alternating current is fed to the electrodes. The electrodes are fed alternating potentials having a phase difference of 180°. A path of current for a given half cycle is therefore from one electrode to the wire and from the wire to the second electrode. By this manner the necessity for transfer of substantial amounts of power through coils of wire is therefore avoided. The preferred operation of this treatment is in air at or near atmospheric pressure. Preferably, a frequency of 1000 to 50,000 cycles/second is employed. The voltage used is sufficient to cause electrical discharge in the atmosphere surrounding the polymeric wire insulation, but this voltage is not sufficient to break down the insulation. Contact times in the neighborhood of three seconds have been found to produce good results with a wide variety of polymeric insulations, and much shorter times were found to be adequate for many insulation materials.

The invention is shown in a specific illustrative embodiment, by the accompanying drawing, in which FIGURE 1 is a diagrammatic illustration showing the relative disposition of the pair of electrodes, the current source, and the wire printing and drying apparatus. FIGURE 2

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is a cross sectional view of one of the electrodes of FIGURE 1 taken along the line 2—2 of FIGURE 1, and FIGURE 3 is a cross-sectional view of the electrode taken along the lines 3—3 of FIGURE 1.

Referring to FIGURE 1, a polymeric coated wire 10, continuously fed from a supply roll 11, is passed through electrodes 12, 13 over idler rollers 14 to a takeup roll 15. The electrodes 12, 13 are connected to a center-tapped transformer 16 which is in turn connected to a source of alternating current 18. Interdisposed between the electrode 13 and the takeup roll 15 is a source of wire coating enamel or the like 19 and a drying oven 20. The center tap of the transformer 16 is maintained at ground potential. Likewise, the wire embedded in the wire coating being treated is maintained at ground potential at the takeup roll 15. The source of alternating current 18 has its voltage increased by the transformer 16. The transformer 16 feeds the electrodes 12, 13 alternating potentials having a phase difference of 180°. Since the wire embedded within the wire coating is maintained at ground potential, the path of flow for the current during a given half cycle will be from one electrode to the wire and from the wire to the other electrode.

Referring to FIGURE 2 which shows a cross section view of the electrode 13, which is formed of a conductive material such as brass, copper or the like, the electrode is drilled through the center and provided with an air gap 21. The spacing of the air gap is maintained by a series of insulators 17 as shown in FIGURE 3. Preferably, the insulators are of a material such as polytetrafluoroethylene or the like.

It is not necessary that the enameling in apparatus 19 and 20 be conducted simultaneously with the electrical treatment. The insulated wire 10 can be passed through the electrodes 12, 13 and directly to the takeup reel 15. It can then be used at a later time for enameling, printing, stripping, potting or the like.

The invention is further characterized by the following examples which are intended to be merely illustrative and not limiting.

Example 1

An electrode assembly was constructed consisting of two brass blocks, each block being three inches in length, and having a hole 0.100 inch in diameter passing through the length of the block. The blocks were mounted on an insulating support so that there was a three inch space of free air axially between the two blocks. The two holes through the blocks were centered on the same axial line. The wire to be treated was a number 22 standard construction consisting of 7 strands of #30 gauge wire covered with a 10-mil coating of extruded fluoroethylenepropylene fluorocarbon resin. The outside diameter of the insulation coating was 50 mils. One end of the wire was drawn from a reel and threaded successively through each of the two electrodes and onto a power driven takeup reel. The wire was centered within each electrode by small ring shaped fluorocarbon resin spacers. There was a concentric air gap of about 25 mils between the outer surface of the wire insulation and the inner surface of each electrode. The electrical generator was connected to the electrodes in such a manner that an alternating potential of 6250 volts RMS at a frequency of 13.5 kc. per second existed between the two electrodes. The conductor of the wire being treated was maintained at ground potential and thus the potential difference between this conductor and each electrode was approximately 3125 volts RMS. Electrical discharge was clearly visible between the outer surface of the wire insulation and the inner surface of each electrode, but no breakdown of the insulation occurred. The insulated wire was drawn through the electrode assembly at a rate of 11 feet per minute. Al-

though the treatment caused no visible change in the appearance of the wire insulation, the surface properties of the polymeric insulation were drastically altered as indicated by the following observations.

(1) Common organic solvents such as those used in formulating printing inks and wire coating enamels wet the surface of the treated wire but not the untreated wire used as a control. Printing, striping and enamel coating could thus be applied to the treated wire and yield coatings of superior adherence.

(2) Common electronic potting resins such as epoxy and polysulfide resins cured to give tight bonds of superior pullout strength with the treated wire. A length of the treated wire was passed through a bath containing a standard commercial polyimide wire coating enamel. From the bath the wire was passed through a die of 0.595 inch inside diameter to remove excess enamel and from there into a vertical oven where the enamel was dried and cured for one minute at 200° C. A second coat of enamel was applied to a portion of the wire. Cut through resistance of the wire insulation was determined by placing the test wire on a steel surface and bearing down on the specimen with a cutting edge of 1/16 inch radius loaded at a rate of 10 kg. per minute until an electrical contact was made between the wire and the cutting edge or the steel surface. Success of the coating operation and proof of good adhesion of the enamel coating to the fluorocarbon resin was indicated by substantial improvement in cut-through resistance. Cut-through resistance values obtained by averaging results of seven determinations on each specimen were as follows:

Untreated wire insulation 12.7 kg.

Wire insulation plus one coat enamel 24 kg.

Wire insulation plus two coats enamel 37 kg.

Cut-through resistance of the enamel coated insulation did not vary substantially between the ends and middle of the wire, and, in other similar runs, uniform results were obtained regardless of the length of the wire used in the electrical treatment step.

An attempt was made to apply wire coating enamel to a fluorocarbon insulated wire by the above procedure, except that electrical discharge treatment was omitted. The fluorocarbon insulation was not wet by the enamel in the bath, and on emergence from the bath the enamel gathered into beads on the surface of the wire insulation and in no case was a continuous and adherent enamel coating obtained following oven treatment.

The treatment procedure was repeated with the exception that the two electrode system was replaced by a conventional one electrode system. The electrode consisted of a glass tube, 4" in diameter, 40" in length, and wrapped on the outside with lead foil. The insulated wire to be treated was passed through the center of the tube in an atmosphere of nitrogen. A spark gap type radio frequency generator of nominal 500 kc./second frequency was connected to the lead foil electrode. The ground terminal of the generator was connected to both ends of the wire being treated by way of the axles on which the wire spools were mounted. The generator voltage was adjusted to yield a corona type discharge within the electrode but insufficient in intensity to break through the wire insulation. A 250 ft. length of wire was treated at 25 ft./minute and coated with two coats of enamel. The cut-through resistance was approximately the same as the two coat product of the two electrode system. When the operation was repeated with the one electrode system on a 2500 ft. length of the same type wire; however, the cut-through resistance of the similarly enamel-coated product was 26% lower. This illustrates the variability

which is sometimes encountered with one electrode systems.

Example 2

The procedure of Example 1 was repeated except that the potential applied between the two electrodes was increased to 9000 volts RMS and the frequency was increased to 25 kc./second. The results were essentially the same as in Example 1.

Example 3

The procedure of Example 1 was repeated except that the polymeric wire insulation was a tetrafluoroethylene-fluorocarbon resin. A potential of 9000 volts RMS was applied between the two electrodes at a frequency of 6.25 kc./second. The treated insulation was found to be suitable for application of printing, striping, and continuous, uniform enamel coatings as contrasted to the untreated wire which was not suitable for these purposes.

Example 4

The procedure of Example 2 was repeated except that the polymeric wire insulation was a polyethylene resin. The treated insulation was found to be very receptive to inks, including water-based inks as contrasted to the untreated wire which was not receptive.

Example 5

The procedure of Example 4 was repeated except that the wire speed was 100 feet per minute. The results were substantially the same.

Example 6

The procedure of Example 4 was repeated except that the outer surface of the polymeric wire insulation was a nylon jacket. The results were substantially the same.

Example 7

The procedure of Example 6 was repeated except that the wire speed was 100 feet per minute. The results were substantially the same.

I claim:

1. A process of rendering a polymeric wire coating suitable for adhesion which comprises continuously passing a polymeric coated wire through a plurality of electrodes, and continuously supplying said electrodes with an alternating current at a frequency of from 1 to 50 kc. per second at a voltage which is maintained between that voltage which causes electrical discharge in the atmosphere surrounding said polymeric coating and that voltage which causes breakdown of said polymeric coating, while maintaining a phase difference of 180° between said electrodes and while maintaining said wire at a potential approximately midway between the potentials of said electrodes.

2. A process according to claim 1 wherein said polymeric coated wire is passed through a pair of electrodes.

3. A process according to claim 2 wherein said wire is maintained at ground potential.

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