March 28, 1944. E. J. FLYNN 2,345,390

PROCESS FOR ENAMELING RECTANGULAR WIRE

Original Filed July 17, 1940

Fig.1.

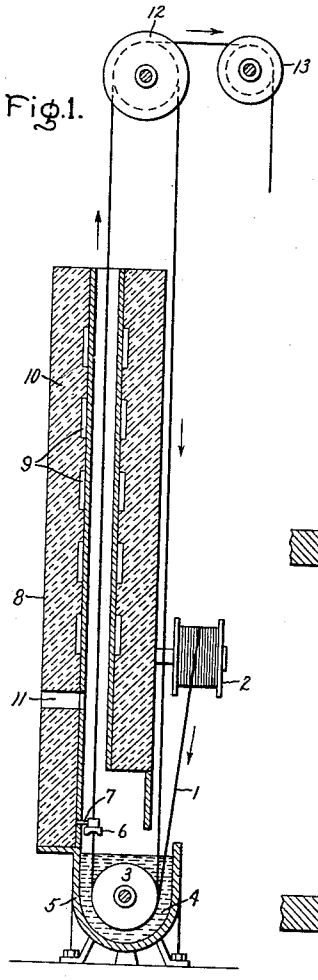


Fig.2.

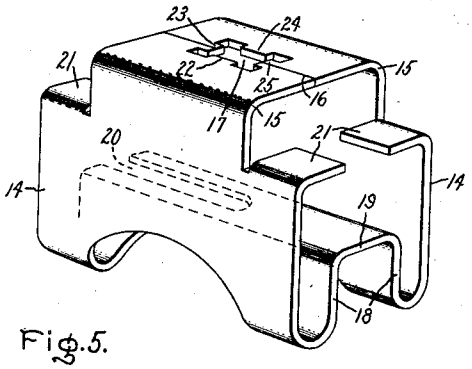


Fig.5.

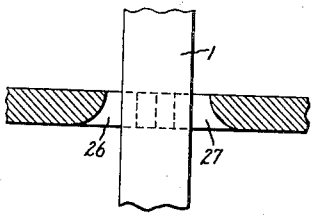


Fig.4.

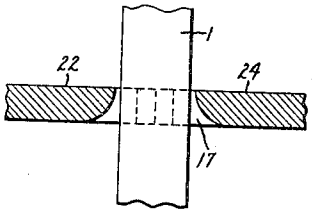


Fig.6.

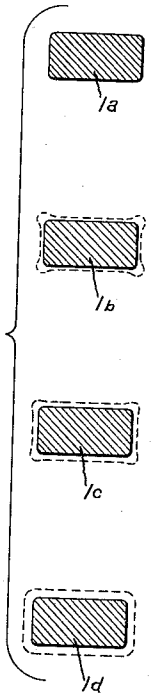
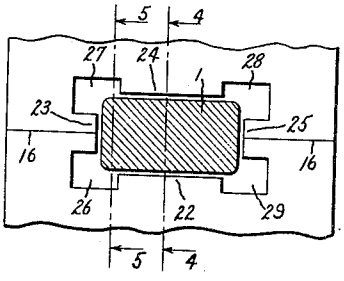


Fig.3.



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2,345,390

UNITED STATES PATENT OFFICE

2,345,390

PROCESS FOR ENAMELING RECTANGULAR WIRE

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Original application July 17, 1940, Serial No. 345,993. Divided and this application April 21, 1942, Serial No. 439,907

2 Claims. (Cl. 117—128)

This invention relates to a process for coating wire or other metallic conductors of rectangular or substantially rectangular cross-section with a liquid coating composition such as an enamel, varnish, lacquer or the like. The invention is concerned especially with the application of viscous coating compositions to wires of substantially rectangular cross-section; such highly viscous compositions including the product resulting from condensing an aldehyde, such as formaldehyde, with a hydrolyzed polymerized vinyl ester, such as the hydrolysis product of polyvinyl acetate. This application is a division of my copending application, Serial No. 345,993, filed July 17, 1940, for Apparatus for enameling wire, and assigned to the same assignee as the instant application.

An object of my invention is to provide an improved method for coating rectangular wire or similar elongated metallic conductors with a uniform coating of enamel or the like whereby the thickness of the coating can be easily and definitely controlled.

Another object of the invention is to provide a method of coating rectangular wire with liquid coating compositions whereby the wire is provided with a film of insulation of uniform thickness about the entire circumference of the rectangular wire.

A further object is to provide rectangular wires with baked films of originally viscous liquid coating compositions which films will be as thick on the edges of the rectangular wire as on the flatter surfaces. In the illustarted apparatus employing the improved method this is accomplished by employing a die having an opening of a particular configuration adapted to supply the major portion of the coating material to certain selected longitudinal portions of the wire.

Further objects of my invention will become apparent from the following description of my invention when taken in connection with the accompanying drawing in which Fig. 1 is a view in cross-section of a coating apparatus embodying the invention; Fig. 2 shows one type of die incorporating the invention; Fig. 3 is a top view of a portion of the die shown in Fig. 2; Figs. 4 and 5 are cross-sectional views taken along lines 4—4 and 5—5 respectively of Fig. 3; and Fig. 6 shows cross-sectional views of the wire and applied coatings during certain stages of the manufacture thereof in accordance with the present invention.

Metallic conductors such as magnet wires have been insulated or coated with enamels or other resinous insulating materials by applying the coating material in a liquid state to the conductor and thereafter baking the conductor to harden the insulation thereon. A process particularly useful in the insulation of wires of circular cross-section is that in which the wire after having been provided with a surface coating of liquid coating material is passed through a suitable die or aperture of a shape corresponding to the cross-sectional dimensions of the wire. Such dies remove excess liquid coating material from the wire and provide the wire with thin uniform layers of coating material. However, it has been found that when wires of rectangular or substantially rectangular cross-section have been coated by this conventional method of drawing the wire through a bath of liquid coating composition, then through a die having a rectangular opening therein, and thereafter baking the coating to harden it on the wire, the resultant baked coating is comparatively thick on the flat surfaces of the conductor and extremely thin on the edges or angular portions of the conductor due to the fact that the liquid coating material originally applied as a uniform layer tends to collect on the flat portions at the expense of the edges of the wire. Although in the practice of this conventional method of coating wire, a plurality of coatings are applied to the wire and each separately baked thereon before the application of the succeeding coating, the ultimate results obtained with rectangular wire are still those described above wherein the amount of insulation on the flat portions of the rectangular wire is considerably more than necessary or desirable and the coating on the edges is insufficient for adequate insulation thereof.

In accordance with the present invention, the above difficulties have been overcome or eliminated and rectangular wires, in particular those wires which have been drawn to a uniform rectangular cross-section, have been provided with insulating coatings of uniform thickness throughout by applying comparatively large portions of enamel to the longitudinal edges of the rectangular wire while maintaining the portions of enamel applied to the flatter surface portions at a minimum and thereafter baking the coated wire before the liquid coating material applied to the edges of the wire has had time to migrate substantially to the flatter surfaces of the wire due to the inherent surface tension characteristics of the ordinary liquid coating compositions.

One suitable apparatus for carrying out my improved method is that shown in the accom-

panying drawing. With reference to Fig. 1 thereof, there is shown by way of illustration a wire coating apparatus in which a wire 1, drawn from a pay-off reel 2 and under a guide sheave 3 immersed in liquid coating material such as a wire enamel 4 contained in container or trough 5 is provided with a thin surface coating of enamel. The coated wire moves upwardly through the die 6 adapted to remove excess enamel therefrom and to apply definite quantities of enamel to selected portions of the wire in accordance with the invention. The die 6, shown in greater detail in Figs. 2–5, may suitably be of the self-centering floating type such as described in Patent No. 2,238,575, issued to Adalbert Alexay on April 15, 1941, and assigned to the same assignee as the instant application. This die is supported on suitable supporting means such as fingers 7 attached to the walls of oven 8 at a point above the coating bath. The oven 8 through which the wire passes immediately after leaving the die is provided with electric heating units 9 supported within the insulating oven walls 10. A port 11 provides means for supplying air to the oven. It will, of course, be understood that any suitable design of baking oven may be employed and that such oven may be heated with gaseous combustion products or any other suitable means instead of the electric heating units shown. The wire with its heat-hardened insulating coating of enamel thereon passes over a driving sheave 12 and is thereafter recirculated through the coating material, additional dies and the oven to receive additional layers of coating material or passes over a pulley 13 to a take-up reel (not shown).

The die 6, shown in greater detail in Fig. 3, is a somewhat modified form of the type of die disclosed and more fully described in the previously mentioned Alexay patent. This die comprises a unitary structure formed from a single sheet of flexible metal which is stamped to provide the necessary openings and extension members. In its final form my die structure comprises two spaced apart side walls 14 extending upwardly to edges 15 and then inwardly to meet along a line 16. Preferably the top of my die between edges 15 is flat or substantially so. An aperture 17 is provided at the center of the flat top of the die and is located equidistant from the opposite marginal edges defining the top. The line at which the two walls of the die meet passes through the center of this aperture 17 the shape of which will be more fully described hereinafter.

By forming the die of a resilient material which is unaffected by the liquid coating composition, as for example, spring phosphor bronze, the bottom wall joining the side walls of the die can be deformed to assure closely fitting reengagement of the sections forming the top after these sections are temporarily separated for insertion of the wire.

The deformation of the bottom wall may take any suitable form. In the specific construction shown in Fig. 2, the lower part of each of the side walls 14 is bent inwardly and upwardly to form extensions 18 spaced from the side walls 14. These extensions are bent inwardly to form a bottom section 19 which is provided with a suitable slot 20 arranged to permit vertical movement of the wire or the like therethrough and through the orifice 17 provided in the top of the die. By means of this slot the die and the wire to be coated may be brought into operative relationship merely by separating the sections forming the divided top portion and bringing the edge of the wire through the opening formed by the separated sections and also through the slot 20. The side walls 14 are provided with inwardly projecting, suitably spaced apart, facing flanges 21 made by deforming portions of the side walls in the regions shown in the drawing. These flanges cooperate with the top of the die and serve to retain the die on the die supporting fingers 7 extending through the opening between the top portion and the flanges 21.

The shape of the die opening or wire passage 17 is of particular importance in accomplishing the purposes of my invention and both the size and shape depend not only on the cross-sectional area of the wire to be received therein but also, for example, upon the required thickness of insulation, the total number of coats ultimately to be supplied to the wire, the viscosity and other characteristics of the enamel or coating material employed, and other influencing variables. Preferably the lower edges of the walls of the orifice 17 are rounded as shown, for example, in Figs. 4 and 5 in order to obtain the optimum self-centering effect of the die about the wire, which effect is maintained hydraulically by the limited amount of coating material passing upwardly through the die opening with the wire.

Much of the die structure hereinbefore described resembles that of the Alexay die. However, in accordance with my invention, it is intended that this or similar dies suitable for coating a circular or rectangular wire should be modified to have a die orifice as a whole of the general shape shown in Fig. 3. As shown in this figure, the die orifice as a whole is such that most of the enamel is applied to the edges of the rectangular wire passing upwardly therethrough while comparatively little is applied to the plane surfaces of the wire. To accomplish these purposes I have provided a substantially rectangular die orifice 17 considerably larger than the wire to be coated having projections 22, 23, 24 and 25 extending inwardly to partially fill the die opening. The substantially rectangular projections, besides forming a wire passage and centering the wire in the die orifice,. also remove most of the liquid enamel from those portions of the wire coming in contact therewith. Thus most of the enamel ultimately applied to the wire passes through the small openings or spaces 26, 27, 28 and 29 between the projections 22, 23, 24 and 25 and the wire 1. In this die structure projections 23 and 25 are split along line 16 permitting insertion of the wire 1 into the die aperture.

Clearances between the wire and the projections along the plane portions of the wire, i. e, between the wire and the walls defining the wire passage, and the comparative size of the spaces between the projections at the edges of the rectangular wire, i. e., the enamel-applying openings, are determined empirically and may, for example, be in the approximate proportions shown in Figs. 4 and 5, respectively showing cross-sectional views of the die opening and wire along lines 4—4 through projections 22 and 24 and along line 5—5 at one of the die openings shown in Fig. 3. Preferably the clearances between the wire and the ends of the projections along line 4—4 and the wire and the corresponding projections 23 and 25 should be no more than is necessary to permit free movement of the wire through the aperture. The corners

of the die orifice may be either square, as shown in Fig. 3, or rounded or otherwise shaped provided they are so proportioned in connection with the projections that most of the enamel is applied to the edges of the wire. This die may also be described as comprising a close fitting rectangular wire passage or major die opening the edges or walls of which correspond to the ends of projections 22, 23, 24 and 25 with portions of the surface 16 cut away at the corners of this major opening to form walls defining smaller openings or spaces 26, 27, 28 and 29 for passage of the enamel.

My method of coating rectangular wires is probably best described by tracing the passage of a single wire through the coating apparatus such as that hereinbefore described as representing one means for carrying the invention into effect.

As the uncoated wire having, for example, a cross-section such as indicated in Fig. 6 by reference numeral *1a* passes through the coating material such as an enamel 4 in trough 5, it picks up an excessive amount of enamel and carries it upwardly to the die 6. As the coated wire passes through the die opening or aperture in die 6, those portions of the enamel clinging to flat surfaces of the wire are substantially removed therefrom by the projections 22, 23, 24 and 25 extending inwardly from each side of the die orifice which projections also center the die about the wire. The excess enamel so removed either returns by gravity flow to the enamel bath 5 or mixes with that clinging to the edges of the rectangular wire and due to the upward travel of the wire is carried through the openings between the adjacent projections of the die in the form of longitudinal ridges adherent to the edges of the wire. These portions gradually flow together after the wire leaves the die aperture because, as previously indicated, the tendency for such liquid coating materials is to collect in comparatively thick layers having rounded surfaces on the flatter portions of the wire leaving the relatively sharp edges substantially free of enamel. However, as the die is located immediately below the baking oven, the heat hardening enamel, particularly the more viscous enamels, becomes baked to a hardened state before this migration of the coating from the edges to the flatter portions of the wire has progressed any considerable degree. Thus the baked coating firmly adhering to the wire as the coated wire leaves the oven has a form approximately that shown at *1b* in Fig. 6 characterized by ridges of baked enamel extending along the edges of the wire.

In coating any type of wire with organic liquid enamels, it is customary to pass the wire through the coating apparatus a plurality of times to obtain the proper insulation thickness or build. On repeatedly passing the coated wire indicated by numeral *1a* through the coating material, dies and oven, the liquid enamel applied to the edges of the wire during these subsequent passes has an even greater tendency to flow away from the edges of the wire and towards the centers of the flatter surfaces. This increased tendency is due primarily to the fact that the edges are now substantially ridged and the flatter surfaces somewhat concave as shown at *1b* and each of these contours favoring the migration of the liquid material in the indicated directions to a substantially greater degree than did the purely right-angle edges and substantially plane surfaces of the uncoated wire *1a*. After two or more additional passes of the wire through the apparatus the plurality of coats of enamel tend to have the form shown at *1c* and ultimately, after one or two more passes, that shown at *1d* in which the baked enamel is of substantially uniform thickness throughout and the edges of the wire are as heavily insulated as the plane surfaces.

Thus, it will be seen that I have provided a simple method for providing substantially rectangular wires with insulating films of baked enamels of uniform thickness around the entire circumference of the wire which method essentially comprises repeatedly applying coating material primarily to the edges of the wire and immediately baking the coated wire before the material has to any substantial degree left the edges due to surface tension effects.

It may be desirable in certain instances to use a series of dies each having a slightly greater distance between opposite wire-centering projections 22 and 24 and 23 and 25 by amounts equal to the thickness of the baked enamel applied to the wire by the previous die.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of providing a wire having flat intersecting sides forming angle edges with a uniformly thick film of baked coating material, said method comprising passing the wire through a body of viscous coating material, thereafter removing a larger amount of the coating material from the central side portions to produce a thin liquid coating thereon and a small amount of coating material from the edge portions to produce a thick liquid coating thereon, and baking the coating after some of the liquid coating material on the edge portions has flown towards and merged with the liquid on the central side portions to form the uniformly thick coating.

2. The method of providing a wire having substantially flat intersecting sides forming edge portions with a uniformly thick film of baked coating material, said method comprising applying a thick film of viscous liquid coating material on the wire, removing some of the material from the central side portions to form a thin film of the viscous liquid coating material on the central side portions, and baking the coating after some of the liquid coating material on the edge portions has flown towards and merged with the liquid on the central side portions to form the uniformly thick coating.

EDWARD J. FLYNN.