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E. J. FLYNN

2,238,687

APPARATUS FOR COATING WIRES AND THE LIKE

Filed July 14, 1937

Fig. 1.

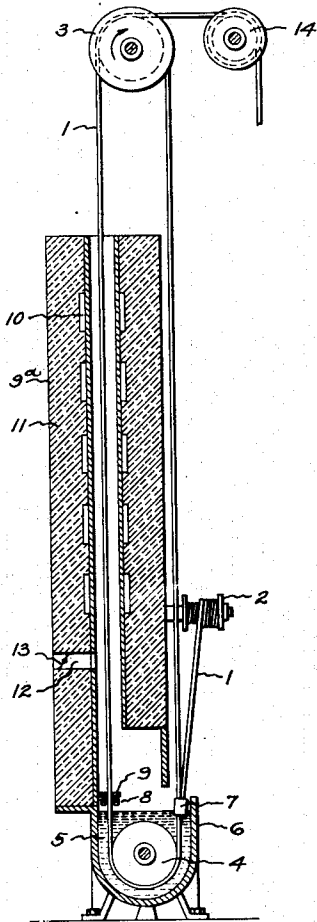


Fig. 2.

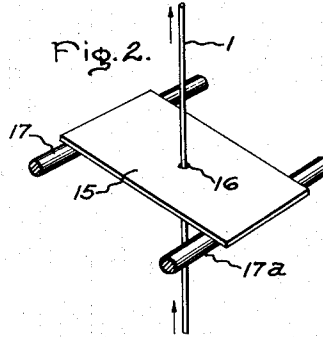


Fig. 3.

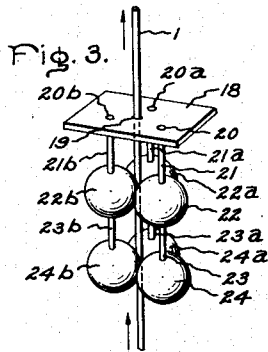
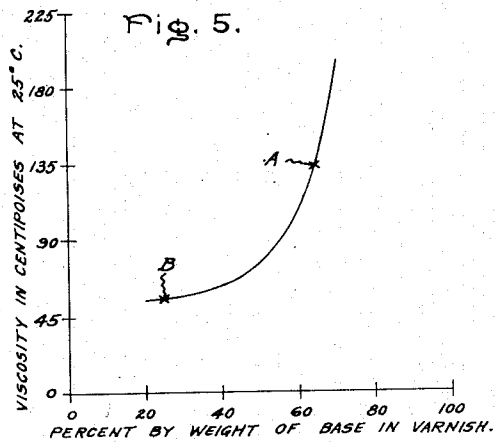
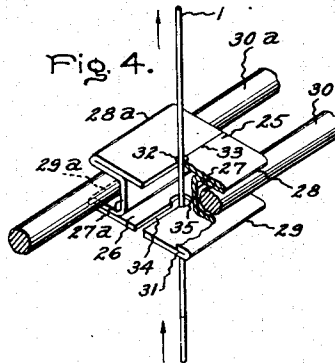


Fig. 4.



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UNITED STATES PATENT OFFICE

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APPARATUS FOR COATING WIRES AND
THE LIKEEdward J. Flynn, Schenectady, N. Y., assignor to
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11 Claims. (Cl. 91—53)

This invention relates to apparatus for applying liquid coating compositions such as enamels, varnishes, lacquers, etc., to metallic conductors in elongated form. The invention is especially concerned with means for coating wire and the like with viscous liquid coating compositions, including a viscous solution of a resinous composition obtained by condensing an aldehyde, such as formaldehyde, with a hydrolysis product of a polyvinyl ester, such as polyvinyl acetate. Specifically my invention provides a novel die assembly for coating wires and the like with liquid coating material, which assembly comprises a die having unitary apertured means for uniformly reducing to predetermined thickness the coating on the article being coated and mechanical mounting means contacting said die by which the die is movably positioned to provide for free but limited lateral and longitudinal movement of the die during the coating operation.

It is an object of the present invention to provide an improved method and apparatus for coating wire and the like with liquid coating composition, whereby the wire may be uniformly coated, the thickness of the individual coats and thus the total thickness definitely may be controlled, the number of coats required to attain a desired thickness may be lessened, the coating may be applied at a higher rate of wire travel, and solvent losses may be decreased.

Another object of the present invention is to provide means for coating wire and the like with solutions of resinous compositions which, in concentrations that are practical for use in enameling wire, are so viscous as to render their application to wire difficult with such wire-enameling apparatus as heretofore has been available.

The stated objects are attained in accordance with the present invention by passing freshly coated wire or the like through a device which is able to move or float with the wire. Such a device, in its practical effect, a self-centering die, that is, a device which centers itself with respect to the wire passing therethrough, irrespective of the movement or the position of the wire.

In the accompanying drawing Fig. 1 is a vertical cross-section of an apparatus for applying liquid coating composition to wires, which apparatus embodies features of my invention; Figs. 2 and 3 are perspective views, and Fig. 4 is a perspective view partly in section, of freely movable, self-centering dies illustrating means employed in accordance with the present invention for providing a wire with a uniform coating of varnish or the like; and Fig. 5 shows graphically the relationship between viscosity and percentage base content of a typical wire enamel.

In the manufacture of electrically insulated metallic wires wherein the insulation is of the so-called "organic enamel" type, the wire usually

is passed continuously first through a bath of enamel, varnish or similar liquid coating material, for example an oleo-resinous varnish. On leaving the bath the coated wire is treated, for example, by passing it, usually in a vertical upward direction, through a heated oven to evaporate the solvent and to harden the coating. Appropriate temperature and atmospheric conditions are maintained in the oven so as to produce on the wire a hardened film having the desired characteristics. Heating the coated wire at such elevated temperature as, for example, about 350° C. ordinarily is sufficient to obtain the desired results. The higher the temperature employed, the shorter is the heating period; and, conversely, the lower the temperature, the longer is the heating time. In practice, it is necessary to coat the wire a number of times, usually from four to eight times, in order to obtain an insulating layer of the desired thickness.

According to conventional practice it is necessary to work with varnishes represented by the more or less horizontal portion of a curve such as shown in Fig. 5. This is due to the fact that in traveling through a bath of very viscous varnish, such as indicated at point A of the curve, at any speed commercially practical, the wire is coated with a layer of wet varnish several times the thickness desirable for effective drying and for the formation of a smooth, uniform film. For this reason it has been common practice to dilute the base material with solvent, thereby to produce a varnish such as that represented, for example, by the point B on the curve, and to pass the wire a number of times through the thus diluted varnish, baking the coated wire after each passage through the coating bath.

The disadvantages of such a process of coating wires may be summarized as follows: (1) Large solvent losses occur. Such losses often are as much as 70 to 75 per cent of the total liquid applied. (2) Numerous coats are required, if the coating operation is to be carried out at reasonable rate of wire travel. (3) Difficulty is encountered in controlling the thickness of the individual coats, and thus the total thickness, due to such influencing variables as, for example, rate of travel of wire through the bath, and surface tension and viscosity of the liquid coating composition. These difficulties become so great when working with a high viscosity varnish, such as represented by point A on the curve of Fig. 5, that it is impractical to apply such varnishes to wire by conventional methods.

To overcome such disadvantages it has been suggested heretofore to use coating compositions of high viscosity and to pass the coated wire through, or otherwise in contact with, wiping devices made of felt or other fabric or fibrous material, for the purpose of removing excess coating

material. Wipers made of metal also have been tried. Wiping devices previously proposed or tried have been rigidly attached to a support and have not been freely movable with the wire passing therethrough. Rigid wipers have been objectionable in that, if composed of fabric or fibrous material, the wet coating was rendered uneven, with resultant lack of uniformity in the thickness of the baked coating. In the case of rigid wipers made of metal or other hard substances, the side sway of the wire as it passed through such wiper resulted in removal of the wet coating from the wire in spots, thereby rendering the dried coating non-uniform. It also resulted in excessive wear of the die opening.

The manner in which my invention may be applied to conventional wire-coating apparatus is schematically illustrated in Fig. 1. As shown in this figure a wire 1 is drawn from a pay-off reel 2 over a driving sheave 3 and a guide sheave 4 immersed in liquid coating material 5 contained in a container or vessel 6. Preferably as the wire enters liquid 5 it passes through a wiper 7, formed of felt or other soft, pliable, closely woven or compacted material. The wiper is partly submerged in the bath of coating material and is wetted throughout its non-immersed portion by capillary action. It is held in place by any suitable means. The numeral 8 designates generally a die and supporting structure used in removing excess coating material from the freshly coated wire, specific embodiments thereof being shown by way of illustration in Figs. 2, 3 and 4. The die is in operative relationship with the vessel 6. At 9 is shown means for limiting the upward movement of the die with the movement of the wire therethrough. Such means conveniently may take the form, for example, of a member such as a plate rigidly held in place and having an opening sufficient for the passage of the wire but insufficient for the passage of the die. The wire with a uniform layer of coating composition of the desired thickness thereon then passes upwardly through a drying or baking oven 9a, consisting of electric heating units 10 supported within a cylinder 11, which is adequately insulated. A port 12 having a damper 13 provides means for controlling the air supply to the oven. Of course it will be understood that any suitable design of baking oven may be employed, and that such oven may be heated with gaseous combustion products, electric heating units or by any other suitable means. The wire with its heat-hardened insulating coating thereon is passed over pulley 14 to a take-up reel (not shown).

The die structure shown in Fig. 2 comprises a member 15 provided with an aperture 16 located equidistant from the opposite marginal edges of said member. The diameter of this aperture is slightly more than that of the wire 1 which is shown as passing upwardly therethrough.

Member 15 may take a variety of forms, the important consideration being that it must be free to move with any swaying movement of the wire passing through its central aperture. For example, the member may be spherical, conical, pyramidal, or in the form of a truncated cone or pyramid. Such bodies may be solid, but more suitably may be of hollow form with an open lower or base section. The member 15 also may take the form of a thin, flat or concave or convex plate, the marginal edges of which are such that the member is round, square, rectangular, hexagonal, octagonal or the like. A preferred form is a thin, flat plate, such as shown in Fig. 2,

which plate may weigh, for example, about two to three grams. Such a die, as well as others made in accordance with this invention, may be formed from any suitable non-porous material which is unaffected by the liquid coating material. For example, it may be made of, or surfaced with metal or alloys such as tin, copper, aluminum, bronze and the like.

The member 15 rests upon a suitable support adapted to receive it, which support conveniently may take the form of a bracket comprising rods 17 and 17a. This bracket has an opening for passage of the wire 1 therethrough and is held rigidly in place by any suitable means, preferably at a level slightly above the point of exit of the coated wire from the liquid coating bath 5 (Fig. 1). Should the member 15 tend to move upward with the movement of the wire passing through aperture 16, it may be limited in its travel on the wire by the use of a rigid member such as the member 9 (Fig. 1) more fully described hereinbefore.

The die structure or assembly shown in Fig. 3 is an integral structure comprising a top section or wall 18, advantageously in the form of a thin, flat plate as shown, but which may be of various other shapes such, for instance, as those mentioned when describing member 15 (Fig. 2). The top section 18 is provided with an aperture 19, which is slightly larger in diameter than that of the wire to be received therein and is located equidistant from the opposite marginal edges of said section. Spaced apart from the top section and rigidly united thereto is a bottom section so constructed and arranged as to provide an opening substantially larger than the aperture in the top section, the center of which opening is in alignment with the aforesaid aperture.

The bottom section may take the form illustrated in Fig. 3. As there shown, annularly arranged below the top section or wall 18, parallel therewith and rigidly united thereto, for example as shown in the figure at the points 20, 20a and 20b by means of the rigid connecting members 21, 21a and 21b, made of stiff wire, rod, tubing or other substantially non-flexible material, are the cooperating guides 22, 22a and 22b, which may be either spheres or discs. For purpose of illustration these guides are shown in Fig. 3 as being spheres. The term "sphere" as used hereinafter is intended to include within its meaning a disc, the sides of which are either flat, convex or concave but which preferably are convex. The annularly arranged spheres are in contact with each other, thereby forming a central opening or wire guide-way between the contacting surfaces thereof through which the wire 1 may be passed, and thence through the aperture 19.

If desired, the bottom section may consist of only one group of annularly arranged spheres or it may consist of groups thereof, as shown by way of illustration in Fig. 3. Thus, annularly arranged below each of the cooperating guides 22, 22a and 22b, and rigidly connected thereto and maintained in the same plane therewith by the rigid, non-flexible members 23, 23a and 23b may be the cooperating guides 24, 24a and 24b, to which latter other cooperating guides similarly may be attached, as desired or as may be required.

The annular arrangement of cooperating guides may consist of three guides, as shown in the figure, or of more than three, as desired or as may be required.

To provide a die structure of a particular weight

required to maintain such device on the exposed surface of, or only partly submerged in the coating material, the cooperating guides 22, 22a, 22b, 24, 24a and 24b, especially when in the form of spheres, advantageously may be hollow and then may be brought to the desired weight by sealing therein lead shot or other suitable weighting material.

With floating or self-centering dies such as shown in Figs. 2 and 3, an end of the wire must be passed upwardly through the die. Fig. 4 is illustrative of a freely movable, self-centering die which is somewhat more convenient to apply to, and remove from a wire. Further, its arrangement permits knobs or enlarged sections of the wire to pass through more readily.

The die shown in Fig. 4 is an integral structure comprising top and bottom parallel sections or walls 25 and 26 spaced apart by the parallel side walls 27 and 27a. The side walls preferably are positioned inwardly from the marginal edges 28, 28a, 29 and 29a of the top and bottom walls 25 and 26, thereby forming channels for a supporting structure or bracket comprising, for instance, the rods 30 and 30a. These side walls may be formed, if desired, by rolling the sheet material back upon itself, as shown for example at 31. The top wall 25 is provided with an aperture 32 located equidistant from opposite marginal edges of said wall. The wall 25 is split or divided as shown at 33 into two equal closely fitting, yieldably separable sections, the dividing line being parallel with marginal edges 28 and 28a. The bottom wall 26 is slotted as shown at 34 in a direction parallel to the marginal edges 29 and 29a, the inner part of said slot preferably being rounded. The center of the rounded inner part 35 is in alignment with the aperture 32. In the figure the wire 1 is shown as passing upwardly through the center of the inner part 35 of the slot 34 and through the aperture 32.

In the use of the die structure shown in Fig. 4 each of the rods 30 and 30a, comprising a bracket or die support, is rigidly secured at least at one end, by any suitable means, at a level which preferably is slightly above the point of exit of the coated wire from the liquid coating bath 5 (Fig. 1). Should there be any tendency for the die to move upwardly with the wire passing there-through, such upward movement will be stopped by the inner portions of the lower walls of the channels, formed as described and illustrated, as they meet the lower portions of the rods 30 and 30a.

The clearance between the die and the die holder or support must be greater than the maximum movement of the wire while running. Ordinarily such movement is very small, being of the order of a fractional part of an inch. Of course it will be understood that the side walls 27 and 27a may be positioned at the marginal edges 28, 28a, 29 and 29a, if desired, and a structure such, for example, as the member 9 (Fig. 1) be used to prevent upward movement of the wire.

From the foregoing description it will be seen that the apparatus shown in Fig. 4 includes means slidably supporting the die, specifically a plurality of transverse rods, for limited lateral and longitudinal movement of the die, and restraining means, specifically a stop spaced from the die, for limiting its longitudinal movement.

Preferably the die assembly shown in Fig. 4, and in all cases at least the top wall thereof, is made of resilient metal such, for example, as sheet phosphor bronze. By using such a metal, the sections of the top wall can be forced apart to pass the wire from the side through the die opening, thereby avoiding the inconveniences encountered when an end of the wire must be passed through a die. The sections yieldingly separate to permit enlarged portions of the wire, for example, brazes (knobs due to brazing) to pass through the die opening, after which they return to their original position.

The size of the die opening required to apply a desired thickness of coat to wire of a particular diameter with a particular varnish is determined empirically. Its diameter depends not only upon the diameter of the wire to be received therein, but also, for example, upon the required thickness of insulation, the total number of coats to be applied, the viscosity and other characteristics of the varnish employed, and other influencing variables. The die openings may or may not be slightly tapered, narrowing in the direction of the upward movement of the wire, as desired or as may be required. Dies of the kind hereinbefore described have been used for prolonged periods of time without plugging of the die opening and with no wear of the opening sufficient to affect materially the thickness of the coating.

In the following table are given data illustrative of the size of opening of a die employed in practicing the present invention under certain particular conditions. Pertinent data also are given with respect to the coating of wire in accordance with practice heretofore in use and in accordance with the invention herein described.

Table I

Method	Wire size in inches	Total thickness of coat in inches	Speed of wire in feet per minute	Viscosity of varnish in centipoise at 25° C.	Varnish composition		Number of coats required
					Percent base (by wt.)	Percent solvent (by wt.)	
Conventional method.....	.0226	.0012	26	48	25	75	4
Method of this invention. Diameter of die opening, 0.0260 inch.....	.0226	.0012	40	135	64	36	3

It is an important feature of a construction in accordance with this embodiment of my invention that the rods 30 and 30a be of a diameter substantially smaller than the width or depth of the channels, so that the die will not be held rigidly but will be free to move to a substantial extent at right angles to the wire passing through the aperture 32 and with any swaying movement of the wire from or out of a true vertical plane.

As clearly shown by comparing the data given in the foregoing table it is possible to coat wires by means of the present invention with much more viscous coating compositions, containing much less solvent, than previously has been possible. A material reduction in solvent losses is thus effected. A lesser number of individually applied coatings is necessary to provide insulation of a desired thickness, when the present in-

vention is practiced, as compared with the number required to obtain a coating of the same thickness with methods heretofore in use. The wire may be passed through the coating bath and drying oven at higher speeds, thus reducing operating costs. Prescribed tolerances for thickness of coating more readily are maintained. Since the total liquid vaporized is much less, the oven draft can be diminished so that less heat is wasted. The effect of variables such as surface tension and viscosity of the coating material is minimized.

The present invention also makes possible the practical utilization of wire enamels or varnishes having as the varnish base resinous compositions which in solution state, even when comprising only a comparatively small proportion of the solution, form such highly viscous solutions that it heretofore has been difficult, from a practical standpoint, to use them for coating wires.

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

1. A die for uniformly reducing to size the thickness of coating on a coated wire, said die being free to move longitudinally and laterally with respect to said wire during the reduction to proper thickness of the coating and comprising a top section provided with an aperture slightly larger in diameter than that of a wire to be received therein, said aperture being located equidistant from the opposite marginal edges of said section, and a bottom section spaced apart from said top section and rigidly united thereto, said bottom section having an opening which is substantially larger than the aperture in said top section and the center of which opening is in alignment with aforesaid aperture.

2. A freely movable, self-centering die for use in coating wires with liquid coating composition which comprises a top section consisting of a thin flat plate provided with an aperture slightly larger in diameter than that of a wire to be received therein, said aperture being located equidistant from the opposite marginal edges of said plate, and a bottom section consisting of a plurality of contacting spheres, said spheres being rigidly united to said top section and adapted to receive said wire between their points of contact.

3. A freely movable, self-centering die for use in coating wires with liquid resinous composition, said die comprising a top wall consisting of a thin flat plate of resilient metal provided with an aperture slightly larger in diameter than that of a wire to be received therein, said aperture being located equidistant from the opposite marginal edges of said plate, said plate being divided into two equal closely fitting sections, a bottom wall spaced apart from said top wall by two side walls which are parallel with a line sectionally dividing said top wall, said side walls being positioned a substantial distance inwardly from the parallel marginal edges of said top and bottom walls, said bottom wall being slotted part way in a direction parallel with the lower marginal edges of said side walls, the slot formed thereby being rounded at its inner part with the center thereof aligned with the aperture in said top wall and the longitudinal center of said slot being aligned with the line sectionally dividing said top wall.

4. A die for applying a uniform film of coating material on wires and the like comprising a member having spaced apart side walls extending upwardly and being bent inwardly to form a

sectionally divided top wall, said top wall having an aperture of sufficient size to receive such article to be coated, and a bottom wall joining said side walls, said bottom wall having an opening aligned with the aperture in the said top wall.

5. A die having spaced apart side walls extending upwardly and being bent inwardly until they meet to form a top wall divided into two closely fitting, yieldably separable sections, said top wall having an aperture of sufficient size to receive a wire or the like therein, a bottom wall joining said side walls, said bottom wall having an opening aligned with the aperture in the said top wall, and means integral with the walls of the die for retaining the die on a die support.

6. A die for use in coating wires or the like with liquid coating material, said die being formed of resilient material and having spaced apart side walls extending upwardly and being bent inwardly until they meet to form a top wall divided into two equal, closely fitting, yieldably separable sections, said top wall having an aperture slightly larger in diameter than that of the wire or the like to be received therein, said aperture being located substantially equidistant from the opposite marginal edges defining said top wall, a bottom wall joining said side walls, said bottom wall having an opening arranged to permit vertical movement of a wire or the like therethrough and through the aperture in the said top wall, and means integral with the walls of the die for retaining the die on a die support.

7. A die formed of resilient metal and having spaced apart side walls extending upwardly and being bent inwardly until they meet to form a top wall divided into two equal, closely fitting, yieldably separable sections, said top wall having an aperture of sufficient size to receive a wire or the like therein, said side walls also extending downwardly and being bent inwardly to form a bottom wall joining said side walls, said bottom wall being slotted part way in a direction parallel with the lower marginal edges of said side walls, the slot formed thereby being rounded at its inner end with the center thereof aligned with the aperture in the said top wall, and suitably spaced apart extensions integral with the walls of the die for retaining the die on a die support.

8. A die assembly for coating wires and the like with liquid coating material, said assembly comprising a die having unitary apertured means for uniformly reducing to predetermined thickness the coating on the article being coated and mechanical mounting means contacting said die by which the die is movably positioned to provide for free but limited lateral and longitudinal movement of the die during the coating operation.

9. A die assembly for use in coating elongated metallic conductors with liquid coating material, said assembly comprising a die including apertured means for uniformly reducing to predetermined thickness the coating on the conductor being coated, means slidably supporting said die for limited lateral and longitudinal movement, and restraining means for limiting said longitudinal movement.

10. A die assembly for use in coating elongated metallic conductors and the like with liquid coating material, said assembly comprising a die including a plate provided with an aperture slightly larger in diameter than the elongated article to be received therein, a plurality of transverse rods for slidably supporting said die to

provide limited transverse movement of said die in any direction, and restraining means providing limited longitudinal movement of said die.

11. A die assembly for use in coating elongated metallic conductors and the like with liquid coating material, said assembly comprising a die consisting of a flat plate provided with an aperture

slightly larger in diameter than the elongated article to be received therein, a plurality of transverse rods slidably supporting said die for limited transverse movement thereon, and a stop spaced from said die for limiting the longitudinal movement thereof.

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