Aug. 1, 1961 H. B. LIT ET AL 2,994,624

WIRE COATING APPARATUS AND METHOD

Filed Oct. 11, 1957

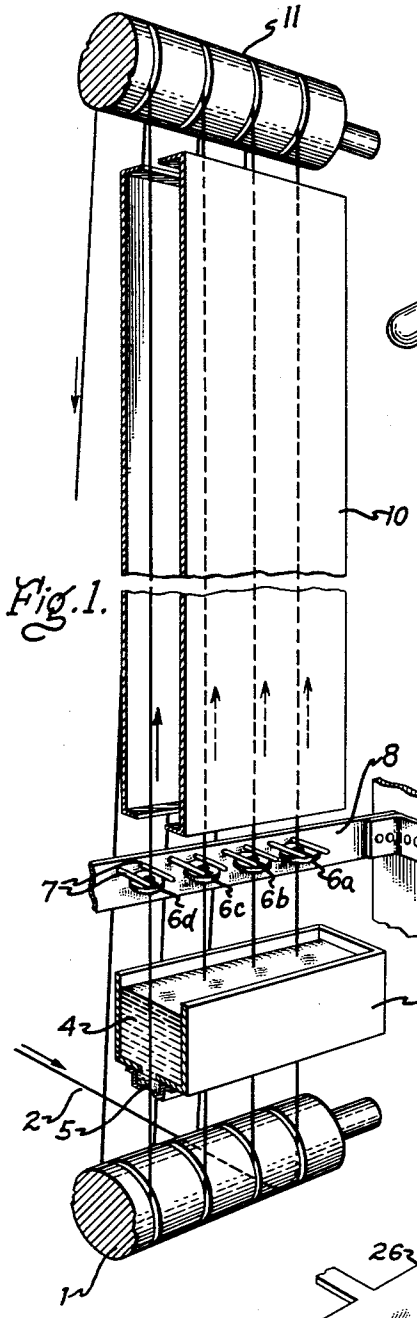


Fig. 1.

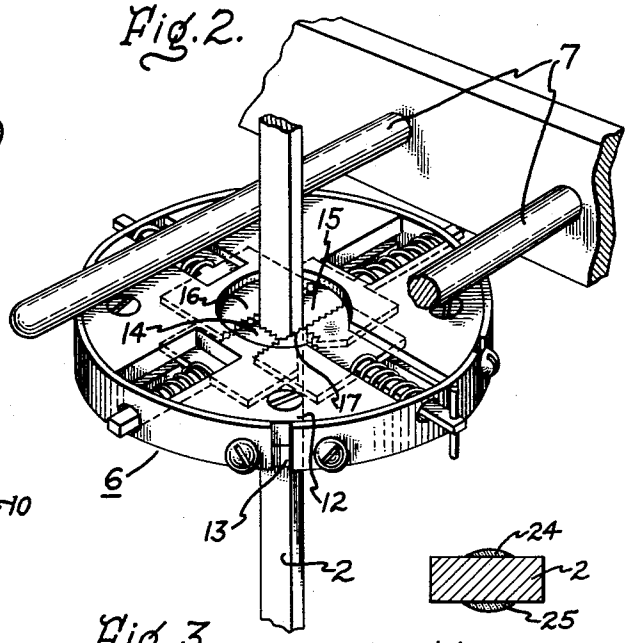


Fig. 2.

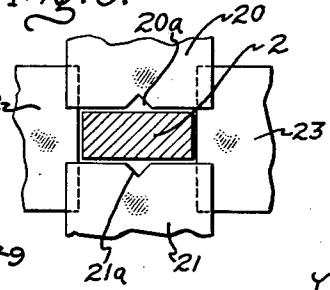


Fig. 3.

Fig. 3a.

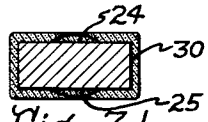


Fig. 3b.

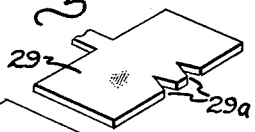


Fig. 4c.

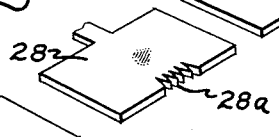


Fig. 4b.

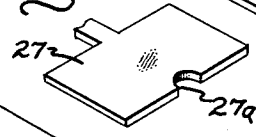


Fig. 4a.

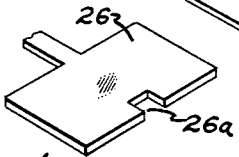


Fig. 4.

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WIRE COATING APPARATUS AND METHOD

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The present invention relates to coated elongated articles such as wire or the like, and more particularly to a uniformly coated rectangular or other polygonal type of wire, to an improved process of applying a liquid coating composition on such wire to provide coatings of uniform thickness thereon, and to apparatus adapted for carrying out such process.

The invention is especially suitable for use in coating rectangular electrical wire with viscous resin solutions, such as polyvinyl formal, to form an electrically insulating film thereon.

In the past, considerable difficulty has been encountered in obtaining uniformly thick coatings on wire of rectangular or other angular configuration. Due to the tendency of the applied liquid material to flow away from the corners of the wire and collect on the flat surfaces, inadequate deposit of coating was produced on the corners. As a result, the dielectric strength of the insulating film was substantially less at the corners than at other parts of the wire. On the other hand, application of additional coats of liquid to overcome this difficulty was wasteful, since excessive coating material was thus deposited on the flat surfaces and made the coating build unnecessarily large.

It is an object of the invention to provide a uniformly coated wire having at least one flat side.

It is another object of the invention to provide a method of applying a coating of uniform thickness on wire or the like having at least one flat side or having an angular cross section, and especially of rectangular cross section.

It is still another object of the invention to provide a method of pre-coating a rectangular wire or the like for the purpose of controlling the subsequent deposition of layers of coating material on the wire, whereby final insulating coatings of uniform thickness around the conductor are obtained.

It is a further object of the invention to provide a wire coating arrangement which is particularly effective and convenient for carrying out the above method.

Other objects and advantages will become apparent from the following description and appended claims.

In one aspect of the invention there is provided a coated wire or the like having at least one flat side, the wire having a uniformly thick coating covering its surface, the coating comprising a ridge of coating material on and extending along the flat side and a deposit of coating material on the remaining surface of the wire, the deposit of coating material having a thickness substantially equal to the height of the ridge.

In another aspect, the present invention provides a method of producing an insulating coating of uniform thickness on a rectangular wire which comprises first forming on each of the flat sides of the wire at least one ridge of the coating material extending along the wire between its opposite longitudinal edges, thereafter applying a hardenable liquid coating material along the wire surfaces, and hardening the thus applied liquid coating material.

In this connection, it will be understood that the term "rectangular" as used herein may also include a square shape.

In an embodiment of an apparatus which is adapted for effectively carrying out the above method, especially shaped die members are preferably employed in the

initial stages of the coating process for producing the described foundation ridge of coating material, after which the wire passes through die members of conventional construction for applying the subsequent film of hardenable liquid coating material. As a result of the provision of the coating ridge as described, the subsequent deposition of liquid coating material uniformly about the wire is made possible.

The invention will be better understood from the following description taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a view in perspective of a portion of a continuous coating apparatus which may be employed in carrying out the present invention;

FIG. 2 is a perspective view of a wire coating die device which may be incorporated in the apapratus shown in FIG. 1;

FIG. 3 is a cross-sectional view of a rectangular wire showing it in operative relation with die members formed in accordance with an embodiment of the invention;

FIG. 3*a* is a cross-sectional view of the rectangular wire with foundation ridges applied thereon by the means shown in FIG. 3;

FIG. 3*b* is a view similar to FIG. 3*a* showing the finally coated wire; and

FIGS. 4–4*c* are views of various other embodiments of wire contacting die members which may be used in practicing the present invention.

Referring now to the drawing, and particularly to FIG. 1, there is shown a continuous coating apparatus for coating a wire with a series of applications of insulating enamel and hardening by heat each coat after it has been applied. For this purpose there is provided a lower guide sheave **1** having grooves to which wire **2** is led from a pay-off reel (not shown), the wire **2** passing from sheave **1** upwardly through vessel **3** containing a supply of the resinous viscous enamel or varnish, such as polyvinyl formal, to be applied to the wire. Wire **2** enters the bottom of vessel **3** through a pad **5** of felt or the like which serves to retain the coating liquid **4** in the vessel **3** at the wire inlet. After emerging from the vessel **3**, wire **2** initially passes upwardly through die device **6***a*, constructed as more fully described hereinafter, which is carried upwardly by the moving wire until restrained from further upward movement by spaced fingers **7**, or other suitable stop means, which permit free lateral or rotational movement of the die device in response to any swaying or twisting movement of the wire. The stop pins **7** are secured to a bar **8** which in turn is mounted on a suitable support **9**.

In passing upwardly through the various die devices **6***a*, **6***b*, **6***c*, **6***d*, and so on, wire **2** undergoes successive stages of application of coating material on the wire. In accordance with the invention, the die devices in the first and also preferably in the second stage, as represented by devices **6***a* and **6***b*, incorporate a pair of especially shaped die members for providing a foundation ridge of coating material on and extending along the opposite broad surfaces of the rectangular wire, as shown in FIGS. 3 and 3*a*. Thereafter in subsequent stages, the die devices incorporate die coating members having conventional forms, such as shown in FIG. 2.

After each application of coating material, including those in the first two stages, the wire **2** passes upwardly through a baking or drying oven **10** of any suitable or conventional type wherein the varnish coating applied to the wire is heat-hardened. Thereafter, wire **2** passes around sheave **11** and back to drive sheave **1** to a groove spaced axially from the initial receiving groove. The passage of wire through the apparatus in repeated stages in the manner described, and shown in FIG. 1, results in a coating of the desired thickness being finally built up,

the total number of stages being normally about 6 to 8. The coated wire is ultimately conducted to a take-up reel or other storage means (not shown).

FIG. 2 shows the structure of die device **6** in greater detail, and as illustrated therein the die comprises in a preferred embodiment a pair of flat plates **12** and **13** constituting the supporting frame of the die and having slidably arranged in grooves therein pairs of movable die members **14, 15, 16** and **17**, the die members being arranged to contact the surfaces of the rectangular wire **2** as it passes through the die device. The die device having die members as shown in FIG. 2 may be used for the coating stages subsequent to the initial ridge-forming stages, but for the ridge-forming stages the conventional die members **14** and **15** contacting the broad sides of the wire are replaced by especially shaped die members as more fully described and shown hereinafter.

The die device **6** shown in FIG. 2 is disclosed and claimed in our copending application Serial No. 594,044, filed June 26, 1956, and assigned to the same assignee as the present invention, now Patent Number 2,875,725, issued March 3, 1959. While this device may be suitably employed in connection with the present invention, it will be understood that other types of die coating devices may be used if desired.

It has been found that when die members are used which have edge faces uniformly spaced from or parallel to the flat sides of the wire over their entire extent, the coating deposited tends to be non-uniform in thickness and, in particular, the coating on the corners of the wire is relatively thinner than elsewhere on the wire surfaces. If such die members having relatively shallow grooves in serrated form are employed, this non-uniformity is manifested by a coating which tends to have an elliptical shape, resulting in excessive coverage of the central portions of the flat sides of the wire and inadequate coverage of the corners. On the other hand, when such die members have relatively deep serrations for applying somewhat thicker layers of enamel at each pass, the deposited coating assumes a distorted or so-called "dog bone" shape due to the greater accumulation of deposit on the flat sides adjacent the corners, and, in this case also, insufficient coating is provided directly on the corners.

Although the reasons for these effects are not completely known, it appears that the form of the deposited liquid coating material on the wire is influenced by its surface tension, which draws the liquid toward the flat surfaces and away from the corners. This effect and the consequent non-uniformity of coating thickness appear to be even more pronounced in the case of relatively wide wire and when coating liquid of relatively low viscosity is used.

In accordance with the invention, the above difficulties are overcome by initially providing a ridge or barrier of coating material along the flat sides of the wire, and thereafter applying the coating proper in the usual fashion using conventional die members. To this end there is provided in the die coating devices in the initial stages of the wire coating apparatus shown in FIG. 1, die members **20** and **21** (FIG. 3) having a particular construction for wiping the opposite side faces of wire **2**, in place of the usual members **14** and **15** shown in FIG. 2. Die members **20** and **21** may be in a variety of forms, as shown in FIGS. 3 and 4–4*c* inclusive, but essentially they are provided with one or more recesses intermediate the outer edges of their contact edge faces for the purpose of depositing, prior to the application of the coating proper, one or more barrier ridges along the faces of the wire.

As shown in FIG. 3, in the initial stages wire **2** passes between straight-edged die members **22, 23** contacting the narrow faces of the wire, and with its broad faces in contact with die members **20, 21** which have suitably shaped recesses **24, 25** therein. As the wire passes through this die with liquid coating material thereon picked up from bath **4**, the narrow sides and the margins of the broad sides of the wire are wiped substantially free of coating material by the flat edges of die members **20, 21, 22** and **23** while mounds or ridges **24, 25** of liquid material are deposited on the opposite central wire portions by virtue of recesses **20***a*, **21***a*. The mounds **24, 25** after hardening in the baking stage thus form solid barriers, which serve to separate on each side thereof the liquid material deposited thereafter on the broad wire faces in subsequent passes of the wire.

Foundation mounds as described may be provided on any one or all of the surfaces of the wire where deemed necessary or desirable. Thus, recessed die members of the invention could also be used in place of die members **22, 23**, along with die members **20, 21**, if wire **2** were square or its edge faces likewise were rather wide.

FIG 3*b* shows the coated wire product **2** after the coating procedure is completed. As shown, the final coating surrounds the wire in uniform depth and comprises ridges **24, 25** on the surface of the central portions of the flat sides and the main coating deposit **30**, having substantially the same thickness as the mounds **24, 25**, on the remaining wire surface complementing the ridges. The thickness of the coating **30** with respect to the wire is not necessarily as shown, and it may vary depending on the degree of protection or insulation desired. It will be understood that the film **30** normally is comprised of a number of deposited layers corresponding to the number of passes the wire undergoes in the coating apparatus, but if desired only a single layer of appropriate thickness may be applied as, for example, by means of die members having serrations of suitable depth.

FIGS. 4–4*c*, inclusive, show various embodiments of the ridge-producing dies which may be used in the initial stages of the coating process to provide a proper foundation on the wire in accordance with the invention. In FIG. 4, the die member **26** has a rectangular groove **26***a* in its face, whereas die member **27** in FIG. 4*a* has a curved depression **27***a*. The ridge may also be produced by a serrated form of recess **28***a* as shown in the member **28** of FIG. 4*b*. Normally, one recess in each die member of the types shown or equivalent forms is adequate for wire of ordinary width. However, where relatively wide wire is to be coated, a plurality of such recesses **29***a* may be utilized, if desired, as shown in die member **29** of FIG. 4*c*.

In general, it is preferable to deposit the foundation ridge centrally between the longitudinal edges of the wire, but satisfactory results may also be obtained even if the ridges are not located at the mid-points.

The ridge provided on the wire in accordance with the invention appears to restrain or reduce the effect of surface tension of the coating applied in subsequent stages with the usual die members and to force the material to flow away from the central portions of the flat sides toward the corners. As a result, it has been found that the elliptical and "dog boning" forms of deposited layers are largely avoided and insulating coatings of much more uniform thickness are obtained.

By provision of such foundation ridges, a fewer number of passes of the wire through the coating apparatus have been found to be necessary than heretofore used to provide adequate corner coverage, and at the same time excessive build of insulating enamel at the flat sides is avoided.

The following is a typical process for carrying out the present invention, it being understood that the procedure described is merely illustrative and that the invention is not intended to be limited in any way by the relative dimensions or other details set forth. A bath of insulating varnish composed of polyvinyl formal with a viscosity of 5000 centipoises was used for coating rectangular copper wire of 200 mils width and 100 mils thickness. For producing foundation ridges in accord-

ance with the invention on the 200 mil surfaces, die members were used having an angular groove in their edge faces of 30 mils deep, a 60° angle, and a base dimension of 35 mils. Passage of the wire through a first set of recessed die members of the above construction provided a mound on the 200 mil surfaces of 75 mils width and about .5 mil high. A second pass through a similar set of die members produced a mound twice as high. After providing such a mound, 6 or 7 additional passes are then made of the wire through the varnish bath and die members of conventional construction to produce an insulating film of desired thickness. In a usual procedure, the finished thickness at the end of the process would be about 2.5 mils. In general, a higher initial mound would be provided for use where a greater thickness of ultimate coating is to be applied in the coating procedure.

The die members used for the narrow edges of the wire, i.e., those represented by members **22**, **23** in FIG. 3, either in the initial or subsequent passes of the wire, may have edge faces which are straight or of any other suitable form.

A series of tests were made to determine the coating and electrical characteristics of wire coated in accordance with the invention as compared to that coated in the conventional manner. In these tests rectangular copper wire having a width of .236 inch and thickness of .132 inch was used for both processes, the liquid coating material being polyvinyl formal. The wire subjected to the conventional coating process was moved through the continuous coating apparatus in six passes, each pass being through standard types of serrated die members. The wire treated in accordance with the present invention was likewise moved through the coating apparatus in six passes, but in this case the die members engaging the broad side faces of the wire in the first two passes were ridge-producing devices having a 30 mil deep angular groove of the type shown in FIG. 3, and in the remaining four passes the standard serrated die members were used.

Measurements of the coating layers produced by these processes showed that in the conventionally coated wire, the coating thickness on the broad faces ranged from about 1.8 to 2.0 mils and on the narrow faces from about 2.2 to 2.4 mils, and the average dielectric strength of four samples of this coated wire was found to be 2.3 kv.

In the case of the wire coated in accordance with the present invention, the finished coatings on the broad faces were uniformly 1.9 mils thick and on the edge faces 2.0 mils thick. The average dielectric strength of four samples of this wire was 4.8 kv.

It is evident from these tests that more uniform coating layers and markedly improved (over twice as great) dielectric strength characterize rectangular wire coated by the present process as compared to wire obtained by the conventional method, using the same number of coating stages.

While the wire shown and described is of flat rectangular shape, it will be understood that the invention is similarly applicable to wire or other elongated articles having other shapes including at least one flat surface, such as square, triangular, half round, and other forms.

Because the foundation ridge provided by the present invention serves to directly control the proper distribution of the subsequently applied liquid coating material over the surfaces of the wire, it makes unnecessary the precise timing and temperature of the baking stage which are relied on in certain prior methods, wherein excessive amounts of liquid are first applied to the corners of the wire then allowed to flow toward the central side portions for a predetermined period before being hardened by baking.

It will be understood that the invention includes the application of the foundation ridge to the wire broadly speaking, i.e., whether the wire is bare metal or already has a uniform film of insulating or other material thereon, since obviously the ridge need not be in direct contact with the wire metal to achieve the purposes of the invention.

While the present invention has been described with reference to particular embodiments thereof, it will be understood that numerous modifications may be made by those skilled in the art without actually departing from the scope of the invention. Therefore, the appended claims are intended to cover all such equivalent variations as come within the true spirit and scope of the invention.

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

1. The method of providing a coating of uniform thickness on wire and the like having at least one flat side, which comprises applying a hardenable liquid coating material on the wire, passing the wire with its flat side in engagement with a wiping surface having a recess formed therein so that substantially all of the liquid coating material is removed except that passing through said recess, hardening said deposited liquid coating material remaining on said flat side so as to form a solid ridge of coating thereon, applying hardenable liquid coating material around the wire in sufficient amount to provide on the remainder of the wire surface a coating having a thickness at least equal to the height of said ridge, and hardening the thus applied liquid coating material.

2. The method of providing a coating of uniform thickness on rectangular wire and the like having opposite flat surfaces, which comprises applying viscous liquid coating material to said wire, passing the thus coated wire through a die means for wiping off substantially all of said liquid coating material except for a portion of said material extending along said opposite flat surfaces intermediate the longitudinal edges of the wire, heating the thus remaining portions of coating for forming solid ridges thereof along the wire, reapplying viscous liquid coating material around the wire, passing the wire through die means for providing on the remainder of the wire surface a thickness of the thus reapplied liquid coating material at least equal to the height of the first mentioned portion, and heating the coating material for hardening the same.

3. The method of providing a coating of uniform thickness on rectangular wire and the like having opposite flat surfaces, which comprises applying viscous liquid coating material to said wire; passing the thus coated wire through a die means for wiping off substantially all of said liquid coating material except for a portion of said material extending along said opposite flat surfaces intermediate the longitudinal edges of the wire; heating the thus remaining portions of coating for forming solid ridges thereof along the wire; forming a deposit of said coating material around the wire by reapplying the viscous liquid coating material around the wire, passing the wire through die means for reducing the thickness of the thus reapplied liquid coating material and heating the coating material for hardening the same; and repeating said last mentioned deposit forming procedure until a coating of a thickness at least equal to the height of the ridges is obtained on the remainder of the wire surface.

4. Apparatus for providing wire and the like having at least one flat side with a coating of uniform thickness comprising, in combination, means for applying viscous liquid coating material to the surfaces of the wire, means for providing a ridge of coating material along the flat side intermediate its longitudinal edges while wiping the remainder of said flat side substantially free of the applied liquid coating material, and means for applying a coating of liquid material of predetermined thickness around said wire along the length thereof.

5. Apparatus for providing rectangular wire and the

like with a coating of uniform thickness comprising, in combination, means for applying viscous liquid coating material on the surfaces of said wire, means for providing a ridge of coating material along the flat sides of said wire intermediate its longitudinal edges while wiping the remainder of said flat sides substantially free of the applied liquid coating material, said ridge producing means comprising a pair of die members contacting the opposite flat sides of said wire, each die member having a wire wiping surface, said surface being formed only in a substantially central portion thereof with at least one recess and being substantially flat in the remainder of its wire wiping surface, and means for applying a coating of liquid material of predetermined thickness around said wire along the length thereof.

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