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CONTINUOUS COATING APPARATUS

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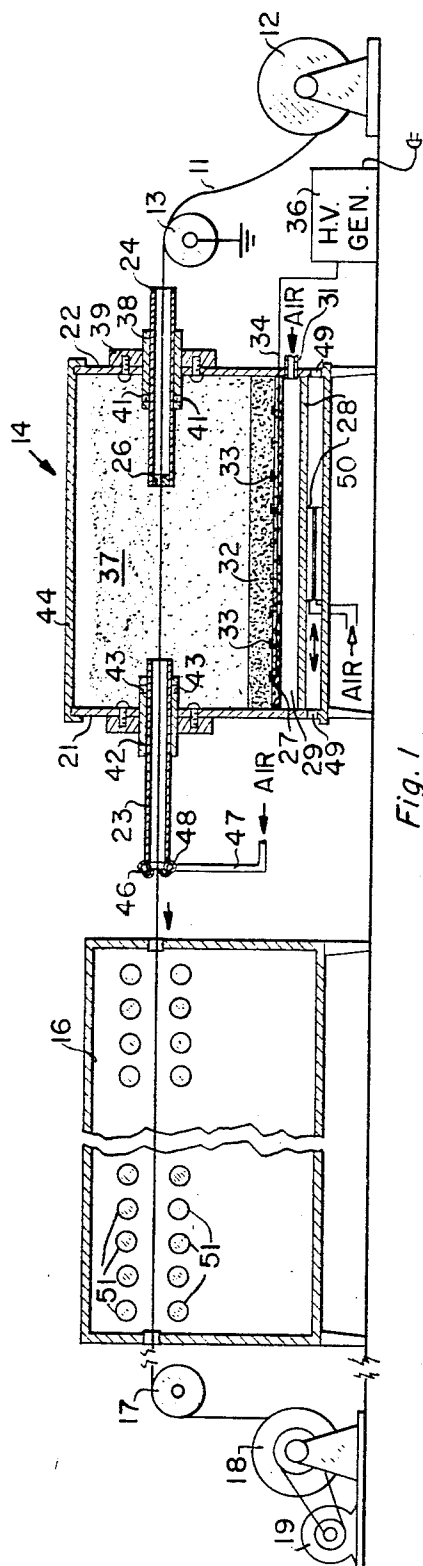


Fig. 1

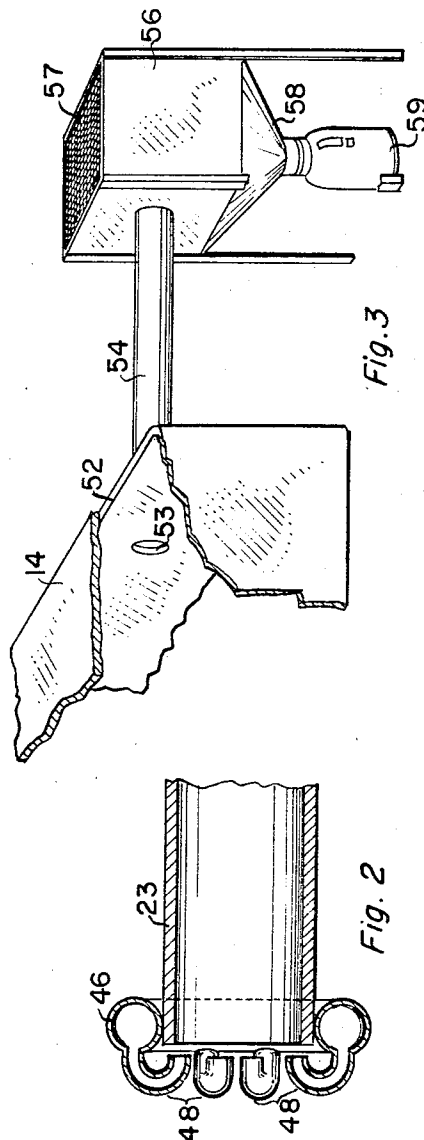


Fig. 3

Fig. 2

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1

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CONTINUOUS COATING APPARATUS

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ABSTRACT OF THE DISCLOSURE

Wire or strip is continuously coated by passing it through a cloud of electrostatically charged particles of enamel maintained above the upper surface of a fluid bed within a covered chamber. The thickness deposited is controlled by adjustable tubes through which the work passes on entering and leaving the chamber and agglomerates of the powder are removed by blowers at the chamber exit. The work passes directly from the chamber through an oven where the enamel is fused.

Our invention relates to an apparatus for continuously coating a wire or strip and particularly for electrostatically coating said wire or strip above a fluid bed.

In the enamelling of magnet wire, both round and rectangular, and of magnet strip, it has been known to apply repeated coats of the enamel in solution until a wall thickness having the desired dielectric strength is built up. Because this process requires the evaporation of enamel solvent, in addition to the curing or fusion of the enamel resin, it is slow, and because the solvents are usually wasted, it is expensive. These shortcomings of known continuous enamelling processes could be overcome if it were possible continuously to apply an insulating powder electrostatically and to fuse the powder onto the wire before it drops off. For a useful electrical product this must be done with a precise insulating wall thickness, free from gaps and lumpiness.

We have now found that this can be done with an apparatus we have invented. This apparatus comprises a chamber with means providing a fluid bed of fusible dielectric particles within the chamber and means applying a high electrical potential to the particles which then form a cloud of charged particles above the bed. Our apparatus has an oven positioned adjacent to the chamber and means for supporting the elongated member suspended within the chamber and the oven so that the member is free from contact between the chamber and the oven. There are means for continuously advancing the elongated member downstream through the cloud of particles in the chamber, whereby a coating of particles are deposited on the member, and through the oven while the oven is heated to a temperature sufficient to fuse the particles.

We have invented a chamber for our apparatus which preferably comprises an adjustable barrier means, such as at least one tube surrounding the elongated member and segregating a portion of the member from the cloud, and blower means for blowing loose particles from the elongated member. In a preferred embodiment the barrier tube is spaced around the farthest downstream portion of the elongated member and our apparatus comprises means blowing gas into the chamber through this tube so as to remove excess loose particles from both the member and the inside of the tube.

In a preferred embodiment the chamber of our apparatus comprises upstream and downstream walls with the elongated member that is being coated passing through tubes extending through these walls. Means are provided so that at least one of the tubes is slidably adjustable relative to the walls. The upstream tube has a seal through

2

which the member passes, and gas is blown upstream through the downstream tube and vented from the chamber through a filter. In addition to affording a means for fine control of insulation thickness the tubes allow higher voltages to be applied for higher speed operation without excessive powder deposit.

A more thorough understanding of our invention may be gained from the study of the appended drawing.

In the drawing:

FIGURE 1 shows a side view, in section, of the apparatus of our invention.

FIGURE 2 shows a side section of an element of FIGURE 1.

FIGURE 3 shows a pictorial representation of a feature of an embodiment of our invention.

An elongated member which in the illustrated case is a rectangular copper wire 11 is paid from a supply reel 12 over a supporting sheave 13 through a chamber 14 and oven 16, over a supporting sheave 17 onto a take-up reel 18 that is driven by a motor 19. The chamber 14 has a downstream wall 21 and upstream wall 22 pierced respectively by tubes 23, 24 through which the wire 11 passes. A seal in the form of a felt plug 26 seals the tube 24, fitting closely around the wire 11. Between the plug 26 and the sheave 17 the wire 11 is free from any solid contact, and is suspended freely, tensions being applied at the reels 12, 18 or otherwise in a known manner to prevent excessive sagging. The chamber 14 has a gas permeable false bottom plate 27 formed of porous ceramic, and an impermeable bottom plate 28. The two plates 27, 28 form the top and bottom of an air passage 29 into which dried air is blown through a pipe 31 from a low pressure source, not shown. Above the porous plate 27 there is a fluid bed 32 of dielectric powder which is maintained fluid by the continuous upward passage of air through the porous plate 27. Embedded in the plate 27 are a large plurality of electrodes 33—33 which are evenly spaced over the entire upper surface of the plate 27 and protrude upwardly into the bed of powder 32. The electrodes 33 are all electrically connected by means of a lead 34 to a high voltage generator 36 which applies a high negative D-C voltage of the order of 40–100 kilovolts to the electrodes 33 and thus to the fluid bed 32. The application of high potential to the bed 32 causes the formation of a cloud 37 of particles within the chamber 14 that rises high above the fluid bed 32 and completely surrounds the advancing wire 11 within the chamber. The tube 24 is slidably mounted within a bushing 38 secured to the wall 22 by a reinforcing plate 39, and can be locked in position by means of set screws 41—41. Similarly the tube 23 slides in a bushing 42 and is locked by set screws 43—43. Access to the chamber 14 is afforded by a removable but close-fitting cover 44. At the downstream end of the tube 23 there is secured a hollow ring 46 connected by means of an air hose 47 to an air supply, not shown. The ring 46 (FIGURE 2) has a series of apertures opening into vent tubes 48 so that air is blown into the chamber 14 upstream through the tube, and also against the wire 11 within the tube and the chamber. The chamber 14 is mounted on rubber or other flexible footings 49—49 and is vibrated by a vibrator 50 which can be of a number of known types such as air or electric vibrators. The speed and amplitude of the vibrator 50 are preferably variable and are set to establish optimum conditions for a fluid bed which are determined by trial.

The oven 16 is equipped with infra-red lamps 51—51 sufficient in number to thoroughly fuse the coating on the wire, and the sheave 17 is spaced sufficiently downstream of the oven 16 to allow the coating to cool to a substantially non-tacky state before passing over the sheave. Other means of heating the oven 16 such as resistance heating and gas heating might also be used. Known means

of accelerated cooling, such, for an example, as blowers, may be applied to the coated wire between the sheave 17 and oven 16, within the scope of our invention.

With reference to FIGURE 3 we show a means for releasing the air blown into the chamber 14 through the ring 46 and pipe 31. A side wall 52 of the chamber 14 has an aperture 53 highly placed therein. This aperture opens into a pipe or hose 54 connecting to a settling bin 56 having a filter 57 as its cover. The bottom of the bin 56 forms a funnel 58 for settling powder carried over with the air into a recovery jar 59 from which it can be returned to the chamber 14 without loss of material.

Fluid beds used as a means for generating a cloud of charged particles are not new. Commercial equipment of this type has been sold by Sames, U.S.A. Incorporated of Palisades Park, N.J. In this known equipment and also in the apparatus of our invention it should be recognized that the fluid bed is a well defined entity and that there is a definite interface between the top of the fluid bed 32 and the cloud 37 of charged particles above it. While it has been known that individual articles could be dipped into a cloud of charged particles above a fluid bed to receive a coating of resinous particles no apparatus has hitherto been known for continuously coating an elongated member of indefinite length with a uniform, controlled thickness of material continuously fused thereon. To do this we have determined that the coating thickness is controlled by the following variables: the magnitude of the potential on the electrodes 33 and the air velocity through the porous plate 27 which affect the density of the cloud 37, the speed of the wire 11, and the length of the chamber 14. The speed of the wire 11, in commercial practice, should be maintained as high as the furnace 16 can satisfactorily heat. The voltage of the electrodes has a definite upper limit determined by the capacity of the high voltage generator 36 and the danger of arcing between the electrodes and the wire, and a lower limit below which the cloud 37 will be irregular and will not completely surround the wire. The proper conditions for obtaining the most effective cloud should be experimentally determined for each type of powder to be applied. However, we have found that a most delicate control of the effective length of the chamber 14 is obtainable by means of the tubes 23, 24 which can be separated or brought together to determine the length of the wire 11 exposed to the cloud 37. This exposure could be controlled by adjusting only one of the tubes 23, 24 but we have found that when both tubes are adjustable it is possible to select an optimum portion of the cloud formation for exposure of the wire 11. The tubes allow much higher voltages resulting in higher cloud densities which permit the application of denser coatings. We have found also that although the powder deposit on the wire 11 which is, at least temporarily, adherent due to the electrostatic charge, is uniformly distributed on the wire, there are, in addition, loose particles, such as agglomerates which may fall from the wall or cover, which if they were permitted to remain on the wire, would fuse into an uneven, lumpy coating in the oven 16. We have found, unexpectedly, that an air current will remove these excess particles and lumps and still will not disturb the desired coating layer. By placing the air ring 46 at the downstream end of the tube 23 we serve the triple purpose of freeing the wire 11 from lumps, keeping the cloud 37 from passing downstream out of the chamber, and freeing the tube 23 from any deposits of powder.

Operation

When a continuous wire is passed through the cloud 37 access to the top of the wire is available only from the sides, not from the back and front as when an individual article is dipped into the cloud. Yet we have found that flat wires held in a horizontal plane can be

satisfactorily coated in our apparatus, and we have coated thousands of pounds of copper wire .065 x .31 inch with an epoxy powder.

The wire 11 was passed at a speed of 35-40 feet per minute to apply a coating 0.0015 inch thick. This speed is about 5 times as fast as the speed for coating by wet methods with multiple passes, and to achieve this speed the oven 16 is about 9 feet long. Since the oven uses infra-red energy sources (the lamps 51) the actual air temperature in the oven is not the important factor in fusing the coating.

The fluid bed was maintained between about 2-4 inches deep and the wire 11 was passed 15 to 18 inches above the porous plate 27. Actually the volume of the fluid bed is not much greater, possibly 20%, than the volume occupied by the powder in an unfluidized condition, but in the absence of fluidization, the electrodes 33 and applied voltage would be useless for the purpose of generating the cloud 37. The length of wire exposed to the cloud 37 was about 18 inches but it is recommended that persons skilled in the art should establish a proper value for this distance by experimentation in each case.

In the application of epoxy resin to copper wire hereinabove described the applied potential on the electrodes 33 was 70-75 kilovolts. The wire 11 and oven 16 and all external parts of the chamber 14 were grounded.

The epoxy powder used has particle size distribution determined by sieve analysis as follows:

Mesh size:	Percent on screen
140 -----	11.9
170 -----	17.4
200 -----	19.0
230 -----	19.0
270 -----	20.7
325 -----	8.9
Through 325 -----	3.1

Testing this powder using a standard test for comparison shows that the powder will fuse and flow out adhering to a wire in 31 seconds at 230° C.

We have invented a new and useful apparatus of which the description hereinabove presented has been exemplary rather than definitive and for which we desire an award of Letters Patent as defined in the following claims.

We claim:

1. An apparatus for continuously coating an elongated member of indefinite length comprising:

- (A) a covered chamber,
- (B) means providing a fluid bed of fusible dielectric particles within said chamber,
- (C) means applying a high electrical potential to said particles thereby maintaining a cloud of charged particles above said bed and means grounding said member,
- (D) an oven positioned adjacent to said chamber,
- (E) means supporting said elongated member suspended within said chamber and said oven,
 - (a) said member being free from contact in the distance between said supporting means, and
 - (b) said member being at all points separated from said fluid bed,
- (F) means continuously advancing said member downstream through said cloud in said chamber whereby said particles are electrostatically deposited on said member, and through said oven, and
- (G) means heating said oven to a temperature sufficient to fuse said particles.

2. An apparatus for continuously coating an advancing elongated member of indefinite length comprising:

- (A) a covered chamber,
- (B) means providing a fluid bed of dielectric particles within said chamber,
- (C) means applying a high potential to said particles thereby maintaining a cloud of charged particles above said bed, and means grounding said member,
- (D) means supporting said elongated member sus-

5

pendent within said cloud in said chamber, and separated at all points from said fluid bed, and

(E) adjustable barrier means within said chamber segregating a portion of said member from said cloud.

3. The apparatus of claim 2 wherein said barrier means comprises at least one tube surrounding said member.

4. An apparatus for continuously coating an advancing elongated member of indefinite length comprising:

(A) a covered chamber,

(B) means providing a fluid bed of dielectric particles within said chamber,

(C) means applying a high electrical potential to said particles thereby maintaining a cloud of charged particles above said bed, and means grounding said member,

(D) means supporting said member suspended within said cloud in said chamber, said member being separated at all points from said bed, whereby said member is electrostatically adherently coated with said particles and is loosely coated with additional of said particles, and

(E) blower means for removing said additional particles while retaining said electrostatically adherent particles.

5. The apparatus of claim 3 wherein said tube is spaced

6

around the farthest downstream portion of said member within said chamber, and said apparatus comprises means blowing gas into said chamber through said tube, thereby removing loose particles from said wire and from the inside of said tube.

6. The apparatus of claim 1 wherein said chamber comprises upstream and downstream walls, tubes extending through each of said walls, said member passing through said tubes, sealing means in the upstream of said tubes, and means for slidably adjusting at least one of said tubes relative to said walls.

7. The apparatus of claim 6 comprising means blowing gas upstream through the downstream of said tubes.

8. The apparatus of claim 7 comprising filter means venting said gas from said chamber.

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