Aug. 29, 1967 O. H. LINDEMANN 3,338,738

METHOD AND APPARATUS FOR APPLYING A HALOGENATED HYDROCARBON SOLVENT-CONTAINING ENAMEL TO WIRE

Filed Aug. 6, 1963 2 Sheets-Sheet 1

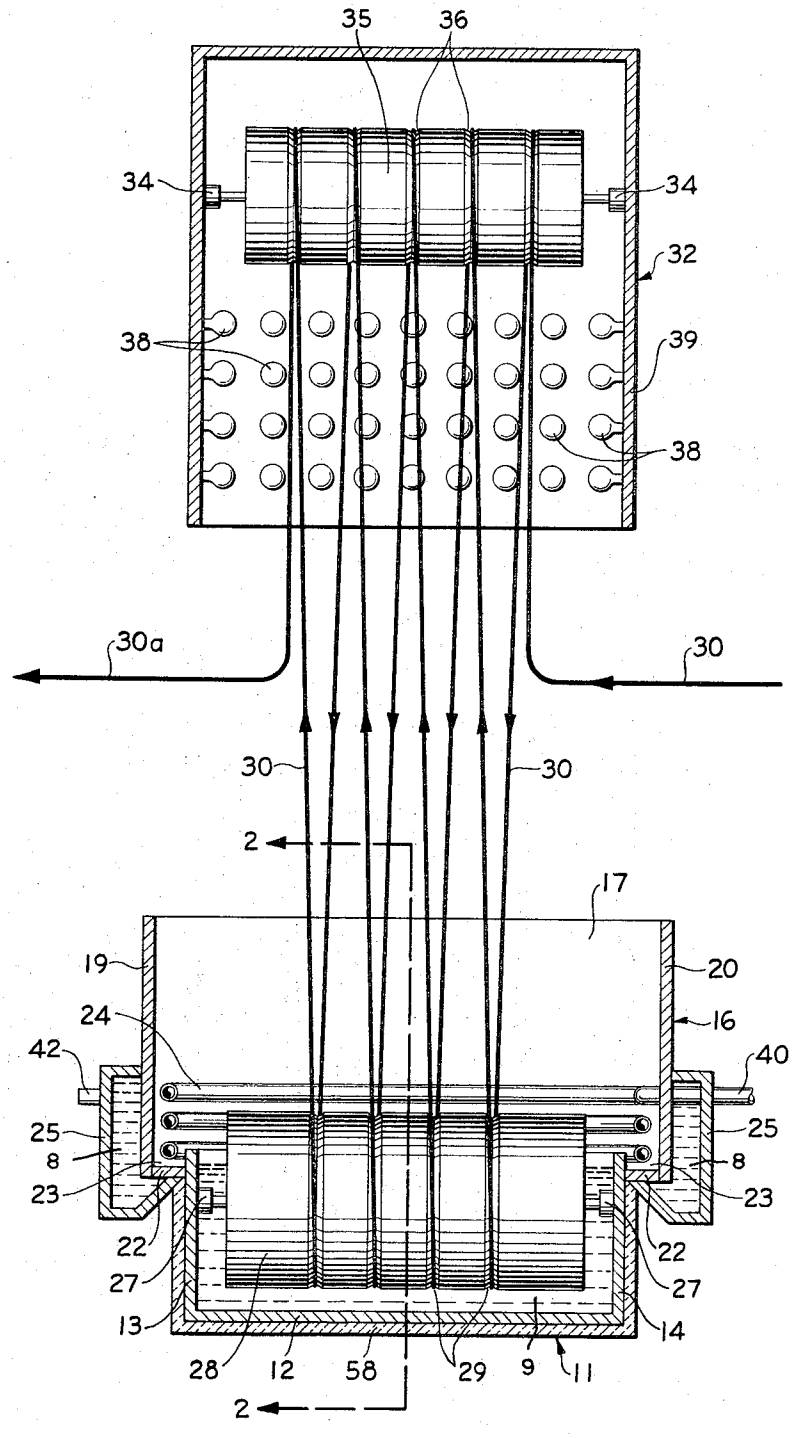


Fig. 1

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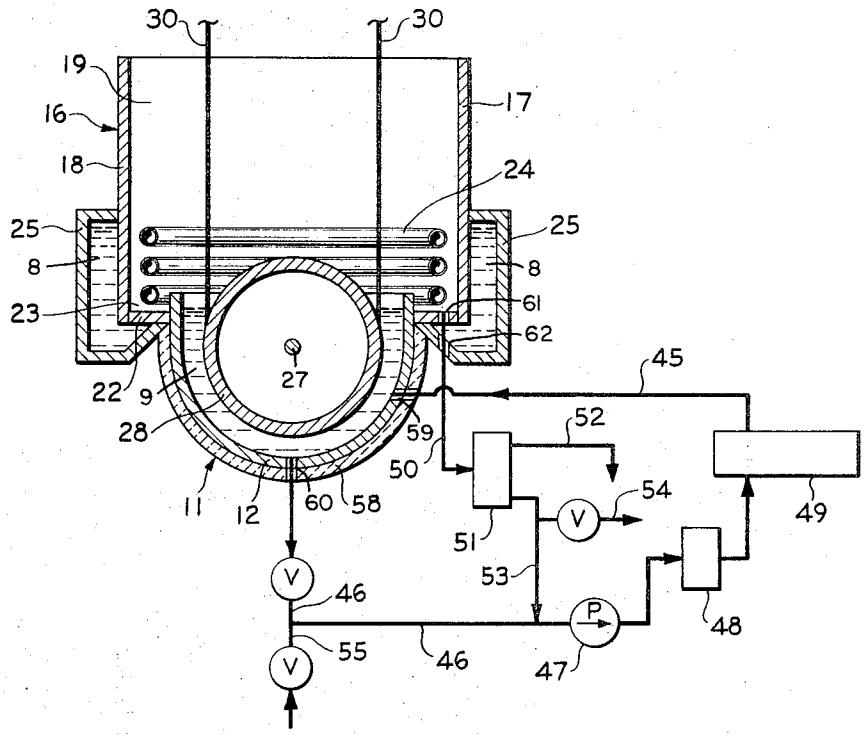


Fig. 2

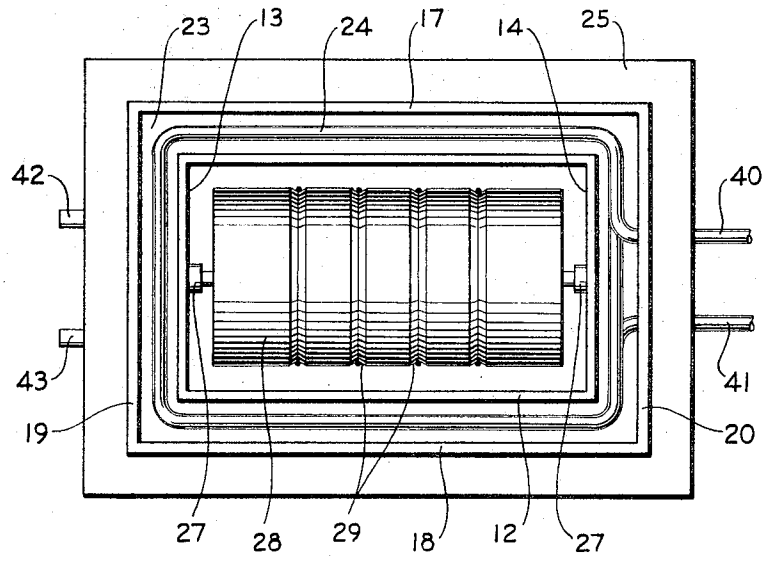


Fig. 3

United States Patent Office 3,338,738 Patented Aug. 29, 1967

3,338,738

METHOD AND APPARATUS FOR APPLYING A HALOGENATEDHYDROCARBON SOLVENT-CONTAINING ENAMEL TO WIRE

Otto H. Lindemann, Buffalo, N.Y., assignor to Hooker Chemical Corporation, Niagara Falls, N.Y., a corporation of New York

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This invention relates to wire-enameling apparatus and is particularly concerned with apparatus of the character mentioned which is intended for use with coating compositions held at elevated temperatures.

It is an object of the present invention to provide novel apparatus by which wire-enameling with hot, substantially non-flammable volatile solvent-based, coating compositions can be conveniently and economically carried out.

Another object of the invention is to provide novel apparatus of the character described which is simple and inexpensive to construct.

Still another object of the invention is to provide a satisfactory process for enameling wire with hot, substantially non-flammable volatile solvent-based, coating compositions.

Other objects and advantages of the invention will be apparent from the following description thereof taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a vertical sectional view of apparatus according to the invention;

FIGURE 2 is a sectional view taken on line 2—2 of FIGURE 1 of the coating tank shown in FIGURE 1; and

FIGURE 3 is a top plan view of the coating tank shown in FIGURE 2.

Hitherto no apparatus has been available for efficient wire enameling with hot liquid coating compositions which include substantial quantities of volatile, non-flammable, solvents, preferably halogenated hydrocarbon solvents such as trichloroethylene, perchloroethylene, carbon tetrachloride, and the like and which are generally maintained during use at temperatures below the boiling points of the solvents. The apparatus of the present invention makes possible the continuous application to a wire of a succession of films of enamel and the necessary baking of the several films while at the same time avoiding loss of the expensive volatile solvent.

Since the compositions used for hot-dip wire enameling in general tend to be somewhat thermally unstable it is contemplated that the coating bath shall occupy a relatively small volume. This has the additional advantage that it facilitates the maintenance of the proper proportions of ingredients in the composition in the coating bath.

In accordance with the present invention, the subject process for coating wire comprises passing a wire to be coated through a halogenated hydrocarbon vapor zone into a hot coating composition comprised of film forming ingredients and a halogenated hydrocarbon solvent for at least the major portion of the film-forming ingredients, said coating composition being at a temperature below the boiling point of the solvent, removing the wire from the coating composition and again passing it through the halogenated hydrocarbon vapor zone, repeating the above procedure so as to form on the wire successive films of

the coating composition and subjecting the wire to heating between successive passages through the coating composition, thereby reducing the solubility of the film of coating compositions on the wire.

Referring more specifically to the drawings, the numeral **11** designates a coating tank which is substantially rectangular in shape at its upper end and is adapted to hold a liquid coating composition bath **9**. The tank **11** comprises an elongated, trough-like body **12** of U-shaped cross section having ends **13** and **14**. Around the upper end of the tank **11** and extending outwardly and upwardly therefrom is a rectangular enclosure **16** which comprises sides **17** and **18** and ends **19** and **20**.

At the bottom of the enclosure **16**, a flange or rim **22** projects inwardly from the sides and ends thereof and is attached to the tank **11** below the upper extremities of the body **12** and the ends **13** and **14**, whereby to form a peripheral trough **23** around the upper edges of the tank **11**. The trough **23** is provided to catch solvent condensed on the cooling coils **24** which are suspended by any suitable means and extend around the inner periphery of the base of the enclosure **16**. A peripheral cooling jacket **25**, containing a coolant **8** is provided around the exterior of the base of the enclosure **16** and under the flange or rim **22**. Thus, the jacket may serve to cool the contents of the trough **23**. It is desirable that the solvents condensing and collecting means, which includes the coils **24**, the jacket **25** and the trough **23**, be positioned in the coating section of the apparatus in such a manner that only a relatively small vapor zone is formed between the upper surface of the coating composition **9** in the tank **11** and the lowermost cooling coil **24**. Often, it has been found that good results are obtained when the height of the vapor zone is not greatly in excess of about 3 to 4 inches, although under some operating conditions appreciably larger vapor zones, e.g., 10 to 15 inches, may be used and still yield acceptable results. Generally, it is desirable that the vapor zone not be of such size that appreciable vapor washing of coating on the product takes place under the operating conditions used.

Rotatably supported in bearings **27** in the tank **11** is a coating drum or roll **28** which is provided with a plurality of longitudinally spaced, peripheral grooves **29** adapted to receive the wire **30**. Preferably, the diameter of the drum **28** is relatively large with respect to the width of the tank **11**, so that the volume of the coating bath will be relatively small.

Spaced from and above the coating tank **11** is a drying of curing section designated generaly by the numeral **32** and suitably supported by means not shown. The curing section **32** may be of any suitable configuration, but conveniently may be a rectangular box-like structure having an open side which is directed downwardly approximately vertically over the coating tank **11**. Within the curing section there are provided spaced bearings **34** for supporting a roll or drum **35** which is preferably parallel with the drum **28**. The roll **35** is provided with a plurality of longitudinally spaced, peripheral grooves **36** which are preferably aligned with grooves **29** on the drum **28**. Around the interior walls of the lower portion of the section **32** are a plurality of heat lamps **38**, suitably connected to a supply of electrical current by means not shown. There is thus provided an oven portion **39** by means of which the wire **30** may be heated.

In using the apparatus described above, the wire **30** is fed around the drums **28** and **35** from a rotatably supported supply reel (not shown), the leading end **30***a* of the wire being secured to a take-up reel (not shown) which may be driven by any suitable means to pull the wire through the apparatus. The wire is held against endwise movement on the drums by the aligned grooves **29** and **36**, and the drums, as well as the supply reel, are freely rotatable. The tank **11** is then filled with the hot, liquid coating composition to form a coating bath **9**, the cooling coil **24** is connected by pipes **40** and **41** to a suitable source of coolant (not shown), and the jacket **25** is also connected by pipes **42** and **43** to a suitable source of coolant (not shown). When the heat lamps **38** in the oven portion **39** are supplied with electrical energy the apparatus is ready for use and the take-up reel (not shown) may be rotated to pull the wire **30** through the system.

As will be apparent, the bare wire **30** entering the apparatus is heated in the oven portion **39** and then passes downwardly through the vapor zone formed between the cooling coils **24** and the upper surface of the coating composition into the coating bath **9**. As the wire emerges from the bath and passes back through the vapor zone, a substantial portion of the volatile solvent in the coating composition flashes off from the film of coating composition on the wire since its vapor pressure is quite high at the temperature of the bath. After passing through the vapor zone, the coated wire passes through the zone between the coating section and the curing section of the apparatus. In this area, generally, substantially all of the the solvent in the film of coating composition, which was not flashed off in passing through the vapor zone, is removed before the wire comes into the curing section. This solvent removal area may be open to the atmosphere, as shown in the drawing. If desired, it may be enclosed and may contain air, or some other gas which is non-reactive or is not objectionably reactive with the coated wire, e.g., nitrogen. In some instances it may be under vacuum. The wire carrying the residual, substantially dry and solvent-free film then passes into the curing section **32** and over the drum **35** and while in the oven **39** is baked sufficiently to substantially insolubilize the film thereon. Because little, if any, solvent is left to be driven off from the film in the oven **39**, there is substantially no surface deformation of the film as would normally be caused by the rapid release of large amounts of solvent in this zone. Accordingly, when the wire leaves the oven and again runs through the coating bath, around the drum **28**, the film already on the wire is substantially continuous and is not dissolved but another film is deposited on the previously applied one.

The wire is repeatedly passed around the drums **28** and **35** so that a succession of insoluble films of enamel or the like is applied thereon until the coating is of the thickness desired. The number of passages through the bath is determined by the number of times the wire passes around the drum **28**. Preferably, a separate groove **29** is provided on the drum for each such passage.

Obviously, the coating material in the tank **11** will change in composition over a period of time because of evaporation of solvent. It is therefore preferred to circulate the coating material continuously during operation of the apparatus. The proportions of the ingredients in the coating composition may thus be maintained constant, new ingredients being added as required. It will be seen that the relatively small volume of the coating bath will result in the complete renewal of the bath at frequent intervals as it is used and new ingredients are added.

In FIGURE 2, the general design of the circulatory equipment and connections employed are shown schematically. Hot coating material of the desired composition is supplied to the tank **11**, adjacent the top thereof, through the line **45**, passing through the inlet **59** in the insulation **58** and the trough body **12**. At the bottom of the tank **11** is a valved drain line **46** which passes through the outlet **60** in the trough body **12** and the insulation **58** and runs to a pump **47** that circulates the coating material withdrawn from the tank through a filter **48** and a heater **49** to the line **45**. The solvent which evaporates from the surface of the coating bath, and from the films of coating material on the wire **30**, condenses on the coil **24** and drips into the trough **23** from which it is withdrawn through the line **50**, passing through the outlet **61** in the trough **23** and the outlet **62** in the cooling jacket **25**, and is led to a separator **51**. In the separator the solvent, being heavier than water, settles out of the associated condensed water vapor. The latter is led by the line **52** to waste, while the solvent is returned to the inlet of pump **47** through the line **53**. In order to control and adjust the composition of the coating material, solvent may be withdrawn from the system through the valved line **54** and additional film-forming ingredients may be admitted through the valved line **55** which connects to line **46**.

It must be kept in mind when considering the apparatus and the wire-enameling process described herein that the apparatus is particularly designed for efficient operation with a process that involves the use of hot, liquid coating compositions which comprise film-forming ingredients and, as a solvent for at least the major portion of said ingredients, a relatively heavy, low-boiling, substantially non-flammable, halogenated hydrocarbon solvent such as trichloroethylene, carbon tetrachloride, perchloroethylene, the trichloroethanes, the tetrachloroethanes, methylene chloride, ethylene dichloride, ethylidene chloride, the dichlorotetrafluoroethanes, the trichlorotrifluoroethanes, the trichlorodifluoroethanes, the tetrachlorodifluoroethanes, the fluorotrichloroethanes, the fluorotetrachloroethanes, methyltrichloroethylene, 1,2-dichloropropane, 1,2-dichloropropene, 1,1,2-trichloropropane, ethyltrichloroethylene, mixtures thereof, as well as other halogen analogs of the above. As will be noted, these materials are generally of about 1 to 4 carbon atoms and about 1 to 6 halogen atoms. Of these, the preferred material is trichloroethylene. It is also to be remembered that for most efficient results a coating composition of the type described should be maintained at a temperature which is not greatly lower than that at which the solvent boils.

In the use of the novel apparatus of the invention, the material used for the enamel coating on the wire is not critical. Various suitable compositions with or without pigments are well-known and many are commercially available. Accordingly, there is no need for specifically setting forth here the formula of any particular composition. Suffice it to say that alkyd resins, phenolic resins, epoxy resins, polyurethane resins and the like are examples of the resins which may be used. The temperature at which the coating bath is maintained will vary according to the composition thereof and particularly in accordance with the specific solvent employed. For example, in some instances, temperatures which are 40–50 degrees centigrade below the boiling point of the solvent may be used. In general, it is preferred to maintain the composition at a temperature only slightly below the boiling point of the solvent used, e.g., 2–25 degrees centigrade. Thus, when using a coating composition based on trichloroethylene as a solvent, the coating material will preferably be heated by the heater **49** to such a temperature as will maintain the bath at about 70–80 degrees centigrade. A layer of insulation **58** may be provided around the tank **11** to assist in keeping the temperature of the bath constant.

Important in achieving the highly efficient operation of the apparatus of the present invention are the building up of a coating layer of desired thickness by successive passages of the wire through the same coating bath, the use of a coating bath of relatively small volume, whereby the composition and temperature of the bath may be better

controlled and maintained constant, and the use of highly efficient condensation means for the volatile solvent.

The first two of the points mentioned above permit economy of space as well as equipment since a plurality of coating tanks are not necessary and the single tank used need be only slightly larger than the drum **28**. The third point referred to is the positioning of the solvent condensing and collecting means in the coating section of the apparatus so as to form the relatively small vapor zone referred to hereinabove. This small vapor zone is desirable in that there is a smoothing or leveling of the coating on the wire as it passes out of the coating bath and through this zone, without excessive removal of the coating film. Additionally, in passing downwardly through this vapor zone into the coating bath, after passing through the curing section, a conditioning of the coated wire surface may be considered to take place to make it more receptive to the next layer of coating. This conditioning may be the result of a slight swelling of the outermost portion of the coating by the solvent vapors in the vapor zone. To further illustrate the advantages of the present process, conventional wire enameling, as generally practiced at present, takes place at room temperature. That is, the paint is at room temperature. Secondly, ordinary wire enamel contains a blend of an aliphatic solvent with an aromatic solvent whereby the KB value (a measure of solvency) is less than 80.

The present trichlor enameling process takes into account the high solvency of the trichloroethylene (about KB 133) and the relatively high temperature of application viz. circa 180 degrees Fahrenheit. It is well known that paint adheres poorly (in most cases) to smooth, baked enamel surfaces and every advantage is needed to improve this adherence. The high solvency of the trichlor in the trichlor enamel and the high temperature of application tend to soften and swell the baked-on enamel. At the same time, the elevated temperature increases the wetting power of the paint being applied.

The vapor zone above the liquid paint allows a faster movement of the wire through the paint because more time is allowed for free leveling before setting of the paint takes place.

It will be appreciated that although the present apparatus has been described in its most preferred embodiment as having the solvent collecting trough **23** positioned laterally outwardly from the tank **11**, this trough may be formed so as to be within the tank, if desired. Also, it will be understood that there are other possible variations in the process and apparatus herein disclosed so that numerous modifications in the apparatus shown may be made without departing from the spirit of the present invention. For example, while the apparatus is preferably formed of metal, the kind of metal may vary. Additionally, of course, the size of the apparatus including the number of grooves in the drums **28** and **35** may be varied as desired, and so may be the shapes and arrangements of various components. Moreover, the apparatus and process of the present invention may be used with substantially non-flammable solvents other than the halogenated hydrocarbons with comparable results. Accordingly, it is to be understood that it is intended that each element recited in any of the following claims is to be understood as referring to all equivalent elements for accomplishing substantially the same results in substantially the same or equivalent manner, it being intended to cover the invention broadly in whatever form its principle may be utilized.

What is claimed is:

1. A process for coating a wire which consists essentially of passing a wire through a halogenated hydrocarbon vapor zone into a hot coating composition comprised of film-forming ingredients and a halogenated hydrocarbon solvent for at least the major portion of the film-forming ingredients, said coating composition being at a temperature below the boiling point of the solvent, removing the wire from the coating composition, effecting leveling and smoothing of the thus-deposited film of coating composition by again passing it through the halogenated hydrocarbon vapor zone, said vapor zone being of a size such that substantially no vapor washing of the film of coating composition takes place, repeating the above procedure so as to form on the wire successive films of the coating composition and subjecting the wire to heating between successive passages through the coating composition, thereby reducing the solubility of the film of coating composition on the wire.

2. A process as claimed in claim **1** wherein the wire is heated before its initial passage through the coating composition.

3. A process as claimed in claim **2** wherein the temperature of the coating composition is within the range of about 2 to about 25 degrees centigrade below the boiling point of the solvent.

4. A process as claimed in claim **2** wherein the coated wire is passed through a solvent removal zone after passing through the solvent vapor zone and before being reheated, whereby substantially all of the solvent in the film coating, not removed in passing through the vapor zone, is removed before the coated wire passes into the heating zone.

5. A process as claimed in claim **4** in which coating composition is continuously withdrawn from said bath and additional hot coating composition is fed to said bath.

6. A process as claimed in claim **5** in which the solvent vapor in the solvent vapor zone is condensed and recovered.

7. Wire coating apparatus for use with hot coating compositions that include film-forming ingredients and a halogenated hydrocarbon solvent for at least the major portion of the film-forming ingredients, said coating composition being used at a temperature below the boiling point of the solvent, which consists essentially of, a coating section and a curing section, the coating section consisting essentially of a container adapted to hold the hot coating composition, solvent condensing and collecting means positioned in the coating section so as to form a relatively small halogenated hydrocarbon solvent vapor zone immediately above the surface of the coating composition in the container, said vapor zone being of a size such that substantially no vapor washing of the film of coating composition on the wire takes place and means for repeatedly passing a wire through the coating composition, so as to pass through the solvent vapor zone, both before and after passing through the coating composition, and the curing section consisting essentially of means adapted to heat the wire between passages thereof through the coating composition.

8. Apparatus as claimed in claim **7** wherein the solvent condensing and collecting means consists essentially of a cooling coil around the upper portion of the container, above the level of the coating composition, a trough positioned below the cooling coils and adapted to collect condensed solvent vapor and a cooling jacket surrounding at least a portion of the underside of the trough.

9. Apparatus as claimed in claim **8** wherein the curing section of the apparatus is spaced apart from the coating section.

10. Apparatus as claimed in claim **9** wherein the area between the coating and curing sections of the apparatus is sufficient to provide a solvent removal zone wherein substantially all of the solvent remaining in the coating composition on the wire, after passage through the vapor zone, is removed prior to passing into the heated portion of the curing section.

11. Apparatus as claimed in claim **10** in which the means for repeatedly passing the wire through the coating composition is a rotatably supported drum, positioned within the container.

12. Apparatus as claimed in claim 11 in which the coating container is a tank which is substantially rectangular at its top.

13. Apparatus as claimed in claim 12 in which the rotatably supported drum in the tank has a diameter which is relatively large with respect to the width of said coating tank.

14. Apparatus as claimed in claim 13 in which means is provided for withdrawing coating composition from said tank and for supplying hot coating composition to said tank.

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ALFRED L. LEAVITT, *Primary Examiner.*

J. R. BATTEN, JR., *Assistant Examiner.*