Jan. 26, 1960 E. F. KEMPEN 2,922,725

METHOD OF APPLYING A THICK FILM COATING TO ARTICLES BY DIPPING

Filed Oct. 10, 1955 2 Sheets-Sheet 1

FIG. 1.

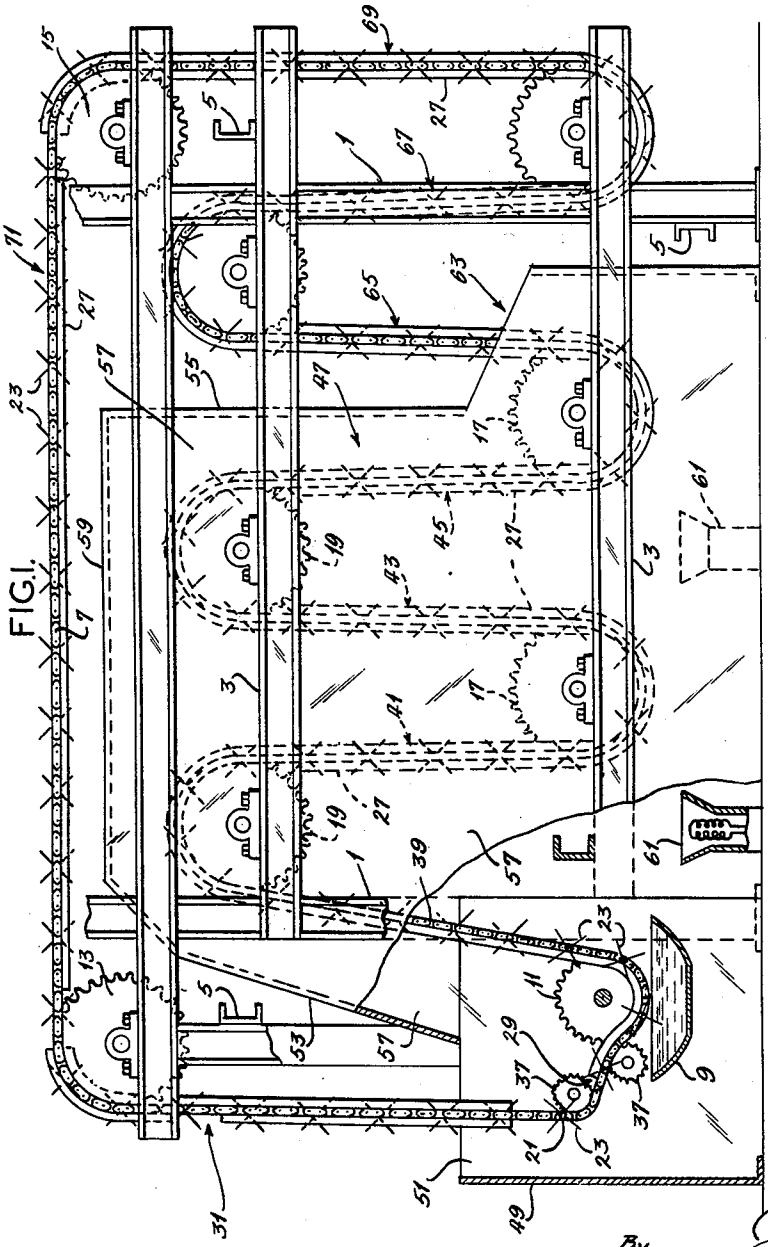
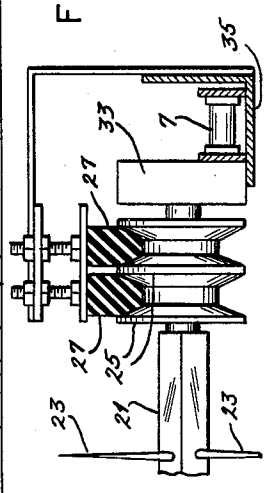


FIG. 3.



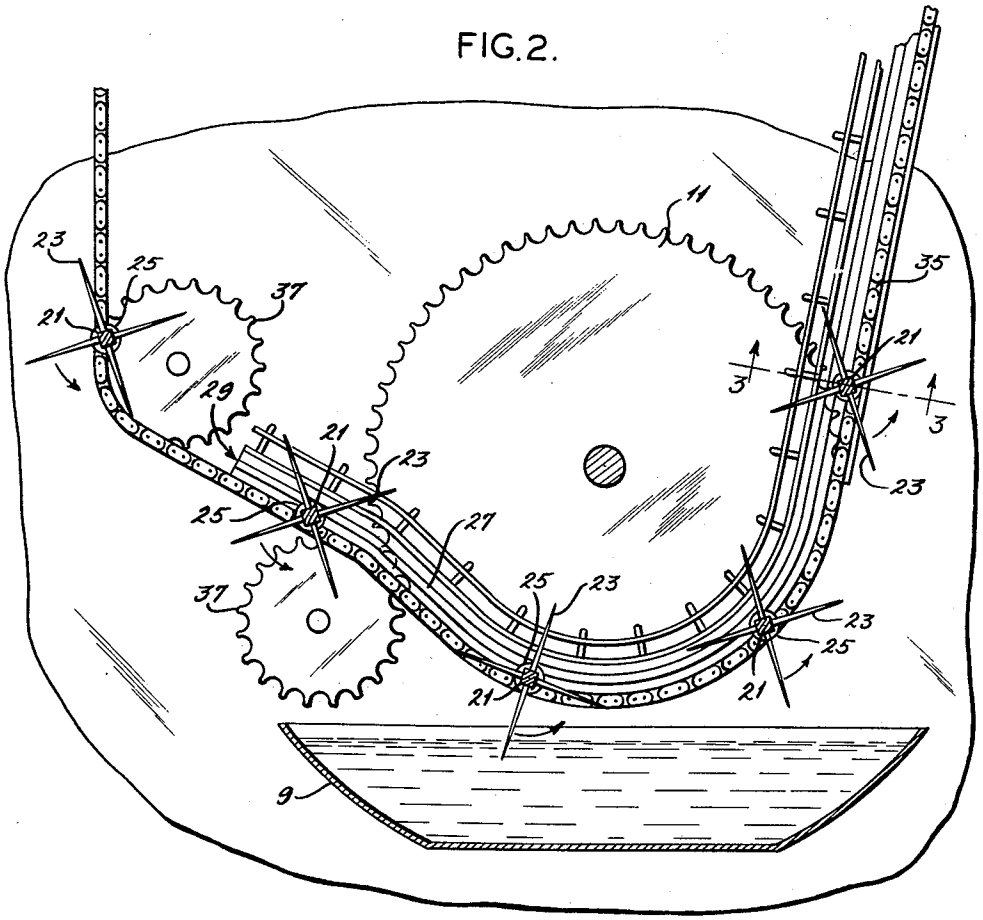
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FIG. 2.



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2,922,725

METHOD OF APPLYING A THICK FILM COATING TO ARTICLES BY DIPPING

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2 Claims. (Cl. 117—113)

This invention relates to the application of lacquer-type coatings, and more particularly to apparatus and methods whereby a thick film of high quality is applied by dipping to such articles as wood shoe heels.

It will be understood that the dipping processes heretofore followed have been of two well defined types. The so-called slow dip involves use of a fast-drying lacquer and a relatively slow withdrawal from the solution. In practice, the rate of withdrawal is such that the coating dries immediately as the article is withdrawn, the speed of withdrawal being equal to the slight downward flow of the lacquer, for example two to six inches per minute. With this procedure, the coating solution is of high viscosity or relatively immobile, and the solvents are very fast. The process is subject to limitations, however, in that it is rather sensitive to the drying conditions, such as room temperature and humidity. Also, it is difficult to avoid the formation of a bead as the object leaves the dip tank. The formation of the bead is somewhat counteracted by upsetting the article immediately after leaving the tank, but flow of the lacquer is hindered by the highly volatile solvents, and such inverting of the article is not easily accomplished because of the necessity otherwise for a slow withdrawal from the coating solution.

The so-called fast dip differs in that the article is quickly pulled from the tank so that a substantial excess of lacquer is picked up, the excess being permitted to drain back into the tank. In this case, slow-drying solvents and low-viscosity coating solutions are desired in order to achieve good flow, but for these reasons, the resulting film tends to be thin and non-uniform.

Accordingly, this invention is directed to apparatus and a process by which a relatively thick film of high quality is produced. A thick film is sometimes desirable for the additional strength and also because it tends to conceal imperfections in the underlying surfaces to be coated.

Briefly, the article is withdrawn from the coating solution at a rapid rate so that there will be a substantial excess of mobile solution, but this excess is not permitted to drain into the tank. Instead, the article is rotated but at a speed sufficiently slow to provide a substantial degree of gravity-induced flow. Ideally, the rate of rotation should be such that the coating flows substantially from end to end of the article, yet the rotation is not so slow as to permit dripping. The coating solution used in this process should have good flowing qualities and a prolonged drying time such that the article may be rotated on the order of one hundred times before all flow ceases.

The machine comprises a pair of vertically-disposed laterally-spaced endless chains, which are trained about sprockets so as to be driven in a closed path of substantial length. One set of sprockets is disposed immediately over the dip tank, and rotatable rods are carried by the chains to span the space therebetween, the rods preferably being removably secured. The articles to be dipped are attached to spikes, which project radially from the rods at spaced intervals therealong; and the rods are provided with small track wheels, which engage with a fixed track extending over the dip tank and for a substantial distance therebeyond.

As mentioned previously, the rate of article rotation should be such as to provide maximum flow but without dripping, hence the speed of article rotation will depend upon the flow characteristics of the lacquer. The lacquer should initially have a marked tendency to flow such as would dictate a revolution every thirty seconds. Also, the lacquer should have a relatively prolonged drying time during which over one hundred reversals of flow may occur. The drying time between dips is determined by the speed and length of the chains, whereas the speed of article rotation is determined by chain speed and the effective diameter of the track wheels. These matters are of critical importance, and it has been found that the chain length should be from 350 to 550 times the effective diameter of the track wheels. In order to provide for quick withdrawal of the articles from the coating solution, the article-carrying spikes should project substantially beyond the track wheels; for example, the effective diameter of the spikes should be over four times that of the track wheels.

Another factor of some importance is the solids content of the coating solution, not only because of the effect upon the flowing qualities but also because it determines the thickness of the resulting film. In general, the viscosity should be of the order of thirty-five seconds, as measured with a No. 4 Ford cup, and the solids content should be as high as possible. In cold dip processes, low-viscosity nitrocellulose is recommended in order to permit a high solids content, but the solids content may be raised additionally without corresponding increase in viscosity, provided the solution is heated. Indeed, volatile solvents might be entirely eliminated by using a hot melt. The hot dip processes, although similar to the cold dip process, require additional measures to guard against premature setting of the film. This is accomplished by providing the machine with two distinct sections, the section immediately adjacent the dip tank being enclosed and heated so as to delay solidification of the coating, during which delay the article is continuously rotated and the coating caused to flow as above described.

Other features of the invention will be in part apparent from and in part pointed out in the following description taken in connection with the drawings, in which:

Fig. 1 is a side elevation of a coating machine embodying features of this invention;

Fig. 2 is a detailed vertical section illustrating that portion of the machine adjacent the dip tank; and

Fig. 3 is a section taken on the line 3—3 of Fig. 2.

In understanding the invention, it will be helpful to view the process as involving several stages. First, the article is withdrawn quickly from the dip tank so as to pick up what might be termed an excess of lacquer, which normally would drain back into the tank. As the article is withdrawn, it is rotated so as to prevent such drainage, and the speed of rotation is of critical importance. Rotation should be slow enough to provide gravity-induced flow to the maximum degree, but not so slow as to permit accumulation at the lower surfaces to a point where dripping would commence. If the speed of rotation is adjusted to the point where dripping almost occurs, the ideal state is achieved, and the lacquer will initially flow from end to end of the article with each revolution of the article. This is important in that drying of the lacquer is facilitated and that the film thickness is more uniform.

It should be understood, however, that this maximum range of flow does not continue, because the solution gradually becomes more viscous with loss of solvents or reduction in temperature. The maximum range of flow

could be preserved if the speed of rotation were reduced with increase in viscosity, but this is considered impractical in most applications. As a consequence, the center portions of the article will have a somewhat thicker film, but the change in thickness is very gradual and does not detract from appearance. In practice, the flow is reversed over one hundred times, hence any tendency towards formation of ridges is so slight as to be unnoticeable.

As indicated previously, the flow characteristics of the lacquer are important in this process and in the use of the machine. Perhaps, the most important factors effecting flowing qualities would be the solvents, diluents and temperature. In a cold dip process, the lacquer should have a substantial proportion of slow solvents. Such medium boiling solvents as butyl acetate, Cellosolve, methyl Cellosolve and butyl alcohol should be included, although it is permissible to employ relatively faster solvents, such as methyl isobutyl ketone, isopropyl acetate and ethyl acetate, in combination with the above. A relatively slow diluent, such as xyluol (xylene), is preferred, although toluol (toluene) might also be utilized. In practice, it has been found that a dipping viscosity of approximately thirty-five seconds, as measured by a No. 4 Ford cup, produces the best results, but the range of thirty to forty seconds is operative.

In the cold dip process, the solids content would be about twenty-five percent by weight, and it will generally be desirable to provide for a sufficient number of dipping steps in order to achieve the most durable and finest finish. Low-viscosity nitrocellulose (one-fourth or one-half second) is preferred in order to provide for a relatively high solids content, but the lacquer composition otherwise would be conventional in including the usual amounts of resin, plasticizer, solvents and diluents. The solution should be one that would solidify in from thirty to fifty minutes under normal atmospheric conditions. In other words, from seventy-five to ninety percent of the solvents would be released within this time.

Referring now to the drawings, the machine is shown to comprise a fixed framework of vertical posts **1**, horizontal side members **3** and transverse frame members **5**, the side members **3** supporting sprockets for a pair of endless chains **7**. A dip tank **9** is provided at the front of the machine, and one set of sprockets **11** is mounted immediately over the tank. A second set of sprockets **13** is mounted on the upper front portion of the machine and a set of sprockets **15** is mounted at the upper rear portion. Otherwise, the endless chains extend over a lower series of sprockets **17** and an upper series of sprockets **19** with the chains extending back and forth between sprockets **17** and **19** so as to provide a compact arrangement. A low speed electric drive is then provided to move the chains synchronously in the direction indicated.

The machine is adapted to be loaded from the front with rotatable rods **21**, which are removably carried by the chains to span the space therebetween. Each rod in turn is provided with a series of radially-projecting spikes **23**, upon which the articles to be coated are attached. In normal practice, the articles would be impaled on the spikes prior to the attachment of the rods to the carrying chains, the articles being wood or otherwise adapted to be impaled. In addition, each rod has one or more wheels **25**, which engage with a track **27**. For reasons that will be more apparent, the track wheels **25** are as small as practical. In order to provide an adequate frictional driving engagement, the wheels may be in the shape of shives, there being four such shives for each rod; and the track is in the form of a V-belt, there being four such belts cooperable with the four shives.

The track **27** commences at **29** as the articles approach the dip tank and continues along the path of the chains to the upper portion **31** of the loading zone. Initially, the track is on the inside of the chains where they pass about the sprockets **11, 13, 15** and **17** but is on the outside where the chains pass about the sprockets **19**.

Referring more particularly to Figs. 2 and 3, the bearings or journals **33** are fastened to the chains at spaced intervals therealong, so as to accommodate the rotatable transverse rods **21**. These journals are on the outside of the chain, at least at the front portion of the machine, and the chains may be guided between the sprockets on guide members **35** of angle cross section. The ends of the rods **21** are adapted to be rotatably received within the bearings, and the arrangement at the front of the machine permits a slight spread of the chains or otherwise provides for insertion and removal of the rods. As the rods move toward the dip tank **9**, the chains may be guided over some smaller sprockets **37** where the track wheels **25** engage with the track. As a result, the rods begin to rotate, the sweep through the tank being in the same direction as the movement of the chains. The articles are lowered into and lifted from the tank as they pass about the primary sprockets **11**, the sprocket size being such that the articles are dipped only once as they move thereabout.

The speed at which the articles are withdrawn from the dipping solution is important, because it determines the amount of coating composition picked up on the article. The speed should be sufficient to pick up a substantial excess of mobile coating material, and a rate of withdrawal on the order of fifty inches per minute is recommended for the cold dip application. The rate of withdrawal is controlled by the speed of rod rotation and the length of the spikes. Since the speed of rotation will be fixed by other considerations, the spike length is the principal variable. It has been found that the effective diameter of the spikes should be at least four times that of the track wheels. Any substantial increase in spike length has adverse effects upon the size of the machine, but the centrifugal effect may be ignored by and large.

Rotation continues as the articles move vertically along the straight sections **39, 41, 43** and **45**, which form an initial flow stage **47**. During this time, the coating is caused to flow smoothly over the articles to the maximum extent.

With passage of time, some of the solvents leave the coating, and it becomes less mobile. Accordingly, the extremities of flow, which initially should be from end to end of the article, gradually retreat toward the center portions. This action might be better understood if the mobile portion of the lacquer is considered as a glob, which moves back and forth, the glob gradually thickening and the range of movement gradually decreasing as the article is conveyed through the first stage **47** of the machine. The rate at which the coating loses its mobility must be slow, however, if ridges are not to be formed in the final film. Ideally, the number of revolutions of the article should approach and preferably exceed one hundred before all flow ceases, but cessation of flow should not normally occur in the first stage **47**.

In other words, the approach should be one of providing for maximum flow (a mobile coating and slow rotation) together with a large number of flow reversals (gradual loss of mobility and many revolutions). The mobility or flow quality of the coating is determined by the initial viscosity and solvent selection, as well as by the humidity and temperature conditions of the air about the articles as they move through the first stage of the machine. An initial dipping viscosity of thirty-five seconds (No. 4 Ford cup) is considered desirable, although this may vary as much as five seconds in either direction. The solids content should be as high as feasible without effecting the flow. In a cold dip, low-viscosity nitrocellulose (one-fourth or one-half second) is recommended because large quantities can be used without raising the viscosity of the solution.

The rate at which the coating loses its mobility may also be controlled by the selection of solvents, medium

and high boiling solids being used in order to provide a long drying period as well as good flow and gloss. If a hot dip is used, the solids content may be raised considerably, thereby providing for thicker films. In other words, the viscosity of the solution might be reduced by application of heat as well as by the solvents. For example, a hot dip solution of nitrocellulose might be held at a dipping temperature of 150° F. Indeed, the volatile solvents might be entirely eliminated by use of a hot melt, where the initial viscosity is achieved solely by means of non-volatile solvents or plasticizers and application of heat. Nitrocellulose, at least for the present, is not considered to be a good component for the hot melt coatings, ethyl cellulose and cellulose acetate butyrate being better adapted for such use. Actual compositions are disclosed in greater detail in my copending applications, Serial No. 466,847 and 504,888, filed November 4, 1954, and April 29, 1955, respectively, and now Patents Nos. 2,875,093 and 2,901,378, respectively.

As mentioned previously, a second way to control the mobility of the coating is by the humidity (moisture and solvent vapor content) of the surrounding air and by elevated temperature during the first stage of the machine. For example, it will be generally desirable to mount a baffle **49** across the front of the dip tank so as to prevent excessive air currents in this region. Baffles **51** may also be extended along the sides of the dip tank for the same purpose, but in a cold dip application for coating material it will generally be more simple to control the mobility of the coating by the selection of solvents rather than by variation of the humidity and temperature conditions. When resort is made to hot dipping, however, it will generally be necessary to substantially enclose the first stage of the machine in order to guard against premature solidification or excessively rapid loss of mobility. In such event, the temperature reduction is more gradual, heat being supplied from the dip tank and perhaps from additional sources, if necessary. In hot melt applications where no volatile solvents are found, the rate of solidification is determined solely by the rate of temperature reduction and supplementary heat will generally be necessary.

Enclosing walls for the first stage of this machine are illustrated in the drawings, there being a front wall **53**, a rear wall **55**, side walls **57** and a top **59** extending over sprockets **19** and beneath the path of the chains between the sprockets **13** and **15**. Provision for supplemental heating is indicated diagrammatically at **61**. It is suggested that the first flowing stage **47** of the machine be about equal in length to the drying stage, although the exact ratio would vary, depending upon the characteristics of the coating materials.

As the articles leave the first stage at **63**, they move through sections **65**, **67**, **69**, and **71**, which constitute a second drying stage. The track extends through all of these sections so that rotation will continue, although such rotation may not be necessary toward the end. Incidentally, the rate of rotation could be reduced because of the gradual loss of mobility in the coating, and this would be desirable but will not generally be economically feasible.

At some point during movement of the articles through the second drying stage, all flow of the coating should stop. In practice, the cold dip will solidify upon release of two-thirds of the solids but the second stage of the machine should be sufficiently long to insure such solidification under adverse drying conditions. For example, the solvent release might be two-thirds as the articles enter the section **65** and from seventy-five to ninety percent as they leave the section **71** and enter the loading zone at the front of the machine. In many instances, it will be desirable to have the articles cycle through the machine several times so that a relatively thick coating is built up. In the cold dip, three or four cycles would be generally desired in coating a wood core for a shoe heel. Upon completion of the desired number of cycles, however, the rods are removed at the loading zone and new rods inserted with uncoated articles.

The relation of the parts, especially the size of the track wheels **25**, the length of the spikes **23**, and length of the chains **7** as well as the speed of the chains, are of critical importance to the successful operation of this machine. In addition, the composition of the coating solution is important insofar as it effects the above-mentioned factors. Preferably, the solution should have flowing qualities or mobility such that the coating initially flows from end to end of the article with rotation of the article once every thirty seconds, and the track wheels accordingly should provide for rotation of the rods at the rate of two revolutions per minute. A greater initial mobility in the coating would require a faster rotation of the article; and since the overall drying time is somewhat proportionate to the initial mobility, the size of the machine would become impracticably large if the mobility and drying time of the lacquer were too large. On the other hand, any substantial reduction in the initial mobility and drying time of the lacquer is considered undesirable because of the adverse effects upon the quality of the finish.

It will be apparent that the rate at which the articles are rotated is determined by the size of the track wheels and the speed of the chains. The chain speed should be slow because the length of the chain determines the drying time, and an unnecessarily long chain would be required if the chain speed were too high. In practice, the limiting factor effecting chain speed is the size of the track wheels **25**. Wheels having an effective diameter much less than 1.25 inches are thought to be impractical, because of the loss in driving engagement with the track, and indeed with wheels of this size it is desirable to provide a V-belt arrangement with four such belts in order to insure an adequate driving engagement for rotating the articles. For similar reasons, the spikes should project upon opposite sides of the rods so that the rotational load will be balanced and no substantial force is required to turn the rods. With track wheels of the above-mentioned size, the desired article rotation is achieved when the chains are moved at a speed of about eight inches per minute. The total drying time of both stages should be on the order of sixty minutes when ideal flow conditions exist, hence a total chain length of at least forty feet and preferably fifty-five feet is desired, the extra chain providing for adverse conditions of operation and loading of the machine. As this works out in practice, the chain length should be from 350 to 550 times the effective diameter of the track wheels in order to achieve the proper relation between the number of flow reversals and final solidification of the coating.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. In the application of a coating to an article, the process that comprises dipping the article within a liquid coating composition having predetermined flow and solidifying characteristics, withdrawing said article from the coating composition at a speed substantially in excess of said predetermined flow characteristic so as to pick up a substantial excess of mobile liquid coating composition, immediately swinging the article about a horizontal axis at a predetermined speed just sufficient to prevent any drain of the coating composition from the article, said rotational speed thereby being sufficient to cause the excess mobile portion of the coating composition initially to flow substantially across the article, and continuing such swinging rotation uninterrupted at said predetermined speed until the coating composition solidifies, said coating composition being of a character such that solidification proceeds gradually as the excess mobile portion thereof flows back and forth across the article during rotation and complete solidification occurring only after the article has received a substantial number of revolutions.

2. The process set forth in claim 1, wherein said coating composition has a viscosity of approximately thirty-five seconds (No. 4 Ford cup) and contains relatively slow solvents, the article being rotated at a speed of two revolutions per minute, and being rotated on the order of one hundred revolutions.

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