

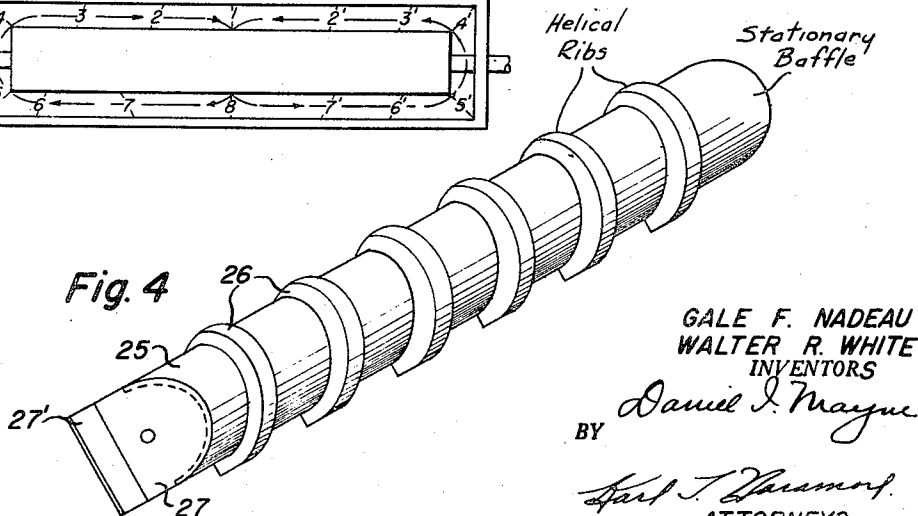
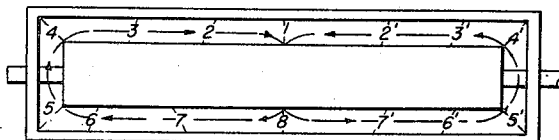
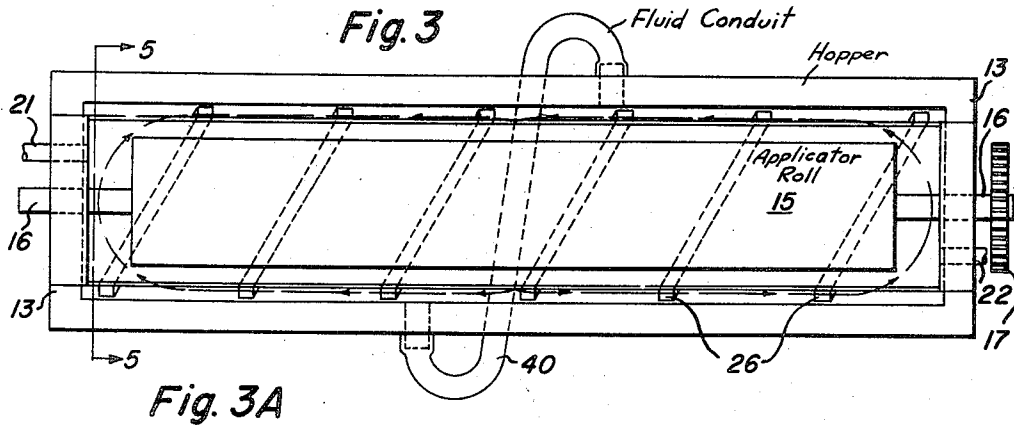
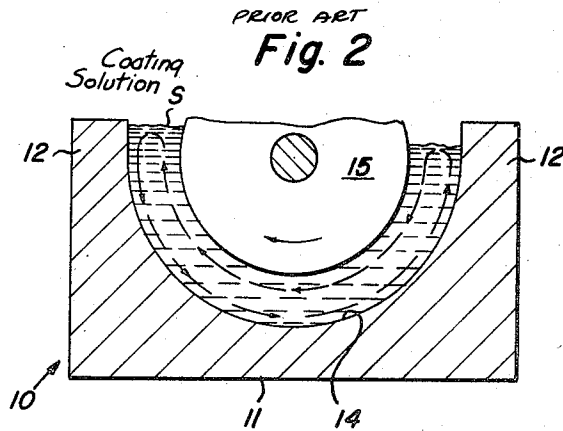
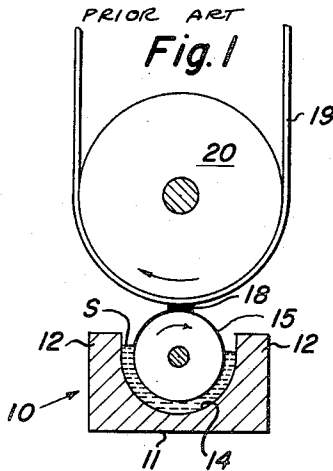
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W. R. WHITE ET AL
COATING APPARATUS

2,855,894

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2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 5

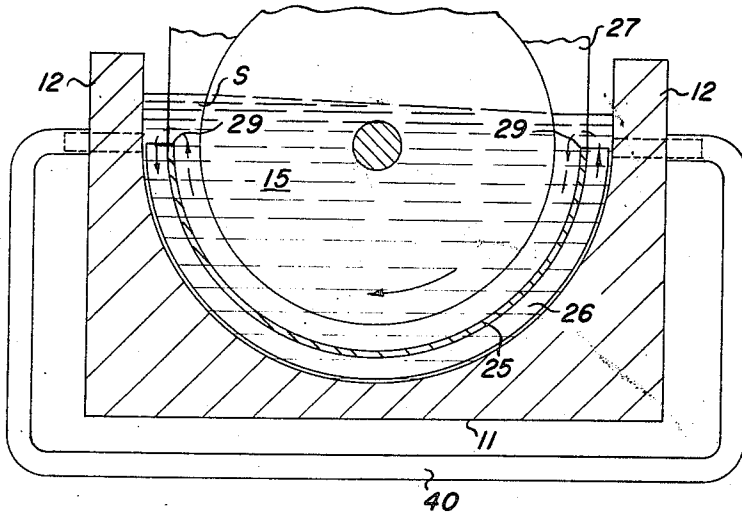


Fig. 6

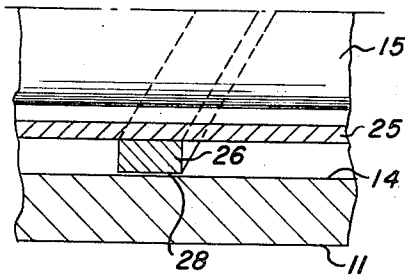


Fig. 6A

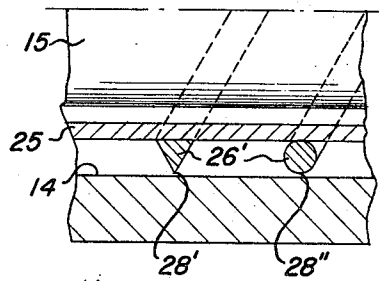
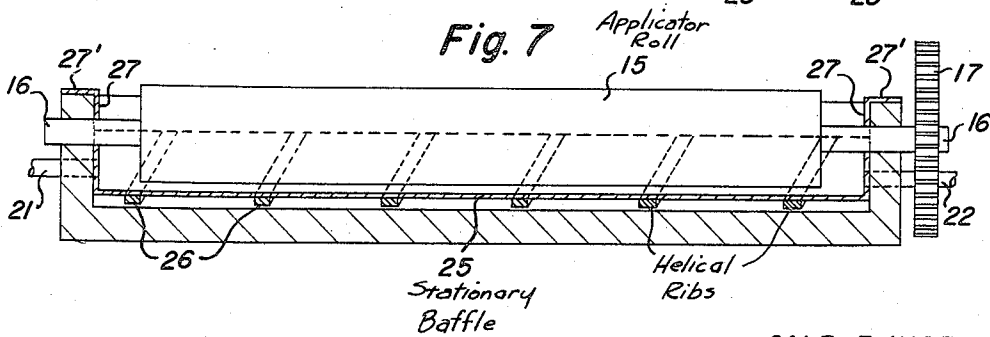


Fig. 7



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2,855,894

COATING APPARATUS

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5 Claims. (Cl. 118—258)

This invention relates to coating apparatus of the type comprising a hopper containing a quantity of coating solution with an applicator roll immersed therein, and particularly to means for obtaining a continuous stirring of the solution in the hopper without the use of a movable outside agency which might tend to transfer a flow pattern to the applicator roll which would in turn be transferred to the surface of the web being coated.

A well-known means of applying liquid materials to the surfaces of webs in a carefully controlled manner is known as roll coating. Such apparatus involves the use of an open-mouth hopper containing the coating solution in which is immersed a rotatable applicator roll. As the roll rotates, it picks up a regulated layer of solution on its periphery which it may then apply directly to the surface of a web or to a second applicator roll which in turn applies the coating to a web.

One big problem with this type of coating apparatus has been to obtain a continuous stirring of the coating solution in the hopper so that all points across the width of a web are coated with solution having the same physical and chemical characteristics. For instance, certain web materials which are to be coated, i. e. plastic webs, contain substances that dissolve in the coating bead and are then transferred by the applicator roll to the coating solution in the hopper. Many times this takes place unevenly along the length of the roll and equilibria are established in the hopper in which there are portions of the coating solution in the hopper differing from other portions. Also, when a coating solution is fed into the hopper at any point, as it travels along the hopper it tends to concentrate by either evaporation or by extraction from the plastic web being coated and, therefore, becomes different than it was when first introduced. Both of these phenomena eventually show a variation of some type of appearance in the coated web.

These and other difficulties with roller coating could be overcome if the liquid in the hopper could be continuously stirred in an efficient manner. When this is done by an outside agency, such as rotary or laterally moving paddles, they transfer a flow pattern to the roll which in turn is transferred to the surface of the web. They are also susceptible to vibrations, corrosion and ultimate contamination of the coating solution. Another method of circumventing the conditions described is to rapidly circulate the coating solution through the hopper. This has the disadvantages that sometimes flow patterns are set up, cumbersome equipment is needed or some coating solution is discarded and wasted.

The primary object of the present invention is to provide a coating apparatus of the type comprising an appli-

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cator roll immersed in coating solution contained in an open-mouth hopper and including means whereby a complete and efficient stirring of the coating solution is maintained in the hopper without the use of any movable outside agency or excessive pumping of the coating solution which might transfer undesirable flow patterns to the applicator roll.

Another object is to provide a coating apparatus of the type described with a solution stirring means which is stationary and makes use of flow currents normally set up in the solution in the hopper of such coating apparatus to obtain an efficient stirring action of the solution.

And still another object is to place between the bottom of the hopper and the applicator roll of a coating apparatus of the type described a plurality of partitions spaced from each other longitudinally of the roll and helically fashioned so as to obstruct the normal flow of that portion of the coating solution in the hopper which is concentric and counter to that of the roll and force that portion of the solution to move along the hopper axially of the roll.

A further object is to feed the coating solution into one end of the hopper and draw it from the opposite end, the draw off end being the one that the helical partitions act to direct the solution toward.

And another object is to place an arcuate baffle in the space between the bottom of the hopper and the applicator roll in concentric relation with the roll periphery and provide the convex side of said baffle with a plurality of helically fashioned ribs spaced longitudinally of the roll and extending to the bottom of the hopper to form the equivalent of the partitions mentioned above. Such construction not only allows the present invention to be readily added to existing coating apparatus as an accessory, but it permits easy cleaning of the hopper and accurately defines the portions of the solution in the hopper which are flowing in different directions concentric to the roll so that the partitions can be proportioned and properly positioned to affect the entire portion of the solution moving counter to the roll.

Another object is to place certain points on opposite sides of the hopper in direct communication so that added circulation of the solution can be obtained by virtue of the influence of gravity resulting from changes in contour levels of the solution at different parts of the hopper and which are characteristic of such coating apparatus.

Briefly, the present invention makes use of the currents of flow and changes in contour level found to be set up in the coating solution contained in the hopper by rotation of the applicator roll to produce a thorough and efficient stirring action through the use of only stationary parts. It has been discovered that rotation of the applicator roll causes the body of coating solution in the hopper to flow in a closed path, generally concentric to the roll, the layer of solution adjacent the roll moving in the direction thereof and the layer adjacent the bottom of the hopper moving counter to the direction of the roll due to the fact that the level of the solution on the up side of the roll is higher than that on the down side. A plurality of partitions spaced from each other and helically fashioned are placed in the path of this layer of solution moving counter to the direction of the roll. These partitions act to deflect this layer from its normal path concentric to the roll and toward one end of the hopper in the manner of a screw feed, but in this case the move-

ment comes from the flow of the solution and the equivalent of the screw is stationary. To aid in such circulation, the solution is fed into one end of the hopper and drawn off at the other end, the draw off end being the one toward which the partitions cause the solution to be fed. This feature can be readily applied to existing coating apparatus by inserting an arcuate baffle into the space between the bottom of the hopper and the roll in concentric relation with the roll periphery and placing a plurality of longitudinally spaced ribs on the convex side of said baffle which are helically fashioned. Added circulation of the solution is obtained by placing in direct communication points on opposite sides of the hopper which are on opposite sides of the center of the applicator roll.

The novel features that we consider characteristic of our invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings in which:

Fig. 1 is a schematic sectional end view of a conventional coating apparatus of the type with which the present invention may be combined;

Fig. 2 is an enlarged schematic end view of the hopper and a portion of the applicator roll and showing one of the flow patterns set up in the coating solution by rotation of the roll;

Fig. 3 is a plan view of the coating hopper and applicator roll and showing a second flow pattern which is set up in the solution in the hopper;

Fig. 3A is a schematic plan view of the hopper and applicator roll showing the contour levels of the solution set up by rotation of the roll and illustrating the flow pattern set up in the roll as the result thereof and also showing how the solution in the hopper is divided into two separate homogeneous volumes as a result of such flow pattern;

Fig. 4 is a perspective view of a baffle which is used in the hopper in accordance with the present invention;

Fig. 5 is a sectional end view of the coating apparatus showing the baffle in operative position in accordance with the present invention and taken on line 5—5 of Fig. 3 but on a different scale;

Figs. 6 and 6A are enlarged sectional details showing a preferred form of rib which might be used on the baffle and its relation to the bottom of the hopper as well as forms of ribs which are less useful; and

Fig. 7 is a longitudinal sectional view of the apparatus showing one manner of positioning the baffle in the hopper.

Referring now to the drawings, the coating apparatus generally may be a conventional one comprising an open-mouth hopper, indicated generally at 10, comprising an elongated trough having a flat base 11, end walls 13 and side walls 12 joined by a semi-circular bottom wall 14 which along with the end walls forms a reservoir for a supply of liquid coating solution S, the level of which is maintained substantially constant by any suitable feeding system. An applicator roll 15 is rotatably mounted in the hopper by having its shafts 16 suitably journaled in the end walls of the hopper. The bottom portion of the applicator roll is immersed in the coating solution S and its top portion extends through the open mouth of the hopper. When the roll is rotated in the direction of the arrow by any suitable means, including a gear 17 on the end of one of its shafts 16, a layer of coating solution S is transferred from the hopper to a bead 18 that contacts and coats the web 19 moved and supported by guide roller 20 which moves in a direction opposite to that of the applicator roll. As is well known in the art, instead of the applicator roll 15 transferring the coating solution to a bead across which the web is moved for coating, such applicator roll might transfer the coating directly to

the web surface or to another roll which in turn transfers the coating to the web directly or indirectly.

With this type of coating apparatus it is necessary to maintain the level of the coating solution in the hopper fairly constant and all sorts of solution feeding means have been used in the past to obtain this end. For instance, means have been provided for feeding the solution into the hopper at the same rate as it is coated onto the web, and means have been provided for feeding an excess of solution to the hopper and having an overflow take-off system controlling the level. In accordance with the present invention, it is preferred to feed the solution into one end of the hopper in excess of that taken away by the web and taking it off the other end of the hopper, the system being a closed one if desired so that no solution is wasted. To this end, there has been shown an inlet pipe 21 through one end wall of the hopper through which solution S is pumped into the hopper and an outlet pump 22 through the other end wall of the hopper through which the solution is drawn off. These pipes may be connected together through a piping system including a supply of solution and pumping means, not shown. The inlet pipe 21 should enter the hopper below the surface of the solution therein, preferably near the bottom, so that the entering solution will not tend to produce waves on the surface of the solution, particularly at the leaving or up side of the applicator roll.

One difficulty encountered with coating apparatus of the type described, particularly where wide webs are being coated, has been keeping the coating solution uniformly mixed from one end of the hopper to the other so that a uniform coating will be applied to the web at all points across its width. As pointed out above, certain materials to be coated, i. e., plastic webs, contain substance that dissolve in the coating bead 18 and are then transferred by the applicator roll back into the coating solution in the hopper. Many times this takes place unevenly along the length of the applicator roll and equilibria are established along the length of the hopper in which there are portions of the coating solution differing from other portions. Also, when coating solution is fed in at any point, as it travels along the hopper it tends to concentrate by either evaporation or extraction from the plastic web and, therefore, becomes different than it was when it was first introduced. Variations of both these types may eventually show as a variation of some type in the physical appearance of the web or possibly as a chemical reaction in the subsequent use of the coated web. To obtain a thorough and efficient mixing of the coating solution throughout the length of the hopper without the use of outside movable agencies is the purpose of the present invention, which will now be described.

As the applicator roll 15 rotates in the direction of the arrow, it tends to raise the surface of the coating solution S in the hopper on the up side of the roll and to depress it on the down side of the roll. Since the levels want to return to their normal equal positions, currents of the coating solution in the hopper are set up. It has been discovered that these currents are of two types illustrated by broken arrows in Figs. 2, 3 and 3A. These two current flows normally occur at the same time but, depending upon the dimensions and clearances in various parts between roll 15 and the bottom wall 14 of the hopper, one of these currents may be much greater than the other.

Considering first the current flow shown in Figs. 2, the layer of solution adjacent the roll periphery is moved by friction in the direction of rotation of the roll whereas the layer of solution remote from the roll periphery and adjacent the bottom wall of the hopper moves in a counter direction concentric with the roll under the influence of gravity since the levels of the solution on opposite sides of the roll tend to equalize at their normal position. Therefore, it is apparent that the body of coating solution continuously moves in a closed path, the major portions

of which are concentric to the roll periphery, that portion adjacent the roll moving in the direction of the roll and that portion adjacent the hopper bottom moving counter to the roll.

Our invention relates to making use of this current flow to obtain an efficient stirring action without the use of outside movable agencies. This we accomplish in a preferred manner by the use of an arcuate ribbed baffle or shell 25 of the type shown in Fig. 4. This baffle may be made of metal, or other rigid material, inert to the coating solution and has a plurality of helically fashioned ribs or partitions 26 extending from the convex side. This baffle is mounted in the hopper in the space between the hopper bottom 14 and the roll and in concentric relation to the roll periphery, see Fig. 5. While this baffle may be mounted in the hopper in any suitable manner, we have shown the ends thereof closed by vertical walls 27 which are provided with flanges 27' and which may rest upon and be fixed to the top of the end walls 13 of the hopper, see Fig. 7. When, as shown in Fig. 5, applicator roll 15 revolves in the direction of the large unbroken arrow, the coating solution circulates as shown by the broken arrows. As the body of solution completes one trip around the baffle 25, it is displaced along the length of the hopper by encountering and being deflected by the ribs 26. The lead of the ribs is such that they tend to feed the solution toward the draw-off end of the hopper or toward the end including outlet pipe 22.

It is advantageous to have the ribs or partitions 26 so arranged that little solution flows between the ribs and the baffle, and between the ribs and the bottom of the hopper. If the ribs were securely cemented or welded throughout their length to both the baffle and hopper bottom, this aim would be accomplished but such an arrangement would be impossible to properly clean or inspect and would not be readily adaptable to existing coating apparatus. One way of accomplishing this aim in a preferred manner is to permanently attach the ribs 26 to the baffle 25 throughout their length and to have them of such depth that they very closely approach the bottom of the hopper, see Figs. 6 and 7. Now if the face 28 of the ribs is made relatively wide and parallel to the bottom of the hopper as shown in Fig. 6, rather than narrow or round as shown at 28' and 28'' in Fig. 6A, then a narrow passage of some length is provided between the ribs and the bottom of the hopper and the normal viscosity of the coating solution will prevent it from flowing through the passage at a detrimental rate. While ribs of a triangular or circular form shown at 26' and 26'' in Fig. 6A would not defeat the invention, they would not be as efficient as the form of rib 26 shown in Fig. 6.

It is pointed out that the invention is not limited to the use of a baffle 25 as shown, but this form of structure makes the present invention readily applicable to existing coating apparatus and permits easy cleaning and inspection of the hopper. It will be appreciated that the same results could be obtained if no baffle were used and the helical ribs 26 were directly connected to the bottom of the hopper and extended toward the periphery of the roll far enough to intercept the layer of solution moving counter to the direction of rotation of the roll. The only difficulty in such an arrangement would be in determining just how deep the ribs should be to intercept all of the layer of solution moving counter to the roll and not the layer moving with the roll. Furthermore, without the arcuate baffle 25 to accurately define or separate the two layers of solution, there is apt to be a more or less stagnant area in the body of solution where there is no definite movement in either direction. This shortcoming could be overcome in this last-mentioned embodiment by supporting an arcuate baffle without ribs on the top of ribs carried by the bottom wall of the hopper.

If the ribs or partitions 26 are to be attached to the bottom of the hopper rather than baffle 25, then the bottom of the hopper should be semi-circular, to obtain the most satisfactory results because the baffles must extend some distance concentrically of the roll periphery in order to function properly. In the case where the ribs are on the convex side of the baffle 25, there is no reason why the bottom of the hopper be semi-circular, as shown, other than to obtain the most efficient operating conditions.

As shown in Fig. 5, the longitudinal edges 29 of the baffle 25 must be immersed in the coating solution S; otherwise, the concentric current flow of the solution in the hopper would be cut off thereby. It has been found that the amount by which the longitudinal edges of the baffle are submerged has some bearing upon the rate of flow although the reasons therefor are not known. We have found that the best results are obtained if the distance these edges are immersed is kept at a minimum, the circulation tending to decrease as the distance of immersion is increased. In actual operation, we have found that good circulation is obtained if these edges of the baffle are immersed from $\frac{1}{16}$ " to $\frac{3}{8}$ " below the surface of the solution in the hopper. The spacing of the baffle 25 from the roll surface will determine the volume of solution which is to be moved by friction from the roll surface and the closer it is to the roll, the nearer the speed of the entire volume of solution confined between the baffle and roll will approach the speed of the roll. The viscosity of the coating solution will help in determining this spacing since the more viscous the solution the more frictional drag that is imposed throughout the volume of solution by the roll surface moving in surface contact therewith. In a commercial application, mentioned below, we have found that a space of about $\frac{1}{8}$ " between the roll periphery and the baffle 25 gives good results.

The following examples illustrate the operativeness of a coating apparatus constructed in accordance with Fig. 5:

Example 1

A solution that is primarily a solvent was roll coated onto a plasticized cellulose acetate web using a baffle, as shown in Fig. 5, and having the solution piped into one end of the hopper and withdrawn from the other end, the circulating system including means for feeding the solution so that a constant level was automatically maintained in the hopper. After four hours, the curl in the web at the feed-in end of the hopper was nineteen units and at the other end of the hopper eighteen units. The appearance throughout the width of the web was good.

The hopper was then dropped, cleaned, the baffle 25 removed, and the solution reapplied to the acetate web under all of the same conditions except that the baffle was removed. After two hours, the curl on one edge of the web (feed-in end of hopper) was twenty units and the curl on the other end was fifteen units. In addition, there were numerous lines parallel to one another and parallel to the edges of the sheet in one-half of the area away from the feed-in end of the hopper. It is common knowledge in the art that such lines normally arise from "stagnation" of the solution in the hopper. The term "curl" as used above designates the curling tendencies of a web and is customarily used as one test for the uniformity of coating applied to a web. Sample strips are cut from different points across the coated web and these strips are laid flatwise on a surface and the amount the ends curl up from the surface is measured in any relative units.

Example 2

A dispersion of gelatin and cellulose nitrate in methyl alcohol, acetone and water was applied to a plasticized cellulose acetate butyrate web using the coating appara-

tus as described in Example 1. After two hours and 45 minutes, samples of the solution were taken and analyzed as follows:

Source of solution	Percent acetone	Percent water	Specific gravity
Tank before entering hopper.....	51.0	4.3	0.8106
In hopper (feed-in end).....	47.7	4.9	0.8131
In hopper (draw-off end).....	47.9	4.7	0.8130

During this time all other properties of the web were substantially the same across the entire width of the web. When the baffle 25 was removed and the apparatus otherwise unchanged, concentration difficulties along the length of the hopper were apparent within one-half hour.

From these two examples it will be seen that by modifying a conventional roll coating apparatus in accordance with the present invention that a more uniformly coated product is obtained than with the conventional apparatus alone, and that the solution is thoroughly mixed throughout the length of the hopper. This is all accomplished without using a movable stirring means in the hopper which would tend to induce other coating difficulties, i. e. lines resulting from undesirable agitation in the surface of the solution of the hopper.

We have also found that additional useful mixing of the solution S in the hopper can be obtained if that side of the hopper on the up side of the applicator roll 15 is placed in direct communication with the side of the hopper on the down side of the roll 15 by a conduit 40, as shown in Figs. 3 and 5. The usefulness of such a mixing action will be apparent from the following description of a probable theory of how the transverse currents of flow are set up in the hopper and the results thereof.

In Fig. 3A there is shown a top plan view of the hopper and roll with contour lines representing the surface of the liquid at the various points in the hopper and with the distance between the roll 15 and the bottom of the hopper exaggerated and the baffle 25 omitted for purposes of clarity. The contour level of the solution increases in height with the numbers 1-8 and the variations can be measured in millimeters. As explained above, the origin of the surface contour is the roll 15 which as it rotates tends to raise the surface of the solution S on the up side of the roll and depress it on the down side. The influence of gravity on the solution as the result of this is to set in motion the transverse flow represented by the broken arrows in Fig. 3A. The final result is two homogeneous liquid volumes represented by two cross hatchings. Any end-to-end variation in feed, machine conditions, application, accidental evaporation, etc. will make the solution in the two volumes different. By making a direct connection between the two sides of the hopper at contour lines 2' and 7, solution will flow from the homogeneous volume at 7 to the other homogeneous volume at 2' by reason of the difference in level at these two points and the two volumes will mix. Similarly, points 2 and 7' can be connected together or both connections can be used at the same time for maximum mixing. It will be understood that this mixing action can be used to supplement that obtained by the use of baffle 25 or it can be used alone if desired.

Although we have shown and described certain specific embodiments of our invention, we are fully aware that many modifications thereof are possible. Our invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the scope of the appended claims.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent of the United States is:

1. In a coating apparatus the combination with an open-mouth hopper adapted to contain a supply of coating solution; means for feeding the coating solution into

one end of said hopper and drawing it off at the other end; an applicator roll rotatably mounted in said hopper with a portion of its periphery dipping into said solution in spaced relation with the bottom of said hopper and another portion extending out of the mouth of said hopper; means for rotating said roll in one direction whereby the coating solution is set in motion concentrically of said roll with that portion adjacent the roll moving in the direction of the roll and the remaining portion adjacent the bottom of the hopper moving in the opposite direction; a plurality of stationary partitions submerged in the solution in the hopper in the space between the roll and the bottom of the hopper and spaced from one another longitudinally of said roll, each of said partitions extending from the bottom of said hopper toward the periphery of said roll a distance substantially equal to the depth of that portion of the solution moving counter to the roll, each of said partitions extending along said hopper in a helical fashion relative to said roll and so disposed that the lead of each is such as to cause that portion of the solution moving in a direction counter to the roll to be forced toward the draw-off end of the hopper.

2. A coating apparatus according to claim 1, in which there is an arcuate baffle disposed between the immersed portion of said roll and the bottom of said hopper and in concentric relation with the periphery of said roll, said baffle extending longitudinally of said roll and having its two longitudinal edges immersed in said solution whereby said baffle defines the thickness of the layers of solution moving in each direction concentric of said roll; said plurality of stationary partitions extending from the convex side of said baffle to the bottom of said hopper.

3. A coating apparatus according to claim 1, in which there is an arcuate baffle disposed between the immersed portion of said roll and the bottom of said hopper and in concentric relation with the periphery of said roll, said baffle extending longitudinally of said roll and having its two longitudinal edges immersed in said solution whereby said baffle defines the thickness of the layers of solution moving in each direction concentric of said roll; said plurality of stationary partitions comprising a plurality of ribs fixed to and extending circumferentially around the convex side of said baffle in helical fashion and extending radially from said baffle to the bottom of said hopper.

4. A coating apparatus according to claim 3, in which each of said ribs does not touch the bottom of said hopper but merely approaches it closely, and said ribs being so formed as to have a relatively wide face adjacent and substantially parallel to the bottom of said hopper whereby a restricted passage between each rib and the bottom of the hopper is formed which will deter the flow of solution therethrough at a detrimental rate.

5. In a coating apparatus the combination with an open-mouth hopper adapted to contain a supply of coating solution; means for feeding the coating solution into one end of said hopper and drawing it off at the other end; an applicator roll rotatably mounted in said hopper with a portion of its periphery dipping into said solution in spaced relation with the bottom of said hopper and another portion extending out of the mouth of said hopper; means for rotating said roll in one direction whereby the contour level of the solution in the hopper is changed, that on the down side of the roll being lowered and that on the upside being raised, whereby as a result of said contour change of the solution and the frictional effect of said roll different currents of flow are set up in the solution, one being concentrically of said roll and others being endwise of said roll from the center portion of the roll on the upside in opposite directions around the end of the roll to the center portion on the down side; a plurality of stationary partitions submerged in the solution in the space between the roll and the bottom of the hopper and spaced from one another longi-

tudinally of said roll; each of said partitions extending from the bottom of said hopper toward the periphery of said roll and also extending in substantially the same helical fashion relative to said roll as to cause that portion of the solution moving concentrically of the roll 5 and counter to the direction of rotation thereof to be forced toward the draw-off end of the hopper; and means for placing in communication that side of the hopper on the down side of the roll at a point to one side of the center of the roll with that side of said hopper on the 10 upside of the roll and at a point to the other side of

the center of the roll whereby the solution is free to circulate between these points due to the action of gravity.

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