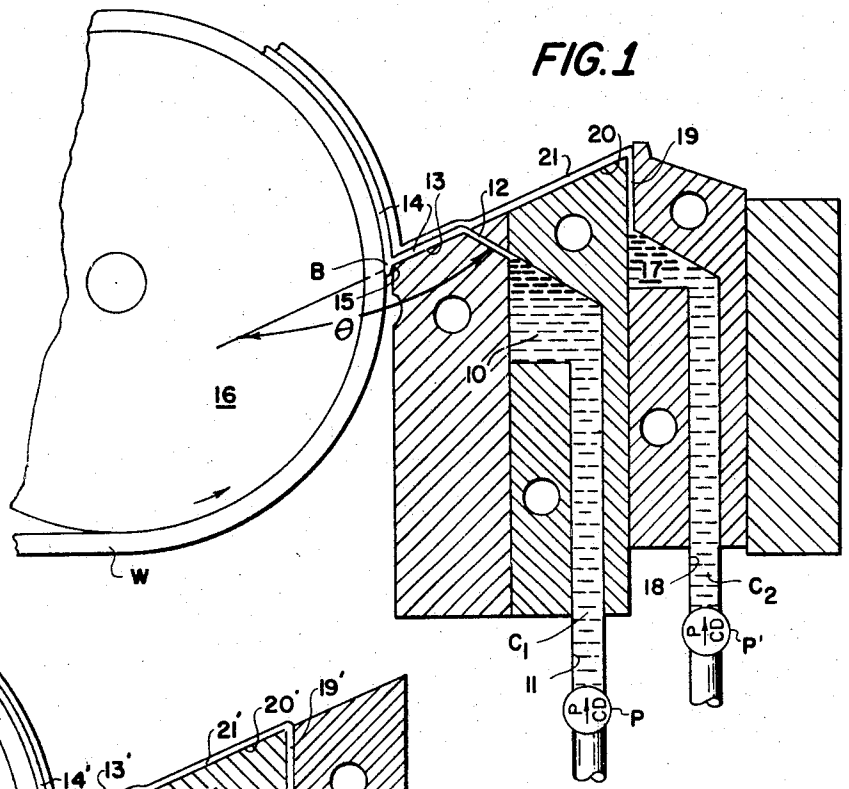
Oct. 28, 1969 T. A. RUSSELL 3,474,758

MULTIPLE COATING APPARATUS

Filed Nov. 6, 1967

FIG. 1



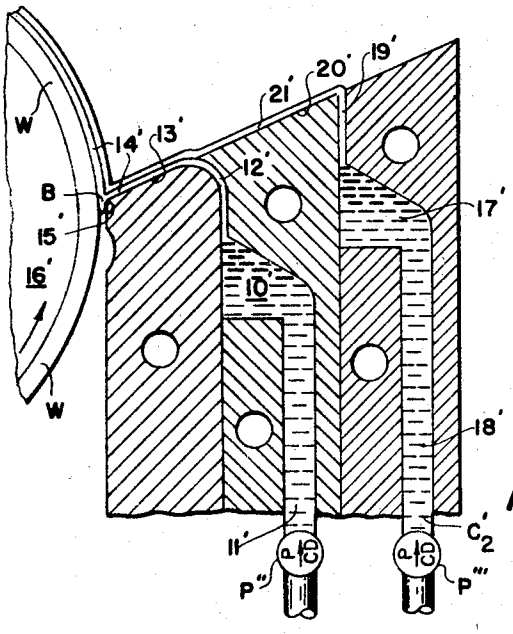
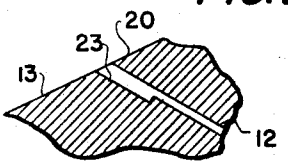


FIG. 3

FIG. 2



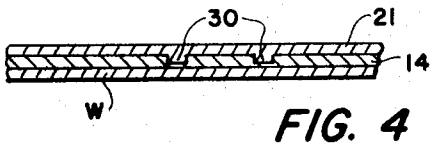


FIG. 4

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MULTIPLE COATING APPARATUS

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U.S. Cl. 118—412 4 Claims

ABSTRACT OF THE DISCLOSURE

An improvement in the arrangement of discharge slots in multi-slide coating hoppers. By discharging the coatings at an angle to the slide surface the emerging flow is directed with a component of its velocity down the slide surface. This component of velocity tends to dislodge bubbles or particles which might otherwise stop at, or near, the slot from which they emerge.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to coating apparatus and particularly to an improved multi-slide coating hopper.

Description of the prior art

A multi-slide hopper is an apparatus that will simultaneously coat two or more liquids onto a solid support in such a way that the layers are not mixed and are individually of uniform thickness. Such a hopper is disclosed in U.S. Patent 2,761,419 and the present invention relates to an improvement in such hoppers which overcomes a decided shortcoming of known hoppers of this type.

The conventional slide hopper performs its coating operation by metering a first coating liquid from a supply through a narrow distributing slot which distributes the liquid uniformly across the top of a downwardly inclined slide surface. This layer of liquid moves down the slide surface by gravity so as to supply an evened out and steady supply to a coating bead across and in contact with which the web to be coated is moved to pick up a layer of liquid therefrom. If the simultaneous coating of two liquids is desired, a second liquid is supplied to, and distributed by, a second distributing slot which in turn directs a uniform layer of the liquid onto the top of a second slide surface so as to flow down to the coating bead, first alone on its own slide surface, and then onto the top of the layer of liquid issuing from the first distributing slot and then down to the coating bead in superposed relation with the layer of first coating liquid. Subsequent liquids may be coated simultaneously by equipping the hopper with the appropriate number of distributing slots and slide surfaces.

It has been found that the conventional multi-slide hopper often tends to produce a defect in the final coated product which appears as a long line or lines running parallel to the direction of coating. These defects are not always visible in the product as coated and very often they become visible only after the product is dried and/or processed (if the coated web is a photographic product) and then is visibly checked. Experimentation has shown that these lines, which will hereinafter be referred to as pencil lines, are the result of long lines which are locally deficient in the coating liquid issuing from the lowermost slot, where a two-slot hopper is used, and which are thicker in the second coating liquid, the total thickness of the two liquids being the same as the unaffected parts of the coatings.

As described in U.S. Patent 3,005,440, these pencile lines can be caused by a blockage in the lowermost of two distributing slots, or in the slot where two layers of liquid

come together in moving down the slides to the coating bead. These pencil lines can be avoided either by removing the cause of the blockage in the distributing slots, i.e., taking out gelatin slugs or unusually large silver grains when silver halide solutions are being coated, etc., or by redesigning a part of the hopper so that the interruption of flow due to such a blockage does not result in a pencil line.

The invention in U.S. Patent 3,005,440 attacked the problem of pencil lines by widening out the exit end of the discharge slots where two liquids come into contact in such a way as to produce a turbulence in the stream of liquid passing through the slot by reason of a sudden change in velocity and before it leaves the slot. This turbulence caused any pencil line formed in the stream by reason of a blockage in the narrow part of the slot to heal itself before the stream issued from the slot and onto its slide surface where it is immediately contacted by a second layer of liquid moving down upon it from a higher slide surface.

SUMMARY OF THE INVENTION

The present invention is directed to an improved arrangement of the discharge slots in a multi-slide coating hopper to eliminate a newly discovered source of pencil lines when using such a coating hopper.

When hunting for particles that were likely to form pencil lines, it was observed that these particles, and sometimes bubbles, frequently lodged on the first ⅛ of an inch of the slide below the lowermost of two adjacent slides. It was easy to remove such a particle, or bubble once it was detected, and however gently it was shifted, it would always continue on its way down the remainder of the slide. These observances suggested that there was a stagnant area of liquid on the first part of the slide and that once the particle had settled there it would be unlikely to be swept away by flowing fluid and it would quite probably be large enough to influence the flow pattern in its vicinity. When multiple layers are applied with hoppers having slots arranged as shown in FIGS. 9 and 10 in U.S. Patent 2,761,791, the materials flowing vertically upward must stop their upward motion before they start down the slides. Particles sometimes stop where they should make this turn and are held by the noted stagnant condition existing at this point. In order to prevent particles and/or bubbles from stopping at or near the exit of a discharge slot where two layers of coating come together, and thus produce pencil lines in the final coating, the exit end of the slot(s) is designed or arranged to direct the flow of liquid therefrom downwardly of the slide at full, or near full, flow velocity. To this end the slots are arranged so that their exit ends are inclined in a range of 95° to 145° inclination in relation to the slide surface onto which they exit. This configuration, which may also be used in conjunction with widened slot ends, such as described in U.S. Patent 3,005,440, provides a desirable solution to the prior art problem of pencil lines described above.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its details of construction and its methods 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.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional detail of a dual hopper constructed in accordance with a preferred embodiment of the present invention;

FIG. 2 is an enlarged sectional detail showing the exit end of the lowermost distributing slot enlarged on the

down side of the slot in accordance with one embodiment of my invention;

FIG. 3 is an enlarged sectional detail showing another embodiment wherein the upper end of the lowermost discharge slot is curved so that its exit end directs the flow of liquid therefrom downwardly of its associated slide at full or near full flow velocity;

FIG. 4 is an enlarged transverse sectional detail of a web coated with a conventional dual slide hopper and illustrating, in an exaggerated way, how undesired pencil lines might appear in the final product.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 my invention is shown on a conventional dual slide hopper of the type disclosed in U.S. Patent 2,761,419. With this hopper, one fluid coating composition C_1 is continuously pumped by a constant discharge metering pump P into a cavity **10** at a given rate through inlet **11** and from which it is forced through a narrow distributing slot **12** in the form of a ribbon and out onto a downwardly inclined slide surface **13** down which it flows by gravity in the form of a layer **14** to a point where it forms a coating bead B between the lip **15** of the slide surface **13** and a web W moved upwardly across and in contact with the bead by a supporting roll **16**.

The second coating composition C_2 is continuously pumped into a second cavity **17** at a given rate by another constant discharge metering pump P' through inlet **18** and from which it is forced through a narrow distributing slot **19** in the form of a ribbon and out onto a second downwardly inclined slide surface **20**. This ribbon of the second coating composition, in flowing down the slide surface **20** under the influence of gravity, forms a smooth and uniformly thick layer **21**. The two slide surfaces **13** and **20** are coplanar, or substantially so, so that as the layer **21** of the second coating composition reaches the ribbon of the first coating composition issuing from slot **12**, it flows up on top of the same and the two then flow together down slide surface **13** and into the coating bead B. The relative thickness of the two layers of coating materials will depend upon the rate at which the individual coating fluids are pumped to the cavities **10** and **17** by pumps P and P'. The slide hopper and the method of coating carried out by the use thereof described up to this point is shown in the above noted U.S. Patent 2,761,419, and the improvement therein which constitutes the present invention will now be described.

The purpose of the distributing slots **12** and **19** is to cause the issuance or extrusion of the liquid coating compositions in a uniform ribbon across the entire width of the hopper or the length of the distributing slots. Since the hopper may be as wide as 48" to 75" and the cavities **10** and **17** for the coating compositions do not extend the full length of the slots, but only over a limited length of the center portion thereof, these distributing slots must be quite narrow in order to do a satisfactory job of distributing the coating compositions throughout the full length of the slots. The length and depth of these distributing slots may vary with the solutions to be coated, the uniformity in thickness required over the full length of the slot, and the flow rates to be used. At best they are very narrow, e.g. .009 or .010 inch. As pointed out above, pencil lines often appeared in the coated product made with slide hoppers.

In FIG. 4 an attempt has been made to illustrate such pencil line imperfections and their character. Looking at FIG. 4, which is a partial and greatly enlarged transverse cross-section of a web coated with a dual slide hopper, it will be seen that the layer **14** of coating composition C_1 directly engaging a web W has two indentation **30** running lengthwise of the web which are filled with the second coating solution forming layer **21**. It will thus be appreciated that at the indentation **30** the thickness of layers **14** and **21** will be relatively different than at other portions of the web notwithstanding the fact that the overall physical thickness of the two layers at these particular points may be the same as at all other points across the web. Obviously then these pencil lines cannot be readily physically measured but will be visually apparent after drying or processing if one of the layers is a silver halide solution and the other is a clear gelatin solution as found in photographic film. As pointed out above, these pencil lines may occur by reason of a small obstruction in the distributing slot **12**, e.g., a grain of silver in the silver halide solution or a slug of gelatin in a photographic emulsion, which causes an interruption in the flow pattern moving out of slot **12** and onto the slide surface **13** or as the result of a particle or air bubble being caught and held at the edge of the exit of the slot, or in the first one-eighth inch of the associated slide, by reason of a stagnant condition resulting from the abrupt change in flow of the fluid as it imerges from the slot and then moves down the slide under the force of gravity. In a single layer exposed to the air this is self-healing due to surface forces tending to reduce the total exposed surface to a minimum. However, when the layer **21** of the second coating composition C_2 is run onto the first as it issues from slot **12**, then the deficiency, or indentations **30**, in layer **14** is filled up with the second coating composition, and providing the interfacial tension between coating composition C_1 and composition C_2 is small or zero, then a pencil line is formed, as shown at **30** in FIG. 4, because there is no healing force at their interface. The top surface of layer **21** soon heals due to its surface tension.

Those pencil lines caused by obstructions within the length of the slots can be removed by redesigning a part of the hopper as taught by U.S. Patent 3,005,440 so that an interruption of flow of this nature does not result in pencil lines. This approach does not, however, eliminate pencil lines caused by particles and/or air bubbles which are trapped on the edge of the exit end of the discharge slot, or on the slide near the exit of the slot, by reason of the stagnant condition resulting from the abrupt change in direction in flow of the coating fluid as it leaves the slot and moves down the slide surface.

The present invention relates to a modification in the hopper design, where it has two or more slides, so as to enable coatings to be made free of pencil lines which result from the trapping of particles and/or bubbles at, or on the slide surface near the edge of the exilt end of the slide due to the abrupt change in direction of flow of the coating solution.

In the dual hopper shown in FIG. 1 this modification in design consists in directing the exit end of the discharge slot **12** downwardly of its associated slide surface toward the coating bead rather than having it extend vertically and enter its slide surface at an acute angle as shown in the noted prior art. The angle θ should preferably be from 95° to 145°. With this configuration, a component of velocity of the flow emerging from the slot will be directed parallel to the slide surface. This component of velocity will tend to dislodge particles and bubbles which would otherwise be trapped at, or on the slide surface near, the exit end of the discharge slot.

To also overcome pencil lines which might result from a blockage within the slot proper the inclined slot may also be modified according to the description of U.S. Patent 3,005,440. Thus, the discharge slots may have their ends enlarged as shown at **23** in FIGURE 2. For further details of this modification reference should be made to U.S. Patent 3,005,440.

In another embodiment, as shown in FIG. 3, the leaving end of the slot **12'** is curved, instead of straight, so that the flow of coating fluid emerges therefrom and onto the slide surface **13'** at full, or near full, flow velocity. This will eliminate any stagnant condition which might result from an abrupt change of direction in the flow of fluid onto the slide surface and insure that any and all

particles and/or bubbles emerging from the slot will pass on down the slide surface rather than being caught at this point and produce pencil lines in the final coating.

While I have disclosed my invention as applied to a dual slide hopper, it follows that it could also be used on a hopper having three, four, or more slides. In these cases, any or all distribution slots below any slide surface, or where two layers are brought into contact, will be angled, or redirected downwardly of its associated slide surface, to prevent the formation of pencil lines.

I claim:

1. In a multiple-layer hopper for feeding a plurality of fluid coating solutions in superposed and distinct layer relationship to a coating bead from which they are simultaneously deposited in such strata relationship onto the surface of a web moving across and in contact with said coating bead, and comprising a multiple-layer slide hopper, a slide surface on said hopper inclined downwardly and terminating in a lip adjacent said coating bead; a plurality of narrow distributing slots, one for each coating composition, extending from the interior of said hopper and opening into said slide surface and through each of which a thin layer of coating composition is adapted to be discharged onto said slide surface, the lowermost of said distributing slots spaced from said lip and the remaining distributing slots spaced above the lowermost slot and each other to provide an uninterrupted slide portion below each slot over which the layer of coating solution discharged therefrom flows by gravity to form a smooth layer of uniform thickness before, in the case of all but the lowermost slot, it reaches the next lowest distributing slot and flows onto the top of, and along with, the layer of coating solution discharged therefrom, and, in the case of the lowermost discharge slot, before it reaches said lip; the improvement consisting of, arranging at least one of said lowermost slots so that its discharge end enters onto its associated slide portion at an obtuse angle relative thereto and directs the layer of coating solution emerging therefrom downwardly of said slide portion so that a component of velocity of the solution emerging from said slot is directed down said slide portion.

2. A multiple-layer hopper according to claim **1**, characterized by the fact that the portion of at least one of said lowermost of said slots approaching the slide surface is curved downwardly toward said lip and the discharge end thereof exits upon the slide portion immediately below it in a downward direction.

3. In a multiple-layer hopper for feeding a plurality of fluid coating solutions in superposed and distinct layer relationship to a coating bead from which they are simultaneously deposited in such strata relationship onto the surface of a web moving across and in contact with said coating bead, and comprising a multiple-layer slide hopper, a slide surface on said hopper inclined downwardly and terminating in a lip adjacent said coating bead; a plurality of narrow distributing slots, one for each coating composition, extending from the interior of said hopper and opening into said slide surface and through each of which a thin layer of coating composition is adapted to be discharged onto said slide surface, the lowermost of said distributing slots spaced from said lip and the remaining distributing slots spaced above the lowermost slot and each other to provide an uninterrupted slide portion below each slot over which the layer of coating solution discharged therefrom flows by gravity to form a smooth layer of uniform thickness before, in the case of all but the lowermost slot, it reaches the next lowest distributing slot and flows onto the top of, and along with, the layer of coating solution discharged therefrom, and, in the case of the lowermost discharge slot, before it reaches said lip; the improvement consisting of, arranging at least one of said lowermost slots so that it is inclined downwardly in relation to the slide portion below it at an angle from approximately 95° to 145° so that a component of velocity of the layer of solution discharged therefrom is directed down said slide portion.

4. A multiple-layer hopper according to claim **3**, characterized by thte fact that the discharge end of at least one of said lowermost of said slots is wider than the major portion of the slot and the enlargement in the slot being sudden and sufficiently great so as to produce a turbulence in the coating solution through the wider portion and thereby heal any interruption of flow that may occur as the result of a blockage in the narrow portion of the slot.

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