Oct. 24, 1961 J. F. PADDAY 3,005,440

MULTIPLE COATING APPARATUS

Filed Jan. 8, 1959

Fig. 1

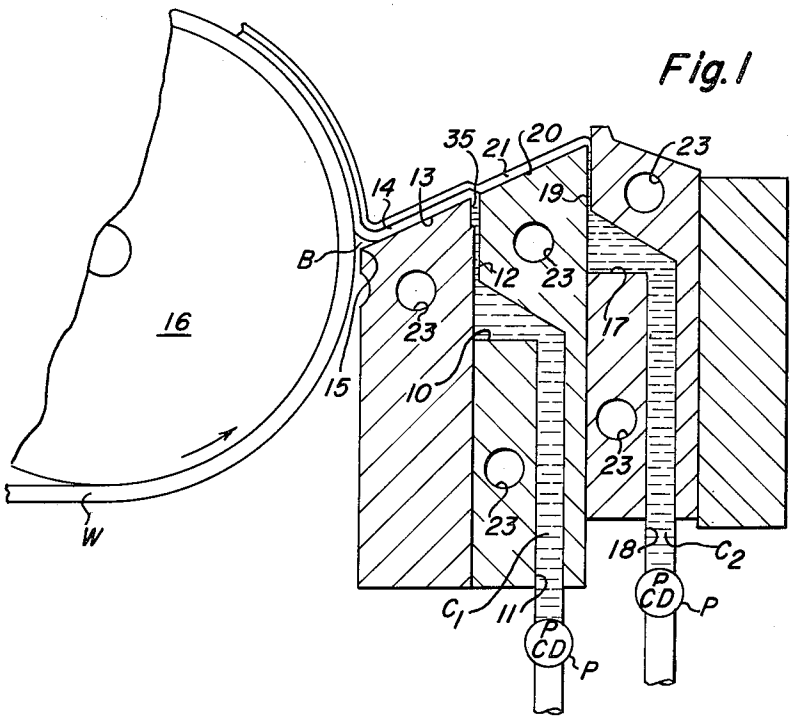



Fig. 2

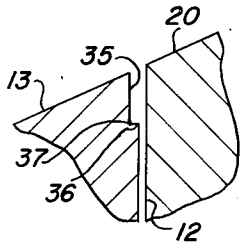



Fig. 3

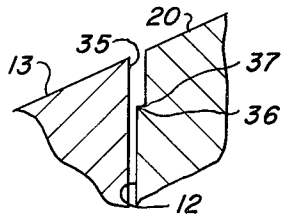
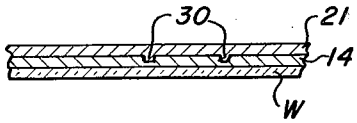



Fig. 4




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# MULTIPLE COATING APPARATUS

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

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 which the web to be coated is moved to pick up a layer of liquid therefrom. 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 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 visually 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.

I have found that these pencil lines are caused by a blockage in the lowermost distributing slot, or in the slots 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 an interruption of flow due to such a blockage does not result in a pencil line.

The primary object of the present invention is to modify the design of the conventional slide hopper having two or more slides so as to enable coatings to be made which are free from pencil lines even when distributing slot blockages occur.

Another object of the present invention is to widen 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 will cause 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 issues 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.

And still another object is to widen the exit end of the distributing slots by cutting back the surfaces of the narrow portion of the slot at right angles so that a sudden enlargement of the slot is achieved. This sharp right-angle corner produces the maximum amount of turbulence in the stream and thereby produces the most effective healing action for any pencil lines formed in the stream by reason of blockages in the narrow portion of the slot.

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, in which:

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 similar to FIG. 2, but showing the exit end of the lowermost discharge slot enlarged on the upside of the slot; and

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 objectional pencil lines might appear in the final product.

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 vertical 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 vertical 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 they are pumped into the respective cavities **10** and **17**. The hopper is provided with pipes **23** through which hot or cold fluids can be circulated to keep the coating compositions in a desired fluid state. 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 54" 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, I have found that pencil lines often appeared in the coated product made with these 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 indentations **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 indentations **30** the thickness of layers **14** and **21** will be relatively different than at other portions of the web notwithstanding the fact that the over-all 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. I have found that these pencil lines 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 geltain in a photographic emulsion, which causes an interruption in the flow pattern moving out of slot **12** and onto the slide surface **13**. 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 healing force at their interface. The top surface of layer **21** soon heals due to its surface tension.

These pencil lines can be avoided either by removing the cause of the blockage, e.g., taking out geltain slugs where the coating composition contains gelatin or removing excessively large dispersed particles where the coating solution is a dispersion, or by redesigning a part of the hopper so that an interruption of flow of this nature does not result in pencil lines.

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 even when slot blockages occur.

In the dual hopper shown in FIG. 1 this modification in design consists in enlarging the exit end of the distributing slot **12**, as clearly shown at **35** in FIGS. 2 and 3, so that obstructions are not likely to interrupt flow in the critical position, making the enlargement sudden and sufficiently wide so as to produce turbulence and thereby heal any interruption of flow that may occur as the result of a blockage, and making the depth of the enlargement sufficient to allow laminar flow to be regained after the initial turbulence. This enlargement may be made either by cutting away the lower side of the slot **12**, as shown in FIG. 2, or by cutting away the upper side of the slot **12**, as shown in FIG. 3. The enlargement of the exit end of slot **12** should be made sudden and sufficiently wide so as to produce sufficient turbulence in the issuing stream of coating composition to heal interruptions of flow due to blockages in the narrow portion of slot **12** under all conditions likely to be encountered when coating photographic emulsions and/or other dispersions. To this end and the enlargement should be cut back at right angles to the surface of the slot to form a sharp corner **36**. Now if an obstruction occurs in the narrow portion of slot **12** and forms an interruption in the flow of the ribbon of coating composition $C_1$, when this ribbon of liquid reaches an enlarged portion **35**, a turbulence will be set up in the flow to heal the interruption before it leaves the slot and passes onto the slide surface **13**. No obstruction will occur in the enlarged end of the slot **12** where turbulence will not heal the interruption it might cause because any particle which can pass through the narrow portion of the slot **12** will obviously pass through the enlarged portion **35** of the slot. The back corner **37** of the enlargement **35** may be provided with a small radius to facilitate cleaning. The depth of the enlargement **35** should be sufficient to allow laminar flow to be regained after the initial turbulence and prior to the time the ribbon of coating composition issues onto the slide surface **13**. The minimum depth of the enlargement depends upon the flow rates and viscosity of the coating solution used, and is more or less proportional to the flow rate. Low viscosity coating compositions and low flow rates would normally require less depth than high viscosity solutions and high flow rates. The width of the distributing slot **12** is chosen such as to obtain a uniform thickness of coating solution over the full length of the exit end of the slot. If a relatively wide slot is used, it must be deep, whereas a narrow slot can be less deep to obtain the desired uniform distribution over the entire length of the exit end of the slot.

With a distribution slot of 0.009", effective working has been obtained using an enlargement of from 0.015" to 0.075" wide and a depth of 0.150". A hopper was constructed from a transparent plastic material in the manner shown in FIG. 1, but with the exit end of the distributing slot **12** modified as clearly shown in FIG. 2. Artificial blockages were introduced at points both in the modified and in the conventional slot. When gelatin and sodium alginate solutions of equivalent viscosity and flow rates were passed through the hopper, pencil lines were seen only behind the blockages in the original design. The modified slots, although blocked, showed no pencil lines.

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 enlarged at their exit ends, as shown at **35** in FIGS. 2 and 3, to prevent the formation of pencil lines.

While I have shown and described specific embodiments of my invention, I am aware that many modifications thereof are possible. My invention, therefore, is not to be limited to the precise details shown and described but is intended to cover all modifications coming within the scope of the appended claims.

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

1. A multiple-layer hopper for feeding a plurality of fluid coating compositions in superposed and distinct layer

relationship to a point of deposition where they are simultaneously deposited onto the surface of a web moving relative thereto in such strata relationship, and comprising a block, a slide surface on said block inclined downwardly and terminating in a lip adjacent said point of deposition, a plurality of narrow distributing slots, one for each coating composition, extending through said block to said slide surface through which a thin layer of coating composition is adapted to be discharged onto said slide surface, the lowermost of said discharge slots spaced from said lip and the remaining distributing slots spaced above this lowest slot and from 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 lowest slot, it reaches the next lowest discharge slot and flows onto the top of, and along with, the layer of coating composition discharged therefrom, and, in the case of the lowest discharge slot, before it reaches the lip; the discharge end of at least one of said lowermost of said slots being 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 composition flowing through the wider portion of the slot and thereby heal any interruption of flow that may occur as the result of a blockage in the narrow portion of the slot.



2. A multiple-layer hopper according to claim 1, characterized by the fact that the wider discharge end of the distribution slot and the narrow portion of the slot are joined by a right-angle corner.

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