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IMMERSION COATING OF STRIP MATERIAL

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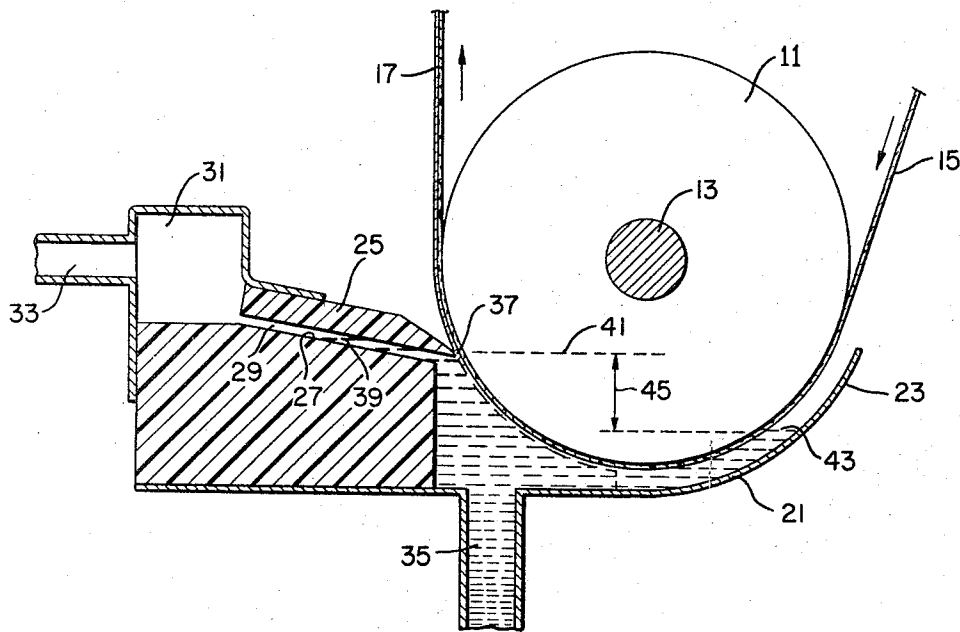


FIG. 1

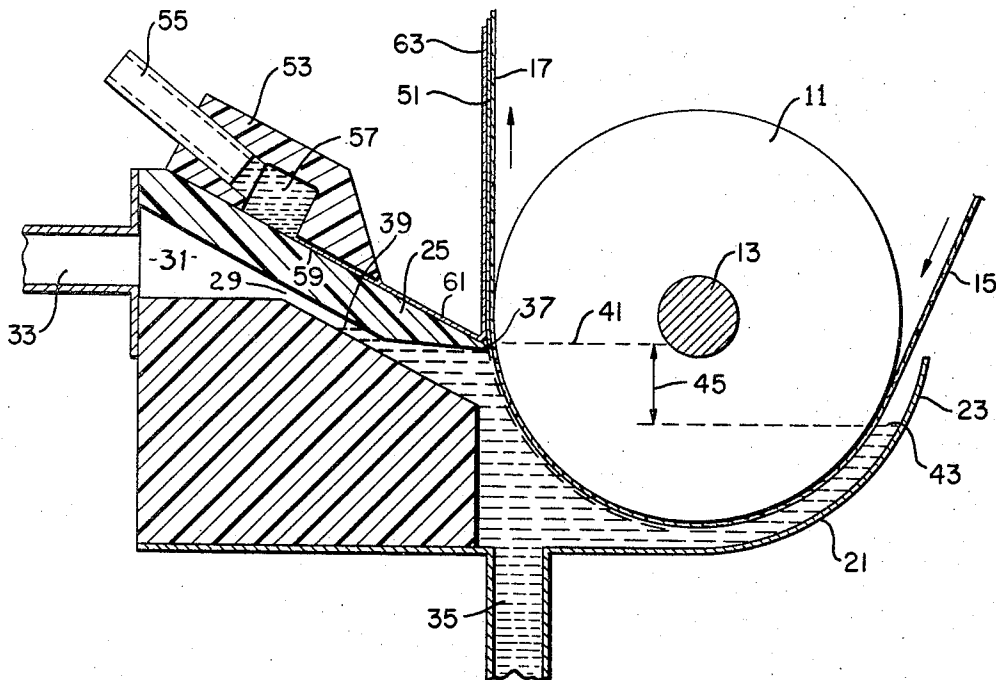


FIG. 2

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IMMERSION COATING OF STRIP MATERIAL

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This invention relates to the application of liquid coatings to webs of material, and is especially useful in the field of photography, for the application of photographic emulsions and other layers (e.g., subbing coatings, filter layers, etc.) to a previously formed web which may be film base or which may be paper or other suitable sheet material.

An object of the invention is the provision of a generally improved and more satisfactory apparatus for applying coatings to webs.

Another object is the provision of a generally improved and more satisfactory method for applying coatings to webs.

Still another object is the provision of a coating apparatus and a coating method having automatic control of the thickness of the applied coating in proportion to the rate of feeding of the liquid coating material to the apparatus.

A further object is the provision of a coating apparatus and a coating method in which coating liquid can be applied to a web while the web is traveling at a relatively high rate of speed, and in which the thickness of the coating can be controlled with such accuracy that the method and apparatus are particularly useful for producing photographic coatings.

A still further object is the provision of a method and apparatus employing dip coating techniques with all the attendant advantages thereof, but so improved with respect to prior dip coating techniques that this technique may be used efficiently for the production of photographic coatings.

These and other desirable objects may be attained in the manner disclosed as an illustrative embodiment of the invention in the following description and in the accompanying drawings forming a part hereof, in which:

FIG. 1 is a schematic vertical section taken transversely through one form of apparatus of the present invention; and

FIG. 2 is a similar view showing another form, wherein two layers of coating material are applied.

Referring now to FIG. 1, there is shown a coating roll 11 rotating on a shaft 13. The web of material to be coated comes to the roll at 15 from any suitable source of supply, goes around the lower part of the roll, and leaves the roll upwardly at 17, proceeding thence to a dryer of any conventional known construction where the liquid coating applied at the roll 11 is dried in the usual way.

A coating trough or pan 21 extends around the lower part of the roll 11, and on the incoming or entering side of the roll the edge of the pan curves upwardly as at 23, but spaced a substantial distance from the surface of the roll, as shown. On the outgoing or exit side of the pan 21, there is an inclined blade 25 which forms a top or cover for the trough on this side of the roll 11. The edge of the blade 25 is parallel to the roll and fairly close to it, but nevertheless spaced from the roll by a distance several times the thickness of the coating to be applied. For example, if a coating having a thickness in the range of 0.001 of an inch is to be applied to the web 15, 17, the edge of the blade 25 may be spaced from the web by a distance of 0.012 of an inch or more.

It should be emphasized at this point that the blade 25 does not function as a "doctor blade." In the coating art,

doctor blades are well known, and they control the thickness of an applied coating by scraping off an excess thickness of coating, leaving only the thickness which will pass between the web and the closely adjacent edge of the doctor blade. It is the spacing of the edge of the doctor blade from the web which determines the thickness of coating. But this is not the case with the blade 25 of the present invention. The edge of the blade in the present case provides a surface against which a meniscus may form, between the edge of the blade and the adjacent web, but the spacing of the edge of the blade from the web does not determine the thickness of the coating. As already mentioned in connection with the above specific example, the spacing of the edge of the blade from the web may be several times the thickness of the coating which is to be applied.

Below the bottom face of the blade 25 there is a wall 27, spaced from and preferably parallel to the bottom face of the blade, providing between the wall and the blade a passageway 29 in the form of a slot leading to a vacuum conduit 31. The pan or trough 21 and the blade 25 extend through the full width of the face of the coating roll 11, and the slot 29 and vacuum chamber 31 preferably also extend through the full width of the roll. There are suitable end walls (not shown) which close the ends of the pan 21, slot 29, and vacuum chamber 31, the end walls extending very close to the end faces of the roll 11, to provide relatively tight sealing at these points. The vacuum chamber 31 is connected by a conduit 33 to any suitable source of partial vacuum, such as a vacuum pump or an eductor.

The liquid which is to be coated onto the web is supplied to the pan or trough 21 by any suitable inlet conduit such as shown schematically at 35. The liquid is supplied at a controlled rate through a metering pump.

With this apparatus, after an initial period of operation sufficient to reach a state of equilibrium, continued operation results in the application of coating material at a thickness dependent upon the rate at which the coating liquid is fed into the system through the conduit 35. When initially starting up, coating liquid is supplied to the pan or trough 21 in sufficient quantity to keep the liquid level in the part 23 of the pan at least as high as the bottom edge of the coating roll 11, and partial vacuum is applied to the chamber 31 to a sufficient degree to draw the liquid level up at least as high as the lower edge of the meniscus blade 25, and preferably a little higher. Only enough vacuum is needed to overcome the hydrostatic head from the bottom of the coating roll to a point slightly above the meniscus which will be formed at 37 at the lower edge of the blade 25. The surface of the liquid, drawn up into the slot 29 by the partial vacuum, will be at some such point as indicated at 39.

As the coating roll 11 rotates in a clockwise direction, feeding the web 15, 17 into the coating pan and then out again, the outer face of the web 15, 17 is thoroughly immersed in and coated by the liquid in the pan, so that as the web passes upwardly at 17 a meniscus will be formed at 37 between the edge of the blade 25 and the web 17, and a thin coating of liquid will remain on the face of the web as it passes upwardly beyond the meniscus. Initially, while the coating liquid is being introduced through the conduit 35 at a metered rate to give the required thickness of coating on the area of the web which passes through the coating pan per unit of time, the coating will take place with the maximum possible hydrostatic head, from the level of the meniscus 37, as indicated by the line 41, to the bottom edge of the coating roll 11. This creates the maximum possible hydrostatic force acting on the meniscus to tend to draw it back against the direction of travel of the web, thereby reducing the quantity of coating liquid which stays on the web beyond the meniscus.

cus. Thus initially the amount of coating applied to the web will be less than the intended amount. But since the amount of coating liquid removed from the pan by the web is less than the amount which is being supplied to the pan through the supply conduit 35, the level of the coating liquid will gradually rise at the incoming side 23 of the pan until it reaches some such level as indicated at 43. This will reduce the hydrostatic head shown schematically at 45, so that there is now less of a backward or downward pull on the meniscus 37, and a greater quantity of the liquid coating material will stay on the web 17 as it passes upwardly beyond the meniscus.

Once the point of equilibrium is reached, the apparatus is self metering from this point onward, and the thickness of coating applied to the web is automatically adjusted to the rate of inflow of the coating material into the coating pan. Assuming, of course, that the rate of travel of the web remains constant and that the viscosity of the coating liquid also remains constant, it will be seen that if the web has a tendency to pick up coating liquid faster than it is being fed into the pan through the conduit 35, this will lower the level 43 of the liquid at the incoming side of the pan, thereby increasing the hydrostatic head 45 between this level 43 and the meniscus 37, and the increased meniscus tension on account of the increased hydrostatic head will tend to pull the meniscus down with greater force, thereby holding back more of the liquid from traveling upwardly with the web 17, reducing the thickness of the coating until equilibrium is again established. Conversely, if the web attempted to take the coating material at a slower rate than the rate at which it is supplied to the pan, the level of the free surface 43 would rise, thereby reducing the hydrostatic head 45 and reducing the meniscus tension or downward pull on the meniscus 37, so that more of the liquid would stay on the web 17 as it passed upwardly beyond the meniscus. Thus the system is self metering, and coats the web at exactly the same rate at which the coating material is introduced into the coating pan. If it is desired to produce a thicker coating, the coating liquid is supplied to the pan at a faster rate, and if it is desired to produce a thinner coating, the rate of supply of coating liquid is reduced. This results in a very satisfactory control of coating thickness, particularly suitable for use in the photographic coating field, such as for coating an emulsion, a subbing coat, a filter layer, or a protective layer. Relatively high coating speeds are possible while still maintaining the accurate self-metering control of thickness.

This system may also be used where it is desired to apply more than one coating to the web at the same time. Referring to FIG. 2, there is shown an arrangement for applying two coatings. The first coating is applied in the same manner above described in connection with FIG. 1, and the corresponding parts of the apparatus are identified by the same reference numerals used in FIG. 1. The first coating on the web 17, applied from the dip pan 21, is indicated at 51, and for the sake of clarity it is greatly exaggerated in thickness.

On top of the sloping meniscus blade 25 there is a structure 53 having an inlet conduit 55 for introducing the liquid which is to form the second coating, flowing into a distribution chamber 57 which extends crosswise, parallel to the axis of the coating roll 11, through the full width which is to be coated. From the distribution channel 57, a small slot 59 extends forwardly toward the coating roll, between the upper face of the meniscus bar 25 and the lower face of the structure 53. This slot 59 likewise extends the full width of the web to be coated. The incoming liquid for the second coating may enter the distribution chamber 57 at only one point or a few spaced points, but the cross sectional size of this channel 57 insures adequate distribution of the liquid throughout the entire width which is to be coated. The liquid runs down the slope or incline of the top surface of the meniscus bar 25, flowing by gravity, as shown schematically at 61, and

flows against the upwardly rising coating 51 previously applied to the web 17 at the meniscus, thus forming a second coating 63 on top of the first coating 51, the web carrying the two coatings to the usual conventional drying chamber, just as in the case of a web with only a single coating.

The second coating is applied independently of the metering effect produced on the first coating by the meniscus tension or hydrostatic head differential described in connection with the first coating. The thickness of the second coating depends upon the quantity of coating liquid which is allowed to flow downwardly through the slot 59 and onto the top of the meniscus blade at 61, since the moving web will pick up all of the available liquid at this point. Hence the thickness of the second coating is controlled by controlling the rate of input feed of the coating liquid through the conduit 55 into the distribution channel 57. The input is controlled, as usual, by a metering pump which accurately meters the input flow.

It is seen from the foregoing disclosure that the objects and purposes of the invention are well fulfilled. It is to be understood that the foregoing disclosure is given by way of illustrative example only, rather than by way of limitation, and that without departing from the invention, the details may be varied within the scope of the appended claims.

What is claimed is:

1. The method of applying a liquid coating of uniform and controllable thickness to a moving web of sheet material, which comprises the steps of providing a bath of the coating liquid, moving a web through a path in which one face of the web enters the bath and then exits from the bath in an upward direction, forming a meniscus of the coating liquid against said face of the web at the point where said face of the moving web exits from the bath, and subjecting the meniscus to downward force of variable amount varying in accordance with the liquid level of one portion of the bath, so arranged that when said liquid level drops, greater downward force is applied to the meniscus to reduce the quantity of coating liquid carried upwardly from the bath past the meniscus by the upwardly moving web, and when said level rises, lesser downward force is applied to the meniscus to allow a greater quantity of coating liquid to be carried upwardly from the bath past the meniscus by the upwardly moving web.

2. The method as defined in claim 1, including the further step of applying a second coating of a second liquid over the first coating, by flowing a quantity of the second coating liquid onto the top of the meniscus in position to make contact with the first coating in overlying relation thereto as the web with the first coating emerges upwardly from the meniscus.

3. Coating apparatus, especially for applying a photographic coating to a moving web of sheet material, comprising a pan for holding a supply of coating liquid, a web guide roller for guiding a moving web of sheet material downwardly into the liquid in the pan on the entrance side of the roller and then upwardly out of the liquid on the exit side of the roller, walls substantially sealing the pan in an airtight manner on the exit side of the roller, said walls including a meniscus bar having an edge parallel to and slightly spaced from the web at the exit side of the roller, so that a liquid meniscus may form between the edge of said bar and the web passing said edge, means for partially evacuating the space within said walls sufficiently to hold the free level of coating liquid on the exit side of said roller at an elevation slightly above said edge of said meniscus bar and substantially above the free level of coating liquid on the entrance side of said roller, and means for introducing coating liquid into said pan at a metered rate equal to the intended rate at which coating liquid is to be removed from said pan by the upward exit motion of said web, the hydro-

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static head resulting from the difference in elevation between the meniscus and the free level of liquid on the entrance side of said roller causing a force at the meniscus which automatically meters the amount of liquid coating remaining on the web as it passes the meniscus, to equate it to rate at which coating liquid is introduced into said pan.

4. Apparatus as defined in claim 3, in which said meniscus bar has a top surface inclining downwardly toward the moving web which passes upwardly past said bar.

5. Apparatus as defined in claim 3, in which said meniscus bar has a top surface inclining downwardly toward the upwardly moving web, further including means for flowing a layer of a second coating liquid downwardly over said top surface so that the layer of second coating liquid flows onto the meniscus and is applied as a second coating layer over the first coating layer as the web with the first coating layer thereon passes upwardly from the meniscus.

6. Coating apparatus for applying a coating liquid to a moving web of sheet material, comprising a pan for holding a supply of coating liquid, guide means for guiding a moving web of sheet material downwardly into the liquid in the pan on the entrance side of the guide means and upwardly out of the liquid in the pan on the exit side of the guide means, means extending parallel to and slightly spaced from the web on the exit side of the guide means and forming a surface against which a liquid meniscus may form between it and the moving web, means for enclosing the pan on the exit side of said guide means in a substantially airtight manner while leaving liquid on the entrance side of said guide means subject to atmospheric pressure and leaving the surface of the meniscus also subject to atmospheric pressure, means for partially evacuating said enclosing means to a sufficient degree to keep the free liquid level therein at a level at least as high as the elevation of said meniscus, and means for feeding coating liquid into said pan at a metered rate equal to the rate at which it is desired to have the coating on the web remove coating liquid from the pan, whereby any lowering of the level of liquid in the entrance side of the pan, caused by removal of liquid by the web at a rate faster than fresh coating liquid is fed into the pan,

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will increase the hydrostatic head caused by the difference in elevation between the meniscus and the liquid level in the entrance side of the pan and thereby increase the force at the meniscus so that less liquid coating will be allowed to pass the meniscus, thereby causing the rate at which coating liquid is carried out of the pan by the web to be equal to the rate at which fresh coating liquid is fed into the pan.

7. Coating apparatus for applying a liquid coating of uniform and controllable thickness to a moving web of sheet material, comprising means for holding a bath of coating liquid, means for moving a web through a path in which one face of the web enters the bath and then exists from the bath in an upward direction, means for forming a meniscus of the coating liquid against said face of the web at the location where said face of the moving web exits upwardly from the bath, and means for subjecting the meniscus to downward force of variable amount varying in accordance with the liquid level of one portion of the bath, said last named means being so arranged that when the liquid level of said portion of the bath drops, greater downward force is applied to the meniscus to reduce the quantity of coating liquid carried upwardly from the bath past the meniscus by the upwardly moving web, and when the liquid level of said portion of the bath rises, lesser downward force is applied to the meniscus so as to allow a greater quantity of coating liquid to be carried upwardly from the bath past the meniscus by the upwardly moving web.

8. Apparatus as defined in claim 7, further comprising means for flowing a layer of a second coating liquid onto the top of the meniscus in position to make contact with the first coating in overlying relation thereto as the web with the first coating emerges upwardly from the meniscus.

References Cited

UNITED STATES PATENTS

2,257,373	9/1941	Fanselow	118—63 X
2,681,294	6/1954	Beguin.	
2,995,469	8/1961	Claire	118—63 X

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