ABSTRACT OF THE DISCLOSURE

A method of applying a coating liquid to a moving web in which the web is moved past an applicator head having three blades with parallel tips which define two closed-ended slots, coating liquid being pumped under pressure from a first said slot on the approach side of the web into the space between the applicator and the web, a fluid seal thereby being formed between the middle blade of the applicator and the web, thereby forming a seal between the middle blade of the applicator and the web, a predetermined portion of the liquid being extracted via the second slot.

This invention relates to a method and apparatus for applying thin coatings to flexible webs travelling at relatively high speeds for example for applying thin layers of gelatin or other colloidial material to film base as a step in the production of photographic materials.

The invention is described with reference to the accompanying drawings which illustrate diagrammatically a form of the invention and the relation of the invention to the prior art proposals.

It has been proposed to apply liquid coating composition to a travelling web by means of a so-called "slot applicator". This consists essentially of a device having two blades defining between them a narrow slot opening. Liquid coating composition is fed from such a slot on to the travelling web as diagrammatically illustrated in FIGURE 1 of the accompanying drawings in which is shown the travelling web 1, the blades of the applicator 2 and 3 defining between them a slot opening 4, the coating composition layer 5 and the body of coating composition 6 created between the slot opening and the web surface. It is essential for this type of coating method that this body of liquid remains between the web and the blades during the whole coating process. When coating at high speeds the viscous shear exerted on this body of liquid by the travelling web tends to displace it, thus causing the web to become incompletely covered with coating liquid. However, it has been discovered that if the pressure at A in FIGURE 1 can be made greater than the pressure at B then this pressure difference acts in a direction contrary to the viscous shear force exerted by the travelling web and this enables a greater coating speed to be obtained before the viscous shear exerted by the web displaces the body of coating liquid between the jaws of the applicator and the web.

One of the prior art proposals to achieve this pressure differential was to apply an air pressure at A in FIG. 1. This produced the requisite pressure differential across the body of coating liquid and thus tended to keep the body of coating liquid in position. Another proposal has been to provide an applicator as illustrated diagrammatically in FIGURE 2. A seal 7 of resilient material such as rubber is provided between the blade 8 and the travelling web 9 then the pressure gradient developed between A and B due to the suction effect caused by the seal is automatically in sense and magnitude sufficient to counter the forces of viscous shear and so to hold the body of liquid stable in position over a wide range of speed and viscosity. It has not been found practicable to produce an applicator having a seal of such material but it has now been discovered that an effective liquid seal can be produced between the lower jaw and the web.

It is the object of the invention to provide a method of coating a travelling web with coating liquid at a high speed using a slot applicator which is provided with pumped liquid seal between a penultimate or earlier blade of the applicator and the travelling web.

According to the present invention there is provided a method of applying a thin layer of a coating liquid to a travelling web which comprises causing the web to travel in a predetermined path and supplying coating liquid to an applicator located in juxtaposition to the web, the said applicator comprising three parallel blades which extend substantially across the width of the web, the said blades defining between them two narrow slot openings which are closed at their ends, the said blades being each located at a predetermined fixed distance from the travelling web, the said coating liquid being pumped through the slot on the approach side of the web into the space between the blades of the applicator and the web, thereby forming a seal between the middle blade of the applicator and the web, a portion of the said coating liquid being extracted from the space between the applicator and the web via the second said slot, the residual portion of the said coating liquid remaining as a coating on the travelling web.

It is to be preferred that a metering pump is used to pump the coating liquid through the first slot and that a metering pump is used to extract the coating liquid out of the second slot so that a known amount of coating liquid may be coated on to the travelling web, this quantity being the quantity delivered by the metering pump through the first slot minus the amount extracted by the metering pump from the second slot.

In a preferred embodiment twice the required amount of coating liquid is delivered by the first pump and half of this quantity is extracted by the second pump.

In order to illustrate the invention one form of apparatus by which the method of the invention can be carried out is diagrammatically illustrated in section in FIGURE 3.

Referring to FIGURE 3, a web 10 on a roller 11 is caused to travel past an applicator 12. Applicator 12 is composed of a top blade 13, a middle blade 14 and a bottom blade 15. Defined by these three blades are two narrow slots 16 and 17. The ends of the slots are covered by end plates of which only 15 can be seen. Connected to the lower slot 16 which is the upstream slot is an expansion chamber 19 into which a duct 20 leads.

Coating liquid 21 is pumped by means not shown via duct 20 into the expansion chamber 19 and thence via slot 16 into the space between the applicator and the web. Connected to the slot 17 is another expansion chamber 22 and connected to this chamber is a duct 23. Coating liquid is removed by means not shown from the space between the applicator and the web via the slot 17 and the expansion chamber 22 out of the applicator through duct 23.

More coating liquid than is required can thus be pumped via the slot 16 in the space between the applicator and the web, this ensuring that the gap 24 between the end of the blade 14 and the web is effectively sealed with coating liquid, thus preventing anything other than coating liquid entering the region of low pressure which exists above the blade 14. The excess coating liquid is then extracted by means of a pump attached to the duct 23 leaving the required amount of coating liquid to form a coating on the web.

It is to be realised that although the applicator has been illustrated positioned with the web travelling ver-
cally upwards, it will work equally well with the web travelling horizontally or in a downwards direction so long as the described relation between applicator and web is maintained.

Using this method of coating thin films on to fast travelling webs coating speeds of at least 100 feet per minute have been achieved with an emulsion of 12% gel concentration. When using a slot applicator of conventional design a coating speed of 20 feet per minute using the same coating liquid and other conditions was attainable.

Provided according to the invention, the blade 13 should be nearly parallel to the web 10 and spaced apart from it by not more than three times the final wet thickness of the coating applied to the web. If the distance of the blade 13 is more than three times the final wet thickness of the coating turbulence will be set up in the coating liquid which will affect the smoothness of the applied coating.

The preferred method of coating is to use an applicator wherein all three blades are at an equal distance from the web, this distance being not more than three times the final wet thickness of the applied coating and twice the required amount of coating liquid is delivered by the first pump and half of this quantity is extracted by the second pump.

It is to be understood that there may be additional slots in an applicator of the type herein employed, e.g. where it is desired to coat two layers of coating material simultaneously on the web. For example in FIGURE 4 there are shown four blades 25, 26, 27 and 28 which define three slots 29, 30 and 31. Coating liquid 32 is pumped through slot 29 into the cavity between the applicator and the web 33. This coating liquid seals the gap between blade 26 and the web. A proportion of this liquid is then drawn off through slot 30, the remainder staying on the web as the bottom coat 34. Another coating liquid 35 is then pumped through slot 31 and this forms a coat 36 on coat 34. In order to prevent the two layers mixing the distance of blade 27 from the web must not be more than three times the wet thickness of layer 34. Also in order to achieve a smooth top coat blade 28 should not be more than three times the total wet thickness of layers 34 and 36 combined from the web.

The invention includes not only the method described above but also the novel apparatus used to carry out the method.

We claim as our invention:

1. A method of applying a thin layer of a coating liquid to a travelling web which comprises causing the web to travel in a predetermined path and supplying coating to an applicator located in juxtaposition to the web, the said applicator consisting of three blades with parallel tips which extend substantially across the width of the web, the said blades defining between them first and second narrow slot openings which are closed at their ends, the second slot being wholly behind the first slot in the direction of travel of the web, the edges of the said blades facing the web being each located at a predetermined fixed distance therefrom, the said coating liquid being pumped under pressure through the first said slot on the approach side of the web into the space between the blades of the applicator and the web, thereby forming a seal between the middle blade of the applicator and the web, a predetermined portion of the said coating liquid being extracted from the space between the applicator and the web via the second said slot, the residual portion of the said coating liquid remaining as a coating on the travelling web.

2. A method according to claim 1 wherein the liquid is pumped through the first said slot at a first metered flow rate, the liquid extracted via the second said slot being pumped at a second metered flow rate which is less than the said first flow rate.

3. A method according to claim 1 wherein the liquid is pumped through the first said slot at a first metered flow rate, the liquid extracted via the second said slot being pumped at a second metered flow rate which is substantially twice the rate required to coat the travelling web, the second metered flow rate being substantially half the first metered flow rate.

4. A method according to claim 3 wherein the first metered flow rate is substantially twice the rate required to coat the travelling web, the second metered flow rate being substantially half the first metered flow rate.

5. A method according to claim 1 wherein the said edge of the outer blade which defines the second slot is substantially parallel to the web and spaced apart therefrom by not more than three times the final wet thickness of the coating applied to the web.

6. A method according to claim 1 wherein the said three blades are spaced apart from the web by not more than three times the final wet thickness of the coating applied to the web.

7. A method of applying two thin layers of a coating liquid to a travelling web which comprises causing the web to travel in a predetermined path and supplying coating to an applicator located in juxtaposition to the web, the said applicator consisting of four blades with parallel tips which extend substantially across the width of the web, the said four blades define, respectively, between them first, second and third narrow slot openings which are closed at their ends, the second and third slots being wholly behind the first slot in the direction of travel of the web, the edges of the said blades facing the web being each located at a predetermined fixed distance therefrom, the said coating liquid being pumped under pressure through the first said slot on the approach side of the web into the space between the blades of the applicator and the web, thereby forming a seal between the middle blade of the applicator and the web, a predetermined portion of the said coating liquid being extracted from the space between the applicator and the web via the second said slot, the residual portion of the said coating liquid remaining as a coating on the travelling web, and pumping one other coating liquid through the third slot located after the said second slot so that one other layer of locating liquid is laid down on the coating previously applied on the web.

8. A method according to claim 7 wherein the liquid is pumped through the first said slot at a first metered flow rate, the liquid extracted via the second said slot being pumped at a second metered flow rate which is less than the said first flow rate, the one other locating liquid being pumped through the third slot at a predetermined metered flow rate.

9. A method according to claim 8 wherein the first metered flow rate is substantially twice the rate required to coat the travelling web, the second metered flow rate being substantially half the first metered flow rate.

10. A method according to claim 7 wherein the edge of the blade which is between the second and the third slot is substantially parallel to the web, and wherein blades being spaced apart from the web by not more than three times the final wet thickness of the first coating applied to the web.

11. A method according to claim 7 wherein the fourth blade is spaced from the web by a distance not more than three times the total final wet thickness of the first coating and the one other coating applied to the web.

12. A method according to claim 7 wherein the first three blades are spaced apart from the web by not more than three times the final wet thickness of the first coating applied to the web, and liquid is pumped through the said first slot at a first metered flow rate which is substantially twice the rate required to coat the travelling web, the liquid extracted via the second said slot being pumped at a second metered flow rate which is substantially half the said first metered flow rate.

13. A slot coating apparatus which comprises means for traversing a web to be coated past a coating head, the said coating head constituting of three blades with parallel tips
which define between them first and second narrow slot openings which are closed at their ends, the second slot being behind the first slot in the direction of movement of the web and two pumps, one for pumping coating liquid under pressure into the first slot and one for extracting coating liquid via the second slot.

14. A slot coating apparatus according to claim 13 wherein the two pumps are both metering pumps.

15. A slot coating apparatus which comprises means for traversing a web to be coated past a coating head, the said coating head consisting of four blades with parallel tips which define between them first, second and third slot openings which are closed at their ends, the second slot being behind the first slot and the third slot being behind the second slot in the direction of movement of the web, and three pumps, one for pumping coating liquid under pressure into the first slot, one for extracting coating liquid via the second slot and one for pumping coating liquid into the third slot.

16. A slot coating apparatus according to claim 15 wherein all the pumps are metering pumps.

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