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(54) **Multiple-layer curtain coating method and apparatus with improved bottom-layer uniformity**

(57) A curtain-coating method and apparatus for coating a moving web by depositing a composite of a plurality of layers of discrete coating compositions comprising a bottom layer and at least one other layer onto a surface of the moving web comprising the steps of:

- (a) forming predictive first and second free-falling adjacent partial curtains from a horizontal lip of an extrusion die, the first free-falling partial curtain being comprised of the coating composition of the bottom layer, the second free-falling partial curtain being comprised of a coating composition of a second layer of the multiple layer composite;
- (b) inspecting the first and second free-falling adjacent partial curtains proximate to the horizontal lip to determine if the width of the first free-falling partial curtain initially gets wider, narrower, or remains constant;
- (c) adding a measured amount of a surfactant to the coating composition of the bottom layer if the width of the first free-falling curtain initially gets narrower such that the width of the first free-falling curtain either remains constant or gets wider proximate to the horizontal lip;
- (d) determining the amount of surfactant to add to the coating composition of the bottom layer of the composite from the measured amount;
- (e) forming the composite of the plurality of layers on a slide surface of a multiple slot curtain coating apparatus, the coating composition of the bottom layer including the determined amount of sur-

factant, surfactant mixture, or other surface-active material;

(f) forming a free-falling curtain of the composite of the plurality of layers;

(g) guiding each lateral edge of the free-falling curtain by substantially vertical edge guides spaced apart by the width of the composite of the plurality of layers; and

(h) impinging the free-falling curtain on the moving web.

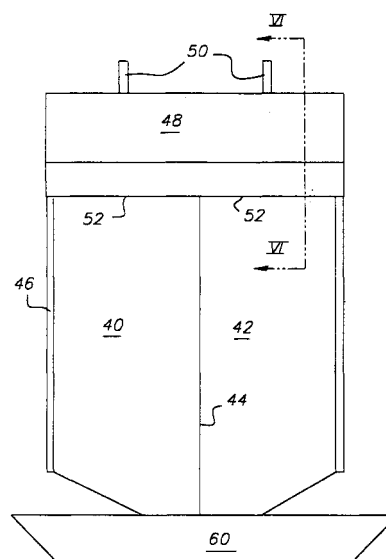


FIG. 4

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Description

[0001] The present invention relates generally to the simultaneous coating of multiple layers by curtain coating, and more particularly to the deployment of surfactants as coating aids to improve the curtain stability and uniformity at the edges thereof.

[0002] In curtain coating, a free-falling curtain of coating composition impinges on a moving receiving surface to form a layer thereon. One curtain coating apparatus is described in U.S. Patent No. 3,508,947 to Hughes, wherein a composite layer comprising a plurality of distinct layers is formed on a slide hopper and dropped therefrom to form a freely falling curtain. The slide hopper has several slots from which coating compositions issue as layers onto an inclined surface, the slide. The layers flow down the slide by gravity. A layer exits each slot and flows down the slide cascading over the layer issuing from the next adjacent slot further down the slide. In this way, a composite layer consisting of up to 10 or more distinct layers is formed. The composite layer detaches from a horizontal lip at the end of the slide to form a sheet of liquid in free fall called a curtain. The edges of the curtain must be supported laterally to maintain its width; otherwise, the curtain narrows as it falls as a consequence of surface tension. To counteract surface tension and maintain curtain width, these edges are placed in wetting contact with substantially vertical, solid support surfaces called edge guides.

[0003] The edges of the curtain are prone to nonuniformities and to the detachment of the curtain from the edge guides. A primary cause of these problems is the drag that the edge guide exerts on the curtain. Unlike the main body of the curtain, the edges of the curtain are not freely falling. The momentum of the curtain stabilizes it against surface tension. However, a consequence of the drag exerted by the edge guide is that an otherwise stable curtain may not stably attach to the edge guide. A second consequence of the drag is that the uniformity of the coating composition may be adversely altered. Many edge guides for promoting curtain stability and uniformity are known. As taught in U.S. Patent No. 5,328,726 to Reiter, edge guides consisting of two, thin, parallel wires are particularly effective. The introduction of auxiliary liquid along an edge guide, as in Reiter, is also known to stabilize the curtain. An auxiliary liquid of low viscosity, usually a solvent for the coating compositions, greatly reduces the drag of the edge guide on the curtain so that the edges of the curtain approach the state of free fall. Means to remove the auxiliary liquid immediately before coating to preclude problems in coating and drying are described in Reiter, in U.S. Patent No. 5,725,910, and in U.S. Patent No. 5,763,013.

[0004] U.S. Patent No. 3,508,947 to Hughes, and U.S. Patent No. 3,632,374 to Greiller, teach the reduction of the level of surface tension through the addition of surfactants to reduce the flow rate at which a stable curtain can be formed and to improve coating quality.

[0005] When a slide hopper is used to form a curtain that is a composite of a plurality of layers, one of the two surfaces of the curtain contacting air originates at the hopper lip. This surface is referred to herein as the back surface of the curtain. The outermost coating composition at the back of the curtain issues from the lowermost slot of the slide hopper and forms the bottom layer of the composite layer. The other surface of the curtain contacting air originates at the uppermost slot of the slide hopper and is termed the front surface of the curtain. The outermost coating composition at the front surface of the curtain issues from the uppermost slot of the slide hopper and forms the top layer of the composite layer.

[0006] In some instances, the bottom layer is observed to retract from the edge guide beginning at the hopper lip and continuing the length of the curtain. In such a circumstance, curtain stability at the edge guide is observed to be compromised, and in the most severe cases a curtain cannot be maintained in wetting contact with the edge guide. When contact can be maintained, coating uniformity is compromised near the edge. This situation can be rectified by addition of surfactant to the bottom-layer composition, but ascertaining this addition has been a matter of trial and error. Empirical approaches are limiting, unpredictable, and costly.

[0007] Surface tension measurements fail to provide unambiguous guidance on surfactant deployment because there is no unique value of surface tension. The value of surface tension depends upon the action of surfactants and surface-active ingredients, an action that is not instantaneous. Surfactant in the bulk composition must move to air surfaces by convection and diffusion, and adsorb there. Additionally, surface area is continuously generated in a coating process. Therefore, the levels of surface tension of the top and bottom layers vary in the flow direction, and it is not obvious what measurement might be relevant to the uniformity and stability of the curtain at an edge guide.

[0008] Although surfactant additions to achieve acceptable curtain coatings can be determined by trial and error, a direct method that is fast, inexpensive, and reliable is preferred. Surfactants in photographic products affect many properties including friction, tackiness, electrostatic charging, rewetting by processing solution, foaming in a processing bath, and in some instances sensitometric response. As such, the indiscriminate deployment of surfactants is generally undesirable. Deployment late in the product-development cycle or at the start of manufacturing can lead to problems and delays.

[0009] U.S. Patent No. 5,871,821 to Kondo, teaches the measurement of a surface-tension value for each layer of a composite layer as a method for deploying surfactants. A test curtain of each coating composition is formed. Stationary

waves are induced in the test curtain by an obstacle, and the orientation of these waves is measured. A surface-tension value is then computed from a theoretical equation. The surface tension values obtained for the compositions of the two outermost layers are compared to the values obtained for the compositions of the intervening layers. The minimum value from the intervening compositions is to exceed the larger of the values of the outermost compositions.

[0010] The method of Kondo has disadvantages. Foremost, the method does not specify the position in the test curtain where surface tension is measured. The surface-tension value is ambiguous because surface tension varies along the length of a curtain. Furthermore, the problem of bottom-layer retraction from the edge guide begins at the hopper lip where the value of surface tension cannot be determined by the method of Kondo. Another disadvantage is that the method requires determining surface-tension differences indirectly from surface tension values that are themselves indirectly determined from wave properties. The surface-tension values must be accurate, and therefore, accurate measurement of flow rate, curtain velocity, and angular orientation of waves is required. As such, the method is difficult in practice.

[0011] It is, therefore, an object of the present invention to provide a method for deploying surfactants in curtain coating such that the bottom layer maintains wetting contact with the edge guide along the entire length of the curtain.

[0012] It is a further object of the invention to deploy surfactant without the measurement of surface tension values, as these surface tension values vary in the flow direction and are ambiguous properties of the coating compositions.

[0013] Still another object of the present invention is to deploy surfactant reliably with minimal expenditure of time and materials.

[0014] The foregoing and other features, objects and advantages of the present invention will become apparent upon a reading of the detailed description, claims and drawings set forth herein. These features, objects and advantages are accomplished by extruding a predictive curtain of two partial curtains differing in composition with a common border in the middle. One partial curtain has the composition of the bottom layer of the composite layer. The other partial curtain has the composition of another layer of the composite layer, and this is repeated with a selection of the compositions of the other layers. Thus, the predictive curtain of the invention is not a composite layer but is the combination of two partial curtains differing in composition that share a common border. If the partial curtain with the composition of the bottom layer is observed to narrow initially in the downward direction, then surfactant is added to the bottom layer composition until this initial narrowing is eliminated. When surfactant is deployed in this way in a composite layer delivery, the bottom layer is observed to maintain wetting contact with the edge guides and preserve the uniformity and the stability of the composite layer curtain at the edge guide.

[0015] The method of the present invention allows for the determination of the amount of surfactant, surfactant mixture, or other surface-active material to add to the coating composition of a bottom layer of a multiple layer composite and comprises the steps of:

(a) forming a predictive curtain comprising first and second free-falling adjacent partial curtains from a horizontal lip of an extrusion die, the first free-falling partial curtain being comprised of the coating composition of the bottom layer, the second free-falling partial curtain being comprised of a coating composition of another layer of the multiple layer composite;

(b) inspecting the common border of the first and second free-falling adjacent partial curtains proximate to the extrusion lip to determine if the width of the first free-falling partial curtain initially gets wider, narrower, or remains constant; and

(c) adding a surfactant, surfactant mixture, or other surface-active material to the coating composition of the bottom layer if the width of the first free-falling curtain initially gets narrower such that the width of the first free-falling curtain either remains constant or gets wider proximate to the extrusion lip.

[0016] The method of the present invention further allows for curtain-coating a moving web by depositing a composite of a plurality of layers of discrete coating compositions comprising a bottom layer and at least one other layer onto a surface of the moving web and comprises the steps of:

(a) forming first and second free-falling adjacent partial curtains from an extrusion lip, the first free-falling partial curtain being comprised of the coating composition of the bottom layer, the second free-falling partial curtain being comprised of a coating composition of a second layer of the multiple layer composite;

(b) inspecting the first and second free-falling adjacent partial curtains proximate to the extrusion lip to determine if the width of the first free-falling partial curtain initially gets wider, narrower, or remains stable;

(c) adding a metered amount of a surfactant to the coating composition of the bottom layer if the width of the first free-falling curtain initially gets narrower such that width of the first free-falling curtain either remains stable or gets wider proximate to the extrusion lip;

(d) determining the amount of surfactant, surfactant mixture, or other surface-active material to add to the coating composition of the bottom layer of the composite layer from the measured amount;

(e) forming the composite of the plurality of layers on a slide surface of a multiple slot curtain coating apparatus, the coating composition of the bottom layer including the determined amount of surfactant, surfactant mixture, or other surface-active material;

(f) forming a free-falling curtain of the composite of the plurality of layers;

(g) guiding each lateral edge of the free-falling curtain by substantially vertical edge guides spaced apart by the width of the composite of the plurality of layers; and

(h) impinging the free-falling curtain on the moving web.

[0017] Additionally, a plurality of second free-falling adjacent partial curtains may be formed in sequence with the other coating compositions of the composite layer with the first free-falling partial curtain always being comprised of the coating composition of the bottom layer. In this way, the steps of inspecting, adding and determining can be repeated with most if not all of the individual layers of the composite.

[0018] It is sometimes necessary to add an additional amount of surfactant, surfactant mixture, or other surface-active material to suppress curtain repellencies in the bottom layer if such repellencies are observed. This becomes necessary when surfactant levels in the bottom layer are insufficient to prevent repellency spots in the curtain. Repellency spots are a problem unrelated to layer spreading but may be controlled by addition of surfactant.

[0019] Fig. 1 is a perspective view of a curtain coating apparatus for forming a composite layer using a slide hopper and applying it to a receiving surface such as a continuous web as shown.

[0020] Fig. 2 is a side elevation of a curtain coating apparatus with a composite layer extruded on the slide surface thereof.

[0021] Fig. 3 is a rear elevational view of the curtain showing the back surface of the curtain near the intersection of the hopper lip and the retraction of the bottom layer from the edge guide along the length of the curtain.

[0022] Fig. 4 shows a front elevational view of a predictive curtain issuing from a die 48 comprising a pair of partial curtains of different coating compositions.

[0023] Fig. 5 shows a side elevational view of the die for forming a predictive curtain depicted in Figure 4.

[0024] Fig. 6 is a cross sectional view of the die for forming the predictive curtain taken along line 5 - 5 of Figure 5.

[0025] Fig. 7 is a cross sectional view of the die for forming the predictive curtain taken along line 6 - 6 of Figure 4.

[0026] Fig. 8 is a schematic of an apparatus for supplying two coating compositions to including the die of Figure 4 for forming a predictive curtain.

[0027] Fig. 1 shows a curtain coating apparatus for forming a composite layer of a plurality of coating compositions and applying the composite layer to a moving web. Slide hopper 10 consists of several die elements 12. Each die element 12 accepts a liquid coating composition supplied through a conduit (not shown) and issues a substantially uniform layer 15 (see Figure 2) from narrow slot 14 onto slide surface 16. The layers 15 flow down the inclined slide surface 16 by gravity. Each layer 15 issuing from a slot 14 positioned higher on the slide surface 16 flows over the layer 15 issuing from the next slot 14 positioned immediately there below on the slide surface 16. In this way, a composite layer or multiple layer composite 18 is formed consisting of a plurality of layers differing in composition. The layers on the slide surface 16 are contained laterally by edge pads 20. The lowermost portion of slide surface 16 curves downward and terminates at horizontal lip 22. The composite layer 18 detaches from the lip 22 to form free-falling curtain 24. The lateral edges of the curtain are supported by solid, substantially vertical edge guides 26. The curtain 24 accelerates as it falls and then impinges on web 28 at impingement line 30 and forms coated composite layer 32 on web 28. For applications demanding the highest coating uniformity, including photographic applications, the web 28 is supported by backing roller 34 at impingement line 30.

[0028] Fig. 3 is a rear elevational view of the curtain 24 showing the back surface of the curtain near the intersection of the hopper lip 22 and the edge guide 26. The back surface of the curtain 24 is the surface in contact with air that originates at hopper lip 22. The front surface of the curtain 24 is a continuation of the surface of composite layer 18 on slide surface 16. In some instances the bottom layer 36 at the back of curtain 24 retracts from edge guide 26 beginning at hopper lip 22 and continuing along the length of the curtain 24. In this situation, one of the other layers 38 is exposed at the back of the curtain 24 adjacent to edge guide 26. The retraction of the bottom layer from the edge guide 26 degrades the uniformity of the composite layer near the edge of the curtain 24. Furthermore, the stability of the curtain 24 at the edge guide 26 is compromised, and in worst cases, the curtain 24 does not spontaneously attach to the edge guide 26, or breaks away from the edge guide 26 during coating.

[0029] The retraction of the bottom layer 36 is believed to be the result of the surface tension of the bottom layer 36 being higher than that of another layer 38 exposed to air at the back of the curtain 24 at the edge guide 26. Such exposure is frequent but not certain. Surface tension for coating compositions is determined by surfactants and other surface-active ingredients, and it varies along the length of the curtain 24. Accurate predictions are not possible, and direct measurements are not practical. Therefore, there is a need for a curtain delivery method wherein the retraction of the bottom layer 36 from the edge guide 26 is anticipated and prevented.

[0030] Figure 4 shows an extrusion die 48 with a horizontal lip 52 issuing a predictive curtain comprising a partial

curtain 40 of a first coating composition and a partial curtain 42 of a second coating composition. It is essential that each partial curtain 40, 42 have the same volumetric flow rate per unit width. The partial curtains share an edge 44 that may not be vertical or straight. Edge guides 46 maintain the width of the combined curtain. Drain 60 captures the partial curtains 40, 42 for disposal.

[0031] Die 48 has two inlet ports 50 through which the coating compositions are supplied. The die 48 has a horizontal extrusion lip 52 where a free-falling curtain forms. Inside the die 48 are two partial cavities 54 (see Figures 6 and 7) connecting to inlet ports 50. These cavities 54 are separated by narrow dividing wall 56, so each coating composition is confined to the cavity 54 to which it is supplied. Partial cavities 54 adjoin partial slots 58 that are also separated by dividing wall 56. The depth of each partial slot 58 of extrusion die 48 is preferably in the range of from 0.1 mm to 0.5 mm to create sufficient resistance to flow to distribute the coating compositions laterally. The width of dividing wall 56 preferentially tapers to a point at lip 52. Each partial slot 58 is preferably flared at its end, as shown in Fig. 7, such that the depth thereof at lip 52 is several times the depth of the main portion of the slot 58, for example 0.5 to 3 mm. In this way, the average velocity of the coating composition at lip 52 approximates the average velocity at lip 22 of slide hopper 10.

[0032] The volumetric flow rate per unit width supplied to each partial curtain 40, 42 are preferably comparable to and of the same order of magnitude as the flow rate per unit width of composite layer 18. Typically, the volumetric flow rate of each partial curtain 40, 42 is 2 cc/sec per cm of width. Precisely the same volumetric flow rate per unit width is supplied to partial curtains 40 and 42.

[0033] Fig. 8 shows means for supplying the coating compositions to partial cavities 54 and slots 58 of identical horizontal width. The compositions are poured into kettles 62 supplying pumps 64. These may be identical positive displacement pumps, for example, gear pumps 64 driven off a common drive 66 to ensure equal volumetric flow rates. The pumps 64 connect to inlets 50 through valves 68. Each valve 68 is also supplied with a flushing liquid from a supply 70. The flushing liquid is miscible with the coating compositions, and for photographic compositions the flushing liquid is typically water. In one valve position, the coating compositions from pumps 64 are directed to die inlets 50, and flushing liquid from supplies 70 is directed to drains 72. In a second valve position, the coating compositions from pumps 64 are directed to drains 72, and flushing liquid from supplies 70 is directed to die inlets 50.

[0034] In the method of the invention, the horizontal widths of partial curtains 40 and 42 are examined within 1 cm of the die lip 52, and a determination of which partial curtain 40, 42 widens in the downward direction or if their widths are constant. One coating composition is that of the bottom layer of composite layer 18, and, as a preferred embodiment, the other coating composition is that of every other layer of the composite layer in turn. The partial curtain 40, 42 corresponding to the bottom layer must have constant width or must increase in width. If that partial curtain 40, 42 narrows instead, a surfactant, surfactant mixture, or other surface-active material is added to the bottom-layer composition until the corresponding partial curtain 40, 42 achieves a constant width or increases in width. The term "surfactant" as used herein is intended to include surfactants, surfactant mixtures, or other surface-active materials. More specifically, the term "surfactant" as used herein is intended to include soluble surface-active compounds commonly used to rapidly reduce the surface tensions of the coating compositions to be coated in a multiple layer composite. Surfactants which are suitable for bottom layer compositions of photographic products are similar to those used as coating aids in top layer compositions. Examples of these surfactants are anionic types such as sodium alkylbenzene or alkylnaphthalene sulfonates, sodium octylphenoxy di-ethoxy ethane sulfonate, sodium secondary-alkyl sulfonates, and sodium di-alkyl sulfosuccinates, or nonionic types such as nonyl phenoxy poly(glycidol)(10), alkyl polyglycosides, and esters of sucrose and fatty carboxylic acids.

[0035] In another preferred embodiment, composite layer 18 consists of three or more distinct coating compositions so that there is at least one layer between the top and bottom layers. In that case, it may not be essential to employ the top layer as a partial curtain 40, 42 depending on the surface tension of the other layers. Because the top layer typically contains high concentrations of surfactants, and its use in the predictive curtain would necessitate similarly high concentrations in the bottom layer. Excessive amounts of surfactant can adversely affect some product properties.

[0036] In a third preferred embodiment, if composite layer 18 consists of only two layers, then the top layer must be employed as a partial curtain 40, 42.

[0037] The risk of exposure of a layer at the back surface of curtain 24 diminishes as the placement of that layer is farther from the bottom layer and closer to the top layer. As a result there can be benefit in employing the compositions of just some of the layers specified above as partial curtains 40, 42. Benefit is particularly likely when the layer adjacent the bottom layer is employed. These omissions are not preferred, however.

[0038] In some cases, partial curtain 40 may initially widen but start to narrow farther away from lip 52. Or, partial curtain 40 may initially narrow but start to widen farther away from lip 52. However, it is the initial response, that is, the reaction of the partial curtains 40, 42 in proximity to lip 52, that is relevant for the purposes of the invention.

[0039] To minimize the surfactant added to a product, the bottom layer may be split and delivered as two layers; in this situation, an additional die element is required. No surfactant is added to the upper portion of the split layer. The lower portion of the split layer is the bottom layer of the composite layer and is adjusted by the method of the invention.

This approach is believed to be successful because surfactant concentration rather than the absolute amount of surfactant determines the suitability of the bottom layer.

[0040] By the method of the invention, the bottom layer is evaluated against selected other layers of the composite layer. Many ways to make this comparison are equivalent for the purposes of the invention. As has been explained, the bottom layer may be compared directly to each of the selected other layers. Equivalently, for example, the selected other layers can be compared two at a time to determine which of those layers initially widens or remains constant against each of the remaining selected other layers; the bottom layer can be adjusted against this reference layer and surfactant additions made in a single step. If the bottom layer so adjusted is subsequently directly compared to each of the selected other layers by the method of the invention, the bottom layer will be found to widen or remain constant in width in each case. Thus, equivalent outcomes can be achieved by different sequences of layer comparisons. The principle by which equivalence can be determined is that if layer A widens or remains constant in width in direct comparison with layer B, and if layer B widens or remains constant in width in direct comparison with layer C, then it will be true that layer A will widen or remain constant in width if compared directly to layer C. Consequently, the bottom layer may be equivalently adjusted by many sequences of direct layer comparisons, and all such sequences are within the scope of the invention.

[0041] The method of the invention determines the minimum surfactant requirement for specified compositions of the composite layer. In some instances, additional surfactant may have to be added to the bottom layer. For instance, repellency spots may be observed in the coating. These are elongated spot disturbances in layer thickness of the bottom and adjacent layers, or perforations in the composite layer caused by small volumes of insoluble, surface-active components or contaminants, acting on the back surface of the curtain. For example, antifoam materials used for silver halide preparation are often insoluble liquid droplets dispersed in photographic compositions that may be highly surface active. Further additions of surfactant to the bottom layer that may be necessary to suppress repellency spots are consistent with the criteria of the invention.

Example 1

[0042] Five coating solutions of the following multilayer composite, consisting of the antihalation and cyan-dye-forming layers of a color negative film product, were evaluated by the measurements described in this invention. This multiple layer composite was to be coated by a curtain-coating method..

Layer 1 (bottom)	Antihalation layer
Layer 2	Slow cyan layer, containing a red-sensitive silver halide emulsion and a cyan-dye forming coupler dispersion
Layer 3	Mid cyan layer, containing a red-sensitive silver halide emulsion and a cyan-dye-forming coupler dispersion
Layer 4	Fast cyan layer, containing a red-sensitive silver halide emulsion and a cyan-dye-forming coupler dispersion
Layer 5 (top)	Interlayer, containing a dispersed interlayer scavenger and coating aid surfactants

[0043] Measurements were made on selected pairs of solutions in order to compare their relative surface tensions in curtain delivery, as described in this invention, beginning with the solutions of the interior layers. The temperature of the solutions during the measurements was 40-42 degrees Celsius. In measuring the fast cyan and mid cyan solutions, the partial curtain of fast cyan solution widened just below the extrusion lip because of its lower surface tension. In measuring the fast cyan and the slow cyan solutions, the partial curtain of slow cyan widened because of its lower surface tension and was then used as the reference solution for measurements of the antihalation layer solution. In measuring the antihalation layer solution and slow cyan solution, the partial curtain of the antihalation layer narrowed significantly because of its much higher surface tension, indicating the need to add some surfactant to the antihalation solution. After the addition of 1.3g of active OPES surfactant* per kilogram of antihalation solution, the partial curtain of antihalation layer solution no longer narrowed below the extrusion lip but had a constant width.

TABLE 1

Partial curtain 2	Partial curtain 1	Surfactant added to curtain 1	Width of partial curtain 1
layer 4	layer3	none	narrows, slight
layer 4	layer2	none	widens, slight
layer 2	layer 1	none	narrows, extreme

TABLE 1 (continued)

Partial curtain 2	Partial curtain 1	Surfactant added to curtain 1	Width of partial curtain 1
"	"	OPES * 0.78 g/kg	narrows, slight
"	"	" 1.04 g/kg	narrows, slight
"	"	" 1.30 g/kg	constant

key : * t-octyl phenoxy di-ethoxy ethane sulfonate, sodium salt, in grams active surfactant based on 1 kg of the coating solution

[0044] The multilayer curtain with the above solutions and OPES surfactant added to the coating solution of layer 1 at 1.30 g / kg of solution had good edge uniformity and stability during delivery with a multiple layer curtain coating hopper and when it was coated onto a moving web of cellulose triacetate film support.

Claims

1. A method for determining the amount of surfactant, surfactant mixture, or other surface-active material to add to the coating composition of a bottom layer of a multiple layer composite layer comprising the steps of:

(a) forming a predictive curtain comprising first and second free-falling adjacent partial curtains from a horizontal lip, the first free-falling partial curtain being comprised of the coating composition of the bottom layer, the second free-falling partial curtain being comprised of a coating composition of another layer of the multiple layer composite;

(b) determining if the width of the first free-falling partial curtain initially gets wider, narrower, or remains constant within 1 cm of the coating lip; and

(c) adding a surfactant, surfactant mixture, or other surface-active material to the coating composition of the bottom layer if the width of the first free-falling curtain initially gets narrower such that the width of the first free-falling curtain either remains constant or gets wider proximate to the horizontal lip.

2. A method as recited in claim 1 further comprising the steps of:

forming the second free-falling adjacent partial curtain with each coating composition of each layer of the composite layer and repeating steps (b) and (c).

3. A method as recited in claim 1 further comprising the steps of:

sequentially forming the second free-falling adjacent partial curtain with each coating composition of each of the plurality of layers of the composite layer with the first free-falling adjacent partial curtain still being comprised of the coating composition of the bottom layer and repeating steps (b) and (c).

4. A method as recited in claim 1 further comprising the steps of:

for a composite layer of three or more layers, sequentially forming the second free-falling adjacent partial curtain with each coating composition of each of the plurality of layers of the composite other than the coating composition of a top layer of the composite with the first free-falling adjacent partial curtain still being comprised of the coating composition of the bottom layer and repeating steps (b) and (c).

5. A method as recited in claim 1 wherein:

said step of forming a predictive curtain is performed with an extrusion die having a slot depth at the lip in the range of 0.5 mm to 3 mm.

6. A method as recited in claim 1 wherein:

said determining step is performed by visual inspection.

7. A curtain-coating method for coating a moving web by

depositing a composite of a plurality of layers of discrete coating compositions comprising a bottom layer and at least one other layer onto a surface of the moving web comprising the steps of:

- (a) forming first and second free-falling adjacent partial curtains from a horizontal lip of an extrusion die, the first free-falling partial curtain being comprised of the coating composition of the bottom layer, the second free-falling partial curtain being comprised of a coating composition of a second layer of the multiple layer composite;
- (b) inspecting the first and second free-falling adjacent partial curtains proximate to the horizontal lip to determine if the width of the first free-falling partial curtain initially gets wider, narrower, or remains constant;
- (c) adding a measured amount of a surfactant to the coating composition of the bottom layer if the width of the first free-falling curtain initially gets narrower such that width of the first free-falling curtain either remains constant or gets wider proximate to the horizontal lip;
- (d) determining the amount of surfactant, surfactant mixture, or other surface-active material to add to the coating composition of the bottom layer of the composite from the measured amount;
- (e) forming the composite of the plurality of layers on a slide surface of a multiple slot curtain coating apparatus, the coating composition of the bottom layer including the determined amount of surfactant, surfactant mixture, or other surface-active material;
- (f) forming a free-falling curtain of the composite of the plurality of layers;
- (g) guiding each lateral edge of the free-falling curtain by substantially vertical edge guides spaced apart by the width of the composite of the plurality of layers; and
- (h) impinging the free-falling curtain on the moving web.

8. A method as recited in claim 7 further comprising the steps of:

sequentially forming the second free-falling adjacent partial curtain with each coating composition of each of the plurality of layers of the composite with the first free-falling partial curtain still being comprised of the coating composition of the bottom layer and repeating steps (b), (c) and (d).

9. A method as recited in claim 7 further comprising the steps of:

for a composite layer of at least three layers, sequentially forming the second free-falling adjacent partial curtain with each coating composition of each of the plurality of layers of the composite other than the coating composition of a top layer of the composite with the first free-falling adjacent partial curtain still being comprised of the coating composition of the bottom layer and repeating steps (b), (c) and (d).

10. A method as recited in claim 7 wherein:

said extrusion die has a slot depth at the lip in the range of 0.5 mm to 3 mm.

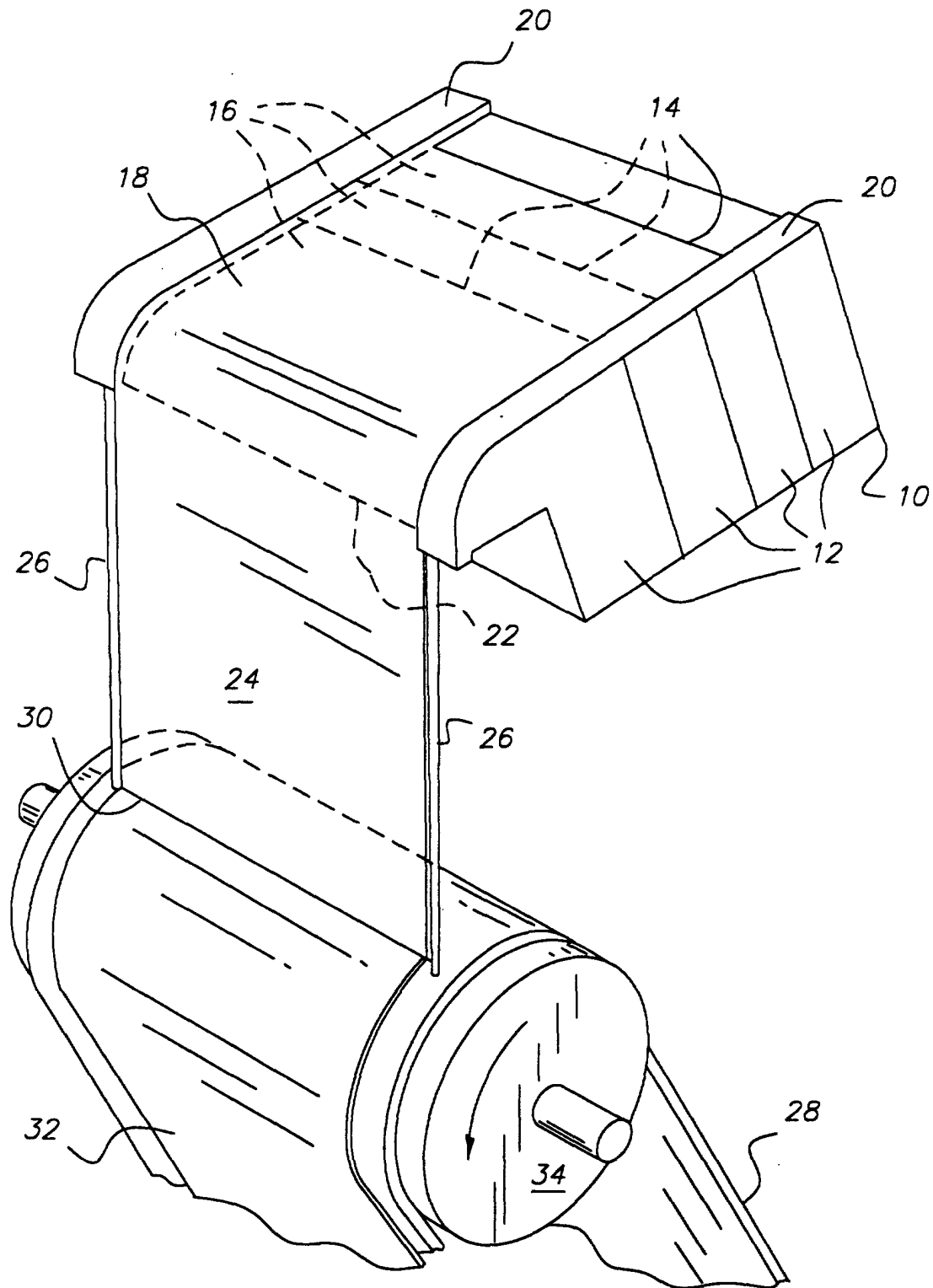


FIG. 1

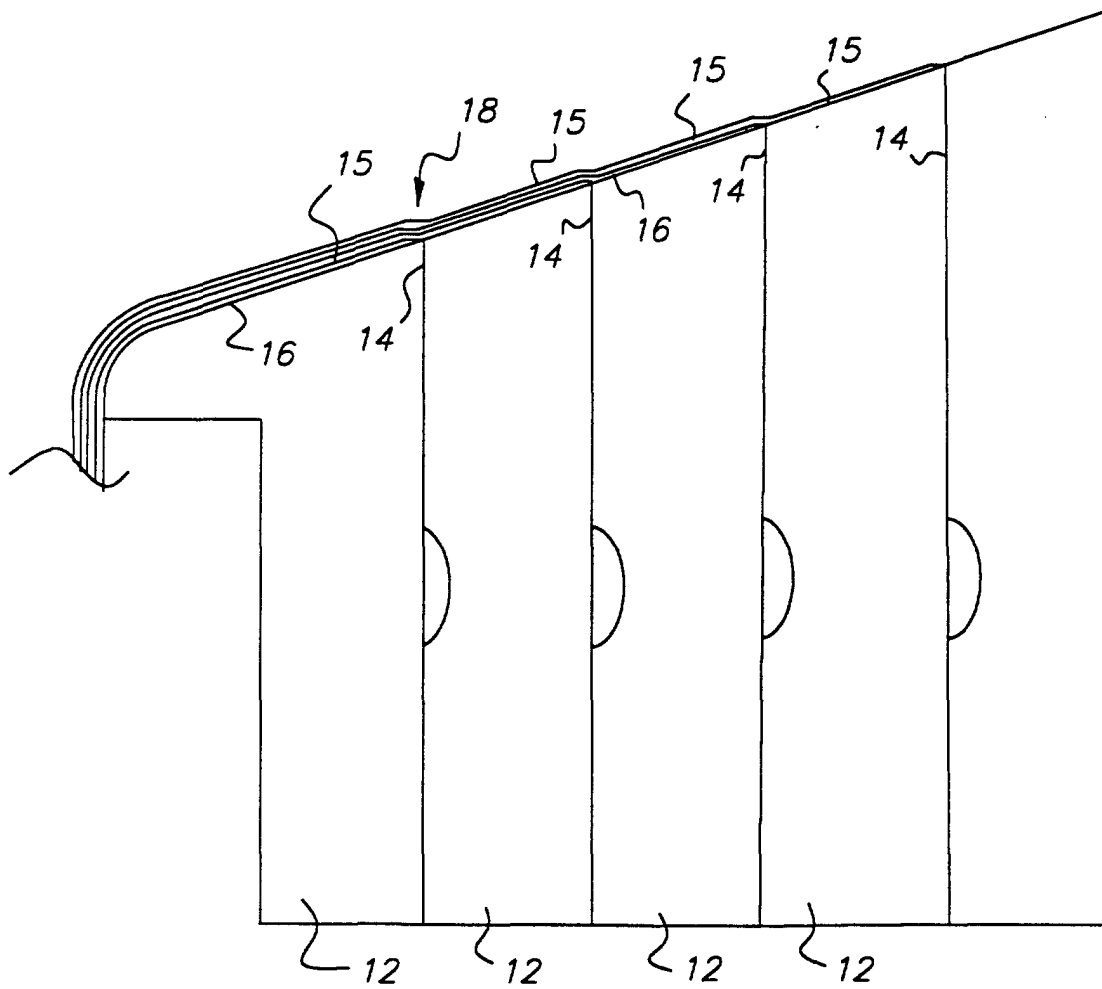


FIG. 2

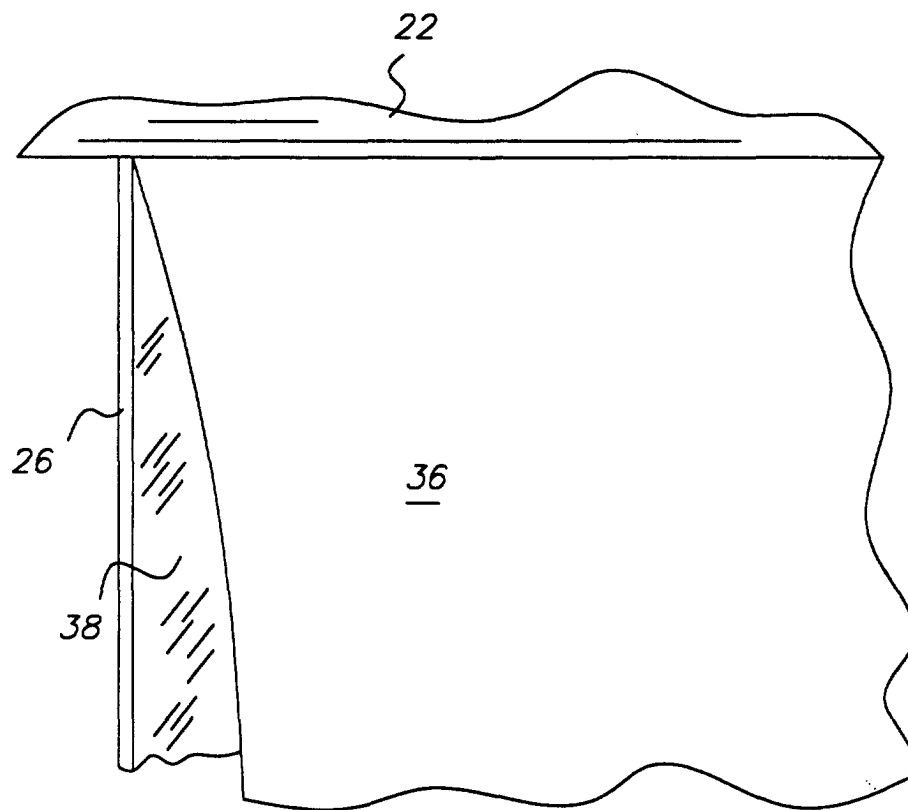


FIG. 3

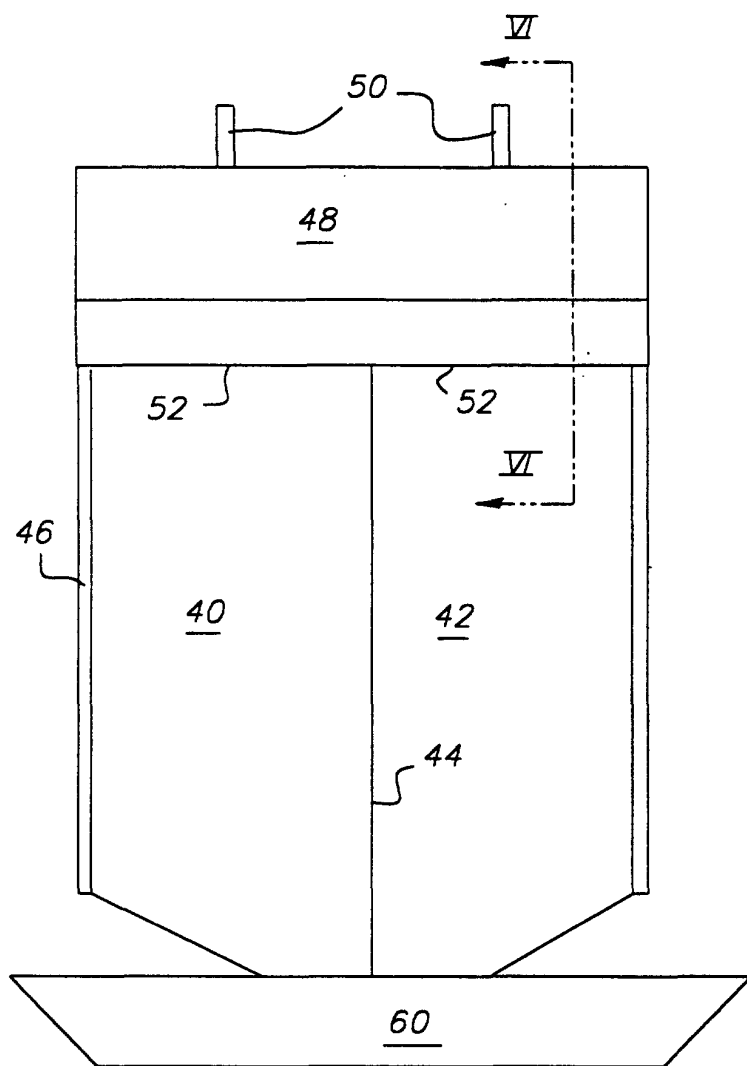


FIG. 4

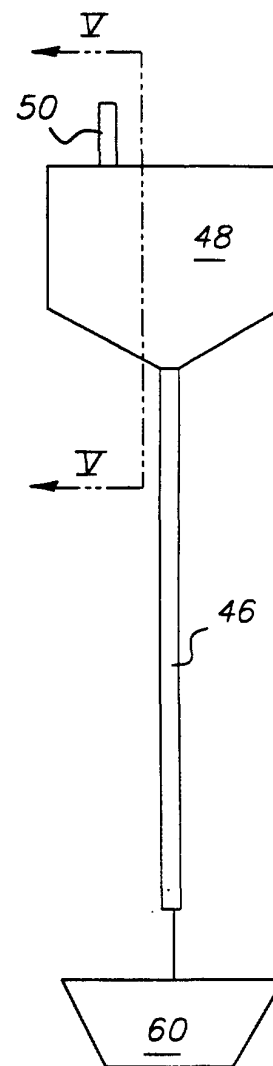


FIG. 5

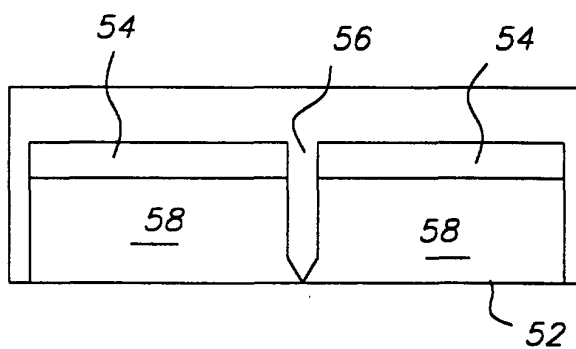


FIG. 6

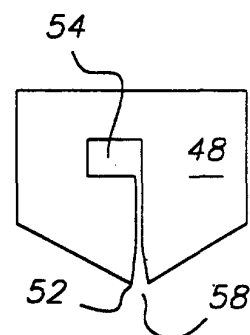


FIG. 7

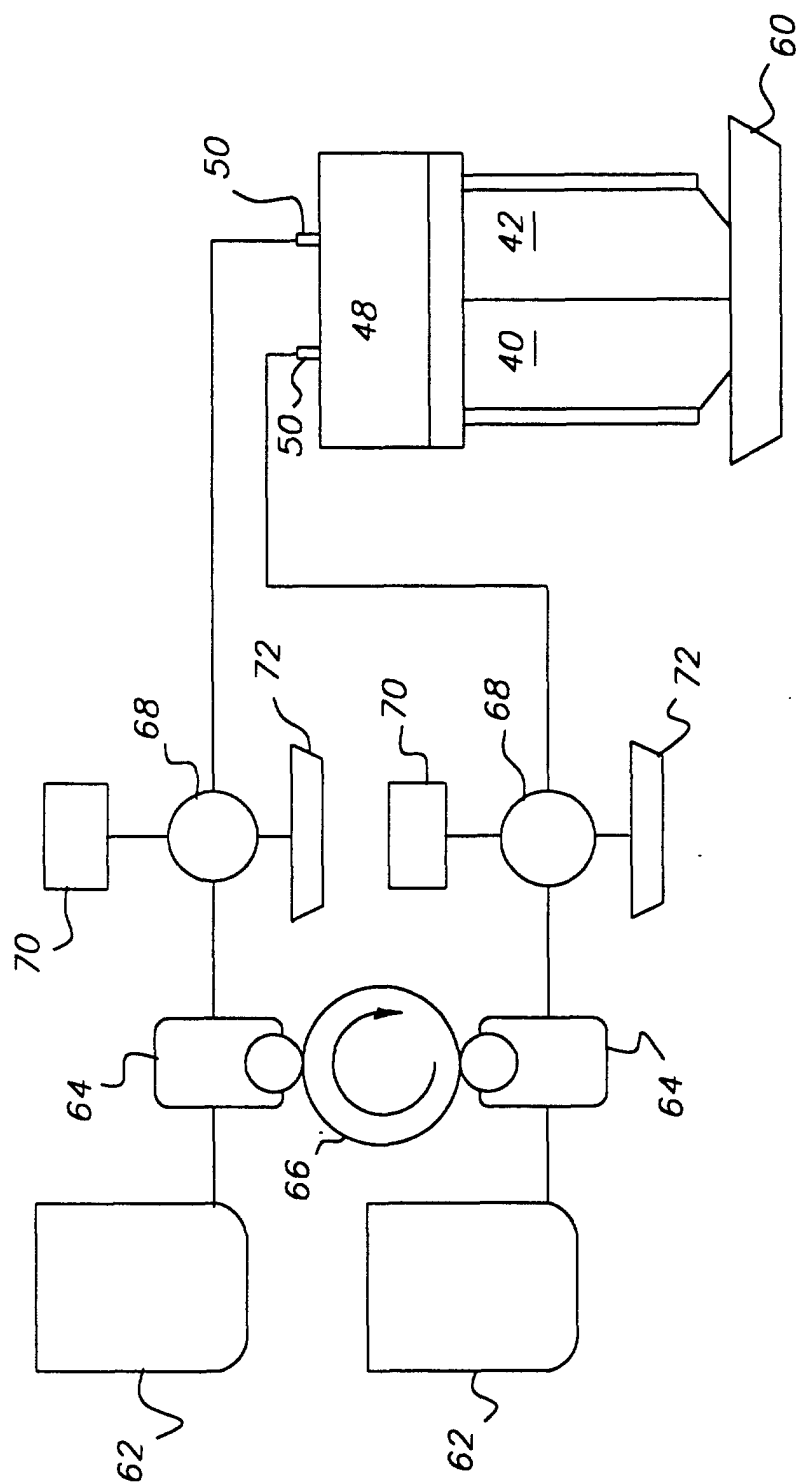


FIG. 8



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 20 3507

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	GB 1 508 198 A (CIBA-GEIGY) 19 April 1978 (1978-04-19) * page 1, line 90 - page 2, line 67 * * page 2, line 106 - line 125; figures 1,3 * * -----	1-10	G03C1/74 B05C5/00
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			G03C B05C
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		8 January 2001	Magrizos, S
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08-01-2001

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