United States Patent

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[54] METHOD FOR COATING A CONTINUOUS WEB

2 Claims, 8 Drawing Figs.

[52] U.S. Cl. .... **117/69,** 117/34, 117/76 P, 117/83, 117/155 R, 117/156, 117/161 UE, 117/164, 118/126, 118/412
[51] Int. Cl. **B44d 1/14,** B44d 1/02
[50] Field of Search .... 118/411, 412, 407, 415, 126; 117/69, 76, 83, 155 R, 156, 161 DE, 164, 34

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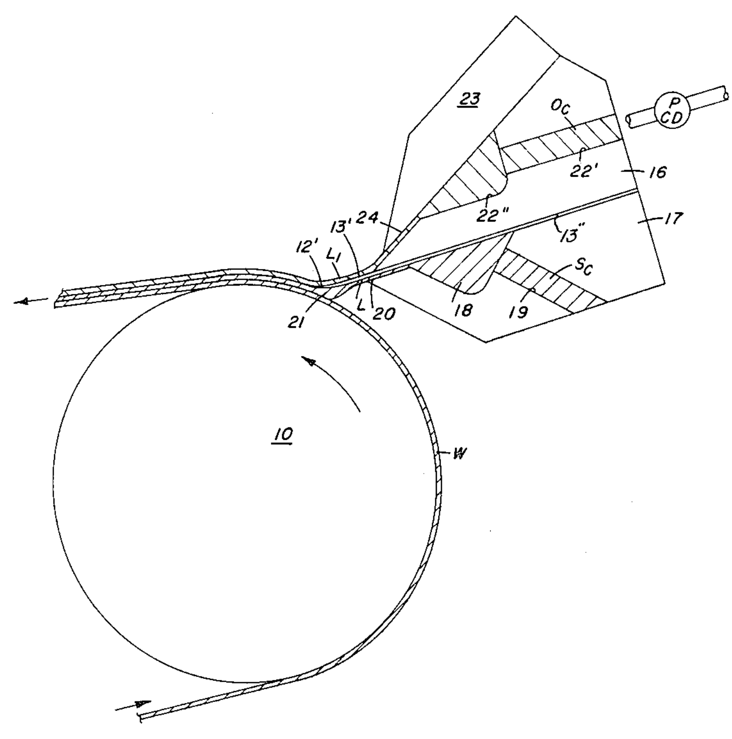
ABSTRACT: Two or more low-coverage coatings are applied substantially simultaneously to a web travelling at high speed by first trowelling a very thin subcoat onto the web with a trailing blade coater to prepare the web surface for an overcoating of the same or compatible coating material, and then flowing the overcoat down the top side of the trailing blade and off the trowelling end thereof directly onto the subcoat. Two or more layers of fluid coating composition can be flowed down the top of the trailing blade and onto the trowelled subcoat in distinct layer relationship with each other and the subcoat.



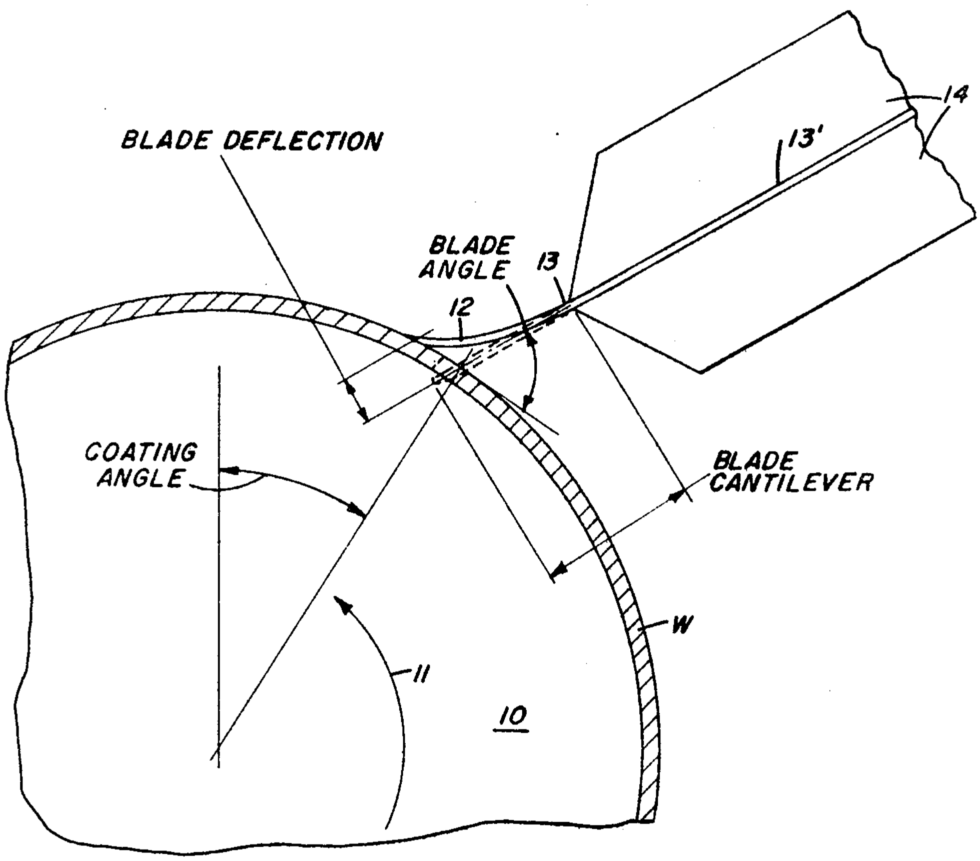


FIG. 1

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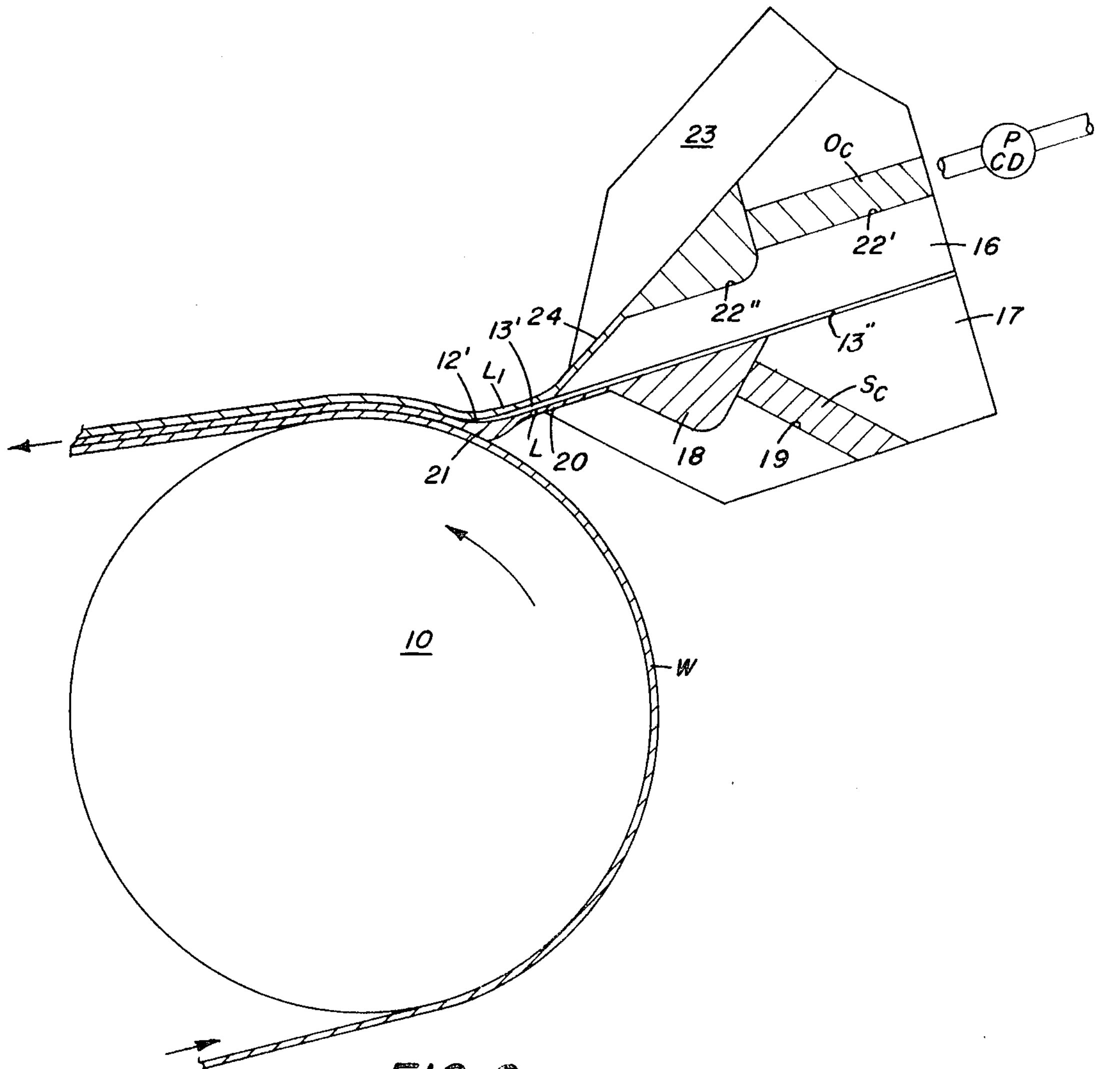

FIG. 2

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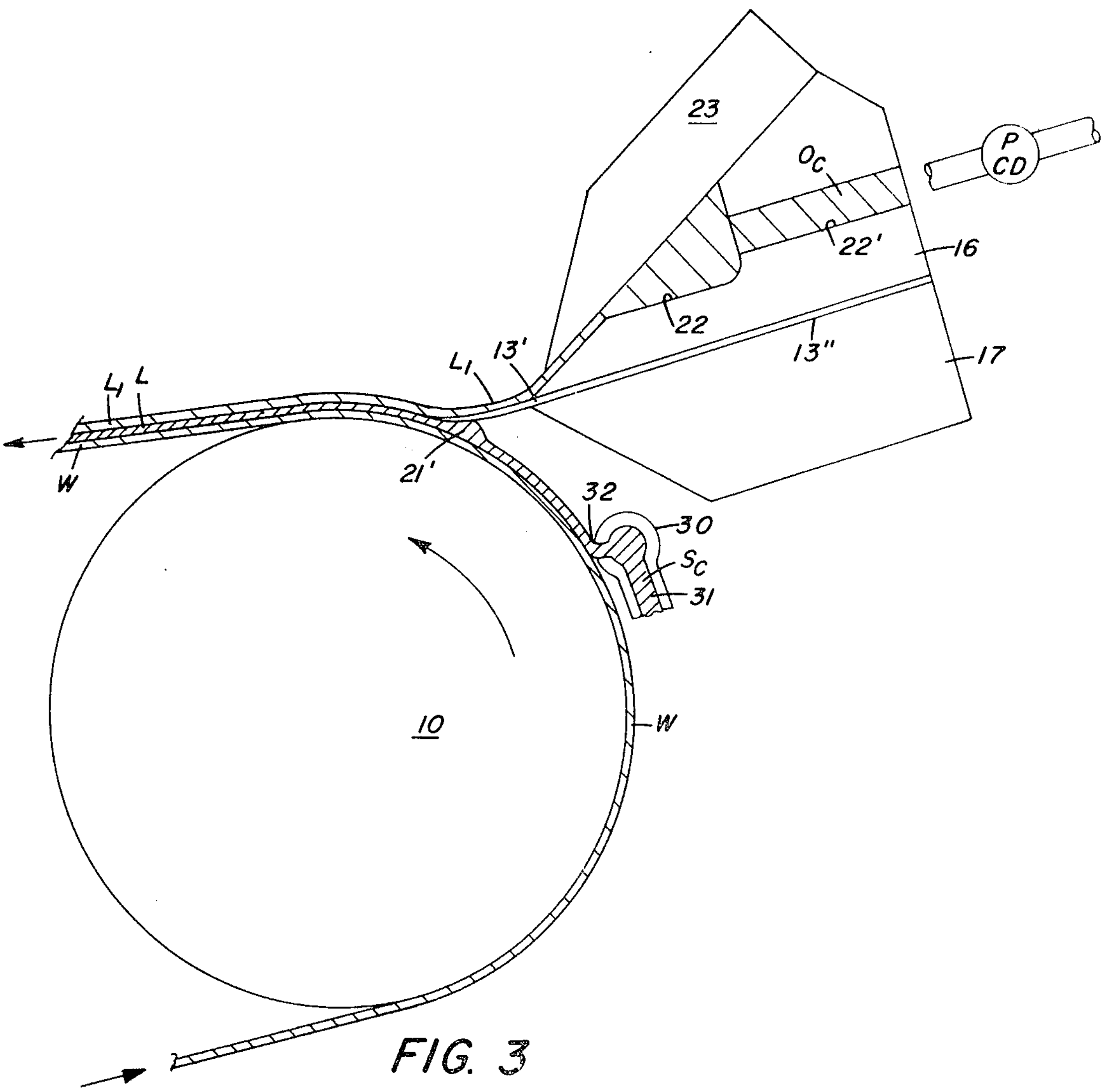

FIG. 3

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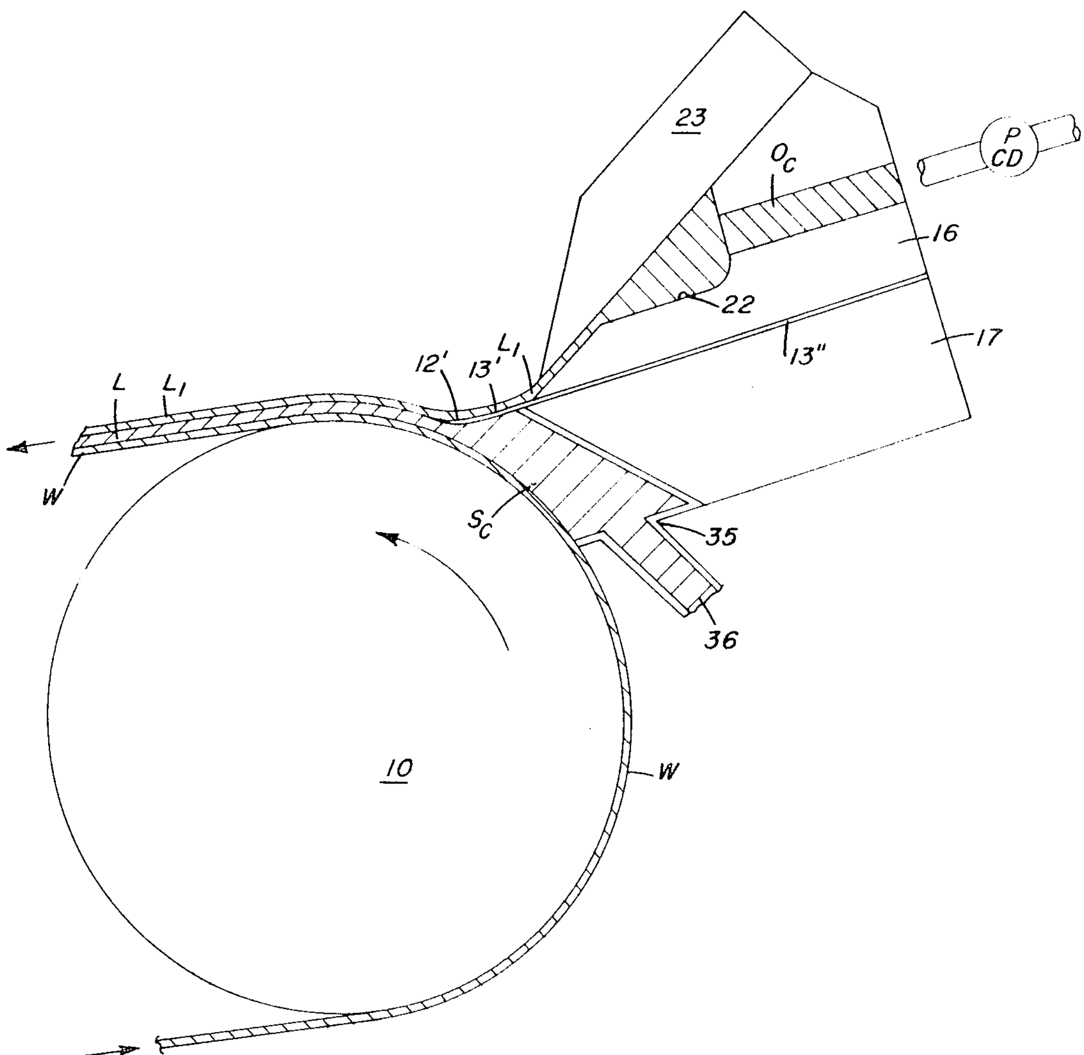

FIG. 4

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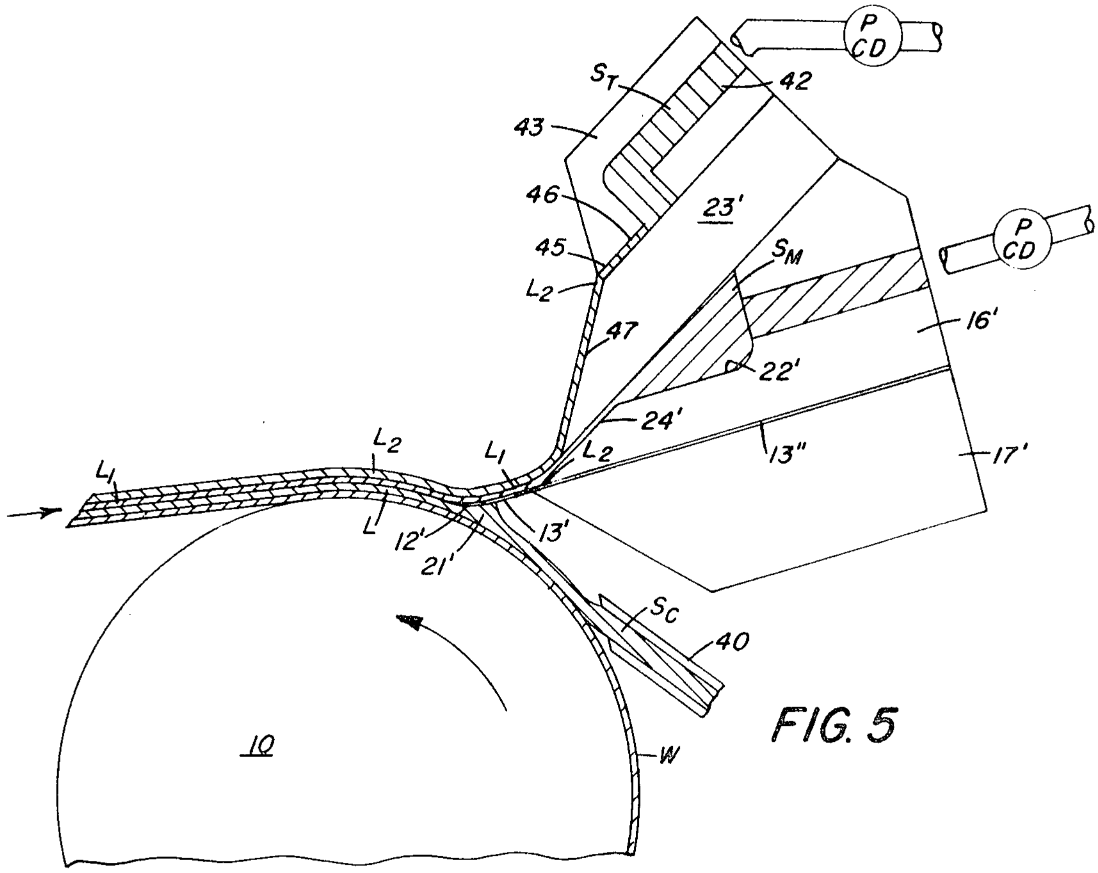

FIG. 5

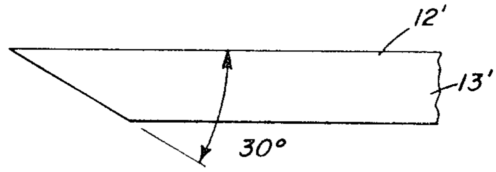

FIG. 6

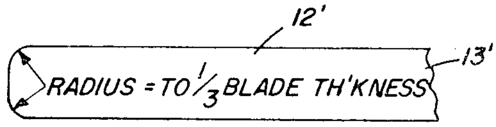

FIG. 7

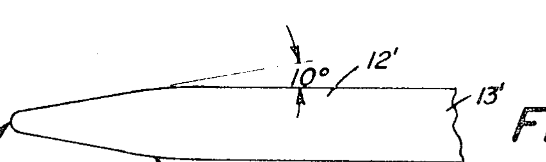

FIG. 8

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METHOD FOR COATING A CONTINUOUS WEB

The present invention relates to coating a continuous web, and particularly to a method and apparatus for applying very low coverage with reasonable uniformity in thickness to a web travelling at high speed.

A very difficult coating problem is the application of very low coverages with reasonable thickness uniformity to a continuous web travelling at high speed. One approach which is used in the commercial coating field is the trailing blade coater. This device, however, operates as a smoothing coater, filling the low areas of the web surface and scraping clean the high points. The resulting coating is not satisfactory for use in arts, e.g., the photographic art, where a reasonable uniformity of thickness of coating is desired, although it is valuable as a surface coater for the stock. One problem encountered with trailing blade coaters is that the fluid coating composition has a tendency to dry on the blade edge and eventually a buildup of solid coating material is formed on the blade edge which produces longitudinal streaks in the coating.

Slide coaters have been used in the art of coating photographic films or plates and wherein the emulsion flows down an inclined surface which extends from a hopper to the surface to be coated, see U.S. Pat. No. 401,771. U.S. Pat. No. 2,761,417 shows a multiple slide hopper by means of which two or more layers of fluid coating composition can be simultaneously applied to a continuous web in distinct layer relationship. While these slide coating techniques are capable of applying reasonably uniform coatings to a continuously moving web, they are somewhat limited in coating speed because at high speed air tends to become entrained beneath the coating as it comes off the slide or is coated from a bead, as the case may be.

The primary object of the present invention is to provide a method of coating which combines the trailing blade and slide methods of coating in such a way as to overcome the shortcomings of both and provide a method by which one or more coating compositions of very low coverages and of reasonable thickness uniformity can be applied to a continuous web at high speeds.

Another object is to provide a method of applying very low coverage coatings to a web travelling at high speed which consists in first troweling a very thin subcoat onto the web surface with a trailing blade coater to prepare the surface for an overcoating of the same or compatible coating material, and then flowing the overcoat down the top side of the trailing blade and off the troweling end thereof directly onto the subcoat.

A further object is to provide a method of coating as described above by the use of which two or more layers of fluid coating composition(s) can be flowed down the top surface of the trailing blade and be flowed directly onto the trowelled subcoat in distinct layer relationship with each other and the subcoat.

And yet another object is to provide a novel coating apparatus for carrying out the above-described methods of coating, and which I have chosen to designate as a trailing blade slide coater.

The novel features that I consider characteristic of my invention are set forth with particularity in the appending claims. The invention itself, however, both as to its organization 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 schematic view of a conventional trailing blade coater, and showing the system parameters thereof;

FIG. 2 is a side view, partly in section, showing a two-layer trailing blade slide coater constructed in accordance with one embodiment of the present invention;

FIGS. 3 and 4 are views similar to FIG. 2, but showing other ways in which the undercoat or subcoat may be applied to the web;

FIG. 5 is a view similar to FIGS. 2–4, but showing another embodiment of the apparatus adapted to apply three layers of coating to a web in distinct layer relationship; and

FIGS. 6, 7 and 8 are schematic views showing different blade edge geometries on an enlarged scale.

Generally speaking, the present method of applying a reasonably uniformly thin layer of a given coating solution to the surface of a web moving continuously at high speed comprises the steps of applying a fluid composition to the surface of the web, troweling said composition as a subcoating on the web surface by moving the web past the end of a flexible stationary blade pressing against the web surface to fill any low areas in the web surface and providing a smooth wet surface on the web; then continuously metering a given quantity of said fluid composition, or another coating composition compatible with said subcoat, in the form of a layer onto the uppermost surface of said trailing blade at a point spaced above the flexible end thereof, said layer of coating composition, under the influence of gravity, flowing down said trailing blade to form a uniformly thin layer which ultimately flows off the end of the blade and onto the surface of the subcoat; and then simultaneously curing the subcoat and the thin layer of fluid coating composition. Two or more layers of fluid composition may be simultaneously applied to the subcoat in distinct layer relationship with each other and the subcoat if desired. The blade applied subcoat acts as a seal to prevent air entrainment under the subcoat(s) which is a major problem in slide or bead coaters when operating at high speeds. The moving liquid layer(s) flowing off the trailing edge of the blade also acts to improve the blade operation by preventing drying of coating material on the blade edge.

Referring to FIG. 1, a conventional blade coater is schematically shown to clarify the system parameters of such a coater as they apply to the present invention as will be described below. The web, W, to be coated is supported in a smooth condition on the surface of a coating roll **10** moving in a counterclockwise direction as shown by arrow **11**. The web to be coated may be raw paper, precoated paper, plastic film base, etc. Riding on the exposed surface of the web W as it moves around said coating roll is the flexible end **12** of a trailing blade **13** whose other end **13''** is clamped, or otherwise fastened, to a rigid support **14**. The trailing blade may be made of any suitable springy material, e.g., stainless steel, blue steel, etc., but it should be made of a material which will not be readily corroded by the fluid composition to be used and should be of such hardness that the trailing edge will not be unduly worn away by the rubbing contact it has with the web. The surface of the coating roll **10** may be metal or it may have a resilient surface which is engaged by the web.

In conventional operation of such a trailing blade coater, an excess of a fluid coating composition is applied to the web surface ahead of the blade and a puddle of the composition builds up ahead of, and adjacent to, the blade across its entire width. The flexible end of the blade then trowels the composition which passes beneath the trailing edge thereof and acts as a smoothing coater, filling in the low areas of the web and scraping clean the high points. The troweling action of the trailing blade can be adjusted by varying the blade cantilever, the stiffness of the blade, and the coating angle of the blade, each individually or any two or three of these parameters in combination. In other words, it will be appreciated that the more pressure that the trailing edge of the blade exerts upon the surface of the web the less coating composition will flow beneath it. As will appear later, the amount of coating composition which will flow past the blade will also depend upon the physical characteristics of the coating composition. It will be appreciated that unless a perfectly flat web is moving past the trailing blade the thickness of the coating trowelled onto the web will not be uniformly thick. In other words, a trailing blade coater is primarily useful only in filling the lower areas of a web surface and conditioning the web surface so that it is smooth.

Looking now at FIG. 2, a trailing blade slide coater for applying two layers of coating solution to the surface of a web, and constructed in accordance with one embodiment of the present invention, is shown and will be described. The object here is to obtain a layer of a fluid coating composition on the web which is thin and uniformly thick. To do this, a subcoat is first applied to the web surface by a trailing blade coater to provide a smooth wet surface on the web onto which the final coating of desired uniform thickness is applied and/or to condition the surface of the web to receive and hold the final overcoat. This subcoat can be the same composition as the overcoat, or it can be a different composition. If it is a different coating composition, then the only requirement is that it be compatible with the overcoat composition so that the overcoat layer(s) will readily spread and adhere to the subcoat and not be adversely affected by the subcoat subsequent to their application.

As in the previously described trailing blade coater, the web W is held in wrapped relation with a coating roller 10 to keep it smooth as it approaches and passes the coating point. A trailing blade 13' is clamped between two sections 16 and 17 of a coating hopper held together by suitable means, e.g. bolts (not shown). The hopper section 17 is provided with a cavity 18, one wall of which is defined by the clamped-end 13'' of the trailing blade. The fluid subcoat composition, Sc, is fed into the cavity 18 through an inlet 19 by a pump P. The subcoat composition exits in a layer L through a discharge slot 20, the upper side of which is defined by the lower side of the trailing blade. As a result, the layer L of the subcoat composition flows down the under side of the trailing blade to form a puddle or bead 21 extending completely across the deflected end 12' of the blade and between it and the web. As the web moves across this puddle or bead 21, it tends to carry some of the subcoat with it, and this is trowelled over the web surface by the deflected end of the blade. This trowelling action of the blade provides a smooth wet surface on the web since the blade causes the subcoat to fill in the low areas of the web and scrapes clean the high points.

The hopper section 16 has a cavity 22 formed therein which is covered by a third hopper section 23 fastened to hopper section 16 in any suitable manner, e.g. by bolts (not shown). Leading from the cavity 22 there is a downwardly inclined, elongated discharge slot 24 formed between spaced faces of hopper sections 16 and 23. The discharge slot 24 will be the same length as the width of the web to be coated and its exit is directly obliquely onto the uppermost surface of the blade 13' at a point spaced above its deflected end 12'. The fluid coating composition, Oc, which is to be coated onto the web in a thin layer of uniform thickness if fed into the cavity 22 through an inlet 22' by a pump P' of the constant discharge type. As the overcoat composition Oc, is fed into the cavity at a constant rate it will exit from the discharge slot 24 in the form of a ribbon or layer onto the uppermost surface of the downwardly inclined trailing blade down which it flows by gravity to form a layer L_1. This layer L_1 as it flows down the uppermost surface of the blade becomes uniformly thin before it slides off the end of the blade and onto the surface of the subcoat which has been trowelled on the web surface by the blade. The deflected end 12' of the trailing blade intersects the web surface at an obtuse angle so that the layer L_1 of overcoat flowing off the end thereof will flow onto the layer of subcoat in such a way as to maintain a distinct layer relationship between the two. This distinct layer relationship between the two coatings is not important if the two coating compositions are of the same material, but it is important in certain cases where the coating compositions are different and a distinct layer relationship between them is desired, e.g. in certain photographic color materials where the several color sensitive and filter layers must be applied in distinct layer relationship.

The puddle 21 of the subcoat composition formed between the web surface and the under side of the trailing blade will prevent the entrainment of air beneath the overcoat layer which slides off the end of the blade and onto the subcoat. At the same time, the trowelling action of the blade on the subcoat composition will further prevent air entrainment under the subcoat. It will thus be seen that this method of coating overcomes the air entrainment problem which is most prevalent in high speed coating procedures. Also, since there is a layer L_1 of overcoat composition continuously flowing off the trailing end of the blade, the trailing blade operation is improved by the prevention of drying of coating material on the blade edge.

The method used in applying the subcoat solution was found to have a major influence on the coating procedure. The method of application best suited for a particular situation depends mainly upon the properties of the subcoat composition to be applied, as will be more fully set forth below.

FIG. 3 shows a two-layer coating system similar to that shown in FIG. 2 but having a different type of subcoat applicator. In this embodiment the subcoat composition is applied to the web surface ahead of the trailing blade 13' from a manifold applicator 30 extending transversely of the web and having one, or more, inlets 31 into which the fluid coating composition is fed by a pump, not shown. The manifold applicator is provided with a plurality of discharge openings 32 spaced along its length through which the coating material issues in the form of individual streams spaced across the width of the web surface. These streams of coating material deposited on the web build up into a puddle 21' behind the trailing blade, said puddle serving to distribute the coating material uniformly across the web immediately ahead of the blade.

FIG. 4 shows another embodiment of a two-layer system similar to that shown in FIGS. 2 and 3 but having a different type of subcoat applicator. In this embodiment the subcoat is supplied from a reservoir-type applicator 35 wherein a relatively large quantity of coating material is maintained on the web surface immediately behind the deflected end 12' of the trailing blade 13'. The coating material is fed into this reservoir through an inlet 36 by means of a pump not shown.

The present method of coating a web can be used to simultaneously apply a plurality of different fluid coating compositions in distinct layer relationship at high speeds. In FIG. 5 an embodiment is shown which is suitable for applying three different layers of coating composition onto a web surface at the same time. Here the web W to be coated is passed around a coating roll 10 in a counterclockwise direction and its surface is engaged by the deflected end 12' of trailing blade 13' clamped between two sections 16' and 17' of a hopper. The fluid coating composition, Sc, which is to form the subcoat is fed onto the web surface ahead of the trailing blade 13' from a plurality of tubes 40, only one of which is shown, spaced across the web. The subcoat material is fed into these tubes by a pump, not shown, and the streams of coating reaching the backside of the deflected end of the trailing blade merge into a puddle 21' from which the material flows under the blade and is trowelled into a layer L on the web surface thereby.

As in the FIG. 2 embodiment the fluid coating composition, Sm, which is to form the middle coat is pumped into a cavity 22' in the hopper section 16' by a constant discharge pump and issues therefrom through a discharge slot 24' in the form of a layer L_1 which is directed onto the uppermost surface of the trailing blade. The fluid coating composition, St, which is to form the top coat is fed into a cavity 42 in another hopper section 43 by a pump of the constant discharge type. This coating composition issues in the form of a layer L_2 from a discharge slot 45 defined by a surface 46 on the hopper section 43 spaced from the top of hopper section 23'. This layer flows down the inclined surface 47 of hopper section 23' and onto the top of the layer L_1 of the middle coat issuing from cavity 22'. The two layers L_1 and L_2 then flow down the uppermost surface of the trailing blade in distinct layer relation and flow off the end of the blade onto the layer L of subcoat while still maintaining a distinct layer relationship with each other and the subcoat. The final thickness of the individual layers L_1 and L_2 are determined, not by the width of the discharge slots through which they issue from and supply cavities 22' and 42, respectively, but by the rate at which they are pumped into their respective cavities. The coverage thickness of the subcoat will depend upon the smoothness of the web surface, the physical properties of the coating composition used and the pressure exerted by the trailing blade in trowelling the coating.

The blade edge geometry has a major influence on the ability of the trailing blade slide coater process to effectively coat a continuous web. FIGS. 6, 7 and 8 show these types of edge geometries used in trials of this method and apparatus of coating. The blade edge shown in FIG. 8 was found to be best suited for use with the trailing blade slide coater process.

The edge shown in FIG. 6 is well suited for applying overcoat layers since the sharp edge makes it easy for the overcoat composition(s) to slide onto the web surface. A disadvantage of this type of blade edge is its high sensitivity to any paper fibers (if the web is a raw paper stock) or foreign particles that may be present on the web surface. The fibers and foreign particles are retained at the blade edge and cause streaks in the coating. The sharp edge blade tends to wear quickly causing additional problems.

The blade edge as shown in FIG. 7 is well suited to applying a blade coat to a continuous web. The rounded edge will apply a coating that has a good finish, and it is not largely influenced by dirt and paper fibers. A disadvantage with this blade is that it becomes extremely difficult to slide and overcoat off the blade and onto a continuous web.

The blade as shown in FIG. 8 is a compromise between those shown in FIGS. 6 and 7. It is designed to utilize the advantages of both the knife edge blade and the rounded edge blade. In a series of coating experiments performed with the trailing blade slide coater, it was found that the coating and trailing blade angles (see FIG. 1) had no major influence on the coating technique. Both angles were varied through large ranges.

The trailing blade slide coating technique has been evaluated on a commercial coating machine using aqueous solutions of gelatin, methanol solutions of polyvinyl acetate (hereinafter referred to as PVA), aqueous solutions of carboxymethyl cellulose (hereinafter referred to as CMC) and aqueous dispersions of baryta and aqueous dispersions of clay-casein as the blade coated materials. Aqueous solution of gelatin, PVA and CC were also used for the slide coat. Satisfactory coverages ranged from 0.06 to 1.40 lb./100 $ft._2$ for the slide coat and 0.08 to 0.50 lb./100 $ft._2$ for the blade coat. Coating speeds ranged from 200 to 1,030 ft./min., this high speed being the upper limit which the machine used was capable of. In some cases dyes were mixed into the coating fluids so that various layers of a coating sample could be differentiated. For the majority of these trials a raw paper stock was used as the continuous web. Paper coated with polyethylene or baryta were also tried in order to determine the effect of precoated paper webs on this coating technique.

The following tables list the experimental details of different trails which were made to evaluate possible limitations of the present coating technique. Table 1 lists trials in which only the blade coat, or subcoat, was applied to the continuous web. Table 2 lists trials in which the blade coat and the overcoat (slide coat) were applied simultaneously. Triple coats applied in a like manner are listed in table 3. Table 4 gives the viscosities for the fluid compositions used.

TABLE 1

Samples of Subcoat Trials Only

Trial	Material	Solids %	Wet Coverage lb./100 ft.²	Machine Speed ft./min.
1	Gelatin	5	0.15	950
2	Gelatin*	15	0.32	200
3	Gelatin**	15	0.35	200
4	Gelatin**	15	0.12	850
5	Gelatin**	15	0.50	950
6	Gelatin	15	0.35	300
7	Gelatin	20	0.14	300
8	Gelatin	25	0.48	620
9	Gelatin	30	0.18	260
10	CMC	3	0.16	300
11	CMC	8	0.12	970
12	PVA	20	0.15	350
13	PVA	12	0.50	310
14	baryta	64	0.28	310
15	baryta	64	0.11	310
16	clay-casein	45	0.10	310
17	clay-casein	57	0.14	300

*Polycoated paper stock

**Baryta-coated paper stock

All other trials raw paper stock.

TABLE 2.—SAMPLES WITH SUB-COAT AND OVERCOAT

	Sub-coat			Overcoat			
Trial	Material	Solids, percent	Wet coverage, lb./100 ft.²	Material	Solids, percent	Wet coverage, lb./100 ft.²	Machine speed, ft./min.
1	Gelatin	15	0.20	Gelatin	5	1.00	200
2	do	15	0.16	do	5	0.29	800
3 [1]	do	15	0.35	do	5	0.11	500
4 [2]	do	15	0.50	do	5	0.11	500
5 [1]	do	15	0.12	do	5	0.29	850
6 [2]	do	15	0.35	do	5	0.30	200
7	do	20	0.11	do	5	0.50	300
8	do	20	0.11	do	5	0.20	300
9	do	20	0.20	do	5	0.17	920
10	do	25	0.30	do	5	0.06	1030
11	do	25	0.48	do	5	0.18	620
12	CMC	3	0.17	do	5	0.06	300
13	CMC	3	0.11	do	5	0.12	990
14	CMC	3	0.23	do	5	0.09	950
15	CMC	3	0.23	do	5	0.15	950
16	CMC	3	0.23	do	5	0.22	950
17	CMC	3	0.09	PVA	20	0.54	940
18	CMC	3	0.14	PVA	20	0.44	670
19	CMC	3	0.20	PVA	12	0.30	370
20	CMC	3	0.16	Gelatin	18	0.09	300
21	CMC	3	0.16	do	18	0.16	300
22	CMC	3	0.16	do	18	0.23	950
23	CMC	3	0.16	do	18	0.10	950
24	CMC	8	0.09	do	5	0.20	310
25	CMC	8	0.12	do	5	0.06	980
26	CMC	8	0.12	do	5	0.10	980
27	CMC	8	0.12	do	5	0.16	980
28	CMC	8	0.12	CMC	3	0.06	970
29	CMC	8	0.12	CMC	3	0.15	970
30	CMC	8	0.12	CMC	3	0.35	970
31	CMC	8	0.09	CMC	3	0.19	300
32	CMC	8	0.09	CMC	3	0.34	300
33	CMC	8	0.10	CMC	3	0.17	650
34	CMC	8	0.18	CMC	3	0.26	810
35	PVA	12	0.15	CMC	3	0.80	300
36	PVA	20	0.15	CMC	3	0.60	300
37	PVA	20	0.08	Gelatin	18	0.08	950
38	Baryta	64	0.14	do	5	0.19	310
39	do	64	0.28	do	5	0.11	950

40	do	64	0.30	do	5	0.11	950
41	do	64	0.37	do	5	0.06	950
42	Clay-casein	45	0.10	do	5	0.50	310
43	do	45	0.10	do	5	0.60	310
44	do	45	0.14	do	5	0.13	930

[1] Baryta-coated paper stock.
[2] Polycoated paper stock.

NOTE.—All other trials raw paper stock.

TABLE 3.—SAMPLES WITH SUB-COAT, MIDDLECOAT AND OVERCOAT

	Sub-coat			Middlecoat			Overcoat			
Trial	Material	Solids, percent	Coverage, lb./100 ft.[2]	Material	Solids, percent	Coverage, lb./100 ft.[2]	Material	Solids, percent	Coverage, lb./100 ft.[2]	Machine speed, ft./min.
1	Gelatin	20	0.15	Gelatin	5	0.70	Gelatin	5	0.70	300
2	CMC	3	0 10	do	5	0.54	do	5	0.54	300
3	Clay-casein	57	0 14	do	18	0.54	do	18	0.54	300

NOTE.—All trials on raw paper stock.

TABLE 4

Viscosities of Coating Compositions

Viscosity testing temperature: 100° F.

Material	Solids %	Viscosity cp.
Gelatin	5	10
Gelatin	15	140
Gelatin	18	350
Gelatin	20	630
Gelatin	25	2,750
Gelatin	30	12,000
CMC	3	400
CMC	8	9,000
PVA	12	140
PVA	20	356
baryta	64	2,000
clay	45	1,200
clay	57	2,000

DISCUSSION OF TRIALS

I. Subcoat (blade coat) Fluid Compositions. (See FIG. 1, Table 1.)

A. Aqueous Gelatin Solutions

In contrast to elastic solids, most liquids are considered to possess no elasticity or rigidity when sheared and should respond immediately to any attempt made to deform them. There are, however, liquids that generate measurable normal stresses when sheared and show both viscous and elastic effects. These liquids are called *viscoelastic* solutions or dispersions.

Windle and Beazley, "The Role of Viscoelasticity in Blade Coating," Tappi, Aug. 1968, Vol. 5, No. 8, shows that viscoelasticity has a large influence on blade coating processes. In most cases, the process becomes unstable when viscoelastic effects become large. In this set of experiments, the aqueous gelatin solutions ranging from 5 percent to 20 percent solids worked very well for the subcoat application. However, when the solids content was increased above 20 percent, the viscoelastic property of the solution became more prominent, with the result that the blade tended to lift off the paper and the coating system become unstable. Therefore, it is felt that the high solids gelatin solutions do not lend themselves readily to blade coat applications.

B. Methanol Solution of Polyvinyl Acetate (PVA)

The 12 percent solids PVA solution worked well as an undercoat material. However, the 20 percent solids PVA solution exhibited a pronounced viscoelastic effect and caused some instability of the blade coat. A methanol solution of polyvinyl acetate does not lend itself to use with an aqueous overcoat, because upon drying, the methanol escapes from the PVA and causes spots on the overcoats.

C. High-Solids Clay-Casein and High-Solids Baryta

Both of these mixtures worked extremely well as subcoat fluids. The clay and baryta dispersions are highly shear sensitive and thin quite readily in a blade coating process.

D. CMC

The CMC (3 percent to 8 percent solids) worked well as a subcoat solution. This material exhibits the same shear thinning qualities as the high-solids clay and baryta materials.

II. Overcoat (blade coat) Fluid Compositions

A. Gelatin

The solids content of the gelatin solutions used for the overcoat ranged from 5 percent to 18 percent. All mixtures that were used worked very well. In some instances, a wetting agent was added to these mixtures to improve their wetting qualities. Although other wetting agents probably could have been used satisfactorily, the one used was that sold under the trademark Triton X-200 and having the chemical name P-(1,1, 33-tetramethylbutyl) phenoxyethoxyethyl sodium sulfonate.

B. PVA

The PVA mixtures (12 percent and 20 percent) solids were found to be good overcoat fluids. There was some slight difficulty in coating this fluid composition because of its quick-drying characteristics.

C. CMC

The 3 percent solids CMC was a very poor overcoat solution. The material would not distribute evenly as it was transferred from the blade to the continuous web and acted much like an elastic material. This problem was found to be characteristic of the CMC solution and not a limitation of the trailing blade slide coater process. The 8 percent solids CMC was not tried as an overcoat fluid due to the problems associated with the lower solids mixture.

Microsections of various coated specimens made in the described trials were made. It was found that subcoats of low solid mixtures were hard to detect on the sections examined. The blade coater, when operating in the correct manner, will apply a very small amount of solution to precoated paper webs. For this reason, low-solids mixtures such as 3 percent CMC and 5 percent gelatin are extremely hard to detect. High-solids mixtures such as the clay and baryta were more easily seen. It is evident from the sections examined that the high-solids mixtures fill in the low areas of the continuous web and act as good surface conditioners.

Microsections of the three-layer coatings were examined to determine if the coating technique was capable of applying two overcoat layers that would remain separated after drying. The apparatus used in applying the three layer coatings is shown in FIG. 5 and the data of the test is detailed in table 3. The sections examined showed separation of the three layers from one another.

As tables 1, 2, and 3 show, the trailing blade slide coating process was tested at speeds ranging from 200 to 1,030 feet per minute. The upper limit is not the coating process limit but the maximum speed at which the machine on which the tests were made could be safely run. Based on experimental tests, it can be stated that the trailing blade slide coating process is capable of speeds in excess of 1,000 feet per minute.

For the tests shown in tables 1, 2 and 3, raw paper, precoated baryta paper and polyethylene-coated paper were used as the continuous web material, and all were coated successfully. A major drawback of the trailing blade slide coater is its sensitivity to dust and paper fibers on the paper web which causes the coatings to be streaked. This problem was more evident in the raw paper coatings because the paper and dust particles were more numerous. As the blade contacts the paper web, foreign particles and paper fibers are contained by the blade edges. After a long period of coating, these particles build up and cause streaked finishes. Cleaning the raw paper web before coacting did alleviate a large part of the problem and helped improve the coating finish. Using a precoated stock also helped to diminish streaks and improve the finish. It is apparent from these experiments that if the web being coated were a plastic film base, rather than paper, this streaking problem would have been less troublesome, particularly if the film surface was cleaned just ahead of the coating point. For a given blade and hopper setting, the precoated paper stock allowed more subcoat fluid to be applied to the web than a raw paper stock because the subcoat cannot be forced into the stock by the trowelling action of the blade. Consequently, for a given setting of the blade, more of the subcoat fluid is left on top of the web, because this situation causes more hydrostatic pressure to be applied to the blade tip by the subcoat fluid.

In the trials carried out, the coating and trailing blade angles had no major influence on the coating technique. Both angles were varied through large ranges.

Although examples of certain synthetic polymeric solvent solutions, aqueous pigment dispersion, and aqueous colloidal solutions which can be coated by the present trailing blade slide coater technique as single or distinct multiple layers have been disclosed it will be obvious that there are many other fluid compositions which can be satisfactorily coated by this technique. For example, an aqueous solution of polyvinyl alcohol could be coated just as satisfactorily as the mentioned solvent solution of polyvinyl acetate. This material could be satisfactorily used as a subcoat under an overcoat of an aqueous solution of gelatin, while the methanol solution of polyvinyl acetate could not because of the methanol causing spots in the overcoat as it escapes during drying. Also, since aqueous gelatin solutions have been shown to coat satisfactorily by the use of this technique it would be reasonable to assume that (photographic) gelatino silver halide emulsions and other coatings used in the photographic art could be readily multiple coated by this technique, see U.S. Pat. No. 2,761,791, Russell, Sept. 4, 1956. It will also be apparent from the disclosure of U.S. Pat. No. 2,761,791 that more than three layers of the same or different fluid coating compositions could be simultaneously applied to the surface of a web by this trailing blade slide coater technique by merely combining more slide hoppers with the blade coater.

Although it is conceivable that the hoppers shown in FIGS. 2–5 could be made from a single block of material, in order to facilitate the fabrication of the same and to make it possible to clean it out when it is desired to change from one coating composition to another, it is more practical to make the hopper up from a number of separate sections, as shown, which can be readily assembled and disassembled. It should also be mentioned that if the coating compositions are of such a nature that they to be heated or cooled while in the hopper in order to keep them in a suitable condition for flow, then the hopper sections may be provided with bores through which a heating or cooling liquid may be circulated, as is well known in the art.

This invention has been described with reference to particular embodiments thereof but it will be understood that variations and modifications may be effected within the spirit and scope of the invention.

I claim:

1. The method of applying a thin layer of uniform thickness of a fluid coating composition onto the surface of a web comprising the steps of:

a. continuously advancing the web while supporting it in a smooth condition;

b. applying a fluid subcoating composition to the surface of said web;

c. trowelling said subcoating composition on the web surface by moving the web while supported past the flexible end of a stationary trailing blade pressing against the web surface to fill any low areas in the web surface and provide a smooth, wet surface on said web;

d. continuously metering a given quantity of said fluid coating composition in the form of a layer onto the uppermost surface of said trailing blade at a point spaced above the flexible end thereof, said layer of fluid coating composition, under the influence of gravity, flowing down said trailing blade to form a uniformly thin layer which ultimately flows off the flexible end of said blade and onto the surface of said subcoat; and

e. simultaneously curing said subcoat and the thin layer of fluid coating composition.

2. The method of applying three fluid coating compositions to the surface of a web in superposed distinct layer relationship comprising the steps of:

a. continuously advancing the web while supporting it in a smooth condition;

b. applying a first fluid coating composition to the surface of said web;

c. trowelling said first coating composition on the surface of the web by moving the web while supported past the flexible end of a stationary trailing blade pressing against the web surface to apply a thin layer of said first coating composition on the web surface;

d. continuously metering a given quantity of the second coating composition in the form of a layer onto the uppermost surface of said trailing blade at a point spaced above the flexible end thereof;

e. continuously metering a given quantity of the third fluid coating composition through a slot and onto a slide surface inclined downwardly and intersecting the layer of said second coating composition at an acute angle and at a point adjacent the point where said layer of second coating composition meets said blade surface whereby said layer of third coating composition flows onto the top of said second layer of coating composition and the two layers gravitate down said blade and off the flexible end thereof onto the top of the layer of first coating composition trowelled on the wet surface; and

f. simultaneously curing said three layers of coating composition deposited on said web surface.

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