United States Patent [19]

Mercier

[11] **3,756,195**

[45] **Sept. 4, 1973**

[54] **APPARATUS FOR COATING A CONTINUOUS WEB**

[75] Inventor: **Joseph A. Mercier**, Rochester, N.Y.

[73] Assignee: **Eastman Kodak Company**, Rochester, N.Y.

[22] Filed: **Aug. 5, 1971**

[21] Appl. No.: **169,489**

Related U.S. Application Data

[62] Division of Ser. No. 55,323, July 16, 1970, Pat. No. 3,627,564.

[52] **U.S. Cl.** **118/126,** 118/411

[51] **Int. Cl.** **B05c 3/12,** B05c 9/06

[58] **Field of Search** 118/411, 412, 413, 118/126

[56] **References Cited**

UNITED STATES PATENTS

2,695,005	11/1954	Lewin et al.	118/412
2,941,898	6/1960	Wynn	118/412 X
3,070,066	12/1962	Faeber	118/413
3,206,323	9/1965	Miller et al.	118/411 X
3,348,526	10/1967	Neubauer	118/410
3,484,279	12/1969	Clark et al.	118/413 X
3,496,005	2/1970	Ishiwata et al.	118/411 X

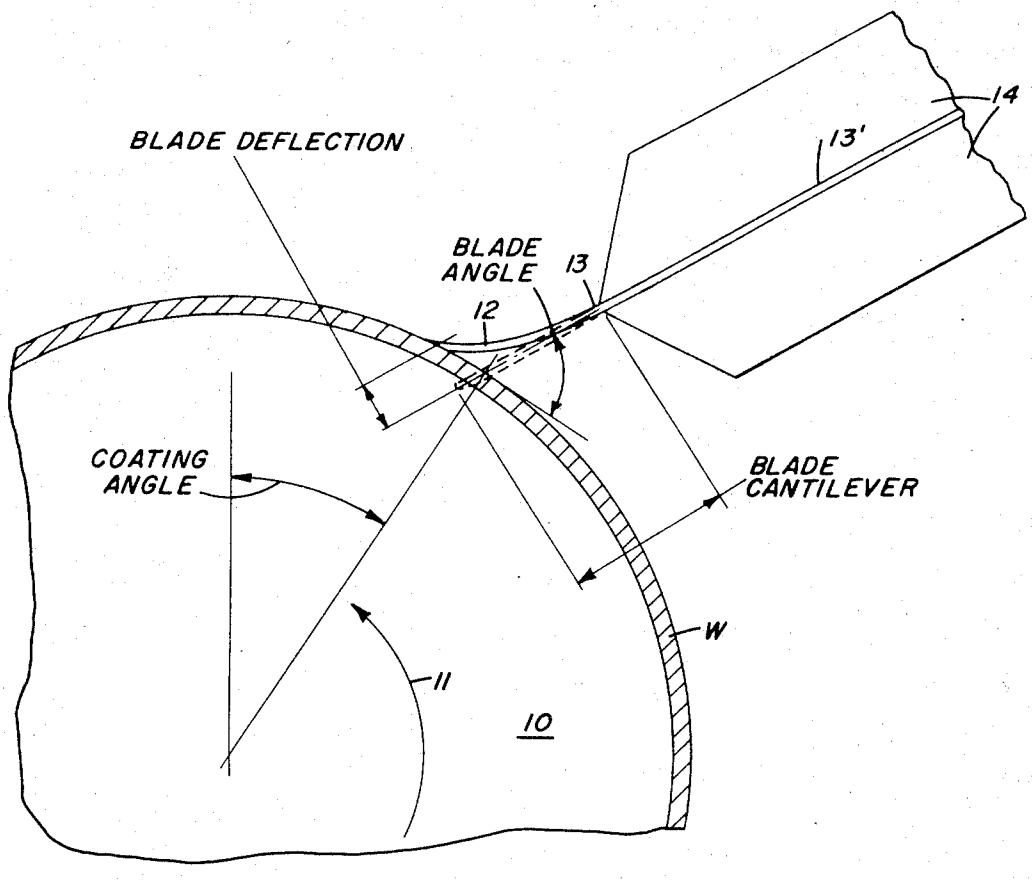
Primary Examiner—John P. McIntosh

Attorney—Karl T. Naramore

[57] **ABSTRACT**

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

8 Claims, 8 Drawing Figures



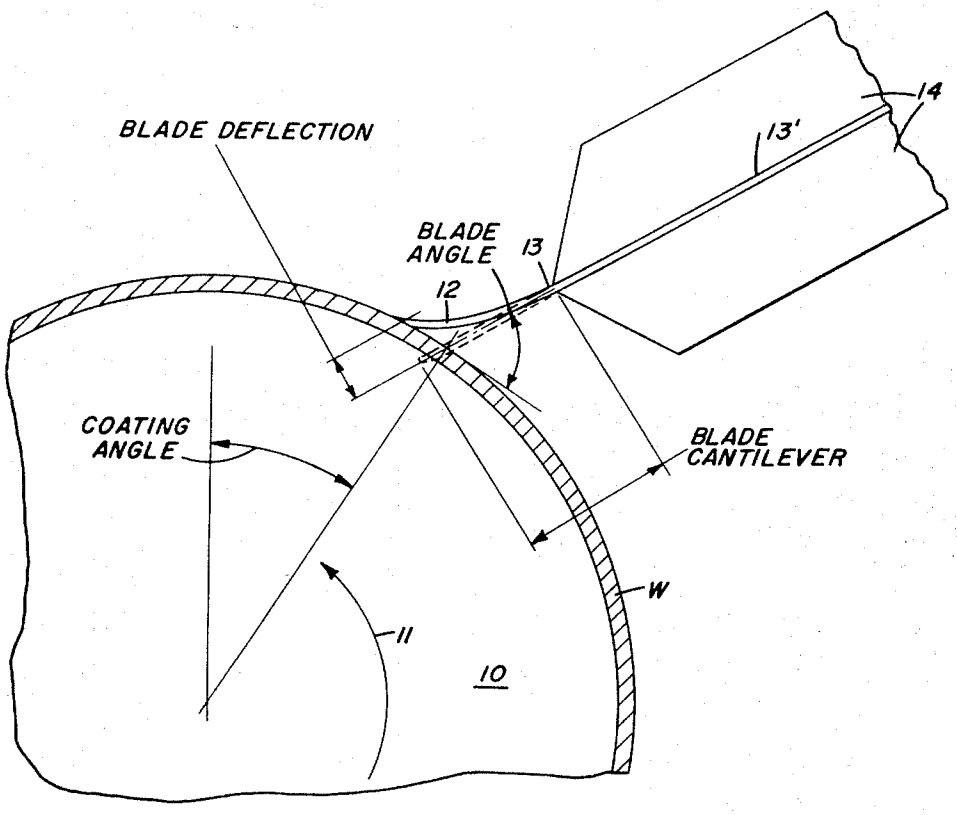

BLADE DEFLECTION
BLADE ANGLE
13
12
13'
14
COATING ANGLE
BLADE CANTILEVER
W
11
10

FIG. 1

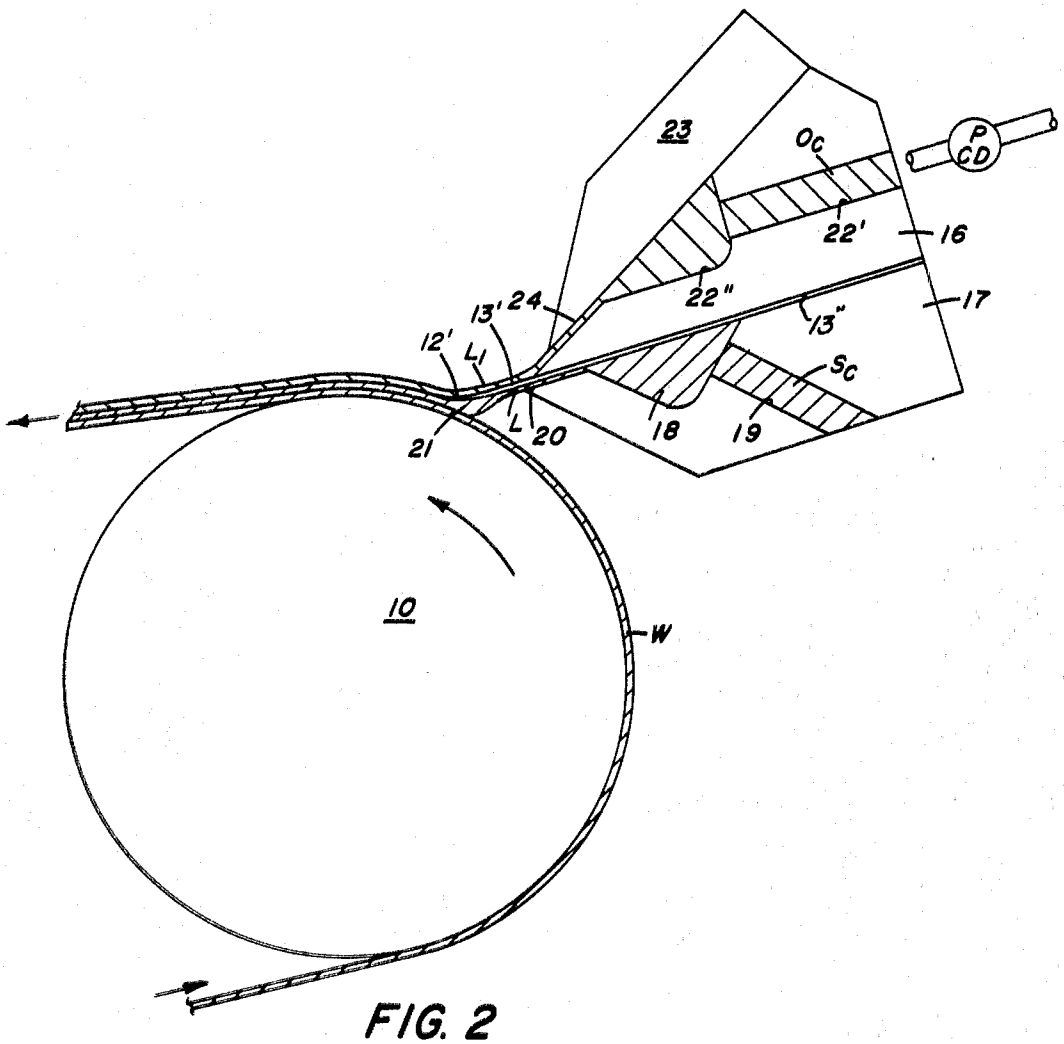


FIG. 2

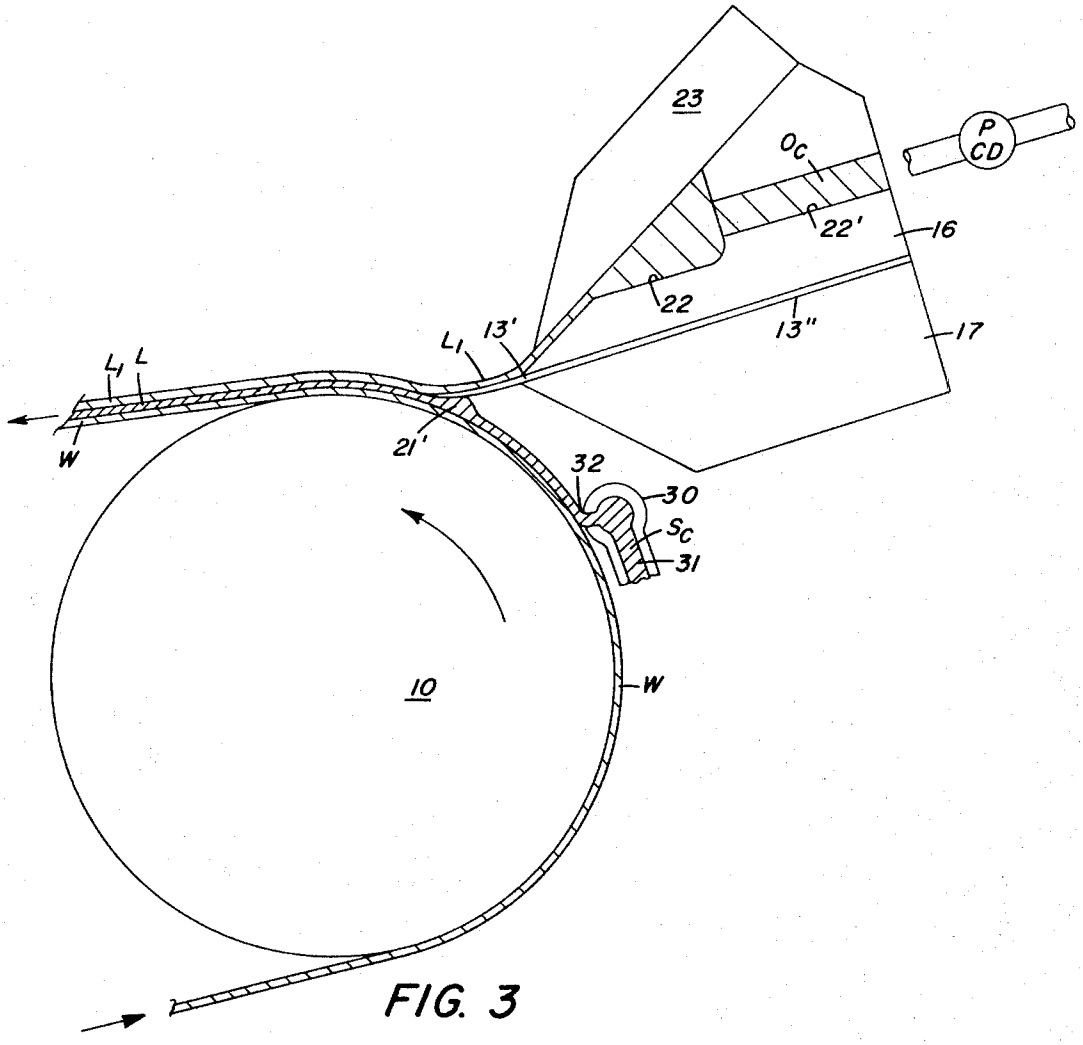


FIG. 3

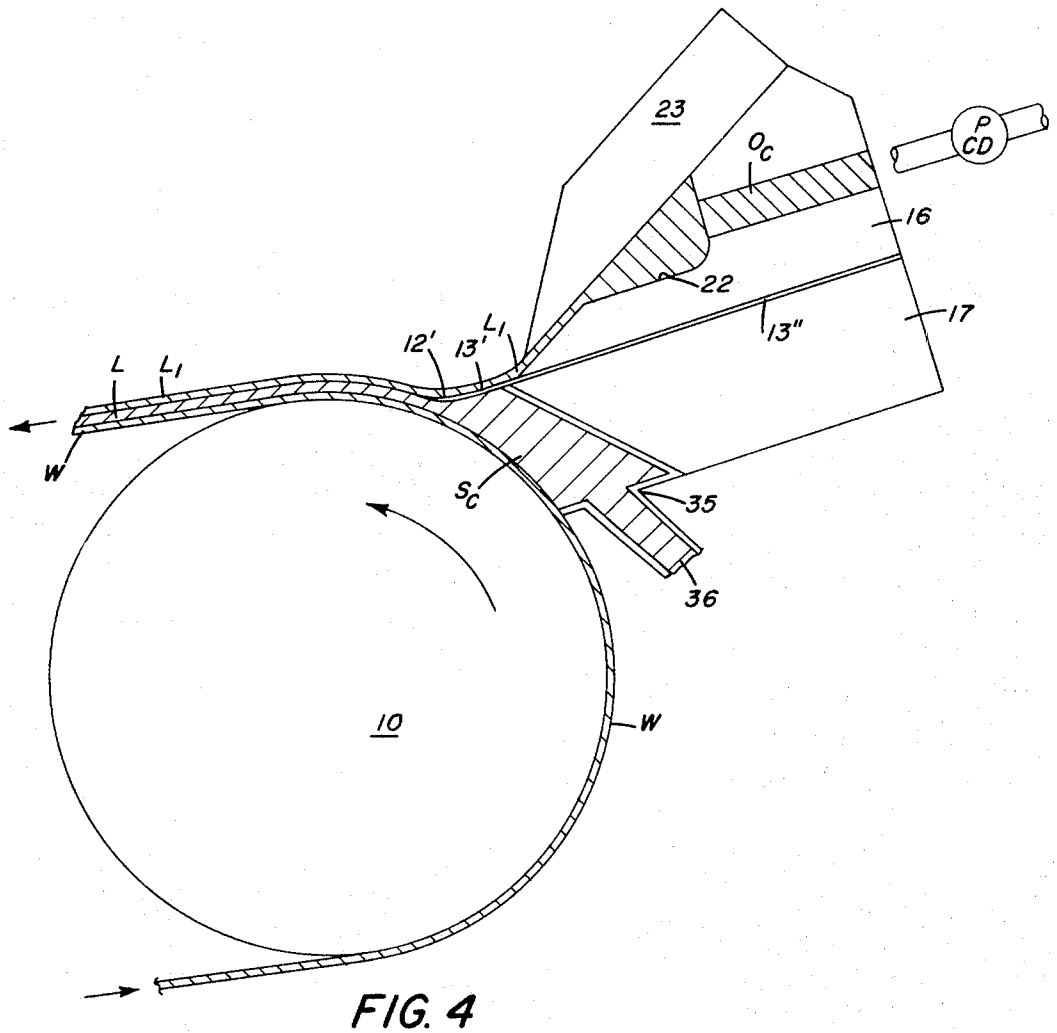


FIG. 4

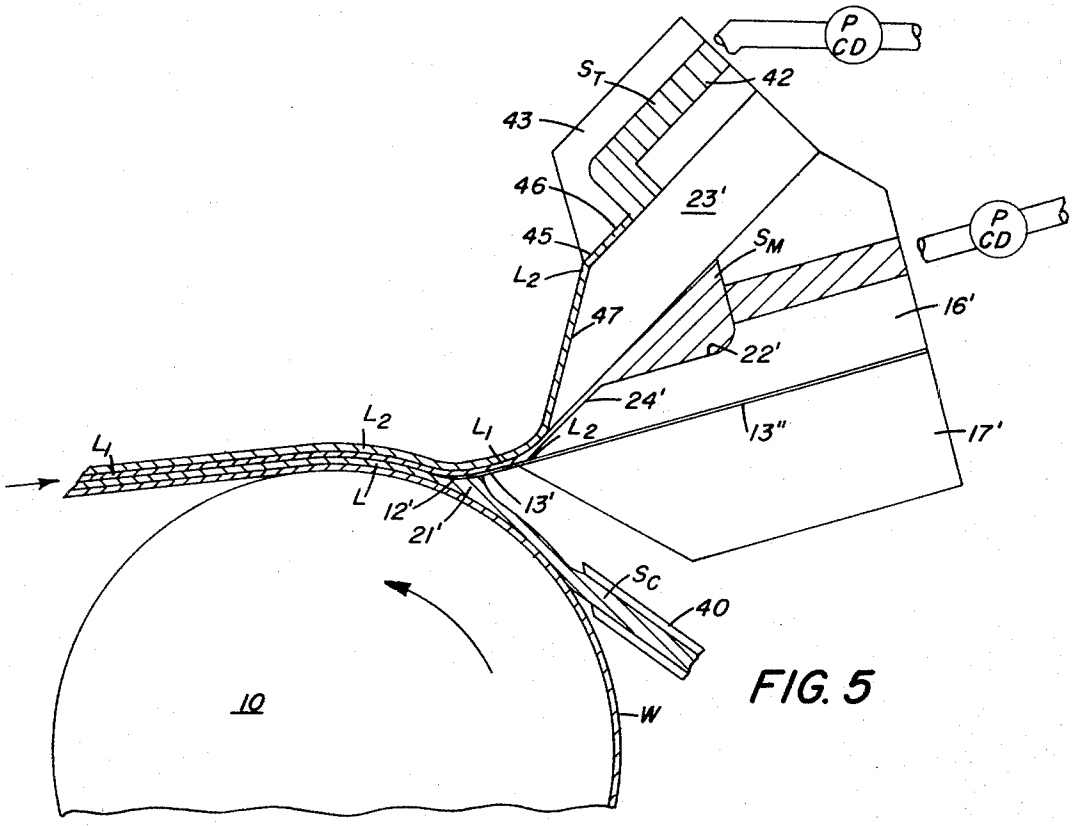


FIG. 5

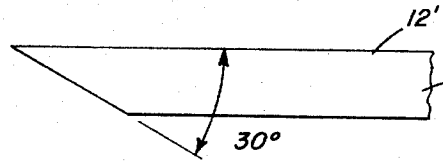


FIG. 6

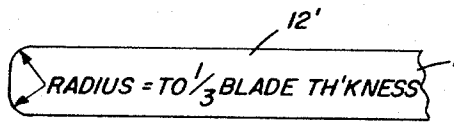


FIG. 7

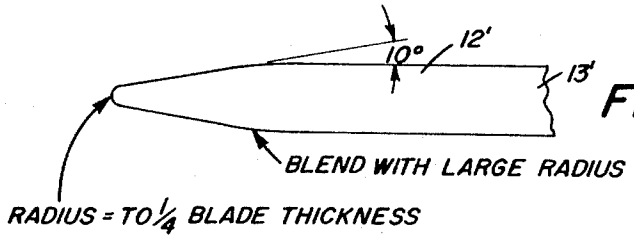


FIG. 8

APPARATUS FOR COATING A CONTINUOUS WEB

This is a division of application Ser. No. 55,323, filed July 16, 1970, now U.S. Pat. No. 3,627,564.

The present invention relates to coating a continuous web, and particularly to 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 build-up 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 coating apparatus which combines the trailing blade and slide methods of coating in such a way as to overcome the shortcomings of both and provide means 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 apparatus applying very low coverage coatings to a web travelling at high speed. The invention also comprises means for first trowelling a very thin sub-coat onto the web surface with a trailing blade coater so as to prepare the surface for an over-coating of the same or compatible coating material, and means for then flowing the over-coat down the top side of the trailing blade and off the trowelling end thereof directly onto the sub-coat.

The invention further provides apparatus for 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 sub-coat in distinct layer relationship with each other and the sub-coat. I have chosen to designate the coating apparatus of the invention "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 sub-coat 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 invention for applying a reasonably uniformly thin layer of a given coating solution to the surface of a web moving continuously at high speed comprises means for applying a fluid composition to the surface of the web, and including a flexible stationary blade for trowelling said composition as a sub-coating on the web surface by moving the web past the end of a trowelling surface of said flexible stationary blade that is pressing against the web surface to fill any low areas in the web surface and thereby provide a smooth wet surface on the web; means for continuously metering a given quantity of said fluid composition, or another coating composition compatible with said sub-coat, in the form of a layer onto a non-trowelling surface of said trailing blade at a point spaced above the flexible end thereof so that said layer of coating composition, under the influence of gravity may flow 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 sub-coat. With apparatus of the present invention two or more layers of fluid composition may be simultaneously applied to the sub-coat in distinct layer relationship with each other and the sub-coat if desired. The blade applied sub-coat acts as a seal to prevent air entrainment under the sub-coat(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 supply 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 counter-clockwise direction as shown by arrow **11.** The web to be coated may be raw paper, pre-coated 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 trowelling 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 in 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 sub-coat 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 over-coat. This sub-coat can be the same composition as the over-coat, 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 over-coat composition so that the over-coat layer(s) will readily spread and adhere to the sub-coat and not be adversely affected by the sub-coat 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 sub-coat composition Sc is fed into the cavity **18** through an inlet **19** by a pump P. The sub-coat 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 sub-coat 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 sub-coat with it, and this is trowelled over the web surface by the the trowelling surface at 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 sub-coat 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 is fed into the cavity **22** through an inlet **22'** by a pump P' of the constant discharge type. As the over-coat 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 or non-trowelling 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 sub-coat 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 over-coat flowing off the end thereof will flow onto the layer of sub-coat 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 sub-coat composition formed between the web surface and the under side of the trailing blade will prevent the entrainment of air beneath the over-coat layer which slides off the end of the blade and onto the sub-coat. At the same time, the trowelling action of the blade on the sub-coat composition will further prevent air entrainment under the sub-coat. 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 over-coat 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 sub-coat 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 sub-coat 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 sub-coat applicator. In this embodiment the sub-coat 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 serving to distribute the coating material uniformly across the said puddle 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 sub-coat applicator. In this embodiment the sub-coat 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 counter-clockwise 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 sub-coat 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 sub-coat material is fed into these tubes by a pump, not shown, and the streams of coating reaching the back side 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 sub-coat while still maintaining a distinct layer relationship with each other and the sub-coat. 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 sub-coat 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 three 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 over-coat layers since the sharp edge makes it easy for the over-coat 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 an over-coat 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 CMC were also used for the slide coat. Satisfactory coverages ranged from 0.06 to 1.40 lbs/100 ft^2 for the slide coat and 0.008 to 0.50 lbs/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 trials which were made to evaluate possible limitations of the present coating technique. Table **1** lists trials in which only the blade coat, or sub-coat, was applied to the continuous web. Table **2** lists trials in which the blade coat and the over-coat (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 SUB-COAT 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

Trial	Sub-coat material	Solids, percent	Wet coverage, lb./100 ft.²	Overcoat 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	9.15	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	6.12	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	360
32	CMC	8	0.09	CMC	3	0.34	360
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	360
36	PVA	20	0.15	CMC	3	0.60	360
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

Trial	Sub-coat material	Solids, percent	Coverage, lb./100 ft.²	Middlecoat material	Solids, percent	Coverage, lb./100 ft.²	Overcoat 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
"	15	140
"	18	350
"	20	630
"	25	2,750
"	30	12,000
CMC	3	400
"	8	9,000
PVA	12	140
"	20	356
baryta	64	2,000
clay	45	1,200
"	57	2,000

DISCUSSION OF TRIALS

I. Sub-coat (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, August 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 to 20 percent solids worked very well for the sub-coat application. However, when the solids content was increased above 20%, 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 became 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 sub-coat fluids. The clay and baryta dispersions are highly shear sensitive and thin quite readily in a blade coating process.

D. CMC

The CMC (3 to 8 percent solids) worked well as a sub-coat 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 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 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.

Micro sections of various coated specimens made in the described trials were made. It was found that sub-coats 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.

Micro sections 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 draw back 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 coating 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 sub-coat fluid to be applied to the web than a raw paper stock because the sub-coat cannot be forced into the stock by the trowelling action of the blade. Consequently, for a given setting of the blade, more of the sub-coat fluid is left on top of the web, because this situation causes more hydrostatic pressure to be applied to the blade tip by the sub-coat fluid.

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

Although examples of certain synthetic polymeric solvent solutions, aqueous pigment dispersions, 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 sub-coat 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 have 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. In a coating apparatus for applying two fluid coating compositions to the surface of a web in superposed layer relation, the combination with a web guiding surface on which a web to be coated is adapted to be continuously advanced while being held in a smooth condition, of a hopper spaced from said web guiding surface; a downwardly inclined flexible trailing blade having one end fixed to said hopper and the other end engaging a first coating on the web on said guiding surface and deflected by such engagement to resiliently press against and trowell the first coating onto the surface of said web as the web is moved past said blade, said blade having an uppermost non-trowelling surface and a lowermost trowelling surface; means for applying said first fluid coating composition to the surface of said web in advance of said blade to be trowelled by said trowelling surface of said blade into a smooth layer; and means for continuously forming a layer of the other fluid coating composition with the aid of gravity flow and flowing it onto the top of said trowelled first layer, and comprising a cavity in said hopper for said other coating composition, and a discharge slot connecting said cavity with the non-trowelling surface of said trailing blade at a point spaced above the flexed end thereof, and means for metering said other coating composition from said cavity through said discharge slot in the form of a layer and onto the non-trowelling surface of said trailing blade, whereby the layer of coating composition formed upon moving down the non-trowelling surface of said blade under the influence of gravity flows off the deflected end thereof and onto the top of the layer of first coating composition applied by the trowelling action of said blade.

2. A coating apparatus as defined in claim **1**, wherein said means for applying a first fluid coating composition to the surface of said web in advance of said blade comprises a second cavity in said hopper for said first fluid coating composition, and a second discharge slot for connecting said cavity with the trowelling surface of said trailing blade at a point spaced above the flexed end thereof; and means for metering said first fluid coating composition from said second cavity through said second discharge slot and onto the trowelling surface of said blade in a layer which flows down the trowelling surface of the blade and onto said web surface.

3. A coating apparatus as defined in claim **1**, wherein said means for applying a first fluid coating composition to the surface of said web comprises means for continuously depositing said first fluid coating composition onto said web surface ahead of said trailing blade in a plurality of separate streams spaced transversely of said web and at such a rate as to form and maintain a puddle of fluid coating composition behind and across the length of said blade.

4. A coating apparatus as defined in claim **1**, wherein said means for applying a first fluid coating composition to the surface of said web comprises a reservoir for said coating composition, the bottom wall of said reservoir formed by the surface of said web supported by said guiding surface as it approaches said trailing blade, and one end wall of said reservoir formed by the free end of said trailing blade which controls the deposition of the coating composition onto the surface of said web as it passes said blade; and means for continuously feeding said first fluid composition into said reservoir at a rate at least equal to that at which said composition is coated out onto said web.

5. A coating apparatus as defined in claim **1**, characterized in that the end of said trailing blade that is trowelling said first coating is tapered to a rounded point having a thickness less than half the thickness of the blade proper and wherein the upper surface of the tapered end joins the upper surface of the blade in a large radius so that the layer of coating flowing down the blade is not subjected to a sudden change of direction.

6. A coating apparatus as defined in claim **1** characterized by the inclusion of means for applying a third layer of fluid coating composition along with said two layers mentioned, said means including a second cavity in said hopper; a downwardly inclined slide surface intersecting said discharge slot at an acute angle, whereby a layer of fluid coating composition flowing down said surface under the influence of gravity is adapted to combine in surface relationship with the layer issuing from said discharge slot and flow down the surface of the trailing blade in such strata relationship and flow off the end of said blade onto the surface of the web in strata relationship with the layer of coating applied thereto by said blade; an elongated layer forming duct connecting said second cavity with said slide surface at a point located above said discharge slot, and means for continuously feeding the coating composition into said second cavity at a rate commensurate with the thickness desired in the third layer after coating.

7. In a coating apparatus for applying a plurality of fluid coating compositions onto the surface of a web in superposed distinct layer relationship, the combination with a web guiding surface on which a web to be coated is adapted to be continuously moved while being held in a smooth condition; of a multiple coating hopper spaced from said web guiding surface; a downwardly inclined flexible trailing blade having a trowelling surface and a non-trowelling surface and further having one end fixed to said hopper and the other end engaging a first coating on the exposed surface of the web on said guiding surface and deflected by such engagement to press against and trowell the first coating onto the surface of said web as it is moved past said blade; means for applying said first fluid coating composition to the surface of said web in advance of said blade to be trowelled by said trowelling surface of said blade into a smooth layer; and means for continuously forming each of the other fluid coating compositions into individual layers, bringing them into superposed and distinct layer relationship with one another and then with the aid of gravity flow depositing them in superposed and distinct layer relationship on the layer of the

first fluid coating composition applied to the web; said last-mentioned means comprising a separate cavity in said hopper for each of said other coating compositions; a duct connecting the first of said cavities with the non-trowelling surface of said trailing blade at a point spaced above the flexed end thereof; means for continuously metering one of said other coating compositions from said cavity and through said duct from which it emerges in the form of a layer which is deposited onto the non-trowelling surface of said trailing blade; and means for continuously metering the remaining coating compositions from their respective cavities in the form of layers and combining said layers in strata relationship with each other and then with the layer of first coating composition as it is trowelled on the surface of said web.

8. In a coating apparatus for applying three fluid coating compositions onto the surface of a web in superposed distinct layer relationship, the combination with a web guiding surface on which a web to be coated is adapted to be moved while being held in a smooth condition; of a multiple coating hopper spaced from said web guiding surface; a downwardly inclined flexible trailing blade having a trowelling surface and a non-trowelling surface and further having one end fixed to said hopper and the other end engaging a first coating on the exposed surface of the web on the guiding surface and deflected by such engagement to press against and trowell the first coating onto the surface of said web as it is moved past said blade; means for applying a first fluid coating composition to the surface of said web in advance of said blade to be trowelled by said trowelling surface of said blade into a smooth layer on the web surface; and means for continuously forming each of the other two fluid coating compositions into individual layers, bringing them into superposed and distinct layer relationship with one another and then with the aid of gravity flow depositing them in superposed and distinct relationship with the layer of the first coating composition applied to said web; said last-mentioned means comprising, a separate cavity in said hopper for each of the other two coating compositions; an elongated discharge slot communicating with one of said cavities and directed downwardly onto the non-trowelling surface of said trailing blade at a point removed from the deflected end thereof; means for continuously metering one of the other two coating compositions from its cavity through said discharge slot in the form of a layer; a downwardly inclined slide surface intersecting said discharge slot an an acute angle; an elongated duct leading from the last cavity onto said slide surface at a point above said discharge slot; and means for continuously metering said third coating composition from said last cavity through said duct and onto said slide surface in the form of a layer which flows down said slide surface and onto the top of the layer issuing from said discharge slot and after which the two layers flow down said trailing blade and off the end thereof onto the layer of coating composition trowelled on the web by said trailing balde.

* * * * *

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,756,195 Dated September 4, 1973

Inventor(s) Joseph A. Mercier

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 45, after "apparatus" insert --for--;
lines 61-62, after "invention" insert --a--.

Column 5, line 5, after "said" insert --puddle--;
line 6, delete "said puddle" and insert --web--.

Column 6, line 41, delete "0.008" and insert --0.08--.
Column 6, Table I, line 67, an asterick (*) should be inserted after "Gelatin";
lines 68 and 69, a double asterisk (**) should be inserted after "Gelatin".

Column 7, line 1, a double asterisk (**) should be inserted after "Gelatin".

Signed and sealed this 9th day of April 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

104