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[54] **MULTIPLE DOCTOR BLADE COATING**
APPARATUS
 1 Claim, 2 Drawing Figs.

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

ABSTRACT: Providing a final doctor blade in a multiple blade coating apparatus having a surface dimension, in the direction of coated web movement, of at least five times that of the proceeding doctor blades.

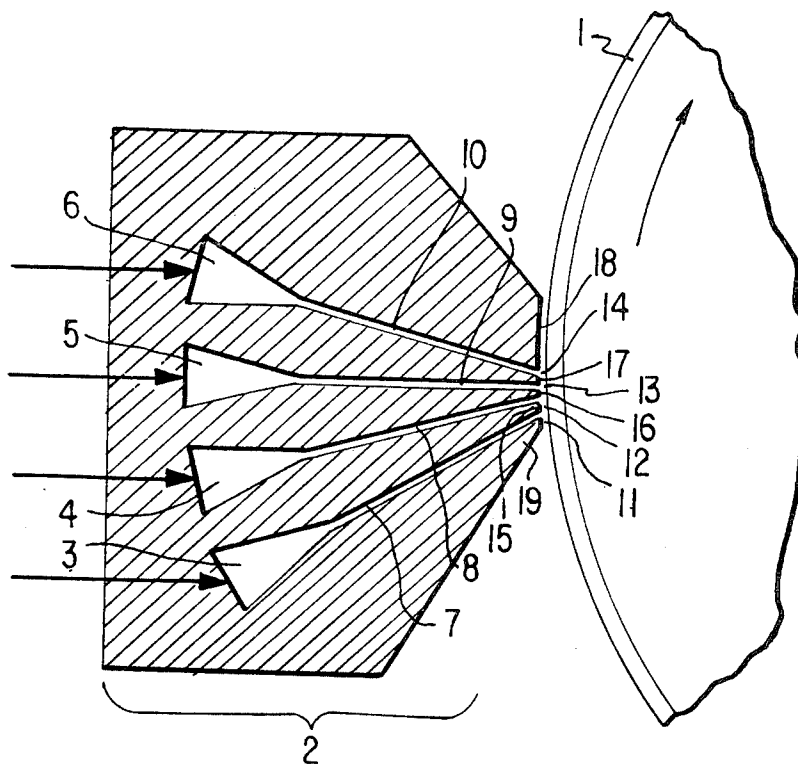


FIG. 1

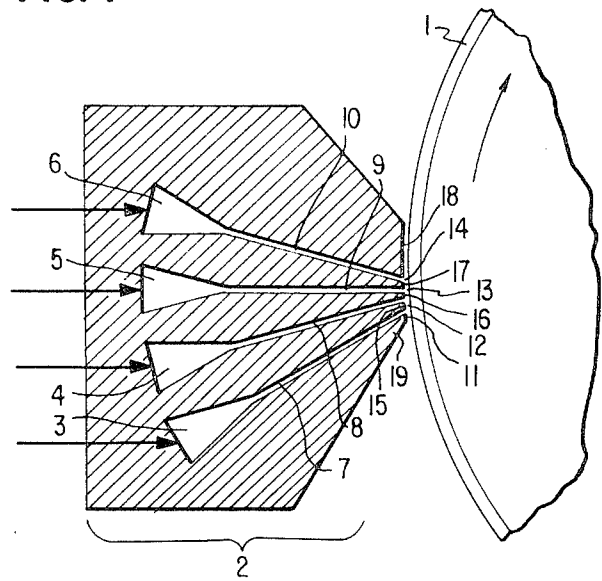
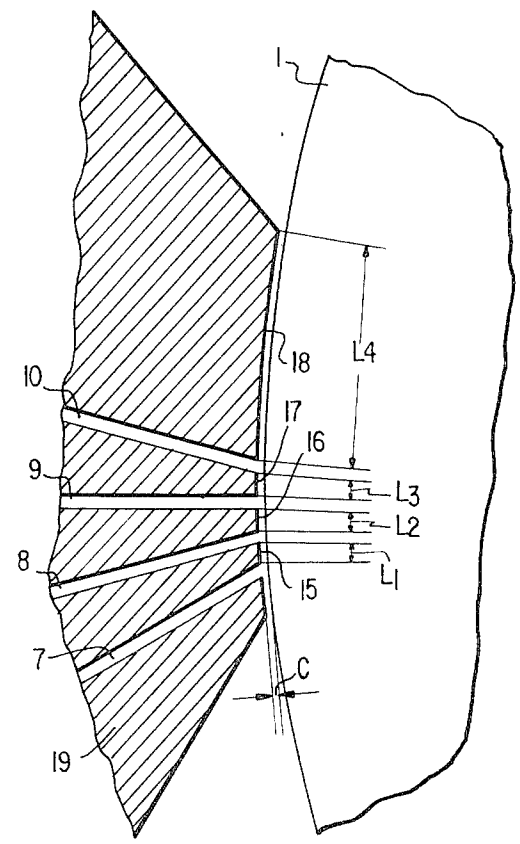


FIG. 2



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MULTIPLE DOCTOR BLADE COATING APPARATUS

This application is a continuation of application Ser. No. 746,176, filed July 19, 1968 and now abandoned.

The present invention relates generally to a multiple doctor blade coating apparatus and more particularly to an improved apparatus suitable for applying successively and at a high speed, a plurality of photographic fluid coating compositions such as gelatino silver halide emulsions, an emulsion for protective layer, an emulsion for antihalation layer, an emulsion for a filter layer and an emulsion for a masking layer, in applying photographic light sensitive materials to the surface of a continuously travelling web such as a film base or baryta paper, in one step, and without setting or drying the coated layers between their application.

We have previously proposed a multiple doctor blade coating apparatus in U.S. Pat. application Ser. No. 589,896 in which a coating device comprising chambers containing fluid coating compositions (a single chamber for each composition). Discharge openings supply each coating composition to the surface of the travelling web separately, each of the discharge openings being connected to a corresponding chamber and facing the web. Doctor blades partition each discharge opening and meter each coating composition onto the travelling web, which is spaced slightly from the surface of the travelling web. Each coating composition is supplied to the corresponding chamber by means of a suitable supplier at a rate corresponding to a desired thickness of coating, and each applies its coating composition separately, through an associated discharge opening to the surface of the travelling web without forming spaces between the coating compositions. The coating compositions are superimposed on the travelling web and metered by a corresponding doctor blade, whereby distinct, superimposed, multiple layers of the coating compositions are formed on the travelling web.

In applying a coating composition to the surface of a web, it is generally desired to reduce the thickness of the coated layer for facilitating drying of the coated layer, to increase the coating speed, and also to reduce the size of the drying equipment to reduce the overall cost of drying.

In the aforesaid multiple doctor blade coating apparatus, the thickness of each coated layer may be considerably reduced as compared to a conventional single layer doctor blade coating system. However, in order to further reduce the coating thickness using a conventional multiple doctor blade coating apparatus, the clearance between the coating device and the web to be coated must be further reduced. However, it is undesirable to reduce the clearance between the coating device and the web over definite limits since it is accompanied by the following defects: cometlike spots are caused by dust or other foreign solid materials deposited on or embedded in the back surface of the web or the surface of a backup roller; coating defects are caused by the unevenness in thickness of web or local deformation of the web, and further the thickness of the coated layer becomes uneven due to poor finishing of the surface of the backup roller or the top of the doctor blade. Moreover, in the case when a joined portion of the web passes through the space existing between the coating device or the backup roller, it is necessary to move the coating device or the backup roller to momentarily enlarge the clearance therebetween.

Therefore, an object of the present invention is to provide an improved multiple doctor blade coating apparatus for achieving thin layer coating without narrowing the clearance between a coating device and a travelling web to be coated.

Another object of this invention is to provide a multiple doctor coating apparatus for applying, in one step, a plurality of coating compositions in thin multiple layers at a high speed.

Still another object of this invention is to provide a doctor coating apparatus for uniformly applying to a continuously travelling web, distinct, superimposed, multiple, thin layers of a plurality of coating compositions.

A further object of this invention is to provide a multiple doctor coating apparatus suitable for simply and economically

preparing photographic light sensitive materials involving multiple photographic layers of photographic coating compositions.

We have noted that the length of each doctor blade in the travelling direction of the web is an important factor for determining the clearance between the coating device and the web in multiple doctor coating and have found that in the case where each coating composition has the same viscosity, a good coating can be achieved by adjusting the clearance between the coating device and the web to the value determined by the following equation:

$$C = \frac{\sum_{j=1}^n (L_j \sum_{i=1}^j t_i)}{\sum_{j=1}^n L_j} \times 2 \quad (A)$$

where:

$i=1, 2, \dots, j$

$j=1, 2, \dots, n$

C: the clearance between a coating device and a web (micron)

L_j : the length (in the travelling direction of web) of the doctor blade corresponding to j -th coating composition (mm.)

t_i : the thickness of i -th coated layer (micron)

n : the number of coating compositions to be coated on the web simultaneously.

According to the present invention, a plurality of coating compositions can be applied to a web in thin layers without reducing the clearance between a coating device and the web by suitably selecting the length of each doctor blade in the travelling direction of web based on the aforesaid equation, that is, by making the length of the doctor blade for the coating composition of the uppermost layer in the travelling direction of web longer than the length of each of other doctor blades.

The present invention will be explained in detail by referring to the accompanying drawings; in which:

FIG. 1 is a cross-sectional elevational view of an embodiment of the coating apparatus of the present invention, and

FIG. 2 is a fragmentary, enlarged, cross-sectional view of the coating section of the doctor blade coating apparatus shown in FIG. 1.

Now referring to FIG. 1 and FIG. 2, a coating device 2 is positioned slightly apart from a continuously travelling web 1 to be coated while supported by a backup roller. The coating apparatus comprises a series of separate chambers 3, 4, 5, and 6, each containing coating compositions for 1st, 2nd, 3rd, and 4th layers respectively and each connected to means (not shown) for supplying separate coating compositions (not shown) thereto. Discharging openings or slots 7, 8, 9, and 10 are provided for applying to, web 1 each coating composition separately, with the slots each connected to corresponding chambers mentioned above. Doctor blades 15, 16, 17 and 18 partition the aforesaid discharging slots from each other and meter each coating composition to the web from the discharging slots. The doctor blades each have smooth top surfaces, finished with high accuracy facing the web. Doctor channels 11, 12, 13 and 14 are formed between the doctor blades and the web. A back plate 19 together with doctor blade 15 forms the discharge slot for the 1st coating composition.

Each coating composition is supplied to the corresponding chamber from supply means (not shown) at a rate corresponding to the desired thickness of coating. The compositions are applied directly to a continuously travelling web 1, separately from each discharge slot or opening to fill the doctor channel formed between the doctor blades and the web and without forming spaces between the coating compositions. Distinct superimposed layers of the coating compositions are successively formed while metering the coating compositions by the corresponding doctor blades respectively in a desired ratio of thickness.

In the apparatus of this invention, the length L_4 of the top plane of the doctor blade 18 in the travelling direction of web 1 and corresponding to the coating composition for the uppermost layer is from 5 to 20 mm., and must be longer than five times the length L_1 , L_2 , and L_3 of the top planes of the doctor blades 15, 16, and 17 respectively in the travelling direction of the web. The length L_1 , L_2 , and L_3 of the top surfaces of the doctor blades 15, 16, and 17 in the travelling direction of web are preferably from 0.5 to 2 mm. Furthermore, if a further thin thickness of the first layer (closest to the web surface) of coating composition is desired, the length L_1 of the doctor blade 15, in the travelling direction of web and corresponding to the first layer of coating composition is desirably shorter than 0.5 mm.

The advantages obtained by using the multiple doctor blade coating apparatus of this invention will be sufficiently understood by the following practical calculations conducted by use of equation (A) as mentioned above.

CALCULATION 1

Number of coatings, 4 Viscosity of each coating composition, 30 cp. Thickness of each coated layer, 50 microns		
	Multiple doctor coating apparatus of the present invention	Previous multiple doctor coating apparatus
Length of doctor blade:		
L_1 , mm.....	1	1
L_2 , mm.....	1	1
L_3 , mm.....	1	1
L_4 , mm.....	10	1
C^* , microns.....	350	250

*The clearance between a coating device and a web.

In applying four coating compositions to a web having the same thickness for the four layers, the clearance between the coating device and the web, in the multiple doctor coating apparatus of this invention, may be 40 percent greater than that of employing a conventional doctor coating apparatus as mentioned above. In other words, as will be easily understood from the above calculation, the thickness of each coated layer can be effectively reduced by employing the multiple doctor blade coating apparatus of this invention.

CALCULATION 2

Number of coatings, 4 Viscosity of each coating composition, 30 cp. Clearance between a coating device and a web, 250 microns		
	Multiple doctor coating apparatus of the present invention	Previous multiple doctor coating apparatus
Length of doctor blade:		
L_1 , mm.....	1	1
L_2 , mm.....	1	1
L_3 , mm.....	1	1
L_4 , mm.....	10	1
Sum of thickness of coated layers, microns..	141	200

By using the multiple doctor coating apparatus of the present invention, the total thickness of the coated layers can be about 30 percent thinner than that of conventional multiple doctor blade coating apparatus.

Calculation 3

Number of coatings:	4
Viscosity of each coating composition:	30 cp.
Thickness of the 1st layer:	20 microns
Thickness of each of the 2nd, 3rd, and 4th layers:	50 microns
Sum of thickness of coated layers:	170 microns.

	Multiple doctor coating apparatus of the present invention	Previous multiple doctor coating apparatus
Length of doctor blade:		
L_1 , mm.....	0.5	1
L_2 , mm.....	1	1
L_3 , mm.....	1	1
L_4 , mm.....	10	1
C^* , microns.....	300	190

*The clearance between a coating device and a web.

By using the multiple doctor coating apparatus of the present invention, the clearance between the coating device and the web can be increased by about 60 percent over that of employing a conventional multiple doctor blade coating apparatus when the total thickness of the coated layers is kept constant.

As is clear from the above-mentioned calculations, by using the multiple doctor blade coating apparatus of this invention, the clearance between a coating device and a web can be effectively reduced when a constant thickness of each coated layer is desired or the thickness of each coated layer can be effectively reduced when the clearance between the coating device and the web is constant. Therefore, according to the present invention it becomes possible to practice high speed thin layer multiple doctor blade coating. This has been impossible to practice in the past, owing to the formation of cometlike spots caused by dust or other foreign solid matter deposited on or embedded in the back surface of a travelling web or the surface of a backup roller; the formation of coating defects caused by the unevenness in thickness of web or a partial deformation of web; the unevenness in thickness of coating thickness caused by the poor accuracy in finish of the doctor blades or the backup roller; and the difficulty in passing the joined portion of web through the clearance or channel between the coating device and the web.

In addition, while the aforesaid calculations were made only for the case where each coating composition has the same viscosity, the present invention can be effectively applied to cases where coating compositions having different viscosity are employed.

Also, besides these advantages, the multiple doctor coating apparatus of the present invention has, as a matter of course, the advantages common to conventional multiple doctor coating apparatus as mentioned above. Since a plurality of fluid coating compositions can be applied to a travelling web in one step without setting or drying each coating composition separately, they are all coated during one coating operation. Efficiency is extremely improved in the case where a photographic light sensitive material having multiple layers such as a color photographic material is prepared by means of the multiple coating apparatus of the present invention.

Since the coating compositions continuously contact each other in the space or channel between the coating device and the web, the wetting property between the coating compositions is better, which facilitates the selection of surface active agents and neither "stripes" nor "commets" which frequently form in the case of conventional multiple doctor blade coating apparatus are formed and uniform coating is achieved. Since the coating compositions contact a continuously travelling web in the space existing between the coating device and the web, the wetting property between the web and the coating compositions is improved, the air entrapped by the travelling web does not enter the space between the coating compositions and the web, even when the speed of the travelling web is increased. Also, the resistance of the coating compositions in the space between the coating device and the web to ambient disturbance is increased, which makes it possible to coat at high speed.

Since the coating compositions are successively superimposed on a travelling web while being metered by a cor-

responding doctor blade, there scarcely occurs mixing and other disturbances of coating compositions at the interface between the coating compositions and hence uniform and distinct superimposed multiple layers of coating compositions can be formed.

EXAMPLE

By using the doctor blade coating apparatus illustrated in FIG. 1, four coating compositions for a cinecolor positive film were applied to an undercoated cellulose triacetate film in one step under the following conditions:

	Viscosity, cp.	Density (g./cm. ³)	Thickness of coated layer, microns
1st coating compound*.....	50	1.05	50
2nd coating compound**.....	50	1.03	50
3rd coating compound***.....	50	1.04	50
4th coating compound****.....	50	1.01	50

Length of each doctor blade:

$L_1=1$ mm., $L_2=1$ mm., $L_3=1$ mm., and $L_4=10$ mm.

Travelling speed of the web: 25 m./min.

(*): blue-sensitive emulsion; (**): red-sensitive emulsion; (***): green-sensitive emulsion; (****): aqueous gelatin solution for protective layer.

The clearance between the coating device and the web was about 350 microns, which coincides with the calculation result obtained by the equation (A) shown before, and a good coating was achieved.

On the other hand, when the coating was conducted under the aforesaid conditions using the conventional multiple doctor blade coating apparatus wherein L_1 , L_2 , L_3 , and L_4 were 1 mm., good coating was impossible where the clearance between the coating device and the web was greater than 250 microns.

In addition, when the color photographic film was tested no cometlike spots were formed, the thickness of the coated layers was uniform, no intermixing of coating compositions between them was observed, and the photographic properties were better.

It is intended that the invention shall not be limited to the kinds of coating compositions and shape of the coating device as shown above.

What I claim is:

1. A multiple doctor coating apparatus for successively applying a plurality of coating compositions to the surface of a web travelling over a backup surface comprising:

a. a coating-head having a plurality of chambers each adapted to receive a coating composition from a suitable supply means;

b. each of said chambers having a discharge opening, each of said discharge openings being successively adjacent each other in the direction of travel of said web with a doctor blade forming a downstream portion of each discharge opening in the direction of travel of said web and located in close proximity to said web;

c. said doctor blades having each an end surface facing said web substantially parallel thereto and spaced substantially equally distant therefrom, said doctor blades acting to meter each of said coating compositions as the coating compositions are discharged from their respective opening into the space between said doctor blades and the surface of said web;

d. each of said end surfaces of said doctor blades having a substantial width in the direction of travel of said web with the width of the end surface of the doctor blade metering the topmost layer being at least 5 times greater than the width of the end surfaces of the other doctor blades, each of the end surfaces of said other doctor blades being approximately 2 mm.

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