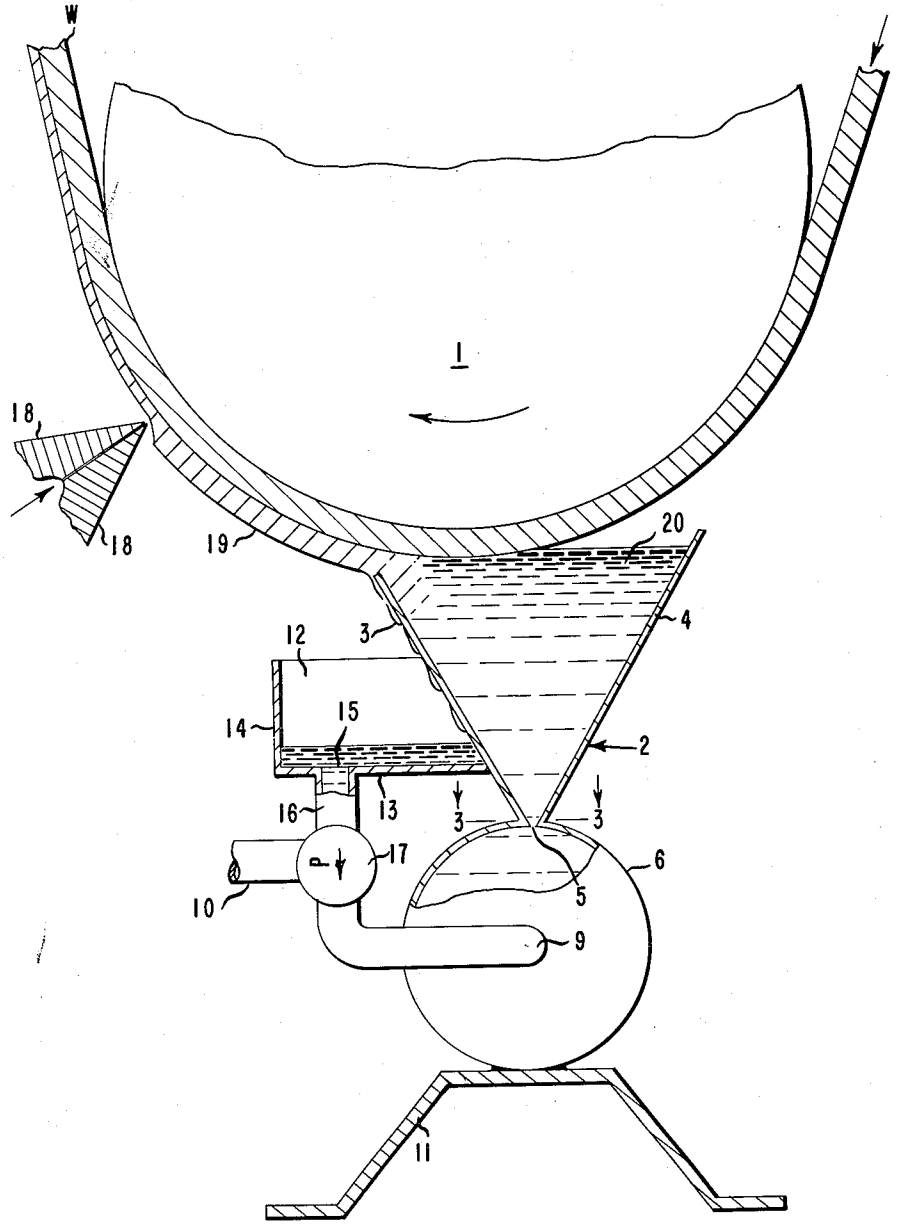
March 20, 1962 K. A. HEILMAN 3,025,828

COATING APPARATUS

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FIG. 1



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FIG. 2

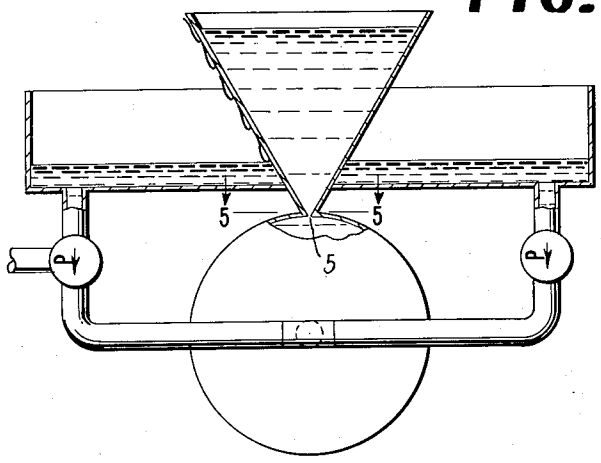


FIG. 3

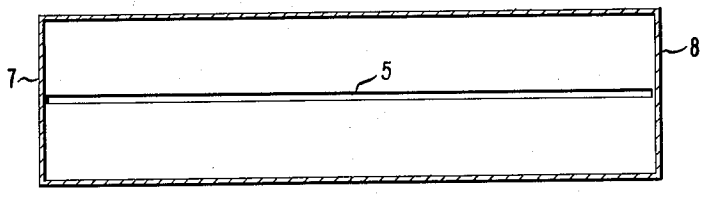


FIG. 4

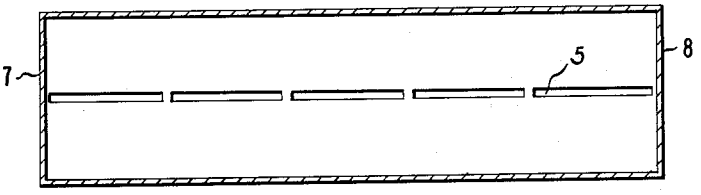
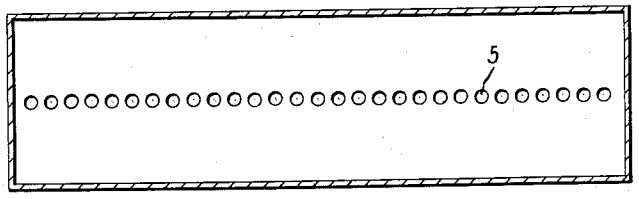


FIG. 5



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3,025,828

COATING APPARATUS

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Filed May 5, 1960, Ser. No. 27,100
12 Claims. (Cl. 118—63)

This invention relates to apparatus for continuously and uniformly coating a web. More particularly it relates to such apparatus which is useful for the coating of dispersions uniformly and continuously without significant settling of the dispersed phase.

The most widely used method for coating a continuous web involves passing the web around a roller so that the web skims the surface of the liquid coating material, which is generally contained in a suitable coating pan. Various other coating devices have been used, such as applicator rolls which transfer coating material from a coating pan to the moving web. As coating speeds have increased, various types of doctors have been used to maintain uniform layer thickness. All of the equipment known in the prior art, however, appears to suffer, in varying degrees, from the problem of stagnation of coating material. "Dead" areas interfere with circulation so that some fraction of the material may undergo undesirable temperature and/or concentration changes. This problem has been relieved to some extent by making use of the technique known as "overflow" coating, i.e., feeding coating material from a temperature-controlled reservoir at a faster rate than it is coated on the web and recirculating the excess material through the reservoir. However, the prior art equipment has not satisfactorily solved the stagnation of "dead" area problem and, in particular, the problem is serious wherein it relates to the settling of relatively large particles dispersed in a dispersing medium of relatively low viscosity. Another problem encountered in the use of prior art equipment, especially with coating dispersions which tend to separate easily, is the excessive loss in production time required for cleaning the apparatus. Still another problem found in coating equipment known in the art is that of nonuniform coating quality caused by nonuniform distribution of inflow of coating material from end to end across the coating pan.

An object of this invention is to provide a coating apparatus for the uniform application of liquid coatings to continuous webs. Another object is to provide a coating apparatus which is free from "dead" spaces and avoids any coating defects due to dispersion separation. A further object is to provide a coating apparatus which requires a minimum amount of lost production time due to necessities of cleaning the apparatus. A still further object is to provide a coating apparatus wherein the inlet flow of coating material is distributed uniformly across the larger coating area without eddy currents and stagnant areas. A more particular object is to provide such an apparatus which is simple in construction and is dependable in operation. Other objects will be apparent from the following description of the invention.

The coating apparatus of this invention comprises an elongated supply chamber having smooth, curved, converging walls at least in the upper portion of the chamber, inlets for introducing fluid coating material into the chamber, an orifice of small cross-section in the upper curved walls extending lengthwise of said chamber and communicating with a coating pan having diverging walls the bottom edges of which are close to the orifice and the upper edges of which are spaced a substantial distance apart and adapted to receive a guide roller and web transported thereby, end walls, and a coextensive

overflow collecting trough adjacent one of said sidewalls. This collecting trough or troughs, preferably, are provided with an outlet and means for recycling the liquid coating material to the chamber. The orifice may be a continuous one extending the full length of the pan, or it may consist of a series of slots with small closed areas between the ends of the slots or a row of holes. The supply chamber is preferably a hollow cylinder but may be a hemicylinder with a flat bottom, or it may be ovoid or some other smoothly-curved shape so that the coating liquid is directed to the orifice without any impediment to smooth flow.

The entire coating apparatus provided by the invention comprises not only the novel chamber, coating pan, collecting pan and auxiliary conduits and related parts, but includes a doctor knife (preferably an air doctor knife) adjacent the coating pan for smoothing the applied coating and regulating its thickness and directing excess coating material into the overflow trough.

The apparatus of this invention will now be described more fully with reference to the accompanying drawings which form a part of this application. The parts have the same reference numerals throughout the several views. In the drawings:

FIG. 1 is an end elevation, with parts in section, of one form of the apparatus of the invention with the coating roll and web and an optional "air knife" in assembled relationship.

FIG. 2 is an end elevation with parts in section of a modified apparatus wherein the front and rear walls of the coating pan are of the same height and there are two overflow troughs.

FIG. 3 is a section taken along lines 3—3 of FIG. 1 showing a single continuous slot orifice.

FIG. 4 is a similar view of a modified orifice consisting of a row of elongated slots, and FIG. 5 is a view like FIG. 3 except that the orifice is a row of holes of small diameter.

Referring now to FIG. 1 of the drawing, the apparatus for continuously coating a web W consists of a guide roller **1** around which the web W passes which is disposed directly above the coating pan **2**. This coating pan has diverging front and rear walls **3** and **4**, the former of which is shorter than the latter. These diverging walls terminate in a narrow orifice **5** in the upper curved wall of the cylindrical supply chamber **6**. The diverging walls **3** and **4** with the end walls **7** and **8** provide a V-shaped coating pan. The end of the cylindrical supply chamber is provided with an inlet **9** connected to a supply pipe **10** which is connected to a suitable source of supply of coating material. The supply chamber is affixed in any suitable way, e.g., by welding, or by means of bolts or straps, to bottom frame member **11**. Coextensive overflow collecting trough **12** having bottom wall **13** is welded or otherwise affixed to side wall **3**. The side wall **14** of this trough extends lengthwise of the coating pan and is provided with two end walls (not shown). The bottom wall of the overflow trough is provided with an outlet **15** connected to pipe **16** which, if desired, is connected to supply pipe **10** so that the overflow material may be recycled by means of a suitable pump, such as **17**, back into the supply chamber and thence to the coating pan.

Adjacent the coating pan in a clockwise direction around the roll are disposed the lips **18** of an air doctor knife (not shown) mounted on a suitable frame (also not shown). Air passes between the lips and impinges upon the layer **19** of coating material **20** fed into the coating pan.

The upper edge of front diverging wall **3** constitutes a "weir" and, as shown in FIG. 1, is at a lesser height than the upper edge of the rear diverging wall. However, the

invention is not limited to this construction as the two walls can be the same height.

Referring now to FIG. 2 of the drawing, the coating pan has the same construction as that shown in FIG. 1 except that the diverging walls have the same height. In addition, a collecting trough is mounted adjacent each of the diverging walls. The second trough is likewise provided with an outlet and a pipe for removing overflow or excess coating liquid and, if desired, recirculating it into the supply chamber **6**. For the sake of clarity, the frame member is not shown in FIG. 2; however, the supply chamber may be bolted or otherwise affixed to any suitable frame member.

With reference to FIG. 1 of the drawing, during a coating operation the coating material, e.g., aqueous dispersion, is forced by any suitable means through supply pipe **10** into the end of the supply chamber **6**. The coating material flows upwardly and through the orifice **5** into the coating pan, filling the latter to the desired height. Web W traveling on guide roller **1** skims across the coating material, removing layer **19** of coating material. As the layer passes by the lips of the air doctor knife the coating is reduced in thickness and smoothed, and the coating material which is blown back and the excess which passes over the "weir" is collected in a collecting trough **12** where it is removed or recycled.

It is not essential to use the air knife as any other suitable kind of doctor blade can be used in like manner to remove the excess of coating material. The "weir" or front edge of the diverging wall **3** can also be used to mechanically smooth or doctor the layer of coating material with or without further smoothing by means of an air doctor knife or other doctor blade. This may be accomplished conveniently by raising or lowering guide roller **1**. Alternatively, the frame **11** may be provided with means for raising or lowering the pan and thus bringing it into the desired proximity of the surface of the web **7** to be coated.

When a particularly high rate of overflow is desired in a coating process, it is expedient to have the diverging front and rear walls **3** and **4** approximately the same height above the layer of coating material in the coating pan. By feeding coating material into the pan at a rate faster than it is removed from the coating pan, there will be overflow over both diverging walls. In such case, collecting troughs are provided on each side of the coating pan as shown in FIG. 2.

The length of the coating pan is dependent on the width of web to be coated. To achieve a coating of the entire width of the web, the pan will normally be of sufficient dimension to extend at least a fraction of an inch beyond each edge of the web. The supply chamber **6** and orifice ordinarily will extend substantially the entire length of the coating pan. However, it may extend somewhat longer on the inlet end if the inlet is disposed at one end of the supply chamber near its center.

The cross-sectional area of the supply chamber may be constant throughout its entire length. However, if the fluid is fed into the chamber at one end, the cross-sectional area of the supply chamber may gradually decrease over its entire length. The particular shape of the supply chamber, moreover, may vary depending upon the rheological properties of the coating material. In general, the supply chamber is a hollow cylinder and the upper walls are smoothly curved to aid in promoting a smooth flow of coating material to and through the orifice.

The width of the orifice from the supply chamber will depend upon the viscosity of the coating material, the desired amount of such material to be applied to the web and upon the other dimensions of the coating apparatus. In general, the width of the orifice will be proportional to the inner radius of the supply chamber and this radius will be 5–25 times the width of the orifice.

The acute angle formed by diverging walls **3** and **4** also will vary according to the material being coated, the rate of coating, etc. For a dispersion which tends to settle rapidly, the diverging walls should be about 5° from the vertical so that the total acute angle is as small as 10°. For dispersions with less tendency to settle or separate, it is advantageous to have a coating pan with the walls diverging farther from the vertical so that a greater volume of the coating material can be maintained within the coating pan. For such dispersions the walls may be inclined up to an angle of 40° from the vertical, thus forming an acute angle between the walls up to 80°. In summary, the useful range of the acute angle formed by the diverging walls may extend from 10° to 80°, each wall being inclined from 5° to 40° from the vertical. Usually the walls will diverge the same degree from the vertical. In some instances the front wall may be inclined slightly more or less than the rear wall.

The invention will be further explained but is not intended to be limited by the following examples:

Example I

A dimensionally stable vinylidene chloride/methyl acrylate/itaconic acid copolymer-coated polyethylene terephthalate film base as described in Example IV of Alles U.S. Patent 2,779,684 was coated with a dispersion containing silica of average particle size 2–4 microns, said dispersion being of the composition as shown in Example I of assignee's Van Stappen copending application U.S. Ser. No. 774,822 filed Nov. 19, 1958.

The dispersion was coated on the support at a coating weight of 100–125 milligrams per square decimeter, using the preferred embodiment of the invention as shown in FIG. 1. The diverging walls were each at an angle of 25° from the vertical. Coating speed was 60 feet per minute. An air knife doctor was used to remove excess coating material according to the following specifications: knife opening .025±.001 inch; clearing from base .060±.001 inch; air impinging parallel to the coating roll radius; and air pressure 1.2 inches water. The air knife doctor was essentially as described in assignee's LeClaire U.S. application Ser. No. 679,342 filed Aug. 21, 1957, now Patent No. 2,995,469. The coating was dried at 90° C. for 30 seconds, then cured at 120° C. for 4 minutes. The thickness of the coated layer was within the range of 0.30 to 0.35 mil. The resulting film was found to be excellent as a drafting film.

The coating material of this example contained relatively large particles (2–4 microns) which exhibited a strong tendency to settle out of the coating fluid. By using the apparatus of this invention, the settling-out tendency was overcome and a uniformly coated product was obtained.

Example II

A gelatino-silver iodobromide photographic emulsion of the medical X-ray type, having a viscosity of 27 centistokes and a solids content of 7.6% by weight, was dip-coated onto one surface of a cellulose acetate web about 7 mils thick. A uniform coating was obtained, and a coating weight of 103 milligrams per square millimeter, using the apparatus of Example I. Coating speed was 62 feet per minute and an air knife doctor was used with settings approximately as described in Example I. The web passed from the coating roll into a chill box and was subsequently dried with circulating warm air.

Example III

An aqueous dispersion of silica and titanium dioxide with a total solids content of 15% and having particle sizes in the range of 1 to 20 microns was recirculated through the coating device shown in FIG. 1. These dispersed particles had an observable tendency to settle out in a few seconds if not continually agitated and yet, when recirculated through the device of the present invention for a period of four hours, there was no sign of settling out in the coating pan.

The various parts of the apparatus according to this invention may be readily constructed from one or more

parts secured together to form the essential features hereinafter set forth in the claims. For example, the side and end walls which form the coating pan may be heavy plates welded to the supply chamber or the pan and chamber may be of integral construction, e.g., a single casting. The coating pan may be constructed of metal (e.g., stainless or plated steels, brass, copper), or composed of plastic or ceramic material. The inner walls, particularly the orifice and upper edgs of the diverging walls, should be carefully machined and highly polished.

Depending upon the material to be coated, it may be desirable to heat or cool the coating pan. This could be accomplished, for example, by jacketing the pan for circulation of a liquid heat transfer medium or by attaching electrical heaters to the jacket or pan.

Coating material is forced into the supply chamber by any suitable means. Such means include gravity feeding from a reservoir located at some point above the distributor tube and pumping means, preferably of the pulseless type.

A variety of coating compositions may be successfully applied to a supporting web using the apparatus of this invention. Such coating compositions could be either aqueous or non-aqueous, containing a variety of binders, both natural and synthetic, pigments, light- or heat-sensitive or magnetic particles, etc. Such compositions may be applied to perform any of various functions, e.g., light filtering, halation protection, ultraviolet or infrared screening, sizing, abrasion protection, and giving "tooth" to a surface. The supporting web upon which the coating is applied may be, for example, film, paper, cloth, or metal, which already may have received one or more coating treatments.

In general, the device of this invention is meant to be incorporated in a coating apparatus embodying the best features of any coating apparatus known in the art. For example, such an apparatus would include provisions for accurate web alignment which is necessary to obtain good coating quality. This, and other such features, however, are well known in the art and form no part of the instant invention.

An advantage of the device of this invention is that it makes it possible to obtain coatings of excellent uniformity from coating material dispersions having a tendency to settle out and thereby cause non-uniformity of coating. In the apparatus of this invention, all areas of low flow rate and all horizontal surfaces have been eliminated from the coating trough. Also, the primary fluid flow through the pan opposes settling. Therefore, the settling out of coating dispersions is reduced to an extremely low level. The apparatus of this invention has great utility in coating dispersions which contain relatively large particles. It is particularly advantageous for coating the dispersions used in manufacturing drafting film as described in Example I and the dispersed particles are maintained in a satisfactory state of suspension.

In addition to the advantage of improved coating uniformity, this invention has the advantage of eliminating or substantially reducing the time normally required for cleaning coating apparatus.

A still further advantage resides in the structure of the supply chamber and orifice to the coating pan whereby uniform end-to-end flow of coating material into the pan assures uniform coating of the web.

I claim:

1. A coating apparatus comprising an elongated supply chamber having smooth curved, converging walls in its upper inner surface leading to a narrow orifice extending lengthwise of said chamber, an inlet for introducing fluid coating material into the said chamber, said orifice communicating with a coating pan having diverging front and rear walls the bottom edges of which emanate from a point close to the orifice and the upper edges of which are spaced a substantial distance apart and adapted to receive a guide roller and a web transported thereby, and end walls for said coating pan.

2. A coating apparatus comprising an elongated supply chamber having smooth curved, converging walls in its upper inner surface leading to a narrow orifice extending lengthwise of said chamber, an inlet for introducing fluid coating material into at least one end of said chamber, said orifice communicating with a coating pan having diverging front and rear planar walls the bottom edges of which emanate from a point close to the orifice and the upper edges of which are spaced a substantial distance apart and adapted to receive a guide roller and a web transported thereby, end walls for said coating pan, and an overflow collecting trough adjacent the front side wall.

3. An apparatus according to claim 2 having means for recycling liquid coating material into the supply chamber.

4. An apparatus according to claim 2 wherein the front and rear walls emanate directly from the walls of the orifice.

5. An apparatus according to claim 2 wherein the front wall is shorter than the rear wall.

6. An apparatus according to claim 2 wherein the orifice consists of a single elongated slot.

7. An apparatus according to claim 2 wherein the orifice consists of a plurality of aligned slots spaced a short distance apart.

8. An apparatus according to claim 2 wherein the orifice consists of an aligned row of holes of small cross-section spaced a short distance apart.

9. An apparatus according to claim 2 having a collecting trough adjacent each of the front and rear walls of said coating pan.

10. An apparatus according to claim 2 having a doctor knife adjacent said coating pan and adapted to smooth the coating applied to the web as it is being transported by the roller.

11. An apparatus according to claim 2 having an air doctor knife adjacent said coating pan and adapted to smooth the coating applied to the web as it is being transported by the roller.

12. A coating apparatus comprising an elongated supply chamber having smooth, curved, converging walls in its upper inner surface leading to a narrow orifice extending lengthwise of said chamber, an inlet for introducing liquid coating material into at least one end of said chmaber, said orifice communicating with a coating pan having diverging front and rear planar walls, the bottom edges of which emanate from a point close to the orifice and the upper edges of which are spaced a substantial distance apart, in combination with a guide roller and a web transported thereby, said roller being of greater diameter than the width of the coating pan; said roller and web dipping into the pan at a point slightly below the surface of any liquid coating material in said coating pan.

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