

April 20, 1948.

C. S. FRANCIS, JR

2,439,802

APPARATUS FOR FORMING FILMS AND COATINGS

Filed Jan. 2, 1945

2 Sheets-Sheet 1

FIG. 1.

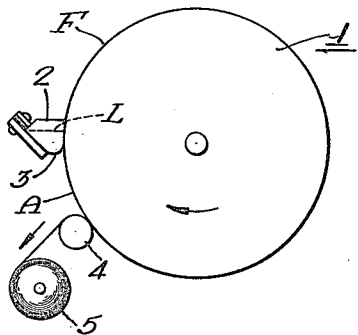


FIG. 2.

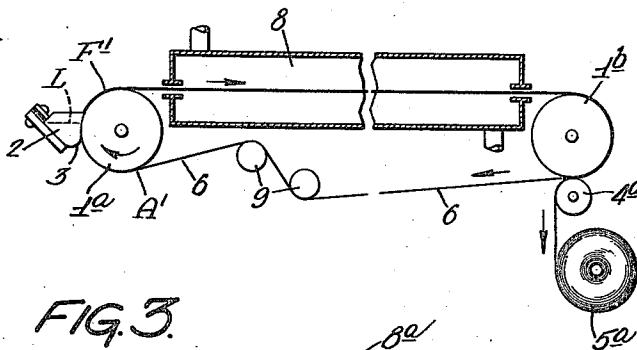


FIG. 3.

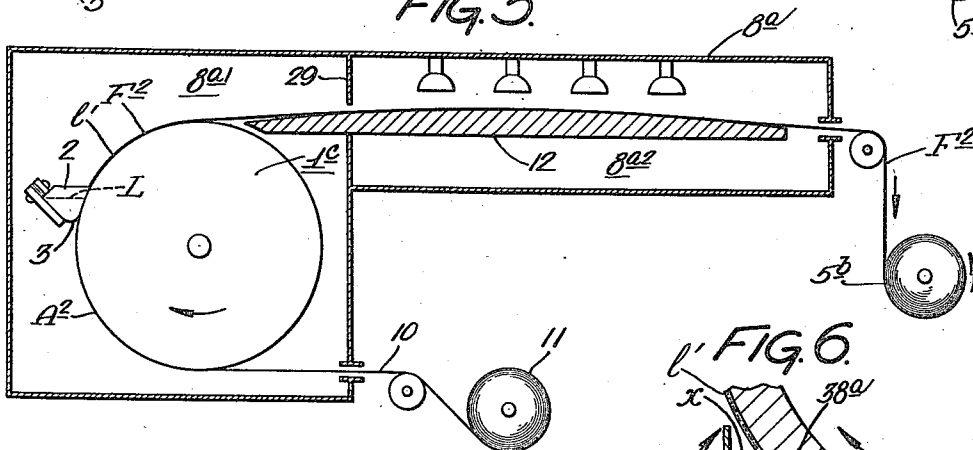


FIG. 4.

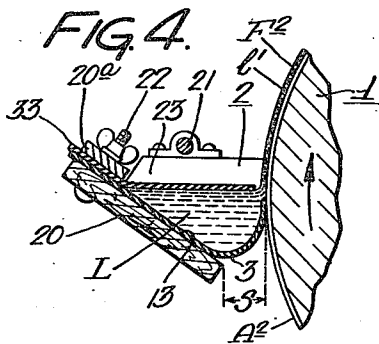


FIG. 8.

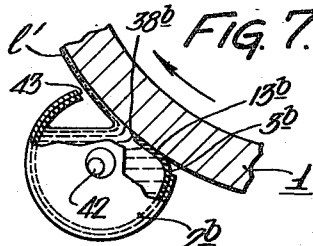
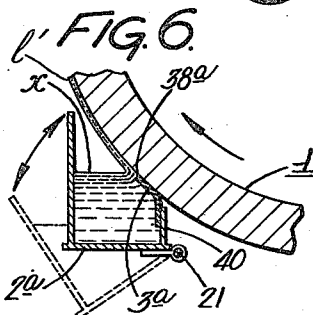
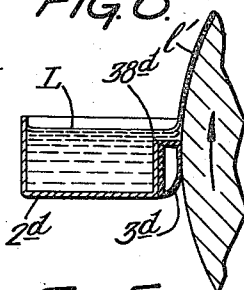
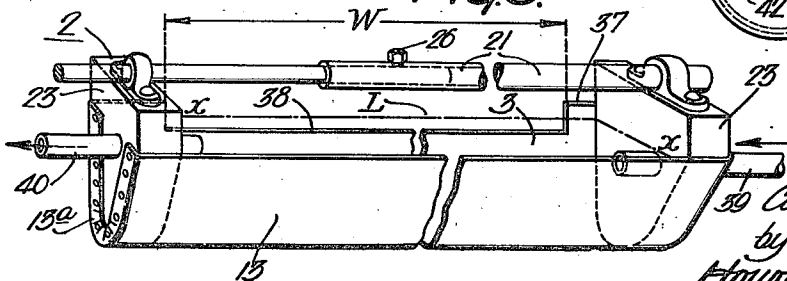


FIG. 5.



Inventor:
C. S. Francis, Jr.
by his Attorneys
Howson & Howson

April 20, 1948.

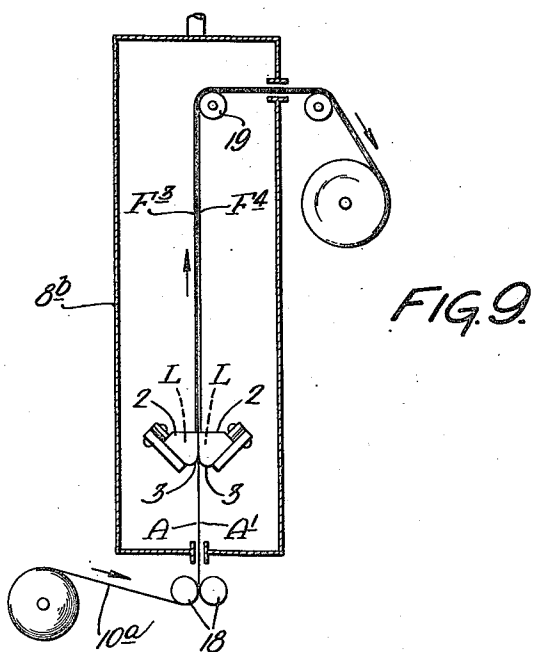
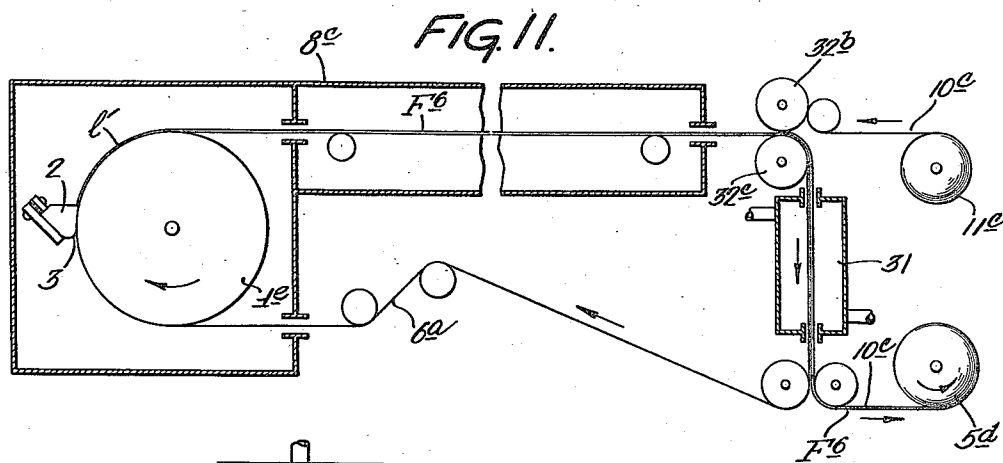
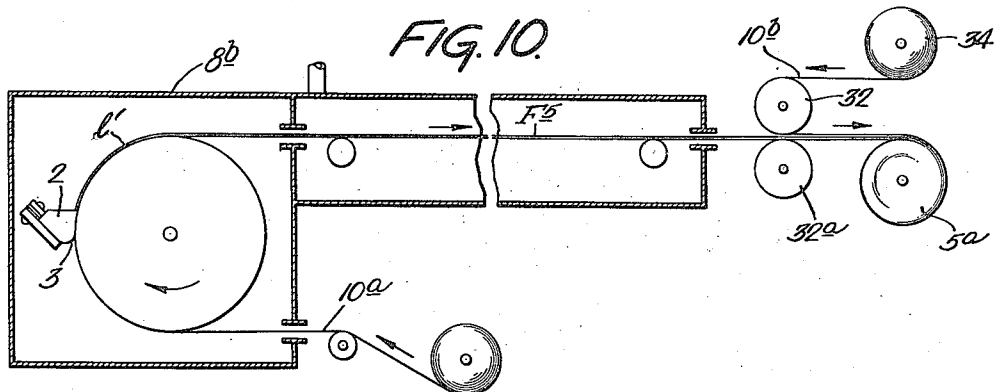
C. S. FRANCIS, JR.

2,439,802

APPARATUS FOR FORMING FILMS AND COATINGS

Filed Jan. 2, 1945

2 Sheets-Sheet 2



Inventor:
Carlton S. Francis Jr.
by his Attorneys
Houison & Houison

UNITED STATES PATENT OFFICE

2,439,802

APPARATUS FOR FORMING FILMS AND COATINGS

Carleton Shurtleff Francis, Jr.,
West Harwich, Mass.

Application January 2, 1945, Serial No. 571,048

11 Claims. (Cl. 91—43)

1

This invention relates in general to coating and film casting and, in particular, to an apparatus for coating sheet materials, and for producing self-sustaining films. The invention relates further to correlated improvements in coating and film coating apparatus designed to increase the efficiency and to extend the uses of such apparatus.

Various devices have been employed heretofore for coating sheet materials and for casting films on temporary supports. In one prior device, a coating composition was applied to one surface of paper or other sheet material by feeding the composition through a wick which made contact with a surface of the sheet material. Coating by means of a wick is limited, however, to the use of liquids of extremely low viscosity, more particularly to aqueous liquids which readily wet the wick and which can be drawn through it without change in composition.

When an attempt is made to use a wick with a multi-component composition, for example, an organic film-forming material, and a plasticizer, dissolved in a volatile organic liquid, it has been found that the solvent evaporates at the surface of the wick, resulting in a gelling of the composition at the surface, while the solvent migrates faster than the other ingredients through the center of the wick. Accordingly, it has been found impractical to use a wick for coating and film casting such multicomponent compositions and in particular for any composition of high viscosity. A wick is also impractical for producing coatings or films of any substantial thickness or with compositions of high viscosity.

On the other hand, it has been proposed to coat paper on one side by bringing the paper into contact with the surface of a body of liquid. However, such devices require special means for preventing the liquid or coating composition from running around the edge of the sheet to be coated. In one such prior device the point of contact of the sheet with the liquid is in a horizontal plane, whereupon the liquid tends to drip from the coated surface, resulting in streaks and non-uniform films or coatings.

If an attempt is made to pass a sheet to be coated vertically through a slit in a rigid walled reservoir, micromatic adjustment of the slit opening is necessary to prevent leaking and it is impossible to coat rough or uneven materials by such devices.

In a third method heretofore employed by the prior art, sheet materials are coated on one or both sides by use of a doctor blade or a knife,

2

the clearance between the edge of the blade or knife and surface of the paper determining the thickness of the film or coating produced therein. Here again it is necessary to use micromatic adjustments on the knife in order to make thin films. It has been found, however, that such devices are impractical where the liquid is one of low viscosity or where it is a composition containing a rapidly volatile solvent. With low viscosity liquids, the liquid tends to flow around the edge of the knife, and frequently it does not spread uniformly over the sheet material. On the other hand, with a composition containing volatile liquids, the evaporation of the solvent in front of the knife or blade results in a change in viscosity, and the deposition of the film or coating has a greater percentage of solids at the end of the run than at the beginning. Rough surfaced materials can not be coated uniformly by means of a doctor blade.

Accordingly, it is a general object of the present invention to provide means for forming films with a liquid film-forming material of uniform thickness.

It is another object of the invention to provide an apparatus for coating sheet materials and for casting thin films on suitable materials where the thickness of the film is not a function of any mechanical means and is independent, therefore, of the mechanical configuration of the coating applicator, and is free of errors resulting from human judgment.

It is another object of the invention to provide an apparatus for forming films which permits a wide variation in thickness of the film and in the speed of operation without alteration in the composition of the coating or film so produced.

It is another object of the invention to provide an apparatus for simultaneously applying a film to one surface of a temporary support and for transferring the film from such support to the surface of material to be coated.

It is another specific object to provide an apparatus for producing uniform thin films from film-forming organic plastics in a simple and economical manner.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

According to the present invention, there is provided an apparatus for forming films, either self-supporting films or coatings, which apparatus includes means for passing the surface on which the film or coating is to be formed upwardly in contact with and beyond the upper edge of a

flexible weir formed by one flexible wall of a reservoir, wherein the level of the film-forming liquid in the reservoir is disposed above the top edge of the wall, so that the liquid overlying the top edge of the flexible wall contacts the film-receiving surface and adheres thereto, due to surface tension.

The apparatus of the invention comprises, in combination a liquid reservoir having at least one flexible liquid-retaining wall which forms the weir and means for passing a surface to be coated, such as a drum sheet, or endless band, upwardly in contact with and beyond the upper edge of the flexible wall, and means to maintain the level of the liquid in said reservoir above the top edge of such wall, so that the liquid overlying the upper edge of the wall contacts the film-receiving surface and adheres thereto, by surface tension.

One of the paramount features of the present invention resides in the provision of a flexible wall for the liquid reservoir which will lie in contact with and automatically conform to irregularities in the surface being coated, primarily as a result of the resiliency of the wall itself and, in the preferred form of the invention, as a result of the hydrostatic pressure of the liquid in the reservoir exerted against the inside surface of the flexible wall acting to force said wall outwardly into firm contact with the surface being coated, to follow all variations therein from a true flat plane and thereby produce a resilient fluid-pressurized surface-conforming seal against said surface, whereby leakage of the liquid downwardly past the upper edge of the weir formed by said flexible wall is efficiently prevented.

In one embodiment of the apparatus, there is provided, in addition to the above, means for bringing a second sheet material into contact with the coating before or after it is dried, and means for applying pressure, with or without heat, to cause the film to bond the two sheet materials together, thus producing a composite laminated article.

In a third embodiment, there is provided means for bringing a sheet material to be coated into contact with the sheet carrying the film, before or after the film has been completely dried, and applying pressure, with or without heat, to cause the film to adhere to the second sheet material, and means for stripping the first sheet from the film so transferred.

For a more complete understanding of the nature and objects of the present invention, reference should be made to the accompanying drawing, of which:

Fig. 1 is a diagrammatic end elevation of one form of apparatus adapted for use in accordance with the principles of the present invention;

Fig. 2 is a diagrammatic sectional elevation of another embodiment of the invention;

Fig. 3 is a diagrammatic sectional elevation of a third embodiment of the invention;

Fig. 4 is an enlarged sectional elevation of the coating head shown in Figs. 1, 2 and 3;

Fig. 5 is a perspective view, partly in section, of the essential elements of the coating head shown in Fig. 4;

Figs. 6, 7 and 8 are sectional views, similar to Fig. 4, illustrating modified forms of coating heads capable of use in practicing the present invention; and

Figs. 9, 10 and 11 are diagrammatical sectional views similar to Figs. 2 and 3, showing further embodiments of the invention.

The apparatus of the present invention is applicable for forming coatings on one or both sides of sheet materials in general, or for casting films on temporary supports in the form of flexible sheet materials. Inasmuch as a coating may be considered as a film, the term "film" will be used in the following detailed description and in the claims in a generic sense to designate coatings which are intended to remain permanently on the sheet material and films which are intended to be self-supporting or transferable.

When the invention is utilized strictly for coating purposes, it is applicable for coating any flexible sheet material such, for example, as paper, textile fabrics, felts, leather, metal foils, and organic plastic films of all kinds. In particular, it is applicable for forming thermoplastic transfers which comprise a temporary support in the form of a flexible sheet material and a thermoplastic film temporarily supported thereon and which is capable of being stripped from the support after the application of heat and pressure. Such thermoplastic transfers are described and claimed in U. S. Patent No. 2,353,717. The apparatus is also applicable for applying adhesive coatings to sheet materials preparatory to laminating.

The apparatus of the invention is applicable for forming films from liquids, solutions, emulsions and molten plastic materials in general. Accordingly, the invention is adapted for the formation of films from aqueous solutions of cellulose xanthates, water-soluble and alkali-soluble cellulose ethers, gelatin, casein, zein, glue, starch, dextrin, polyvinyl alcohol, rubber latex, and the like, or from solutions in organic solvents of synthetic resins as a class, cellulose derivatives as a class, synthetic and natural rubber, and mixtures thereof or molten masses or emulsions of such organic plastic materials. When thermosetting resins are used they may be converted to the infusible state during the hardening of the film.

Referring to Fig. 1, there is shown one embodiment of the apparatus comprising, in combination, a horizontal rotatable drum 1 of large diameter which, if desired, may be provided with suitable heating means of conventional type. The liquid L to be formed into a film is contained in the reservoir 2, the reservoir having at least one longitudinal flexible side wall 3 which presses against the peripheral surface A of the drum 1, and is held in surface conforming contact therewith by the hydrostatic pressure of the liquid contained in the reservoir. The liquid in the reservoir is maintained above the top edge of the flexible wall so that the liquid contacts the peripheral surface A of the drum 1, above the upper edge of the flexible wall 3 and is drawn upward by the surface A in the form of a thin layer.

The layer of the liquid L which clings to the surface A is converted into film F on the surface A of the drum by evaporation, cooling, oxidation or other means, and the film so formed may be stripped from the drum by means of a suitable stripping roll 4, at a point spaced from the point of formation of the film. The film is then wound directly into a self-supporting roll 5 or onto a suitable reel, spool or other core element.

The embodiment shown in Fig. 2 is similar to that shown in Fig. 1 except that in place of the large diameter drum 1, there is employed an endless belt 6 which travels around a pair of relatively small horizontally spaced drums 1a and 1b and passes upwardly around the drum 1a into

5

contact with the flexible wall 3 of the reservoir 2 to collect a thin layer of liquid on the outer face A1 of the belt.

The layer of liquid on the carrying face A1 of the belt 6 is converted into a film F1 by passing the coated belt through a solidifying chamber 8, and the film F1 is stripped from the belt by a stripping roll 4a, and wound in a roll 5a the belt being maintained under suitable tension by means of the adjustable rollers 9.

The use of the belt 6 traveling around the small diameter drum 1a past the reservoir 2, has the advantage of causing the liquid, shortly after application to the belt, to pass from a substantially vertical position to a horizontal plane, thus reducing the formation of flow lines therein.

That embodiment shown in Fig. 3 is similar to the apparatus in Fig. 2 with the exception that instead of a belt, a film F2 is formed on one face A2 of a web 10 of sheet material, taken from a roll 11. The web 10 is passed upward around a drum 1c, and after being coated, it is passed over a horizontal support 12 on which the layer of liquid is converted into the film F2 and the sheet material 10 carrying the film F2 is then wound on a reel 5b. Instead of the rigid support 12 of the type shown in Fig. 3, there may be used an endless belt to support the sheet 10 in a horizontal plane during the formation of the film F2. The apparatus may be enclosed in a chamber 8a.

The liquid reservoir employed in each of the apparatuses shown in Figs. 1, 2 and 3 comprises, in one embodiment as shown in Fig. 4, a rigid supporting or floor plate 20 which is preferably disposed at an angle to the film-receiving surface A, A1 or A2, as shown, leaving a space S therebetween of a width, for example, of from $\frac{1}{8}$ to 1 inch between the edge of the plate 20 and the film-receiving surface of the drum 1, belt 6, or sheet 10, as the case may be.

The reservoir 2 has at least one liquid-retaining wall 3 which, as shown in Fig. 4, preferably comprises a flexible, and in some instances elastic, liquid-retaining sheet of suitable material 13 supported, in part, on the base or floor plate 20 and having a width greater than the combined widths of the plate 20 and space S, so that it is curved upwardly to form the wall 3 which lies against the surface A, A1, A2 of the drum 1, belt 6 or sheet 10, as the case may be, the flexible wall 3 being maintained in this position by the upward movement of the drum 1 and the hydrostatic pressure of the liquid in the container 2, while the sheet 13 as a whole is supporting the body of liquid L.

The sheet 13 may be maintained in position on the floor plate 20 by means of a top plate 20a which may be caused to press the sheet 13 against the base plate 20 by means of screws 22. The plates 20 and 20a and the sheet material 13 extend across part or the full width of the face of the drum, sheet or belt.

As shown in Fig. 5, the ends of the reservoir of Fig. 4 are closed by means of relatively movable dams 23, the lateral distance between the dams being adjusted by suitable means, for example, as a telescopic rod 21 having its opposite ends respectively secured to said dams, said rod being provided with a set screw 26. The ends 13a of the sheet 13 are extended beyond the dams 23 and may be turned up and sealed to the outer faces of the dams, to make a liquid-tight container.

As shown in Fig. 5, the upper edge 37 of the flexible wall 3 is cut away longitudinally of the

6

reservoir on a horizontal line disposed below the edge 37 as indicated at 38, to lower the effective weir-like edge 38 of the flexible wall 3 to an elevation below that of the remaining walls of the reservoir 2, and below the operating level of the film-forming liquid L, which level is indicated by the broken line x-x.

The film-forming liquid L may be introduced through a pipe 39 and the level x-x maintained by suitable means, such as an overflow pipe 40 which is positioned a predetermined distance above the effective weir edge 38 of the flexible wall 3. The area to be coated is controlled by the width of the weir edge 38 of the wall 3, as designated W in Fig. 5.

The liquid reservoir may be considered as a means for resiliently supporting the liquid L, comprising the end walls formed by the dams 23, the bottom and side wall formed by the flexible sheet 13, supported by the base plate 20, and the flexible wall 3 formed by the curved upturned portion of the flexible sheet 13. During operation, a continuation of this latter wall is formed by the surface A, A1 or A2, as the case may be, which is being coated.

Whenever the liquid L contains a volatile organic solvent, it may be desirable to prevent the evaporation of the solvent from the surface of the liquid L while it remains in the reservoir. Accordingly, as shown in Fig. 4, a second sheet 33 of liquid-impermeable material may be inserted in between the plates 20 and 20a, the sheet 33 being narrower than the base sheet 13 so that it floats on the surface of the liquid.

That embodiment of the reservoir shown in Fig. 6 comprises a trough-like vessel 2a of which one side wall 40 is cut away longitudinally and there is attached to this wall, by suitable adhesive or by other conventional means, a narrow sheet 3a of flexible material, this sheet being sufficiently high at the ends of the trough to complete the wall 40 and prevent the escape of liquid, the major central portion of the sheet being cut away so that the top edge 38a of the flexible wall formed by the sheet 3a is normally below the operating level x of the liquid in the reservoir. By mounting this trough upon a pivot rod 21 at the base of the wall 40, the coating may be discontinued by merely lowering the trough to the position indicated by the broken line, whereupon the level of the liquid will fall below the top edge 38a of the wall 3a.

That embodiment of the reservoir shown in Fig. 7 comprises a metal cylinder 2b mounted on an eccentric shaft 42, a longitudinal opening 43 being provided in the wall of the cylinder. The longitudinal opening 43 is partly closed by a sheet 13b of flexible liquid-impermeable material. By rotating the cylinder 2b, the level of the liquid therein may be brought to a level above the top edge 38b of the flexible wall 3b and simultaneously brought in contact with the surface to be coated, such as the drum 1.

The invention is not limited to an apparatus for coating a single surface only of a sheet material, but may be readily adapted for coating both surfaces thereof, and the sheet material may be in the form of an endless band or a long web. For example, there is shown in Fig. 9, one embodiment of suitable means for forming a film on both sides of a sheet material. In this embodiment a reservoir 2, similar in construction to those shown in Figs. 4, 6 or 7, is disposed on either side of a sheet 10a of suitable material and the sheet 10a is passed upwardly between the flex-

ible walls 3, 3 of the reservoirs 2, 2. The sheet material 10a is maintained in the exact central position by means of the guide rollers 18, 18 and 19, and the sheet 10a, carrying the films F3, F4, passed upwardly through a vertical chamber 8b for a sufficient distance to enable the film F3 and F4 on the opposite surfaces of the sheet 10a to be converted to a non-tacky condition before the film on the one side contacts the upper supporting roll 19. When the apparatus is not in use, the flexible walls 3, 3 of the opposed reservoirs 2, 2 lie against and support each other and are thus maintained in proper position.

It is characteristic of all embodiments of the present apparatus shown in Figs. 1 to 7 inclusive, for example, that the surface to be coated bears against the flexible wall of the reservoir and supports this wall against the hydrostatic pressure of the liquid contained in the reservoir. For this reason it may be desirable to maintain the depth of the liquid in the reservoir as low as possible, and this is accomplished in the embodiments illustrated by making the reservoir correspondingly shallow. Since the liquid is drawn from the reservoir by contact with the surface being coated, a great depth of liquid is not required.

In operation, as the surface A, A1 etc. to be coated moves upwardly in contact with the flexible wall 3 of the reservoir 2 said wall tends to be bent upwardly by the upward movement of the film-receiving surface and is supported thereby. The hydrostatic pressure of the liquid L in the reservoir 2 forces the flexible wall into firm conforming contact with the upwardly moving film-receiving surface A, A1, etc. Next, the surface to be coated makes contact with the liquid L, above the weir edge 38 of the wall 3, and as this surface continues to move upwardly it will be coated with a uniform layer of the liquid L. As the coated surface continues to advance, the liquid layer 1' thereon is converted into the solid film F as above described.

For the flexible wall 3 of the reservoir 2, there may be employed any suitable flexible sheet material which is impervious and inert to the film-forming liquid held in the reservoir. With aqueous film-forming liquids, there is employed a hydrophobic sheet material such, for example, as a sheet of moisture-proof regenerated cellulose, a sheet formed of solvent-soluble cellulose derivatives as a class, organic solvent-soluble synthetic resins as a class, synthetic and natural rubber, and mixtures thereof, or a fibrous sheet material such as paper, fabric, and felts coated with such hydrophobic materials. On the other hand, with non-aqueous organic film-forming liquids, there is employed a sheet material inert thereto such, for example, as a hydrophilic sheet material, such as non-moisture-proof regenerated cellulose, gelatin, casein, hydrophilic cellulose ethers, and the like, or a fibrous sheet material such as paper, fabric, or felt coated with such hydrophilic materials or with dextrin, starch, and the like. With both aqueous and non-aqueous film-forming liquids there may be used a non-porous paper such as glassine, or a fabric paper or felt provided with a continuous coating of an insoluble thermo-setting resin or a flexible metal foil. Since the flexible sheet 3 is relatively inexpensive, it may readily be replaced; therefore, it is not objectionable if it becomes slightly softened by the liquid in the reservoir.

It is to be understood that the thickness of the film formed will be a function of the speed of the surface being coated and the viscosity of

the liquid. Liquids of low viscosity will form thinner films than liquids of high viscosity when the speed of the surface is constant. On the other hand, with a liquid of constant viscosity, thicker films will be formed by slower movement of the casting or film-receiving surface, and thinner films by a more rapid movement of such surface. Since there are two factors affecting the thickness of the film, it is possible to vary the thickness over a wide range.

The thickness of the film will be determined also in part by the surface tension of the film-forming liquid and by the roughness and porosity of the surface being coated.

When coating with apparatus of the type shown in Figs. 1, 2 and 3, the elevation of the reservoir with respect to the horizontal axis of the drum 1, 1a etc. is a factor. In Fig. 1 it will be noted that the reservoir is positioned in substantially the same horizontal plane as the axis of the drum 1, whereupon the layer 1' of liquid picked up by the surface A of the drum 1, and which ultimately becomes the film F moves for a considerable distance through a substantially vertical path. Under these conditions, the effect of viscosity and surface tension play a more important role than the speed of the drum. On the other hand, when the reservoir is positioned substantially above the horizontal axis of the drum 1, 1a or 1b as shown in Fig. 3, the film-forming layer of liquid 1' rapidly passes into a horizontal plane, so that the speed of the casting surface becomes relatively more important in effecting the thickness of the film than the viscosity or surface tension. The reservoirs of the type shown in Figs. 6 and 7 may be positioned below the horizontal axis of the drum 1, 1a, etc.

For film-forming liquids which have low surface tension but a relatively high specific gravity, it is desirable to position the reservoir above the horizontal axis of the drum as shown in Fig. 3, in order to minimize the tendency of the liquid to develop streaks and droplets due to gravity. With very viscous liquids or liquids of high surface tension, the reservoir may be positioned as shown in Figs. 1, 6 and 7.

Solutions of certain synthetic resins and organic solvent-soluble cellulose derivatives dissolved in a volatile organic solvent are frequently characterized by exhibiting a rapid skinning effect which results from the evaporation of the solvent at the outer surface of the liquid layer 1' and the formation of a thin gel film thereon which traps the remaining solvent in the body of the layer 1' and the resulting film F. When this occurs, forced evaporation of solvent through the skin surface of the film frequently results in objectionable pin holes and blisters. To avoid these defects, the apparatus as shown in Fig. 3 is enclosed in a drying chamber 8a which is divided into two sections 8a1 and 8a2 by a partition 29. The forward chamber 8a1 may be considered as the film-forming chamber, and the rear chamber 8a2 may be considered as the film-drying chamber. There is preferably maintained in the chamber 8a1 a high concentration of the solvent used in the film-forming composition, and the atmosphere, as well as the surface being coated, is preferably heated so that the solvent is only slowly evaporated from the film. In this way, the liquid layer 1' and resulting film F may be caused to form a solid uniform gel throughout its thickness. The gelled film then passes through the chamber 8a2 where the remaining solvent is evaporated and the film hardened. The chamber 8a2 may

be heated by conventional means, such as a plurality of infra-red lamps 30.

When the apparatus is used for coating fabrics, felt and porous papers, there will be, in general, substantially no tendency of the coated sheet material to curl during drying. On the other hand, when relatively non-porous sheet materials, such as calendered paper, glassine, Cellophane, a non-fibrous film, are coated on one side only, there is usually a tendency of the edges of the coated sheet material to curl inward toward the coated surface. To prevent such curling, the supporting platform 12, as shown in Fig. 3, may be provided with an upper surface which is arcuate longitudinally and/or horizontally. When tension is applied to the reel 5b, the coated sheet will be prevented from curling as it passes over the platform 12.

When the apparatus is to be used for forming self-supporting films, the surface on which the film is cast may be an endless surface 6, as shown in Figs. 2 and 10, or a long web 10 as shown in Fig. 3.

The operation of forming the film and of adhering the formed film to another surface may be carried out simultaneously by using apparatus of the type illustrated in Figs. 10 and 11. In Fig. 10 there is shown suitable means for laminating sheet materials by the use of the film formed in the apparatus of the invention. Thus, at the exit end of the drying chamber 8b, there is disposed a pair of pressure rollers 32 and 32a, so that the sheet material 10a carrying the film F5 on its upper surface is brought into contact with another sheet material 10b which may be unwound from a reel 34 and passed between the pressure rollers. The composite laminated material (10a+F5+10b) may then be wound up on the reel 5a. The adhesion of the two sheets may be effected before or after complete drying of the film. After complete drying, adhesion is effected by heating the film to the adhesive stage.

The apparatus of the invention is especially adapted, however, for the formation of thermoplastic transfer films and their use for coating and finishing. There is shown in Fig. 11 one embodiment of apparatus for this purpose, in which the endless belt 6a is coated with a film F6 by means of the reservoir 2 as it passes around the drum 1e, the film F6 deposited thereon being dried in the chamber 8c and then passed through the heated pressure rollers 32b and 32c. A sheet material 10c to be coated is unwound from the reel 11c. The sheet 10c is preheated by surface contact with the upper roller 32a, and then caused to adhere to the film F6 by passing both between the nip of the rollers 32b-32c. As a result of the heat and pressure, the thermoplastic film F6 is caused to adhere to the surface of the sheet material 10c, after which the assembled sheets are cooled as in the chamber 31. Then the belt 6a is stripped from the coated sheet material F6 by means of a stripping roll 36, the coated sheet material being wound on a reel 5d.

While the invention has been described with reference to the use of a reservoir 2 which extends substantially the entire width of the drum, sheet or belt, on which the film is formed, it is to be understood that by moving the dams 23 closer together, as when the sheet 13 is of an elastic nature, the liquid reservoir may be confined to any predetermined portion of the width of the drum, sheet or belt.

By using a plurality of dams 23 with a common

flexible wall, a plurality of separate liquids may be simultaneously applied in strips on predetermined areas of the surface being coated. In this manner, there may be produced a composite film or coating comprising a multiplicity of longitudinal striations which may differ from each other in chemical nature, thickness, color or opacity.

In an alternative embodiment, the tacky surface of the freshly formed film may be decorated by scattering effect materials thereon, such as, for example, comminuted metallic powders, pigments, dyestuffs, and short fibres of the same or different colors. The invention contemplates that the film, as it passes from the drying operation, may still be in a surface tacky condition which will facilitate the adhesion of the film to another sheet material or to itself for building up composite articles.

By way of illustration but not by way of limiting the invention, there will be given the following examples:

Example I

A solution of an ammonia-preserved natural rubber latex is cast into a film on a heated drum by means of the apparatus shown in Fig. 1 using a flexible sheet of cellulose acetate as the flexible wall of the latex reservoir.

Example II

Using the apparatus of Fig. 2, the flexible wall of the reservoir is made of a non-fibrous film of cellulose acetate-butyrate, and the endless belt is formed of a fabric coated with cellulose acetate-butyrate. The belt is coated with gelatin, and after passing through the drying chamber the film is stripped from the belt and used as a wrapping material.

Example III

Using the apparatus of Fig. 3, the flexible wall 3 of the reservoir is made of a sheet of non-moisture-proof regenerated cellulose, and an endless web 10 of non-moisture-proof regenerated cellulose is passed around the drum 1 and coated with a molten mixture of wax and rubber. After passing through the cooling chamber to harden the coating, the coated film is used as a moisture-proof wrapping material.

Example IV

Using the apparatus of Fig. 9, the flexible wall of the reservoir is made of a sheet of calendered paper coated with an infusible urea-formaldehyde resin. The liquid coating composition comprises polyvinyl acetate dissolved in a mixture of acetone and alcohol. A web of uncoated paper is passed around the drum 1 and coated with the polyvinyl acetate solution. The film is dried, and a second web of paper is brought into contact with the film while it is still in a tacky condition. Upon the application of heat and pressure, the two sheets of paper are laminated together to form a composite sheet material.

The present invention provides an apparatus for forming uniform films from liquid film-forming materials without the limitations imposed on such materials by the use of wicks and doctor blades employed in prior devices. The present apparatus permits a wide latitude in the range of viscosity and in the nature of the surface to be coated. In particular, it is possible in the present apparatus to coat sheet materials which are so rough and irregular that they can-

not be coated with uniform films by the use of doctor blades or other prior equipment which requires contact between the surface and the rigid element. It is also possible with the present invention to coat corrugated or crepe materials which cannot be coated with such prior devices. The present apparatus permits the formation of extremely thin films of uniform thickness by relying chiefly upon the physical properties of the film-forming liquid rather than upon micromatic adjustments of mechanical elements.

Since certain changes may be made in the apparatus illustrated and described herein, without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

For example, as shown in Fig. 8, the reservoir 2d may be of a rigid walled construction with one wall 41d lying adjacent a film-receiving surface A8 with its top edge disposed in a predetermined horizontal plane lower than the top edges of the remaining walls of the reservoir, and this lower wall may be provided with a hollow resilient seal forming element 3d which together therewith will form the resilient wall or resilient weir 38d of the reservoir, over which an upper component of the body of liquid L contained in the reservoir would normally be free to flow, in a predetermined channel formed by and between the end walls 23d of the reservoir. However, the flowable component of liquid L is transversely intersected by the upwardly moving film-receiving surface A8 with which the component liquid contacts and adheres by surface tension, as the surface A8 passes upwardly. Downward seepage of the liquid disposed above the weir 38d would be prevented by the resilient element 3d conforming to the surface A8, below the liquid overlying the weir 38d. This conformity may be maintained by fluid pressure filling the hollow element 3d and derived from any available pneumatic or hydraulic pressure source, including or other than the hydrostatic pressure of the liquid L in the reservoir 2d.

The pressure of the fluid within the hollow seal-forming element 3d may be regulated by any suitable means (not shown), in accordance with the viscosity and other characteristics of the liquid L and the character of the surface A8 in order to avoid undue pressure being exerted against said surface.

Thus it will be seen that the foregoing disclosures may give use to various other ways and means of attaining the result of this invention without departing from the spirit thereof.

I claim:

1. An apparatus for forming films from a film-forming liquid, comprising a reservoir including an upright longitudinal flexible side wall having an upper horizontally extending terminal edge and an adjacent marginal area parallel thereto adapted to function as a flexible weir, and means for moving a film-forming surface upwardly in contact with and beyond said weir to engage a body of said liquid overlying said weir, said weir being adapted to be flexed and maintained in conforming relation to said surface by hydrostatic pressure of a body of said liquid contained within said reservoir by said flexible side wall behind and below said weir.

2. An apparatus for forming films from a liquid film-forming material comprising a reser-

voir including one upright flexible surface-conformable liquid-retaining wall, and means for moving a film-receiving surface upwardly in contact with and beyond said flexible wall with the level of the liquid in said reservoir above the top edge of said flexible wall, one upright face of said wall being adapted to be pressed into conforming contact with said surface by lateral pressure exerted by said liquid against the opposite upright face of said wall.

3. An apparatus for forming films from a liquid film-forming material, comprising a reservoir including one upright flexible surface-conformable liquid-retaining wall, means comprising a rotatable drum for moving a film-receiving surface upwardly in contact with and beyond said flexible wall, one upright face of said wall being adapted to be pressed into conforming contact with said surface by lateral pressure exerted by said liquid against the opposite upright face of said wall, means for maintaining the level of the liquid in said reservoir above the top edge of said flexible wall, and side portions on said flexible wall extending upwardly beyond said liquid for determining the effective width of the film formed on said surface.

4. An apparatus for forming films from liquid compositions, comprising a reservoir for said liquid including at least one upright wall formed of a flexible liquid-retaining surface-conformable sheet material, a rotatable drum positioned adjacent said flexible wall, and an endless belt passing around said drum and upwardly with its outer surface in contact with said flexible wall, one upright face of said wall being adapted to be pressed into conforming contact with said surface by lateral pressure exerted by said liquid against the opposite face of said wall.

5. An apparatus for forming films from liquid compositions, comprising a reservoir for said liquid including at least one upright wall formed of a flexible surface-conformable liquid-retaining sheet material, means for moving a sheet material to be coated upwardly with a surface thereof in contact with said flexible wall, one upright face of said wall being adapted to be pressed into conforming contact with said surface by lateral pressure exerted by said liquid against the opposite face of said wall with the level of the liquid in said reservoir slightly above the top edge of said flexible wall whereby the liquid contacts the upwardly moving sheet material and adheres thereto by surface tension, and means for solidifying the liquid on said surface.

6. An apparatus for forming films from liquid compositions, the combination of a reservoir for said liquids having at least one upright wall formed of a flexible surface-conformable liquid-retaining sheet material, a rotatable drum positioned adjacent said flexible wall, means for passing a sheet material upwardly around said drum with a film-receiving surface of the last said sheet material in contact with said wall, one upright face of said wall being adapted to be pressed into conforming contact with said surface by lateral pressure exerted by said liquid against the opposite face of said wall with the liquid in said reservoir at a level above the top edge of said wall, and means for solidifying the liquid which adheres to said film-receiving surface.

7. An apparatus for forming films from liquid compositions, comprising a reservoir for said liquid including at least one upright wall formed

of a flexible surface-conformable liquid-retaining sheet material, a rotatable drum positioned adjacent said flexible wall, means to pass a sheet material around the periphery of said drum upwardly in contact with said wall, one upright face of said wall being adapted to be pressed into conforming contact with said surface by lateral pressure exerted by said liquid against the opposite face of said wall with the liquid in said reservoir at a level above the top edge of said wall, a chamber enclosing said drum and reservoir, and means for drying the liquid deposited on said sheet material while it passes through said chamber.

8. An apparatus for forming films from liquid compositions, comprising a reservoir for said liquid including at least one upright wall formed of a flexible surface-conformable liquid-retaining sheet material, a rotatable drum positioned adjacent said flexible wall, means to pass a sheet material around the periphery of said drum upwardly in contact with said wall, one upright face of said wall being adapted to be pressed into conforming contact with said surface by lateral pressure exerted by said liquid against the opposite face of said wall with the liquid in said reservoir at a level above the top edge of said wall, a chamber divided into two compartments, one of said compartments enclosing said liquid reservoir and said drum and the other compartment communicating with the first compartment and provided with means for drying the deposited liquid into a film.

9. An apparatus for forming films from liquid compositions, comprising a reservoir for said liquid including at least one upright wall formed of a flexible surface-conformable liquid-retaining sheet material, a rotatable drum positioned adjacent said flexible wall, means for passing a sheet material around said drum upwardly with a film-receiving surface thereof in contact with said wall, one upright face of said wall being adapted to be pressed into conforming contact with said surface by lateral pressure exerted by said liquid against the opposite face of said wall with the liquid in said reservoir at a level above the top edge of said wall, and an elongated support positioned with one end adjacent said drum and at an elevation closely adjacent the upper part of said drum for receiving the film-laden sheet from said drum and over which said film-laden sheet passes with the uncoated surface thereof in contact with said support.

10. An apparatus for forming films from liquid

compositions, comprising a reservoir for said liquid including at least one upright wall formed of a flexible surface-conformable liquid-retaining sheet material, a rotatable drum positioned adjacent said flexible wall, a horizontal support positioned adjacent said drum and at an elevation closely adjacent the upper part of said drum, said support having an arched upper surface, and means for passing sheet material around said drum upwardly with one surface thereof in contact with said wall and for passing the said sheet from said drum and along said support with the opposite uncoated surface of said film-laden sheet in contact with said support, one upright face of said wall being adapted to be pressed into conforming contact with said sheet surface by lateral pressure exerted by said liquid against the opposite face of said wall.

11. Apparatus for forming films from a liquid film-forming material, comprising a reservoir for such liquid material, said reservoir including an upwardly extending wall laterally movable relative to the rest of said reservoir; and means for moving a film receiving surface upwardly in contact with and beyond the top edge of said wall with the level of said liquid material above said top edge, said top edge being disposed adjacent said surface, the pressure of the liquid material in said reservoir moving said wall laterally toward said surface and serving to maintain said top edge in firm engagement with said surface.

CARLETON SHURTLEFF ^{his} X FRANCIS, Jr.
mark

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,680,711	Weston et al.	Aug. 14, 1928
1,805,070	Bates	May 12, 1931
1,258,840	Wheelwright	Mar. 12, 1918
1,228,225	Lynah	May 29, 1917
2,068,253	Williams	Jan. 19, 1937
414,689	Edwards	Nov. 12, 1889
1,072,705	Destribats	Sept. 5, 1913
1,174,995	Kremer	Mar. 14, 1916
1,388,353	McTuitty	Aug. 23, 1921
1,757,636	Jury	May 6, 1930
2,269,150	Flynn	Jan. 6, 1942
2,128,312	Murphy	Aug. 30, 1938
2,329,034	Buck	Sept. 7, 1943