

April 26, 1938.

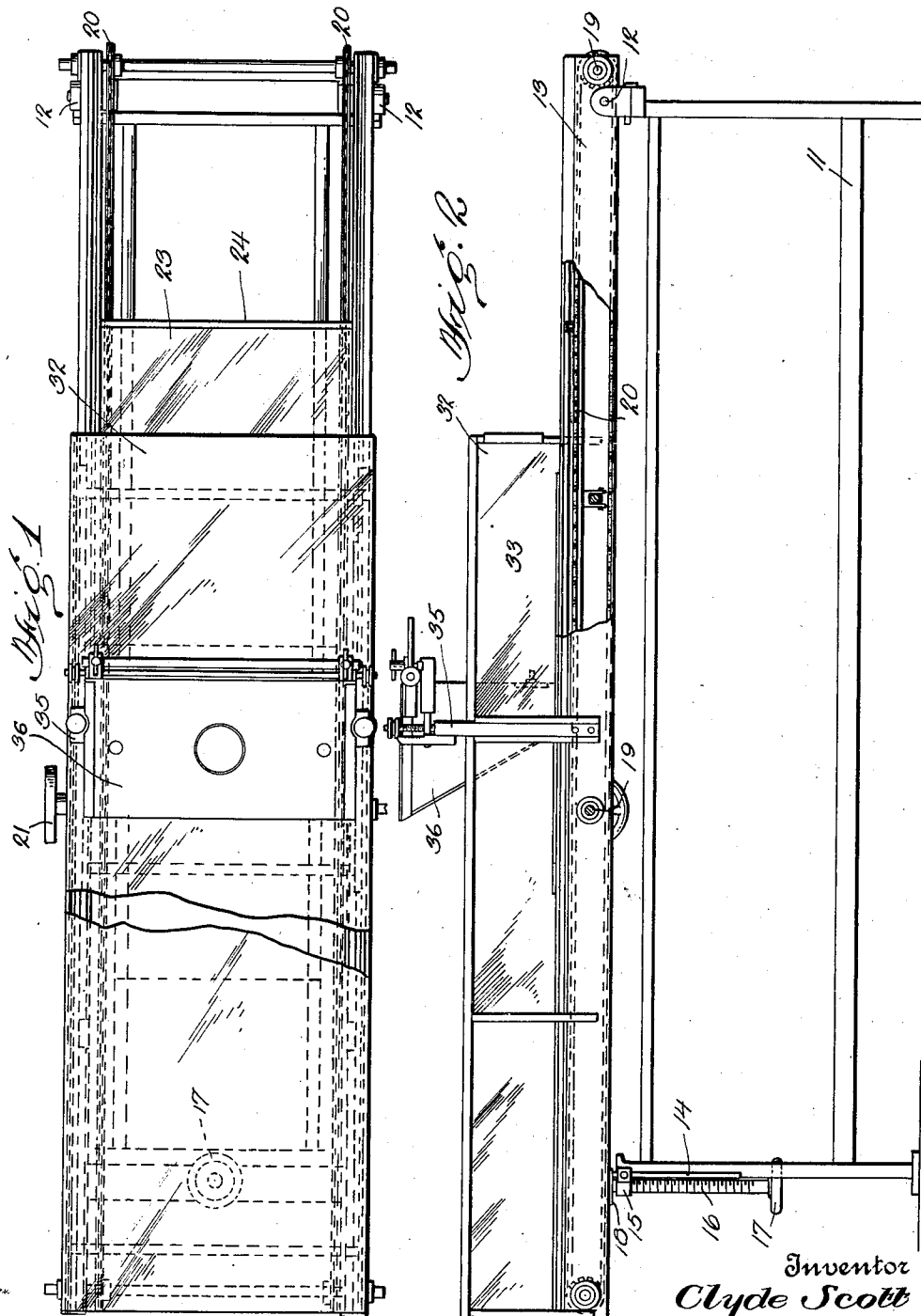
C. SCOTT

2,115,044

APPARATUS FOR CASTING FILMS

Filed March 16, 1934

3 Sheets-Sheet 1



By his Attorney

Elmer Stewart

Inventor
Clyde Scott

April 26, 1938.

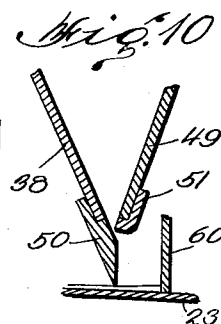
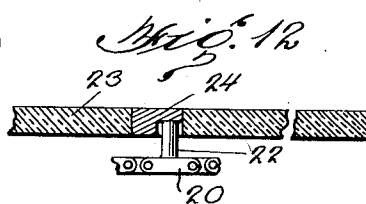
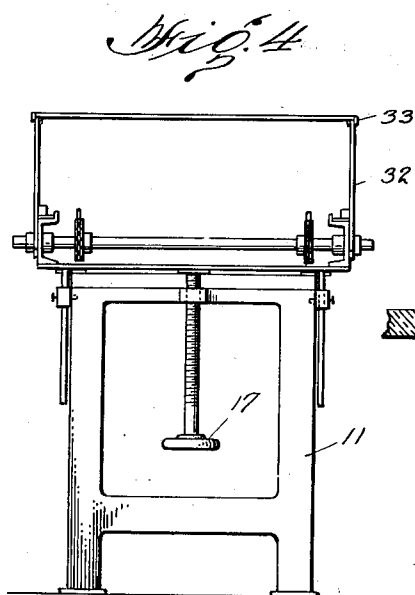
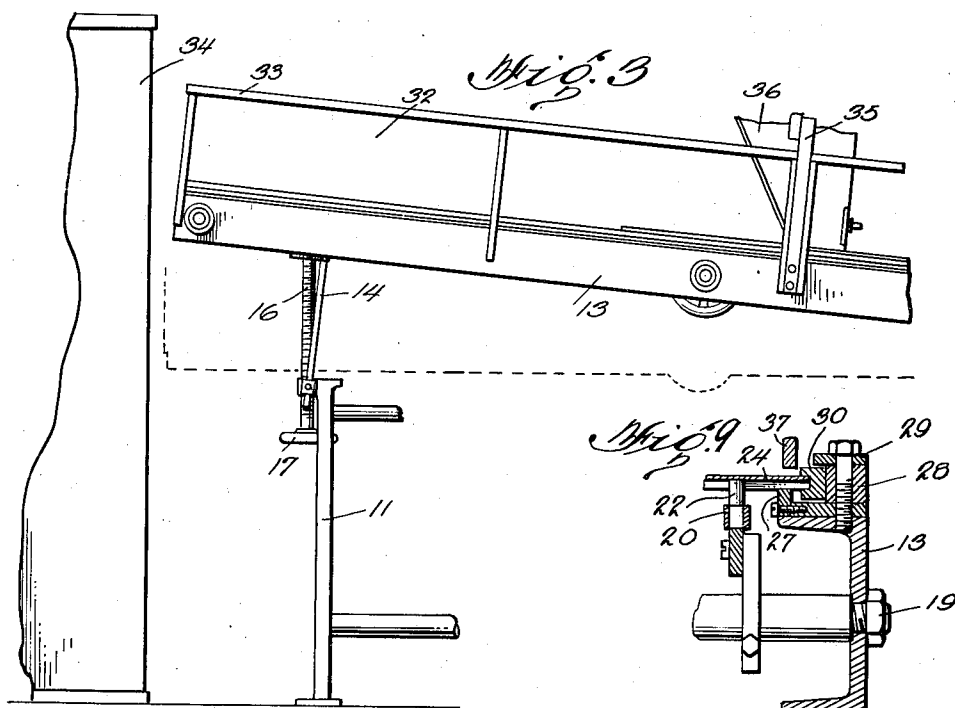
C. SCOTT

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APPARATUS FOR CASTING FILMS

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3 Sheets-Sheet 2



Inventor
Clyde Scott

By his Attorney

Elmer Sturges

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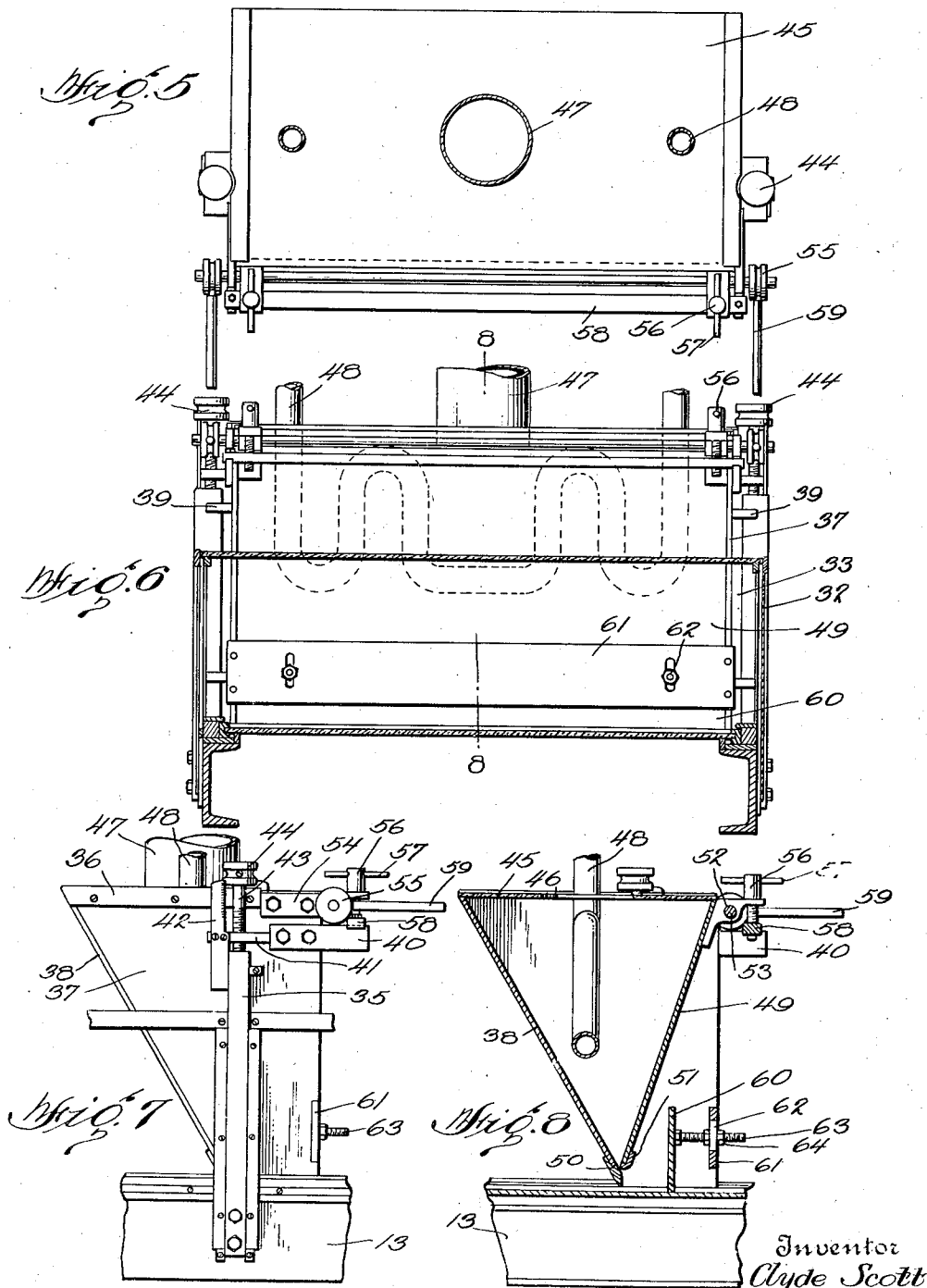
C. SCOTT

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APPARATUS FOR CASTING FILMS

Filed March 16, 1934

3 Sheets-Sheet 3



Inventor
Clyde Scott

By his Attorney

Edmund Starnes

UNITED STATES PATENT OFFICE

2,115,044

APPARATUS FOR CASTING FILMS

Clyde Scott, Newark, N. J.

Application March 16, 1934, Serial No. 715,897

14 Claims. (Cl. 18—15)

This invention is in part a continuation of my co-pending application, Serial Number 666,358, filed April 15, 1933 for Method for casting films.

The invention to which the following description relates, deals with improvements in apparatus for continuously casting film in sheet or strip form from solutions of cellulose or like material. I have found that the film is improved and its production facilitated by maintaining an accurate and close control of the conditions under which the operation is carried out. Further, this controlling operation is facilitated by improvements in the mechanism relating to the casting operation, the surfaces upon which the film is deposited and the subsequent operations by which the film is produced in final form.

The working temperature of solutions and apparatus is important. Diffusion in cellulosic solutions is ordinarily a very slow process, but may be accelerated by rise in temperature. A homogeneous solution remains homogeneous and of the same viscosity only so long as the different parts are maintained at the same temperature. When one part of the initially homogeneous solution is kept at a different temperature from the other parts, the solution becomes heterogeneous insofar as flowability is concerned, the colder part becoming more concentrated and viscous, and the warmer portion more dilute and thinner flowing, while the dissolved substances diffuse from the warmer into the colder portion of the solution. By means of the apparatus forming the subject matter of this invention these disadvantages are substantially overcome, with the result that more uniform films are obtainable as to composition and physical characteristics, and the operation may be made continuous with the formation of films of indefinite length and of great uniformity in composition.

My herein described apparatus involves a process wherein a wide scope of forming films is permissible, irrespective of the chemical composition of the cellulosic portion of the film, when cast according to the methods herein described with the apparatus herein illustrated.

For example, when an endless belt or drum is employed the viscosity of the film-forming component must permit of great fluidity. The solvents or solvent combination must be sufficiently volatile so that the deposited solution will have a definite, known and controllable speed of evaporation and hence time of setting, in order that the solid or solids deposited from the solution may be stripped from the casting surface before

one complete cycle of the casting surface has been made.

In heretofore proposed apparatus, the film-forming solutions have been deposited upon supports having an even, close or polished surface to which the film in the dried condition will not adhere, or at least adhere so tenaciously as to be removable with difficulty. It is, as a rule, deposited upon the casting surface to within one or two inches from each edge of the support, and upon drying, the film immediately detaches or separates from the casting surface (particularly at the edges), due to lack of adhesion or deficiency in adhesion.

Films produced by endless belt, or drum apparatus are usually of dimensions of from 0.003 to 0.007 or 0.008 of an inch in thickness. One of the major difficulties in producing and stripping thinner films, due to the separation from the casting surface from the edges, prevents the satisfactory production of films thinner than 0.003 of an inch in thickness. Obviously very heavy gauge thick films cannot be produced by such means in continuous operation even though a plurality of means be provided for depositing successive layers, as has been proposed, and this is because of the limited area available for drying purposes.

The method of applying the solution to the casting surface in a pool from which the film is withdrawn permits the solution to come in contact with the guide-strips at the side for an extent many times greater than the thickness of the final film. The result is that this wetting of the guide-strips by the solution forms an extended attaching edge with greatly increased adhesion. This bond with the guide-strips remains, during the drying and subsequent treatment of the film on the casting surface. It follows that there is an improved holding effect which maintains the film under tension, flat against the surface of the casting surface. This permits complete drying without danger of curling and successive coating solutions may be applied without impairing the uniformity of the film or distorting it.

Because of the ability of the guide-guard strips on my machine to retain thoroughly dried films (and particularly very thin and very thick films) in intimate contact with and upon the plane surface of the travelling-supports, it becomes possible to cast very thin multi-layer laminae—i. e., composite films of one to two one-thousandths of an inch thick—and dry under tension each successive layer without the films separating from

the support at the edges, and without distortion, wrinkling, warping, or curling of the film during the process of manufacture or after removal from the casting-surface.

5 In the depositing of this film I have provided an improved discharge hopper by which the solution is first maintained in the proper condition of low viscosity and then delivered in accurately measured quantities as is desired in order to make
10 a suitable film.

Among the objects of my invention is the provision of an improved casting surface which is mechanically advanced past the above mentioned hopper. In the use of this casting-surface it is
15 maintained at the proper temperature in conformity with the temperature of the solution so that the evaporation of the film will not be disturbed by local temperature changes which might cloud the film or produce irregularities or
20 blemishes in it.

Another object of my invention is to provide improved means in the form of guide strips by which the full surface area of the casting-surface is made available for the film and the necessity
25 of trimming wastage from the latter is minimized to a great extent.

As an incident of this object of my invention it is to be noted that the device provides means by which the film, when once cast on the surfaces,
30 is held rigidly in place without distortion, warping or curling and may thus be subsequently treated by the deposition of successive layers of similar or dissimilar material.

Among the further objects of my invention is
35 the completion of the film-forming operation by subjecting the solution when cast to travel along an upward gradient opposite to the direction in which the solution is first applied, in an atmosphere of the solvent used in the film and kept at
40 a degree of saturation and moderate temperature that will permit the evaporation of the film in the most effective and prompt manner.

The film produced by this invention may be the subject of a further successive deposition by which
45 its waterproof, moisture-proof or fire-proof properties will be improved or modified. As a final step the invention contemplates the conditioning of the film as a continuous strip or in shortened sections in a conditioning chamber.

50 In order to illustrate the preferred form which my invention may take, I have shown in the following drawings, for the purpose of example only, a machine by which the above and other related objects may be attained. In the drawings

55 Fig. 1 is a top plan view of the improved machine;

Fig. 2 is a side elevation thereof;

Fig. 3 is a side elevation showing the adjustment in inclination of the casting machine;

60 Fig. 4 is an end elevation;

Fig. 5 is a top plan view of the improved hopper;

Fig. 6 is a side elevation thereof;

Fig. 7 is an end elevation of the same;

65 Fig. 8 is a vertical section on the line 8—8 of Fig. 6;

Fig. 9 is an enlarged transverse detailed section of the casting element and associated parts;

Fig. 10 is an enlarged view of the hopper discharge shown in Fig. 8;

70 Fig. 11 is a fragmentary detail side view of the casting plate and its mounting and

Fig. 12 is a longitudinal section of the casting surface drive means.

75 The casting machine consists generally of a device for advancing a series of casting plates to

form a continuous surface on which the cellulose solution may be deposited and subsequently treated. In the drawings this machine is shown to consist in a stand or table 11 having at one end a pair of trunnions 12. Between these trunnions
5 12 there is a table which extends for the full length of the stand 11. This table 13 is supported at the other end of the stand by means of a pair of standards 14 which are locked in adjusted position to the stand 11.

A cross bar 15 at this end of the stand forms a journal for the lifting screw 16, one end of which is manipulated by the hand wheel 17. The upper end of the lifting screw 16 supports the cross bar 18 beneath the table 13 and serves to lift
15 the latter to give it any desired inclination or gradient. In this way the left or discharge end of the table 13 is raised relatively to the opposite end an amount dependent upon the operating factors of the casting machine such as the viscosity
20 of the material, the rate of travel of the casting-surface and the rate of evaporation.

The table 13 has a series of transverse shafts 19 which carry a pair of parallel spaced endless conveyor chains 20, 20 by means of appropriate
25 sprocket-wheels or the like. This may form one endless conveyor connecting the opposite ends of the table 13 or the conveyors may be arranged in overlapping relation serving successive zones along the table and delivering the casting plates
30 from one conveyor or zone to another. One of the transverse shafts 19 is provided with a driven wheel 21 by which the conveyor or series of conveyors is caused to operate. The conveyor chains
35 20 are provided at appropriate distances with engagement pins 22 by which the casting plates are advanced along the length of the table.

The casting plates consist of polished glass or metal plates 23 which rest at their side edges on appropriate tracks or shoes and are advanced
40 by means of transverse metal bars 24 also resting upon the shoes and being engaged by the pins 22. As is shown in the drawings the metal bars 24 are of substantially the same thickness as the glass casting plates but are undercut or
45 rabbeted along one edge to accommodate the pins 22. The lengths of the plates 23 and bars 24 are such as to provide a continuous top surface upon which the solution may be cast or caused to flow.

50 In those instances where it is feasible and desirable to use a metal casting plate it may take the form of a plate 25, (not shown in drawing), the opposite ends of which are rabbeted as shown in 26 (not shown in drawing) to accommodate
55 the pins 22.

Referring to Fig. 9 it will be seen that the casting plate 25 is urged in a forward direction by the pins 22. The plate rests upon an accurately proportioned shoe or track 27 which in turn is
60 mounted on the side member of the table 13.

The table 13 also carries along its upper side edge a curbing 28 and above that an inwardly extending flange 29. This flange begins in advance
65 of the point where the solution is deposited on the casting-surface and may continue into the subsequent zone of evaporation.

A guard strip 30 having a U-shaped cross-section is provided to be carried along the side edges of the casting plate 25. This guard strip 30 fits
70 snugly against the side wall of the curbing 28 but there is sufficient vertical clearance between the flange 29 and the side member of the table 13 to prevent the guard strip from binding against either the flange or the side member of the table
75

and the overlap of the strip 30 with the side edges of the casting plate 23 compensates for variations in the horizontal direction.

These guard strips 30 are of the same length as the individual casting plates 25 and travel with the plates from the point of their placement on the conveyor to the opposite end of the machine.

The vertical adjustment of the shoe or track 27 insures a straight line of travel for the casting plates while the curbings 28 prevent lateral movement of the plates.

The casting operation is carried out along a portion of the table 13 which is equipped with a suitable cover to form a chamber for the solvent vapors. As illustrated in Figs. 1 and 2 this chamber comprises panels 32 which latter extend along the sides, ends and top of the frame to form a relatively closed chamber 33. Panels 32 are illustrated as being of framed sheet glass so that the casting operation can be observed readily. The ends of the chamber 33 are open at the bottom sufficiently to permit the introduction and withdrawal of the casting plates or similar elements without substantial loss of the solvent vapors or the production of undesirable air currents.

The chamber 33 is provided with suitable means, not illustrated, for its temperature control and for the withdrawal of excess vapors produced from the evaporation of the film solution. In this way these vapors are recovered and the solvent made available for use again while the rate of evaporation is also controlled by changes in the vapor tension.

The casting plates with the deposited film may be subjected to further treatment before being removed from the closed chamber, for example, by the deposit of one or more subsequent film laminae of the same or dissimilar character, either prior to or subsequent to the substantial completion of the evaporation from the originally deposited film.

The film, either of single or multiple layers, is discharged from the chamber 33 into a conditioning chamber 34 which may be a mechanical dryer or other device by which the film is further and finally treated.

In the delivery of the film from the chamber 33 it may pass as a continuous strip or web or may be cut into pieces of the desired length. In the latter case the sections of the casting surface will be made of the selected length so that the individual sections of the casting surface together with the film deposited thereon will be transferred to the chamber 34.

One standard 35 is bolted or otherwise attached to each side member 13 of the frame and extends upwardly within and above the chamber 33. These standards provide guides and supports for the casting hopper 36. This hopper includes a pair of end walls 37 and a rear wall 38. The end walls 37 have yokes 39 by which the hopper is slidably held by the standards 35. Each end wall 37 has bolted thereon a bar 40 which extends beyond the front of the end wall 37 and has a rearward extension 41. This extension 41 is screw-threaded at the point which overlies the end of the standard 35. The extreme end of the extension 41 carries a gauge 42.

Vertically extending through each extension 41 is an adjustment screw 43 the lower end of which rests upon a bearing in the end of the standard 35. The upper end of the adjustment screw 43 carries a handwheel 44 the edge of which is calibrated.

The adjustment screw 43 supports the weight of the hopper and its load on the ends of the standards 35 and the hopper is prevented from movement in any but a vertical direction by means of the yokes or guides 39. The spacing of the hopper with respect to the casting-surface is indicated by the gauge 42 and the calibration on the handwheels 44 so that a close control can be made of each end of the hopper and a uniform spacing for the casting film thus maintained.

The top 45 of the hopper has an opening 46 through which the inlet 47 of the film solution projects.

The top 45 also supports a heating coil 48 the convolutions of which extend generally through the body of the film solution and serve to maintain it at such a degree of temperature as will lower its viscosity and control the conditions under which the solution will be delivered with greatest effectiveness. The back wall 49 of the hopper is formed of a panel which is hinged at the top and the lower end is free to move inwardly with respect to the rear wall 38. The rear wall 38 has a depositing lip 50 toward which a corresponding lip 51 on the back wall 49 is adapted to be spaced, both lips serving to reinforce the sheet metal walls 38 and 40. In this way a delivery slot is established through which a thin stream of the film solution passes to the casting-surface.

The upper edge of the wall 49 has two or more hinged brackets 52 by which the wall is suspended pivotally on the cross bar 53. The cross bar, in turn, is freely journaled in bars 54 on the ends 37 and carries calibrated dials 55. The free ends of the brackets 52 are apertured to carry adjustment screws 56. The heads of the screws 56 rest upon the free ends of the brackets 52 and carry operating levers 57. The lower ends of the screws 56 pass through screw-threaded openings in a bar 58 which in turn extends transversely of the hopper between the bars 40. In this way the adjustment of the screws 56 will cause the wall 49 and the lip 51 to vary the size of the discharge slot. When operating circumstances demand, an operating handle 59 mounted on wall 49 may be used to move the latter inwardly until the discharge slot is entirely closed. It is to be understood that the side edges of the wall 49 will come in such close contact with the end walls 37 of the hopper as to prevent undesirable discharge of the solution at these points.

It is not intended primarily that the discharge from the hopper will control directly the operation of depositing the film but mainly will serve as a feeder for the solution. The solution passing from the hopper flows backwardly and forms a slight pool on the casting-surface due to the upward slope of the latter. The deep end of the pool is formed by a baffle 60 which extends in front of the feeding lips 50, 51 and for the full width of the hopper of the end walls 37. A cross plate 61 connects the end walls 37, 37 and is vertically slotted as at 62. The baffle 60 has adjustment screws 63 extending horizontally therefrom and passing through the slots 62 in plate 61. Locknuts 64 are used to adjust the position of the baffle 60 relative to the discharge end of the hopper and also to control the clearance of the lower edge of the baffle 60 with respect to the casting plates passing thereunder.

In place of individual casting plates 23 the endless conveyor 20 may have a casting-surface or member carried directly thereon. Such a casting member will be in the form of an endless belt of flexible material. The coated surface of this

conveyor belt is smoothly polished to provide an appropriate casting-surface which will hold the solution during the evaporation of the film.

Such a casting-surface may also be equipped as desired with flanges or ledges upon its side edges which will operate similar to the guide strips 30 to hold the edge of the film while drying.

The operation of this device may be briefly described as the continuous presentation to a discharge hopper of a casting-surface which may either be continuous or in suitable removable sections. This casting-surface or member is brought to uniform temperature with the solution and the conditions in chamber 33 so that the operation of evaporation of the solvent will not be attended by undesirable effects such as occur when a composite film comes in contact with a plate of a different temperature causing a differential solidification and separation out of the film of that component which solidifies at a temperature lower than the remaining components.

The casting plate 23 as it is advanced to the hopper is equipped with the guide strips 30 which prevent the lateral spread of the solution deposited.

The solution is discharged from the slot in the base of the hopper and between walls 37 and 38 and the panel 49. The rate of discharge is accurately controlled by the adjustment of the discharge lips 50 and 51. The solution on discharge spreads laterally into contact with the guide strips 30 and drains downwardly to the baffle 60. The baffle 60 causes the solution to accumulate in a shallow pool, the upper surface of which extends slightly to the left of the lip 50 as shown in Fig. 8.

Due to the upward slope of the casting plate 23 and its continuous movement toward the upper end of the conveyor, there is a tendency for the solution to flow in the opposite direction from that of the casting plate and to return to the pool. This action insures first, an adequate deposit of the solution upon the casting plate regardless of variation in viscosity and immediately thereafter the draining of excess solution to the pool so that the desired thinness of the film may be attained and its upper surface remain quite flat.

In the course of the travel of the plate together with the deposited film solution through the chamber 33, there is produced an evaporation of the solvent dependent upon the rate of travel, the temperature maintained and the surface tension or degree of saturation of the solvent which is permitted to remain in the chamber. The film, therefore, dries or evaporates uniformly. There is no tendency for the surface of the film to dry too fast and form a coating through which the solvent cannot escape from the interior of the film. It is also possible in this way to regulate the evaporation without producing a current or draft of air which might injure the desired surface of the film.

The film on reaching the discharge end of the chamber 33 will be sufficiently hardened to permit it to be cut into sections defined by the size of the casting plates. The latter with the film still adhering both to the plates and to the guide strips may then be transferred to the conditioning chamber 34.

Where the conveyor itself carries the casting surface, the conveyor may be extended to pass through the conditioning chamber 34 and thus carry the film in a continuous strip.

In like manner the chamber 34 may extend for sufficient distance to permit the use of a second or subsequent discharge hopper. Thus the film deposited from the first hopper may be partially or substantially evaporated and coated with a second film of the same or a different film solution and the composite film evaporated prior to reaching the discharge point from the conveyor.

Through the procedure outlined above and by means of the machine as described, provision is made for casting laminated sheets and strips in continuous operation and for drying the sheets thoroughly between successive coatings. The firmness with which the films are held under tension on the surface of the casting element and the particular atmosphere of solvent vapors maintained reduces the likelihood of surface irregularities such as craters and pits. The accurate control of the conditions of temperature permits the casting of pre-heated solutions at elevated temperatures and upon pre-heated casting surfaces.

The provision of the chamber of solvent vapors is of primary importance as permitting the use of inexpensive low-boiling solvents in conjunction with inexpensive diluents. At the same time it is a great improvement in preventing blushing which would be otherwise caused by precipitation of moisture. It will also be evident that such a controlled atmosphere during evaporation prevents surface-sealing and pin-holes.

By causing the solution to accumulate first in a pool of substantial depth and in contact with the guide strips, the latter are thoroughly wet to form an edge contact with the film which remains throughout the subsequent operations.

Where the solution contains oxidizing products, glycerol, phthalate resins or drying oils, which require baking or other heat treatment to dry, the upwardly inclined travel through the heated chamber of solvent vapors is of particular advantage.

The mechanism above described will thus be seen to be suitable for the continuous production of films of various types and kinds. While one particular form of the device has been described, many variations in structural details and operation are comprised within the scope of the invention as defined by the following claims.

What I claim is:—

1. A film casting machine comprising a movable casting surface, film retaining members on the side edges of said surface, and means for depositing a film solution on the surface between and in contact with said retaining members, said retaining members being adapted to hold film-forming compounds against retraction.

2. A film casting machine comprising a casting surface, means for moving said surface longitudinally and upwardly, detachable flanges on the side edges of said surface, a baffle transversely above said surface and means for depositing a film solution to form a pool over the surface within the baffle and said flanges.

3. A film casting machine comprising a movable casting surface, flanges detachably carried on the side edges of said surface, means for depositing a pool of film solution on the surface, a chamber for enclosing said surface and for drying the film attached to the surface and said flanges, said chamber comprising a regulatable atmosphere of solvent vapors, and means for withdrawing said surface from the chamber and depositing same into a conditioning chamber.

4. A film casting machine comprising a movable casting surface having means for adjustably lifting one end, and a discharge hopper for film solution, supported above and across said surface.

5. A film casting machine comprising a movable casting surface having means for adjustably lifting one end, a hopper for film solution supported adjustably above and across said surface.

5 6. A film casting machine comprising an adjustable movable casting surface having means for adjustably lifting one end, a hopper for film solution supported adjustably above and across said surface, and means for varying the rate of
10 discharge from said hopper.

7. A film casting machine comprising an adjustable movable casting surface having means for adjustably lifting one end, a hopper for film solution supported adjustably above said surface,
15 a discharge outlet from said hopper extending uniformly across said surface and means for varying the size of said outlet.

8. A film casting machine comprising a movable casting surface having means for adjustably lifting one end, a hopper for film solution supported above and across said surface, means for varying the discharge from said hopper and means for controlling the temperature of the solution in the hopper.

25 9. A casting surface adapted to receive one or more evenly applied uniform coatings of similar or dissimilar film-forming solutions and hold same against retraction, said casting surface having means at its opposite sides or edges
30 adapted to firmly hold the forming and formed film rigidly in place without substantial distortion of the film, said surface being adapted by said means to receive and retain said coatings over substantially the full surface area of said
35 casting surface.

10. A film casting machine comprising a casting surface movable upwardly in a straight, slightly inclined direction, means for depositing a film solution on said surface, and a relatively
40 closed chamber into which said film solution passes and through which the said surface moves during and subsequent to the deposit of the film.

11. A film casting machine comprising a casting surface movable upwardly in a straight, slightly inclined direction, means for depositing a film solution on said surface, a relatively closed chamber into which said film solution passes and a baffle supported adjustably and across said surface for maintaining a shallow pool of solution through which the surface moves.

12. In an apparatus of the kind described comprising means for continuously moving a casting surface upwardly in a straight, slightly inclined direction, a hopper for film solution supported adjustably above and across said surface, means for varying the discharge from said hopper, and a relatively closed chamber into which said film solution passes.

13. A film casting machine having means for conveying and mechanically advancing a series of casting plates which form a continuous top surface under a discharge hopper, said conveyor being provided with means to engage said casting plates on the under side thereof and advance said plates in a forward direction, a series of casting plates having means on the under side thereof to accommodate said conveyor engaging means, regulatable means for depositing film solution upon said surface, and a relatively closed chamber into which said film solution passes.

14. In an apparatus of the kind described comprising means for continuously moving a casting surface upwardly in a straight, slightly inclined direction, means for depositing a film solution on said surface, means to partially evaporate volatile solvent from said deposited solution to form a film within a relatively closed chamber, a conditioning chamber, means to subsequently substantially completely evaporate volatile solvent from said film within said conditioning chamber.

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