April 22, 1958 D. W. BUSHNELL 2,831,211

APPARATUS FOR PREVENTION OF SLUG FORMATION IN THE CASTING OF FILM SUPPORT AND SHEETING

Filed July 1, 1955 3 Sheets-Sheet 1

Fig. 1

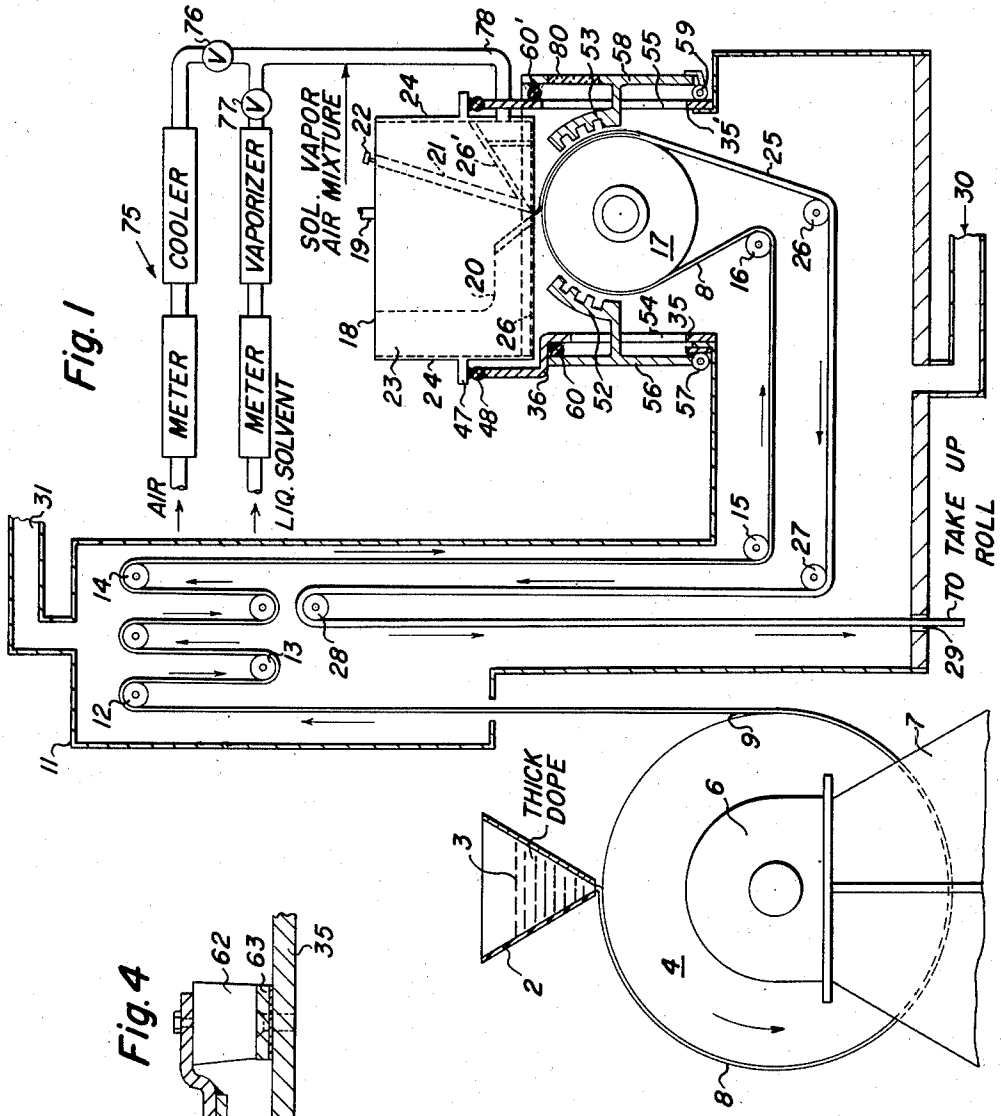
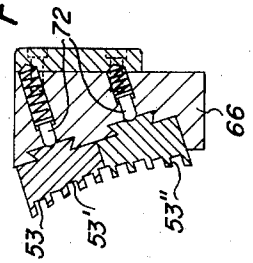


Fig. 4

Fig. 5



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APPARATUS FOR PREVENTION OF SLUG FORMATION IN THE CASTING OF FILM SUPPORT AND SHEETING

Filed July 1, 1955 3 Sheets-Sheet 2

Fig. 2

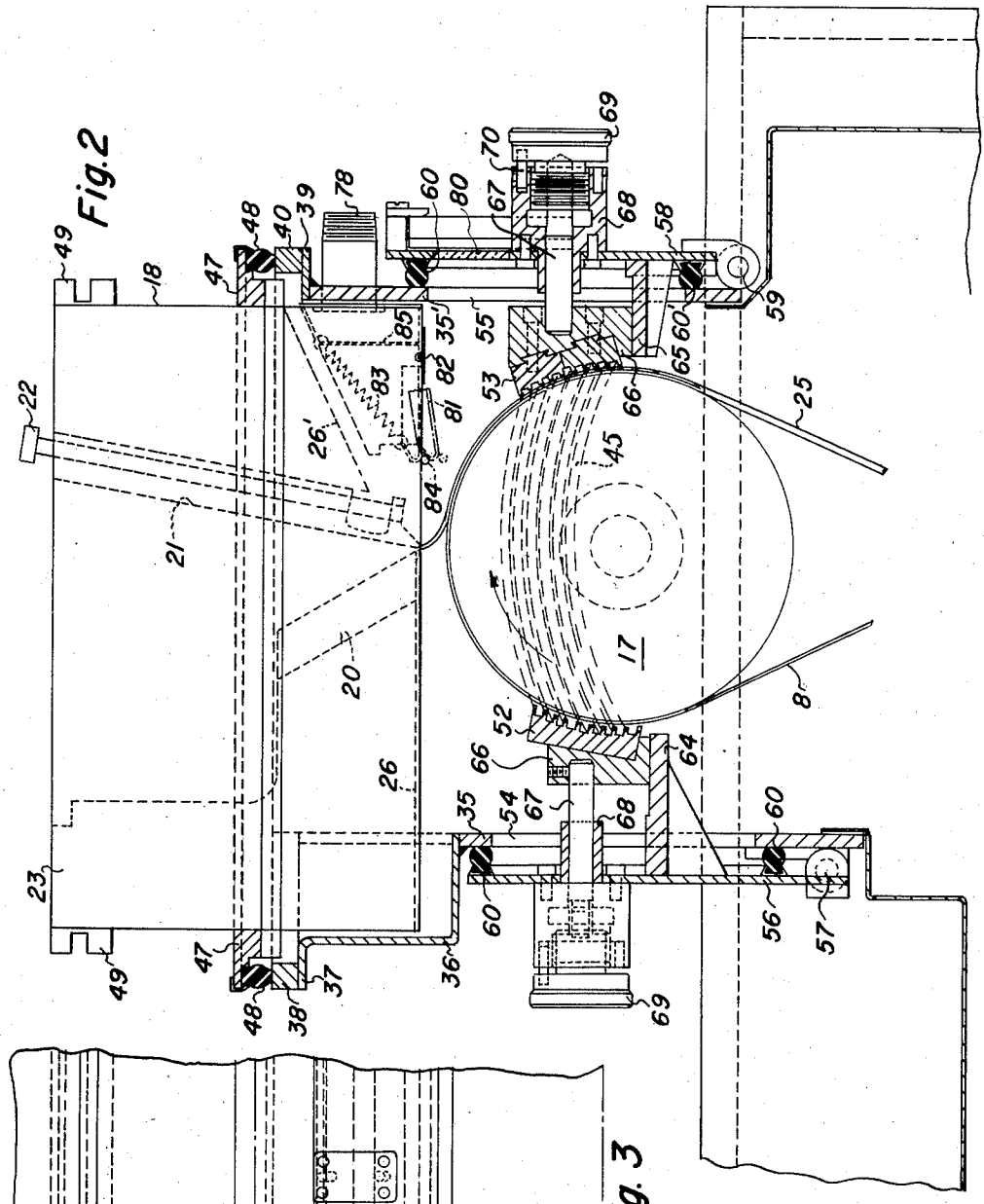
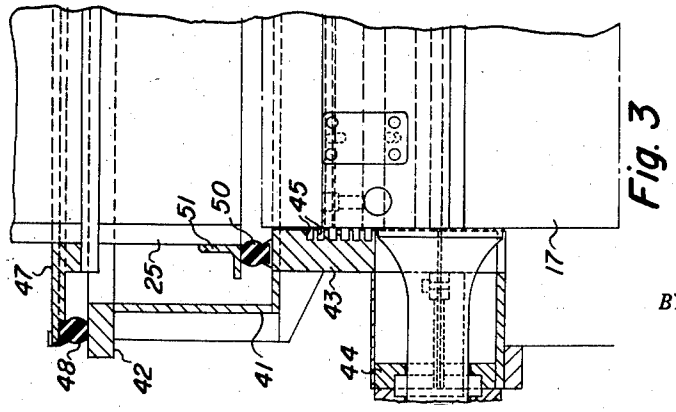


Fig. 3



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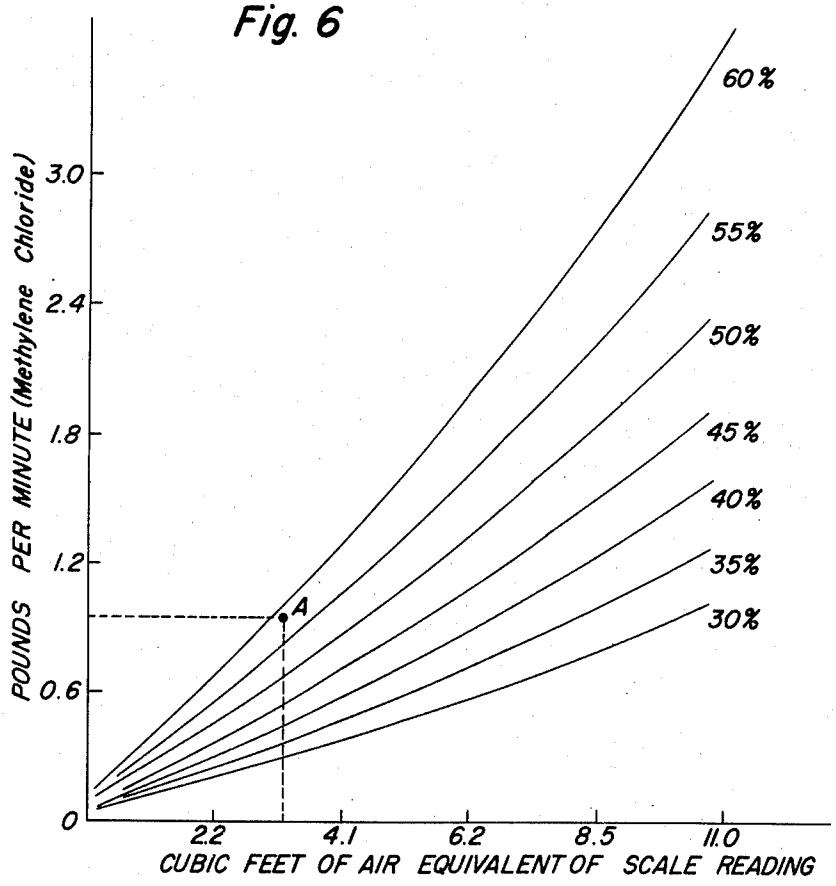
April 22, 1958 D. W. BUSHNELL 2,831,211

APPARATUS FOR PREVENTION OF SLUG FORMATION IN THE CASTING OF FILM SUPPORT AND SHEETING

Filed July 1, 1955 3 Sheets-Sheet 3

Fig. 6



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2,831,211

APPARATUS FOR PREVENTION OF SLUG FORMATION IN THE CASTING OF FILM SUPPORT AND SHEETING

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Application July 1, 1955, Serial No. 519,596

6 Claims. (Cl. 18—15)

The present invention relates to an improved method and apparatus of manufacturing film base or sheeting, and particularly to an improved process for maintaining the proper conditions at the beginning and throughout the casting operation and to an improved type of apparatus for accomplishing this result.

As is well known to the art, cellulosic film or sheeting is formed by spreading a thin coating of a cellulose ester in suitable solvents onto an appropriate surface and permitting, or causing, the solvents to evaporate therefrom. The method generally employed consists in feeding the solution or dope from an appropriate hopper device onto a polished metallic surface of a slowly rotating wheel or drum. The solvent evaporates from the film more or less progressively as the wheel turns until, in less than a complete revolution, sufficient solvent has been removed to admit of the film being removed therefrom and conveyed to a wind-up or carried over other rolls or drums for further treatment.

The device usually employed for feeding the solution to the casting wheel comprises a V-shaped hopper provided with spaced apart blades mounted at an angle to one another at the apex of the V to form a coating or discharge slot. Usually one or both of these blades is adjustable with respect to the other so as to provide means of controlling the thickness of the dope stream and, therefore, the sheet being formed.

Serious difficulties often arise from the tendency of the cellulose ester solutions to form slugs or encrustations on the edges of either or both of the hopper blades, since, when these slugs form, they project down into the dope stream and give rise to uneven coating and the formation of streaks in the finished product which renders it unfit for use. This slugging action is known to be due to the fact that small amounts of cellulose ester solution creep along the outer surfaces of the blades as it flows out of the hopper instead of being carried along in the dope stream onto the wheel. The solvent evaporates from these small portions of dope and cause them to solidify, thus forming slugs. These slugs tend to increase in size due to further accretions of dope and eventually become sufficiently large to project below the edges of the blades and cause the troublesome results mentioned.

The prior art has recognized that one way of preventing the formation of slugs on the lips of coating hoppers is to enclose the area therearound to outside air and maintain therein an atmosphere made up of concentrated vapor of the dope solvent. This has led to the difficulty of the solvent condensing out of the vapor when striking parts of the apparatus which are cool enough for such a condition to exist. When this occurs and the drops of solvent drop down upon the casting surface ahead of the dope stream or on top of the deposited dope stream, undesirable dope pits appear in the sheet. Efforts have been made in the prior art to overcome this condensation problem by purposely condensing the solvent vapor at a point adjacent the coating point and collecting and conducting it away from the coating area.

The problem of maintaining a completely air-tight enclosure about the discharge lips of a coating hopper is a very difficult one since the casting wheel must continually move into and out of this area and seals physically engaging the wheel surface cannot be formed. This problem is especially difficult in cases of multiple casting techniques, i. e. where the final thickness of web is built up in two or more applications of dope, because in such cases the second casting wheel is usually one of small diameter, i. e. 10 feet in diameter or less, whereas the first casting wheel is generally large, i. e. 18 feet in diameter, and for all practical purposes that area of the wheel to be enclosed is substantially flat. The problem is aggravated in the case of small casting wheels by reason of the fact that the solvent vapor is generally several times as heavy as air and tends to flow down and around the wheel past any useful seals by virtue of gravity.

The primary object of the present invention is to provide a film casting apparatus so designed that the formation of slugs on the hopper lips can be eliminated and at the same time no condensation problem is presented.

Another object is to provide a film casting apparatus wherein the space between the discharge slot of the hopper and a limited area of the casting surface approaching and leaving the casting point is provided with an enclosure which is as air-tight as practically possible and still allow the casting surface to move therethrough. A solvent vapor-in-air mixture is then pumped into this enclosure at such a rate as to maintain a solvent vapor concentration in this area, despite any dilution thereof due to outside air leaking into the enclosure, which is high enough to prevent the formation of slugs but below the point where solvent will condense out on parts of the apparatus and drop down on the casting surface or deposited film and form solvent pits in the film.

And a further object is to provide a film or sheet casting apparatus of the type described wherein the air and solvent vapor mixture is under the control of the operator for ready regulation and is pumped into said enclosure at such a rate as to maintain the enclosure under a positive pressure as the result of which all leaks relative to the enclosure are outward rather than inward.

And another object is to provide a slug prevention system which is particularly adapted for application to casting wheels of small diameter, and can therefore be used in multiple casting techniques, as well as large casting wheels.

And a further object is to provide a slug prevention system which gives the operator complete control over the concentration of solvent vapor surrounding the discharge slot of the hopper and permits the existence of a desirable condition to this end right from the time of start-up rather than depending for the existence of solvent vapor in this area upon the flow of dope to the casting wheel.

And yet another object of this invention is to provide an enclosure for the area bounding the discharge slot of the hopper and the surface of the casting wheel which includes arcuate labyrinth seals concentric with the casting surface, and the seal on the approaching side of the discharge slot is substantially close to the discharge slot so that if a partially cured web is moved to the casting point on the wheel, as in the multiple casting technique of forming a web, then only a limited length of the uncured and partially formed web is subjected to the effects of the solvent vapor before the next coat of dope is applied thereto.

And still another object of this invention is to provide an enclosure for the discharge slot of the hopper and the surface of the casting wheel which, when filled with a regulated concentration of vapor-in-air mixture, allows the discharge slot of the hopper to be raised above the casting surface by as much as one-half inch without en-

countering the formation of slugs. As a result of this increased sepaartion between the discharge slot of the hopper and the casting surface, a relatively long unsupported stream of dope is provided whereby any imperfections which might normally appear in the stream due to imperfections in the lips of the discharge slot and/or uncontrollable variations in the width of the slot throughout its length have a chance to smooth themselves out prior to the time the stream is cast on the wheel, or in the case of multiple casting on a layer passing over the wheel, at which time any imperfections remaining in the dope stream are "frozen" in the deposited layer.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings in which:

Fig. 1 is a schematic side elevational, partly in section, view of a multiple casting apparatus and the second, or small, casting surface incorporating means for preventing the formation of slugs in accordance with a preferred embodiment of the present invention;

Fig. 2 is an enlarged sectional detail end view of the hopper associated with the second or smaller casting wheel provided with a slug preventing apparatus constructed in accordance with one embodiment of the present invention;

Fig. 3 is a side sectional detail showing one end of the casting hopper and the casting drum, and showing how the end of the drum and hopper is sealed against the inward flow of air to the discharge slot of the hopper to prevent the formation of slugs in accordance with the present invention;

Fig. 4 is a sectional detail showing how the doors of the enclosure surrounding the discharge slot of the hopper may be held closed by magnets;

Fig. 5 is a sectional detail showing how the ends of the labyrinth seals of the enclosure may be releasably mounted to permit removal for cleaning surfaces without breaking the entire seal of the enclosure; and

Fig. 6 is a graph illustrating the relationship between percent by volume of methylene chloride solvent-in-air to condensation temperature.

As pointed out above, in the manufacture of photographic film base and other sheeting material, cellulose esters dissolved in suitable solvents are cast out of a slot hopper onto a wheel where a sufficient amount of solvents are cured out of the solution, usually called "dope," to allow the sheet to be stripped off of the wheel. Previously considerable difficulties were encountered with the formation of "slugs" (dope which has hardened due to the loss of solvents) around the edges of the hopper blades. In an effort to eliminate the slug formation, the prior art has attempted to tightly baffle the discharge slot of the hopper around the top of the wheel to prevent solvent loss. The prior art has also included the introduction of 100% pure solvent vapor locally along and at the ends of the hopper slot. This practice often results in condensation of the solvent vapor on the undersurface of the hopper to the extent that droplets of liquid solvent fell onto the product.

When this same type of baffling and solvent vapor supply were tried in the multiple casting technique (casting a second layer of dope on partially cured sheeting to build up the final thickness to a given value) there was little success. One reason for this was that while regular single stage casting is carried out on an 18-foot diameter wheel in which instance that portion on which the casting is performed is substantially flat, in multiple casting the second coating is usually deposited on a relatively small wheel (i. e. 8½" in diameter) and in which case the portion on which the dope is cast is far from flat and, in fact, falls away on each side of the discharge slot of

the hopper so sharply that baffling techniques previously used were of little or no use. Organic solvent vapors evaporating from the cast dope are generally heavier than air (methylene chloride, 2.8 times) so that they have a tendency to fall away from the dope hopper blades which are located at the top center of the small casting drums. It has not been practical to construct baffles of prior art design around the film support entering and leaving the multiple casting position to prevent appreciable loss of solvent vapor in the area around the hopper blades.

Inasmuch as my invention is particularly adapted for use with small casting wheels, although not limited to such use, I have chosen to show it in combination with the small casting wheel of a multiple casting apparatus. Referring to Fig. 1, a multiple casting apparatus may comprise a conventional hopper **2** adapted to contain a film-forming solution. These film-forming solutions, which are frequently referred to in the art as dope, are indicated at **3**. Suitable conduits and the like mechanism for continuously or otherwise feeding the dope **3** to the hopper **2** are provided as desired, but are not shown in the present drawings.

Positioned in close proximity to the discharge slot of the hopper **2** is a casting wheel or drum **4**. Here again this wheel may be comparable to the devices presently used in the art. It may comprise a metal wheel of large diameter (i. e. 18 feet) having a highly polished metal surface. This wheel is mounted in bearings **6** carried by suitable supports **7**. As shown, the wheel **4** is positioned so that a stream of dope flows onto the wheel periphery forming a support or sheet **8**. This film of freshly deposited dope sets up on the wheel **4** as it rotates in the direction of the arrow due to loss of solvents, the gelled or set film being removed or stripped from the wheel at point **9**.

Associated with the mechanism just described is a drying chamber designated over-all as **11**. This drying chamber is provided with a plurality of rolls **12**, **13** and **14**, for example, of conventional construction. That is, some of these rolls may be conventional idler rolls whereas others may be positively driven as may be needed. While only a few rolls have been shown, a relatively large number may be present. The function of these rolls is to receive the partially cured sheet **8** as its leaves the wheel **4** at point **9** and carry it through a sufficient length of loop travel in the drying chamber so that further removal of solvent and drying may take place.

The film from the roll **14** then feeds down over rolls **15** and **16**, the latter of which is below and in rather close association with a second, and small, casting wheel **17**. This second casting wheel, in all respects except size, may be like casting wheel **4**. For example, it must have a highly polished periphery so that when the partially cured sheet **8** is moved into contact therewith the sheet surface will not be marked. Actually this second wheel **17** is much smaller than the first casting wheel **4** (i. e. as small as 8½" in diameter) although it is impossible to accurately indicate the relative sizes in the drawings and still make it possible to show the detail of the hopper structure associated with this second wheel, and which structure constitutes the present invention. It will be noted that the roll **16** is located well under wheel **17** so that the film **8** as it is directed to the wheel thereby is wrapped tightly about a major portion of the periphery of the wheel.

Located in close proximity to this second casting wheel **17** is another hopper device designated over-all as **18**. This hopper device is preferably one of the enclosed type known as a pressure hopper and into which the dope is fed under pressure through an inlet pipe **19**, and the dope is extruded in a thin stream from a discharge slot formed between the spaced ends of blades **20** and **21** directly above the casting wheel **17**. Blade **21** may be adjusted by one or more screws **22** spaced along its length in order to adjust the width of the discharge slot. The dope containing part of the hopper proper is enclosed by a box **23**

made up of side walls **24**, end walls **25** and a bottom wall **26**. That portion of the bottom wall to the right of the discharge slot, looking at Figs. 1 and 2, and designated **26'** is inclined upwardly to allow entrance of a solvent vapor-in-air mixture to an enclosure surrounding the discharge slot as will be hereinafter fully described. A heating medium, hot water, steam, etc. may be circulated within the box 23 surrounding the dope hopper proper in order to maintain the temperature of the dope at the proper temperature up to the time of casting. As the partially cured sheet 8 is moved past the discharge slot of hopper **18**, another layer of dope is applied to the surface thereof to build up the thickness of the sheet to a desired final thickness. The dope applied at this point usually is the same composition as that deposited on wheel 4 but need not be if a composite sheet of two different materials is desired. The composite sheet **25** is then directed over rolls **26, 27, 28** in the drying chamber **11** for curing of the dope and then through an exit **29** to further curing chambers if necessary and ultimately to take-up roll. Drying air may be admitted to drying chamber **11** through inlet **30** and exhausted through outlet **31.**

The present invention is not limited in any way to the type of dope which is cast to form the film support or sheeting but is useful with any dope which contains a solvent which when it evaporates prematurely tends to cause undesirable slugs to form on the hopper blades. Furthermore, it makes no difference whether it is the same or a different dope which is cast in succession on the two wheels to form the final film support or sheeting, the criterion in the present instance being that the dope cast on the second wheel **17** is of a type which is of such character that there is a tendency for slugs to form on the blades of hopper **18** and whose formation must be prevented. The following are examples of different dopes which might be cast by the present apparatus.

Example I

Cellulose acetate (43.5% acetyl)		100 parts
Methylene chloride	520	426 parts
Cyclohexane		42 parts
Methyl alcohol		52 parts
Triphenyl phosphate		15 parts
Viscosity at 80° F		600 poise

Example II

Cellulose acetate (43.5% acetyl)		100 parts
Methylene chloride	550	490 parts
Methyl alcohol		60 parts
Triphenyl phosphate		15 parts
Viscosity at 80° F		450 poise

Example III

Cellulose acetate butyrate (17% butyryl)		100 parts
Methylene chloride	350	280 parts
Cyclohexane		35 parts
Butyl alcohol		35 parts
Triphenyl phosphate		8 parts
Viscosity at 80° F		520 poise

While different thicknesses of films or sheeting can be produced by this multiple casting technique for film base, it would be preferred to keep the final thickness, say from .004" up to .009". If this final thickness is made up in two steps as described the first layer is usually made equal to more than one-half the final desired thickness and the second layer is then obviously thinner than the first laid down.

Coming now to the present invention, I prevent the formation of slugs on the blades of the second hopper **18** by providing a small volume perimeter enclosure between the base of the hopper **18** and the top half of the small casting wheel **17** and flood this enclosure with a solvent vapor-in-air mixture pumped into the enclosure under pressure so as to maintain the pressure within the enclosure slightly higher than that outside of the enclosure.

Thus, any leaks which there might be between the enclosure and the outside will be to the outside rather than inwardly. Then the solvent vapor-in-air mixture is so proportioned as to maintain an atmosphere within the enclosure whose concentration is high enough to prevent the formation of slugs and at the same time not high enough to cause condensation of the solvent on the bottom of the hopper.

In accordance with the present invention, the space between the bottom of the hopper **18** and the top half of the casting wheel **17** is enclosed by vertical walls **35** and **35'** running lengthwise of the wheel and extending from a point below the wheel to a point in line with the top of the wheel and below the bottom of the hopper as in the case of wall **35** and to a point above the bottom of the hopper as in the case of wall **35'**. Fastened to the top of wall 35, as by welding, is an offset wall section **36** which terminates in a horizontal flange **37** having a supporting rim **38** carried thereby. Fixed to the top of wall **35'**, as by welding, is a horizontal flange **39** in the same plane as flange **37** and having a supporting rim **40** carried thereby. The ends of the wheel and hopper are enclosed by offset walls **41** terminating at the upper end in horizontal flange **42** and at the bottom end in a labyrinth seal **43** supported from the bearing **44** of the wheel **17**. These labyrinth seals **43** at each end of the wheel are arcuate in shape and fit the end face of the wheel as closely as possible and still allow the wheel to turn. On the face adjacent the wheel these seals are provided with a plurality of concentric grooves **45** which act to restrict the passage of air between themselves and the end of the wheel by reason of the fact that they each constitute small expansion chambers into which any leaking air would tend to flow rather than moving freely between the smaller space between the wheel ends and the ribs between the grooves.

Encircling and fixed to the hopper walls is a supporting rim **47** which carries a rubber gasket **48** adapted to engage the supporting rims **38, 40** and flange **42**, which are all in the same plane, to form an air-tight seal. The hopper **18** is provided with a channel shaped support rim **49** which is adapted to engage an elevating mechanism, not shown, and by means of which the hopper can be raised and lowered from the wheel surface for threading purposes or just to obtain minute adjustments between the discharge slot of the hopper and the wheel for best operation. The gaskets **48** should be made of sufficiently resilient material so that they can accommodate slight adjustments of the hopper slot relative to the wheel without breaking the seal at this point. Because there is a tendency for slugs to form at the ends of the hopper discharge slot faster than in the middle portion, I provide an additional seal **50** at this point which is fixed to and extends across the horizontal portion of the end wall **41** of the enclosure and engages an angle **51** fixed to the end wall of the hopper **18**, see Fig. 3.

The enclosure is completed by a pair of labyrinth seals **52** and **53**, the faces of which are concentric with the wheel **17** and are provided with a plurality of parallel grooves which provide expansion chambers which act to resist the flow of leaking air between the wheel and the seals. Labyrinth seal **52** is on the side of the wheel over which the partially cured layer **8** approaches the discharge slot whereas labyrinth seal **53** is on the leaving side of the wheel **17** where the composite sheet must pass from the enclosure.

To permit threading of the device, or to permit access to the enclosure for any other purpose, walls **35** and **35'** are provided with openings **54** and **55** respectively. Opening **35** is adapted to be closed by a door **56** hinged at its lower end to a pintle **57** carried by the wall, and opening **55** is adapted to be closed by a door **58** hinged at its lower end by a pintle **59** carried by wall **35'**. Each of these doors is bounded by a sealing gasket **60** or **60'** which is adapted to engage the wall **35** or **35'**, respec-

tively, when the door is shut. While any suitable means may be provided for releasably latching the doors 56 and 58 closed, I have found that this can be satisfactorily accomplished by means of permanent magnets 62 fastened to one part and adapted to engage a soft iron piece 63 attached to the other part, see Fig. 4.

The labyrinth seals 52 and 53 are adjustably mounted on supports 64 and 65, respectively, extending from the doors 56 and 58 so that as the doors are opened for threading, the seals move away from the wheel surface. Since both seals are mounted on their respective doors in the same manner, only one of the two mechanisms will be described. The seal proper is carried by a block 66 which slidably engages the support 64 or 65 and is fixed to the end of a rod 67 slidably mounted in a tubular sleeve 68 carried by the door. Rod 67 is adjusted axially without turning by means of a double threaded connection between itself and a knob 69. Knob 69 is limited to substantially a single rotation by means of a pin 70 extending into a groove in the underside of the knob. If desired, this knob can be provided with suitable calibrations for facilitating adjustment of the labyrinth seals in accordance with different thicknesses of sheets moving into and out of the enclosure confining the discharge slot of the hopper.

There is some tendency for slugs or other build up of material to occur on the extreme ends of the labyrinth seal 53 since the layer of dope passing this seal is completely uncured and the hopper does not lay the stream of dope down uniformly completely to the edge. So that this difficulty can be readily overcome without shutting down the machine or completely breaking the seal for the enclosure, I form the extreme ends of the labyrinth seal 53 in two separate sections 53′ and 53″, see Fig. 5. Each of these sections are provided with undercut rails which slidably engage correspondingly shaped grooves in the block 66 so that they can be slid axially into and out of position separately. They are each frictionally located in position by spring-pressed pins 72. It can thus be seen that one of these sections can be slid out of place for cleaning without breaking the complete seal for the enclosure.

So that a solvent vapor-in-air mixture of adjustable concentration can be fed into the enclosure under a given pressure, I provide a mixing device as shown at 75 in Fig. 1. The desired mixture of solvent vapor-in-air is regulated by valves 76 and 77 and is fed into the enclosure through inlet pipe 78. In this way the enclosure surrounding the dope hopper discharge slot can be flooded and pressurized with an externally proportioned solvent vapor-in-air mixture. Since with this arrangement all leaks will be from the enclosure to the outside, it is possible to purge the enclosure of air and maintain the desired concentration beneath the hopper. The level of solvent concentration in air can be maintained uniformly within close limits throughout the space under the hopper—high enough to prevent slug formation at the discharge slot and still low enough that condensation will not occur on the undersurfaces of the hopper. The graph of Fig. 6 illustrates the relationship between percent by volume of methylene chloride solvent in air to condensation temperature. Point A on this graph shows an operating point which has proven satisfactory under commercial operating conditions with one type of film dope.

Inasmuch as the methylene chloride vapor is practically three times as dense as air and hence flows to the bottom of the enclosure under the hopper like water, whereby the pressure in the enclosure varies from top to bottom of the enclosure, it has been found practically impossible to accurately measure the pressure or concentration of the vapor-in-air mixture in the enclosure by conventional instruments. The procedure which I have found very satisfactory for controlling the solvent-in-air mixture is by visual inspection, and to this end the door 58 is provided with a window 80. By looking through the window 80, the operator can adjust the valves of the vapor-in-air mixing device to obtain a mixture which just tends to form condensation on the underside of the hopper and then cut the concentration down just until this condensation ceases. Likewise, if he sees an encrustation start to form at any point, he can immediately increase the concentration of the vapor-in-air mixture until it disappears. By this means of visual control, very critical and rapid control of the vapor-in-air mixture concentration can be effected.

Looking at Fig. 2, the vapor-in-air mixture is directed toward the discharge slot of the hopper by the inclined bottom wall 26′ of the hopper and a baffle 81 hinged at point 82. This baffle is adapted to automatically move from the lower operative position to the upper inoperative position when the hopper is raised from the wheel for threading purposes. A spring 83 normally tends to raise the baffle 81 and a pin 84 movable with the hopper and engaging the end of said baffle controls its movement between its two positions as the hopper is moved to and from the wheel. To prevent the vapor-in-air mixture from striking the stream of dope extending from the hopper slot to the wheel surface, a perforated baffle 85 separates the inlet 78 from the discharge slot of the hopper.

Experiments with this type of enclosure using the controlled solvent vapor-in-air mixture as described have been made on a production machine at both the multiple casting and regular casting positions with good success. Solvent-in-air concentrations were provided and maintained under both of these hoppers to successfully prevent slug formation at the hopper slot.

By way of conclusion the following several advantages of this method of preventing slug formation in film and sheet casting are noted. Both the quantity and concentration of the vapor solvent-in-air mixture are under the positive control of the operator at all times and are not dependent upon the rate of solvent evaporation from the product or the leakage from the enclosure. The concentration can be maintained above the level at which slugs form and at the same time below that at which condensation takes place on the bottom of the hopper. Local dilution of the solvent-in-air concentration under the hopper is not possible as there can be no inward leaks with the pressurized enclosure. The relatively high concentration of solvent-in-air mixture required for prevention of slug formation is confined to a very small enclosed volume of the hopper. It is desirable from a hazard point of view to keep this volume to a minimum. Furthermore, with the multiple casting technique, it is desirable to subject the uncured sheet 8 to as short an exposure to this concentrated vapor-in-air mixture as possible before the second layer is applied on wheel 17 so that the surface of the first layer is not damaged. The length of exposure of the first cast layer to the high solvent-in-air concentration under the second casting hopper is short, which is an advantage in the control of creases. And probably the greatest advantage of the present invention is that the solvent vapor-in-air mixture can be supplied at any desired concentration to the dope hopper enclosure before the dope is admitted to the hopper, thereby preventing the formation of slugs at startup. With prior art methods which rely upon solvent vapor coming from the dope itself to condition a confined area about the hopper slot, slugs can, and usually do, form at startup before sufficient solvent can be evaporated from the product to prevent their formation.

The present invention is so effective in the elimination of slugs that it permits lifting the discharge hopper a substantial distance from the casting surface so that a relatively long unsupported stream of dope is present at the point of deposition. In fact, I have found that with the present invention the hopper slot can be spaced from the wheel as much as ⅜″ to ½″ without slugs tending to

form. With conventional dope casting apparatus it is necessary to have the hopper slot located quite close to the wheel in order to avoid the formation of slugs, since the longer the dope is exposed to air between the time it leaves the hopper and the time it is actually laid down, the greater the tendency for slugs to form. There is a decided advantage in being able to cast the dope with a relatively large spacing between the hopper slot and the casting surface. Such technique results in a sheet having less cross lines in the deposited sheet which may be caused by irregularities in the finish on the blade tips, variations in width of the slot throughout its length, etc. When the hopper slot is spaced from the casting surface by 3/8" to 1/2", there is provided an unsupported stream of dope which is sufficiently long so that any irregularities in the stream leaving the hopper slot have time to smooth themselves out before the stream is deposited on the casting surface. Furthermore, with such a separation the stream actually flows onto the casting surface rather than, in fact, being pulled from the hopper slot by the moving casting surface, as in the case of close separations, and which action tends to aggravate the so-called cross-line problem in the final sheet.

While I have shown and described certain specific embodiments of my invention, I am aware that many modifications thereof are possible. My invention, therefore, is not to be limited to the specific structural details shown and described, but is intended to cover all modifications coming within the scope of the appended claims.

Having thus described my invention, what I claim is new and desire to secure by Letters Patent of the United States is:

1. In a film or sheet-forming apparatus the combination with a casting surface, means for continuously moving the same, a hopper having a discharge slot in its bottom spaced above said casting surface and adapted to continuously deposit onto said casting surface a thin stream of a flowable dope composed of solids dissolved in a volatile solvent; of means forming a substantially air-tight enclosure embracing the bottom of said hopper and a portion of the casting surface ahead of and beyond the point where the stream of dope is deposited thereon, means external of said enclosure for preparing a mixture of air and solvent vapor of given concentration, and means for pumping said solvent vapor-in-air mixture into said enclosure at a rate such as to maintain a concentration of solvent vapor in said enclosure which is great enough to prevent the formation of slugs on the lips of said discharge slot despite dilution which might be caused by any leakage of air into said enclosure but less than enough to cause condensation of the solvent on parts of the enclosure.

2. In a film or sheet-forming apparatus the combination with a casting surface, means for continuously moving the same, a hopper having a discharge slot in its bottom spaced above said casting surface and adapted to continuously deposit onto said casting surface a thin stream of a flowable dope composed of solids dissolved in a volatile solvent; of means forming a substantially air-tight enclosure embracing the bottom of said hopper and a portion of the casting surface ahead of and beyond the point where the stream of dope is deposited thereon, and comprising walls embracing all sides of the bottom portion of the hopper and extending toward the casting surface and terminating in sealing members approaching said movable casting surface as closely as practically possible and still allow the same to move into and out of said enclosure without damaging the casting surface or the layer of dope deposited thereon; means external of said enclosure for preparing a mixture of air and solvent vapor of given concentration, and means for pumping said solvent vapor-in-air mixture into said enclosure at a rate such as to maintain a positive pressure within said enclosure whereby any leaks from the enclosure will be outward rather than inward and the given concentration of solvent vapor will be maintained around said discharge slot to prevent the formation of slugs on the lips of said discharge slot.

3. In a film or sheet-forming apparatus the combination with a casting wheel, means for continuously rotating the wheel, a hopper having a discharge slot in its bottom spaced above the periphery of said casting wheel and adapted to continuously deposit onto the surface of said wheel a thin stream of a flowable dope composed of solids dissolved in a volatile solvent, of means forming a substantially air-tight enclosure embracing the bottom of said hopper and a portion of the periphery of said casting wheel in advance of and beyond the point where the dope is deposited thereon, and comprising walls embracing all sides of the bottom of said hopper and extending downwardly toward the casting wheel, each end wall terminating in a labyrinth seal spaced from the end of the casting wheel as close as possible and still allow the wheel to turn, each side wall terminating in an arcuate labyrinth seal concentric with a portion of the wheel surface and spaced as close to the surface as practically possible and still allow the same to move into and out of said enclosure without damaging the casting surface or the layer of dope deposited thereon, means for preparing a mixture of air and solvent vapor of given concentration, and means for pumping said solvent-in-air mixture into said enclosure at such a rate as to maintain a positive pressure within said enclosure whereby all leaks relative to the enclosure will be outward rather than inward and the given concentration of solvent vapor will be maintained around said discharge slot to prevent the formation of slugs on the lips of said discharge slot.

4. In a multiple film or sheet-forming apparatus the combination with a casting wheel greater than ten feet in diameter, a hopper mechanism for continuously depositing onto the surface of said casting wheel a thin stream of flowable dope composed of solids dissolved in a volatile solvent, a drying chamber through which the film of dope after being stripped from said casting wheel is moved for partial curing, a second casting wheel less than ten feet in diameter, means for guiding said partially cured film of dope leaving said drying chamber onto the surface of said second casting wheel for the application of a second layer of dope thereto, a second hopper having a discharge slot spaced above said second casting wheel and adapted to continuously deposit onto said partially cured film of dope a thin stream of the same dope to build up the final thickness thereof, of means forming a substantially air-tight enclosure embracing the bottom of said second hopper and a portion of the periphery of said second casting wheel carrying said partially cured film of dope, and including walls embracing the bottom of said second hopper and extending downwardly toward said casting wheel, each side wall terminating in an arcuate labyrinth seal concentric with the wheel surface, one seal spaced from the surface of the wheel a slightly greater distance than the thickness of the uncured film of dope entering said enclosure and the other seal spaced from the surface of the wheel a distance slightly greater than the thickness of said uncured web plus the thickness of the stream applied by said second hopper, means for preparing a mixture of air and solvent vapor of a given concentration, and means for pumping said solvent-in-air mixture into said enclosure at such a rate as to maintain a positive pressure within said enclosure whereby all leaks relative to the enclosure will be outward rather than inward and a given concentration of solvent vapor will be maintained around said discharge slot to prevent the formation of slugs on the lips of said discharge slot.

5. A film or sheet-forming apparatus according to claim 3, and including means for adjustably mounting each of said arcuate labyrinth seals on its respective side wall for adjustment to and from the casting surface, and means external of said enclosure for adjusting said seals.

6. A film or sheet-forming apparatus according to claim 3, including means for mounting each of said arcuate

labyrinth seals on its respective side walls to permit swinging movement of said seals from said casting surface for threading purposes and to permit critical adjustment of said seals relative to said casting surface for the best casting technique, said means including a hinged door on each of said side walls adapted to close an opening therein,

and means for adjustably mounting one of said seals on each of said doors.

References Cited in the file of this patent

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