Sept. 14, 1943. C. W. SHIELDS 2,329,421

APPARATUS

Filed July 31, 1940 2 Sheets-Sheet 1

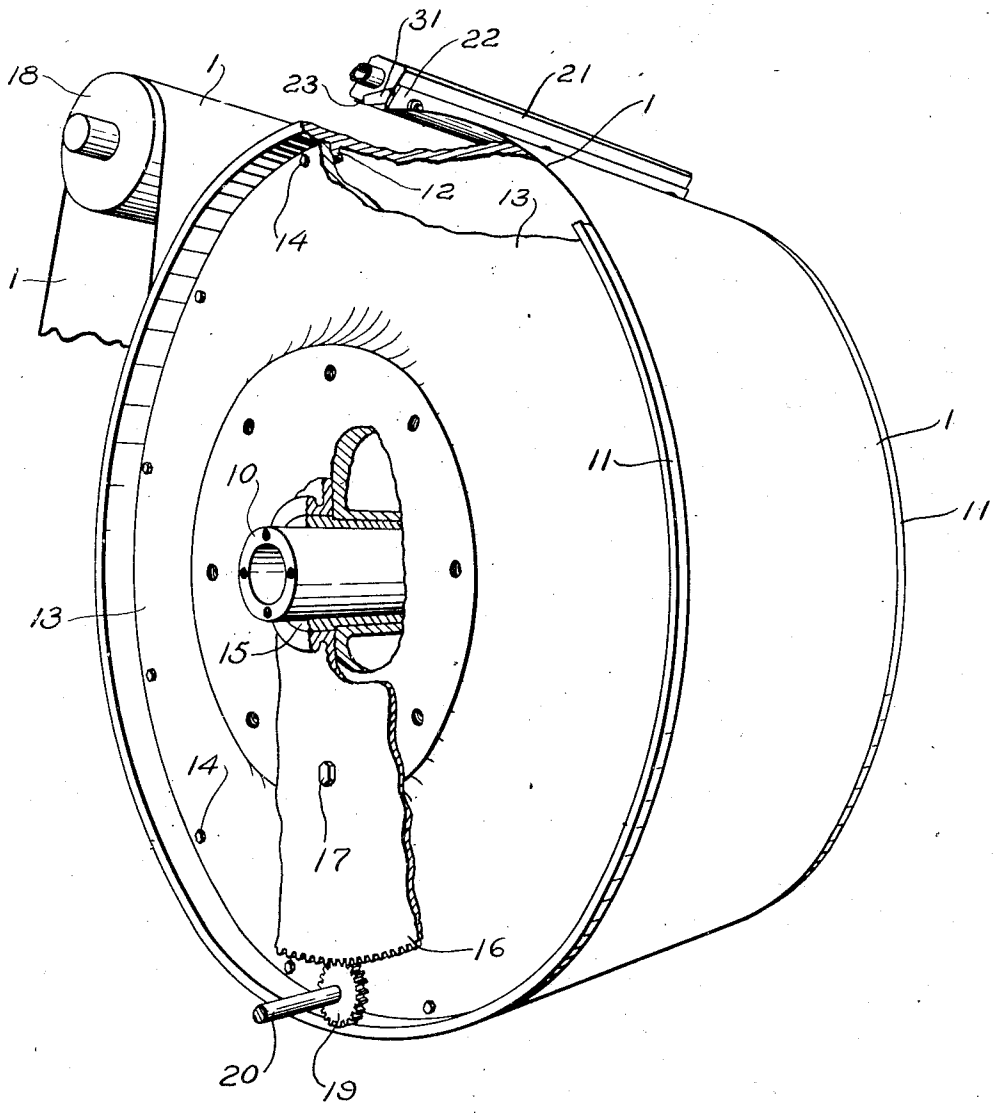


Fig. 1

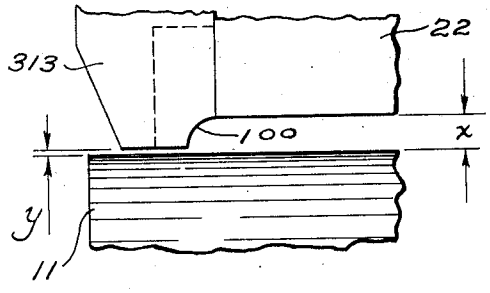
INVENTOR.
Charles W. Shields
BY
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ATTORNEY

Sept. 14, 1943. C. W. SHIELDS 2,329,421

APPARATUS

Filed July 31, 1940 2 Sheets-Sheet 2

Fig. 10



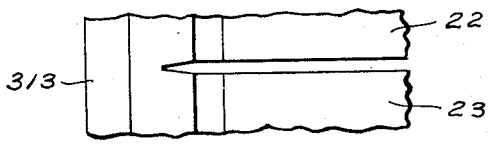


Fig. 11

Fig. 2

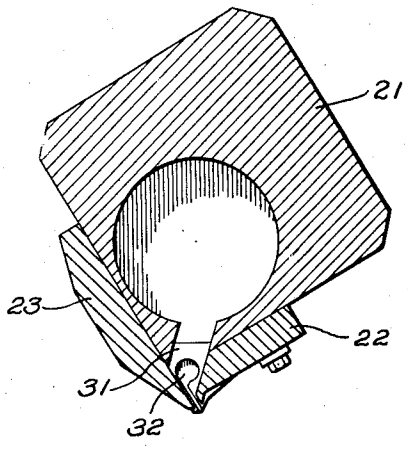
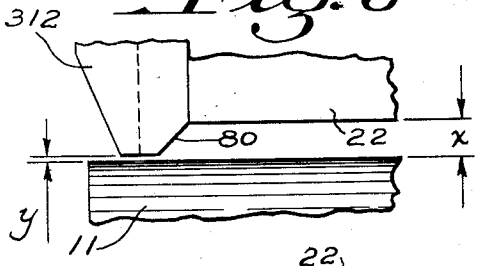


Fig. 8



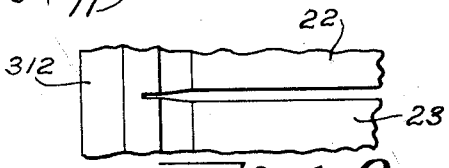
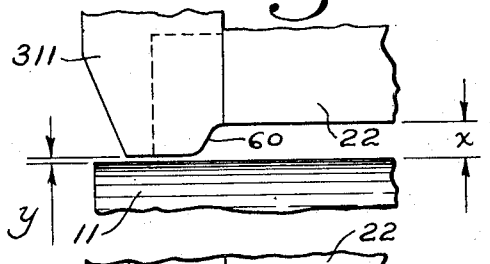


Fig. 9

Fig. 6



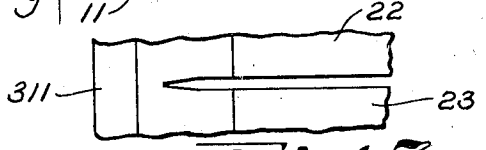


Fig. 7

Fig. 4

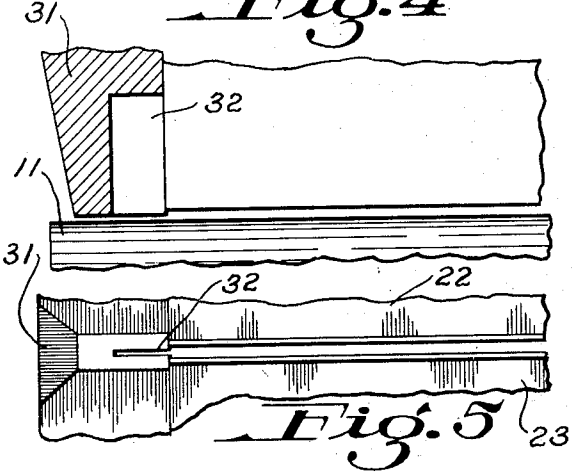


Fig. 5

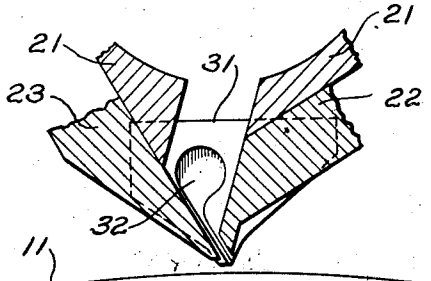


Fig. 3

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2,329,421

UNITED STATES PATENT OFFICE

2,329,421

APPARATUS

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Application July 31, 1940, Serial No. 348,886

10 Claims. (Cl. 18—15)

This invention relates to the "dry" (evaporative) casting of thin film, especially to apparatus for the continuous formation of cellulosic sheet wrapping material. More particularly, it appertains to a casting hopper which increases the output of the casting surface.

The dry casting of continuous webs of cellulose acetate of 51%–56% combined acetic acid content and similar substances, can be carried out by depositing a solution of the web forming material on to a rotating drum, evaporating the solvent during partial revolution, and continuously stripping the resulting set web therefrom. The conventional method of depositing the "dope" (solution of the substance to be sheeted) is to extrude it on to the moving casting surface through a slit whose length corresponds to the width of the web being formed. Usually the hopper (reservoir for the dope about to be cast) lips which delineate the slit are adjustable so that the extrusion orifice may be conveniently narrowed or widened.

The moving surface on to which the dope is cast, whether it be a wheel or endless belt, must be prepared with a great deal of care in order to present a true running surface which will maintain constant at all times throughout its width the distance to the extrusion lips. The surface must be uniformly hard and uniformly polished, so that no imperfection will be transferred to the film dried thereon. Such surfaces are usually formed of nickel, and when such is the case, in order to give the surface the necessary hardness, high density and extremely fine grain structure, it is formed by a slow electroplating process which may require a period of weeks or even months to build up a satisfactory thickness of plating metal. The surface must then be trued by gringing with successively finer grinding materials, and finally polished to a mirror-like finish. Such factors as slow motion, light abrasive pressure, hard abrasive stone and suitable lubricating material properly combined, have been very helpful in securing the required finish. It is obvious, therefore, that a casting wheel or belt is an extremely expensive item in the building of a plant for producing sheet material by the aforementioned casting method.

Damage to the casting surface is a very serious and expensive matter. If a replacement casting surface is not available, the plant must be shut down until the casting surface can be reconditioned. It would of course be possible to provide equipment suitable for rehabilitating the casting surface in place, but such apparatus is very expensive, and affords practically no cost advantage over a replacement. It is obvious, therefore, that means for making the costly and time consuming replacements or repairs more infrequent is a great desideratum in this field.

The most frequent source of stoppage when operating with a clearance of 0.01 to 0.02 inch between the wheel surface and casting device, is marring of the casting surface. Gouging and scratching (both deep and microscopic) of the casting surface and/or hopper lips occur so frequently that it is almost impossible to operate a casting surface for an extended period of time. It has now been discovered that raising the extrusion slit from the casting surface inordinately reduces, or completely eliminates, the scratching and gouging. An attendant advantage to raising the extrusion slit is that the lips thereof can be moved farther apart. A wider slit makes inequalities in lip surface and/or adjustment less critical. When the lips are close together, scratches and other slight inequalities may make very noticeable (and undesirable) inequalities in the cast web.

Heretofore there has been no way of utilizing this discovery, since raising the extrusion slit from the casting surface causes the edges of the cast web to thicken into beads several (ordinarily two to eight) times as thick as the main portion of the web. The heavily beaded edges require a much longer time for the evaporation of the solvent, with the result that production is greatly decreased because the casting surface must be slowed to a speed commensurate with the drying time of the beaded edges. With the heavy casting solutions there is the additional disadvantage of "hooking" (the formation of ragged edges on the cast film).

This invention has for an object the provision of an improved method and apparatus for dry casting continuous webs from film-forming solutions. Other objects were to produce improved sheet material, to produce films free from striations, and to produce continuous webs without beaded edges of excessive size. Still other objects were to greatly increase the speed of castings, and to greatly extend the life of the casting surface between refinishing operations. Yet another object was to overcome the disadvantages resulting from increasing the distance between the extrusion slit and the casting surface. A general advance in the art, and other objects which will appear hereinafter, are also contemplated.

It has now been found that the casting hopper

in dry casting apparatus can be spaced from the casting surface a distance sufficient to prevent scratching of the casting surface and the hopper lips, without the formation of ragged edges or undesirable thickened edges in the cast film, if the extrusion slit is extended a short distance into the block which closes the end of the extrusion slit, and the exit surface of the said extension of the extrusion slit is maintained much closer to the casting surface than the exit surface of the main portion of the extrusion slit.

From the following description, in which is disclosed certain embodiments of the invention as well as details of what is believed to be the best mode for carrying out the invention, it will be apparent how the foregoing objects and related ends are accomplished. The written description is amplified by the accompanying drawings, in which:

Figure 1 is a diagrammatic perspective view, partly in section, showing a portion of a continuous web dry casting apparatus incorporating the end block of this invention;

Figure 2 is a diagrammatic end elevation view partly in section of a casting hopper showing its relation to the end block;

Figure 3 is a diagrammatic end elevation view partly in section of a portion of the casting hopper lips, showing the relation of the same to the end block and their positions relative to the casting surface;

Figure 4 is a front elevation view partly in section of the end block and adjoining hopper lips of Figure 3;

Figure 5 is a bottom view of the end block and hopper lips shown in Figures 3 and 4;

Figures 6 and 7 are views corresponding to Figures 4 and 5 of a modified form of end block;

Figures 8 and 9 are views corresponding to Figures 4 and 5 of another modified form of end block; and

Figures 10 and 11 are views corresponding to Figures 4 and 5 of still another modified form of end block.

Similar characters refer to similar parts throughout the several views.

Referring to the drawings, particularly Figures 1, 2, 3, 4 and 5, the numeral **1** indicates a thin web which has been cast on the surface of the casting wheel **11** from the casting hopper **21**. The front lip of the casting hopper is indicated at **22**, and the rear lip is indicated at **23**. The end block of this invention is shown at **31**.

The casting wheel comprises an outer cylindrical shell having internal flanges, one of which is indicated at **12** in Figure 1. This flange is bolted to a supporting disc member **13** by means of bolts **14**. A driving gear **16**, secured thereto by means of bolts **17**, drives the casting drum at the desired speed. A fixed hollow shaft **10** supports the rotating drum and gear through bearing sleeve **15**. Power is supplied through shaft **20** and pinion **19** to the gear **16**. The cast web is stripped from the casting surface by the idler roll **18**, which passes it on to a suitable wind-up or other collecting mechanism.

As is shown in Figures 2, 3 and 4, the end block **31** is recessed at **32** to provide a continuation of the extrusion slit. As will be clear from these figures, that portion of the exit surface of the extrusion slit in the end block is closer to the casting surface **11** than that portion defined by the front and rear lips **22** and **23** on the casting hopper.

It is not necessary that the end block extend perpendicular to the casting surface after it leaves its junction with the hopper lips. It may extend away from the lips in a straight line at various angles. It may also curve from its exit surface up to the exit surface of the hopper lips.

Three modifications of this type are illustrated on page 2 of the drawings. In Figures 6 and 7, the exit surface of the casting slit of the end block **311** joins the hopper lips through the curved surface **60**. In Figures 8 and 9 the surface **80** in the end block **312** performs the corresponding function. This surface is at an angle of 45° with the exit surfaces of the end block and the hopper lips. In the modifications shown in Figures 10 and 11, the concave surface **100** of the end block **313** serves a similar purpose.

The angle which the slits in the end blocks (and the extrusion slit) make with the casting surface can be varied from that shown in Figure 3. Usually it slopes downward in the direction of movement of the film.

Extrusion hoppers of the pressure type, i. e., hoppers in which the web-forming solution in the hopper is under super-atmospheric pressure, are preferred to those of the gravity type. Pressures of several pounds per square inch are generally used. The specific pressure employed depends upon the viscosity of the casting solution, and is coordinated with the concentration of solids in the casting solution, the specific solvents (one or more organic liquids) used, the type of sheet material being cast, and other well known factors. A very desirable range of pressures for the casting hopper is 10 to 100 pounds per square inch (or even more). When casting at 400 to 500 inches per minute, a cellulose acetate (56% combined acetic acid) solution in acetone containing about 35% total solids and having a viscosity of about 600 poises, can be cast through a slit opening of about 0.015 inch at a pressure of 25 pounds per square inch, very satisfactorily.

In the drawings, the distance from the exit surface of the end block slit to the casting surface is indicated by the letter y, and the distance between the exit surface of the hopper lips and the casting surface is indicated by the letter x. It is generally advisable to have the ratio of the distance y to the distance x of the order of about 1:3. If the distance from the end block to the casting surface (y) is relatively large, for example 0.02 inch, this ratio may in some instances be no greater than 1:2. If the distance y is as small as 0.01 inch, the ratio may be as much as 1:6, or even 1:8 or possibly more. In the device of Figures 3, 4 and 5, a value for y on the order of 0.01 to 0.02 inch would operate well with a value for x at least 2 or 3 times as great or thereabouts, for example, 0.04 to 0.08.

The lengths of the extrusion slit in the end block (extension of the extrusion slit) may vary widely, but in general it need only be a fraction of an inch, for example, ¼ inch. In casting a web 50 inches in width, a slot in each end block only ⅛ inch long is very satisfactory.

Generally, good results are secured when the width of the slit in the end block is somewhat less than the width of the slit between the front and rear lips of the casting hopper, but the extension of the extrusion slit into the end block may be the same width as the main portion of the extrusion slit and still give satisfactory results. Reducing the width of the slit in the end blocks decreases the amount of solution extruded at these places, and this aids in reducing the thickness of the edge of the cast film. Mechanical wedges in the

end block slits can be used to control the amount of solution issuing therefrom, and this expedient has been found desirable when the end lips are the same width as the main hopper slit. For a lip opening adjusted to 0.015 inch, an end block slit width in the neighborhood of 0.012 inch is preferred.

The invention is applicable to web-forming solutions of various concentrations and of various viscosities, but the most beneficial results have been noted when the concentration is high, for example, over 30% total solids, and the viscosity is relatively high, for example, 300 to 400 or more poises.

The invention may be applied to extrusion dry casting of any web-forming material of any reasonable thickness. It is especially beneficial in the dry casting of thin sheeting such as would be suitable for wrapping purposes, for example, sheeting having a thickness of 0.0005 to 0.003 inch.

The invention is especially applicable to the dry casting of continuous web from solutions of organic cellulose derivatives, particularly such substitution derivatives as cellulose esters (cellulose acetate, cellulose acetate propionate, cellulose acetate butyrate and cellulose propionate), and cellulose ethers (ethyl cellulose and benzyl cellulose). Cellulose acetate of 56% combined acetic acid content, and ethyl cellulose of 48% ethoxyl content, cast according to this invention, make very satisfactory sheet wrapping materials. The invention can also be satisfactorily used in connection with the dry casting of solutions of vinyl polymers (polyvinyl alcohol, polyvinyl acetals, polyvinyl alcohol esters, etc.). The vinyl chloride, vinyl acetate interpolymers, rubber hydrochloride, and like film-forming solutions, also merit special mention, as do synthetic linear polymers such as those disclosed in U. S. A. Patents No. 2,071,250, 2,071,252 and 2,071,253 (Carothers).

Cellulose derivatives requiring a coagulation treatment may also be formed into webs by means of this invention. Viscose (cellulose xanthate solution), cellulose formate solutions, lowly esterified cellulose solutions and lowly etherified cellulose solutions (U. S. A. Patent No. 2,123,883 to Ellsworth) may be dry cast into webs in accordance with this invention and then subsequently regenerated by treatments with heat, regenerating baths, or any other desired means.

Materials which facilitate removal of the web (foil, film, sheet, tissue) from the casting surface (strip agents), may be incorporated in the casting dope, if desired.

Other modifying substances, such as plasticizers may also be added to the casting dope.

In the preferred mode of operation, the film is stripped from the casting wheel while it still contains 5% to 15% of the solvent. In all cases the major portion of the solvent should be removed before stripping the film.

The truest running characteristics for the casting wheel have been obtained when the shaft 20 was driven by a conventional speed reducer, which in turn was driven by a geared motor.

When desired, a heating or cooling medium, such as water, may be supplied and removed from the interior of the casting wheel through the hollow shaft 10.

Any desired means can be utilized for varying the size and position of the hopper extrusion slit. One method which involves controlling the position of the two adjustable parallel hopper lips in relation to each other and the casting surface, is illustrated in U. S. A. Patent Application Serial No. 218,125 (Eberlin).

The hopper lips are usually bolted to the hopper, and outline 90% or more of the extrusion slit. The end blocks are usually secured secured to the hopper lips by means of stud bolts in such a way that the solution channel therein communicates with the main solution channel between the lips.

Air is the most economical evaporative medium for removing the solvent from the cast film, but, as will be obvious, other environments may be employed.

The main advantages of the present invention are believed to be obvious from the foregoing. Since the hopper lips are spaced at a substantial distance from the casting surface, less trouble, such as scratching of the lips and casting surface, will be encountered. For the same reason, precise control of the opening between the lips is much less critical, so that minor scratches and minor imperfections on the lips have no harmful effect on the cast product. Any striations or film marks due to imperfections in the finish of the slots in the two end blocks are of no consequence, since these end zones constitute at most a very minor portion of the film, and are normally slit from the film as it is being wound up on the mill roll.

Because of the greater latitude possible in all these adjustments, the present invention can be used for casting many solutions that could not be satisfactorily cast into thin films (of the order of 0.001 inch) heretofore. The amount of lost production due to shut-downs for repairs, and the cost of maintenance, are very greatly reduced. In addition, dry casting at much higher speeds over longer periods of time, are now possible. The investment per unit weight of production is reduced to an important extent, due to the increase in speed possible by the more rapid drying of the film when the thickness of the edge bead is reduced as above described.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that this invention is not limited to the specific embodiments thereof except as defined in the appended claims.

I claim:

1. In a film or sheet forming device for use with film forming solutions of high surface tension which tend to contract, a hopper having a coating slot therein for feeding a film forming solution to a moving film forming surface positioned thereunder, relatively narrow solution guide members positioned at the ends of the slot extending from the slot downward toward, but out of contact with, the film forming surface for guiding the solution to the film forming surface in a stream substantially the width of the length of the slot.

2. In a film or sheet forming device for use with organic solvent soluble cellulose acetate film forming solutions of high surface tension which tend to contract, a hopper having a coating slot therein for feeding a film forming solution to a moving film forming surface positioned thereunder, relatively narrow solution guide members comprising channels constituting extensions of the ends of the slots positioned at the ends of the slot extending from the slot downward toward, but out of contact with, the film forming

surface for guiding the solution to the film forming surface in a stream.

3. In a film or sheet forming device for use with organic solvent film forming solutions of high surface tension which tend to contract, a hopper having a coating slot therein for feeding a film forming solution to a moving film forming surface positioned thereunder, relatively narrow solution guide members positioned at the ends of the slot extending from the slot downward toward, but out of contact with, the film forming surface for guiding the solution to the film forming surface in a stream substantially the width of the length of the slot, said guide members comprising channels constituting extensions of the ends of the coating slot, the exit edges of said channels being parallel to the casting surface at their nearest approach to the said casting surface and said edges being joined to the edges of the hopper coating slot by a concave channel exit.

4. In a film or sheet forming device for use with organic solvent film forming solutions of high surface tension which tend to contract, a hopper having a coating slot therein for feeding a film forming solution to a moving metallic film forming surface positioned thereunder, relatively narrow solution guide members positioned at the ends of the slot extending from the slot downward toward, but out of contact with, the film forming surface for guiding the solution to the film forming surface in a stream substantially the width of the length of the slot, said guide members comprising channels constituting extensions of the ends of the coating slot, the exit edges of said channels being parallel to the casting surface at their nearest approach to the said casting surface and said edges being joined to the edges of the hopper coating slot by a plane channel exit.

5. In a film or sheet forming device for use with organic solvent film forming solutions of high surface tension which tend to contract, a hopper having a coating slot therein for feeding a film forming solution to a moving wheel film forming surface positioned thereunder, relatively narrow solution guide members positioned at the ends of the slot extending from the slot downward toward, but out of contact with, the film forming surface for guiding the solution to the film forming surface in a stream substantially the width of the length of the slot, said guide members comprising channels constituting extensions of the ends of a coating slot, the exit edges of said channels being parallel to the casting surface at their nearest approach to the said casting surface and said edges being joined to the edges of the hopper coating slot by a reverse curve offset channel exit.

6. In a film or sheet forming device for use with organic solvent film forming solutions of high surface tension which tend to contract, a hopper having a coating slot therein for feeding a film forming solution to a moving film forming surface positioned thereunder, relatively narrow solution guide members comprising channels constituting extensions of the ends of the slot positioned at the ends of the slot extending from the slot downward toward, but out of contact with, the film forming surface for guiding the solution to the film forming surface in a stream substantially the width of the length of the slot, said channels being of less width than the slot.

7. In a film or sheet forming device for use with organic solvent film forming solutions of high surface tension which tend to contract, a hopper having a coating slot therein for feeding a film forming solution to a moving wheel film forming surface positioned thereunder, relatively narrow solution guide members comprising channels constituting extensions of the ends of the slot positioned at the ends of the slot extending from the slot downward toward, but out of contact with, the film forming surface for guiding the solution to the film forming surface in a stream substantially the width of the length of the slot, the said slot having a width of about 0.015 inch and the said channels having a width of about 0.012 inch.

8. In a film or sheet forming device for use with organic solvent film forming solutions of high surface tension which tend to contract, a dry casting hopper for casting film having a thickness in the range of from about 0.0005 inch to 0.003 inch having a coating slot therein for feeding a film forming solution to a moving film forming surface positioned thereunder, relatively narrow solution guide members comprising channels constituting extensions of the ends of the slot positioned at the ends of the slot extending from the slot downward toward, but out of contact with, the film forming surface for guiding the solution to the film forming surface in a stream substantially the width of the length of the slot, the said coating slot constituting at least 90% of the extrusion slit and the side end channels being of less width than the slot.

9. In a film or sheet forming device for use with organic solvent film forming solutions of high surface tension which tend to contract, a dry casting hopper for casting film having a thickness in the range of from about 0.0005 inch to 0.003 inch having a coating slot therein for feeding a film forming solution to a moving film forming surface positioned thereunder, relatively narrow solution guide members comprising channels constituting extensions of the ends of the slot positioned at the ends of the slot extending from the slot downward toward, but out of contact with, the film forming surface for guiding the solution to the film forming surface in a stream substantially the width of the length of the slot, the said coating slot constituting a least 90% of the extrusion slit, the length of the slot in the said guide members not exceeding ¼ inch and the said channels being of less width than the slot.

10. In a film or sheet forming device for use with organic solvent film forming solutions of high surface tension which tend to contract, a dry casting hopper for casting film having a thickness in the range of from about 0.0005 inch to 0.003 inch having a coating slot therein for feeding a film forming solution to a moving film forming surface positioned thereunder, relatively narrow solution guide members comprising channels constituting extensions of the ends of the slot positioned at the ends of the slot extending from the slot downward toward, but out of contact with, the film forming surface for guiding the solution to the film forming surface in a stream substantially the width of the length of the slot, the said coating slot constituting at least 90% of the extrusion slit, the length of the slot in the said guide members being ⅛ inch and the said channels being of less width than the slot.

CHARLES W. SHIELDS.