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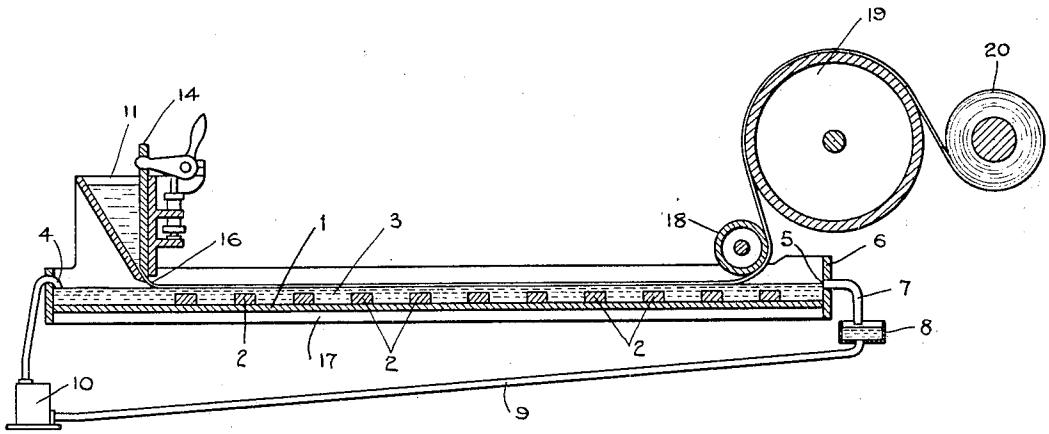

JAMES F. WALSH
JOHN H. STEVENS
KIRTLAND FLYNN
AMERIGO F. CAPRIO
THOMAS E. ALCORN

INVENTORS

BY Selby & Swinson
ATTORNEYS

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JAMES F. WALSH, OF EAST ORANGE, JOHN H. STEVENS, OF SOUTH ORANGE, KIRTLAND FLYNN, OF ORANGE, AMERIGO F. CAPRIO, OF NEWARK, AND THOMAS E. ALCORN, OF MAPLEWOOD, NEW JERSEY, ASSIGNORS TO CELLULOID CORPORATION, A CORPORATION OF NEW JERSEY

APPARATUS FOR MAKING FLOWED FILMS AND SHEETS

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This invention relates to a process of making flowed films or sheets and is particularly directed to a continuous process for producing such films. It is especially directed to the production of sheets or films made from or containing cellulose or cellulose derivatives, the latter being either organic or inorganic in nature.

Heretofore it has been customary to produce films or sheets of cellulosic materials by pouring more or less viscous solutions of the cellulosic materials upon a polished surface of glass or other suitable material. Also such films and sheets have been made by pouring the cellulosic solution upon a belt or wheel with a high finished surface, preferably of metal. In all of these processes the surface upon which the dope solution is formed are rigid and subject to much wear and tend to become corroded and/or pitted. In view of this fact they must be renewed or refinished frequently in order to yield satisfactory films. These frequent renewals of the film forming surfaces together with the limitations imposed by the use of a rigid and fixed surface have greatly curtailed the output of films and sheets with the consequent increase in their cost.

An object of our invention is to provide a process for the continuous production of sheets or films. Another object of our invention is to provide a new medium for use as a film forming surface. Still another object of our invention is to devise a process wherein a moving liquid medium, specifically metallic mercury, can be utilized as a film forming surface. Other objects and advantages of our invention will appear hereinafter in the description and claims.

We have found that improved films and sheets of celluloid like materials can be produced from more or less viscous solutions of cellulose or cellulose derivatives if the solution is poured or delivered onto a moving liquid bed or bath. The liquid employed should, of course, be of such a nature that it will have no deleterious effect upon or be affected by the cellulosic solution which is employed for the film formation. The bath will have to be of such a nature that its composition will not be changed by the solvent present in the cellulosic solution in order to insure a film which will be uniform in composition and in physical appearance and also to enable the liquid to be continuously recirculated through the system.

Metallic mercury has been found by us to meet all these requirements and to yield excellent films or sheets when used as the film forming surface. Its great mobility and its smooth, high-glossed surface, together with its inertness towards the solvents usually employed in the manufacture of films and sheets of cellulosic materials make it especially suitable for the process at hand.

Instead of mercury a low melting alloy can be used, particularly when it is desired to effect a rapid evaporation of a solvent. For example such an alloy could be employed where the resulting film or sheet, containing some residual solvent, is rolled or piled up into a "chase" and consolidated into a block under heat and pressure, as is often done in the cellulose plastic art. Also such a low melting alloy could be utilized when solvents of high boiling points or low volatility are employed.

As an example of such an alloy the following may be given:

	Per cent
Lead	25.0
Tin	12.5
Bismuth	50.0
Cadmium	12.5

This alloy has a melting point of about 55° C. and was found to give good results when employed in the place of mercury. Other suitable low melting alloys can also be used.

The process is carried out by depositing the ribbon or sheet of cellulosic solution on a moving body of metallic mercury. The dope is preferably deposited on to the mercury as the solution issues from a hopper and, due to the smoothness of the mercury surface and the fact that the mercury is continuously moving away from point at which it receives the sheet or film, a sheet or film of uniform thickness and high gloss is obtained. The thickness of the sheet or film can be varied as desired by increasing or

lowering the speed of travel of the mercury bath as well as by varying the thickness of the ribbon or dope issuing from the hopper.

In the accompanying drawing, showing means for carrying out this invention, the figure is a sectional diagrammatic view showing one arrangement of apparatus for producing the films and for winding up finished product.

In the drawing, forming a part of this specification, 1 represents a trough with baffle plates 2, 2 arranged along its base and sides to insure a uniform flow of mercury, 3, in the trough. The mercury is fed into the trough through inlet 4 and due to the fact that the trough is elevated at the inlet end, the mercury will flow through the trough over the baffles 2, 2 toward the outlet or outlets 5, in the end plate 6. The mercury is drawn off through an overflow pipe or pipes 7 and is fed to overflow tank 8. The mercury is then recirculated through conduit 9 and mercury pump 10, the latter delivering the mercury to the inlet 4.

The hopper 11, containing the dope or solution 12, is arranged with a slit like outlet 13 in proximity to the surface of the traveling mercury. The hopper is provided with a gate 14, manipulated by the lever arrangement 15 to vary the width of the opening 13, through which the curtain or sheet of dope 16 is delivered. The trough 1, is provided with a compartment 17 in which heating means may be installed or through which a heating medium may be passed to maintain the mercury at elevated temperatures in order to facilitate the evaporation of the solvent in the dope solution.

The stripping roll 18 is positioned near the outlet end of the trough 1 and takes up the film from the surface of the mercury. The film thus taken up is passed from the roll 18 to the drying drum 19 and thence to the winding spool or drum 20. One or more drying rolls may be used as desired and the film or sheet may be passed over several rolls similar to 18 before being passed to the drying drum or drums.

In operating in accordance with our invention we proceed as follows. Upon a surface of metallic mercury of sufficient depth and so arranged that it will flow of its own level-seeking tendency a broad sheet or ribbon of a solution of cellulosic materials is deposited, the supply of dope being regulated in accordance with the thickness of sheet or film desired, the rate of travel of the mercury, the volatility of the solvent employed, etc. Where deemed advisable the flow of the mercury can be accelerated by utilizing submerged propelling devices in the mercury bath. In such an event care must be taken that the smoothness of the mercury surface is not destroyed or disturbed. A natural flow induced solely by the inclination of the trough and the draw off means at the lower end of the trough is preferable, since it makes it possible to operate with a much shallower depth of mercury in the bath and also because it reduces the possibility of distortion or rippling on the mercury surface.

The uniform forward moving of the mercury is insured by the proper distribution of the baffles 2, 2 for instance, by spacing the same about a foot apart along the length of the trough. These baffles, of course, are sufficiently narrow or shallow so as to permit the mercury to completely cover the same. This arrangement of baffles overcomes or counteracts the usual tendency of liquid steams to move at a greater rate of speed in the centre than at the sides.

The constant forward moving of the mercury bath serves to uniformly draw the dope solution from the hopper outlet and as the sheet or film moves forward the solvent evaporates, leaving the comparatively dry sheet or film on the surface of the mercury. This evaporation of the solvent can be expedited by maintaining the mercury at elevated temperatures in any desired manner.

The film or sheet, in more or less dried condition, is removed from its mercury support by means of the stripping roll. If the sheet or film has a sufficiently low percentage of solvent remaining therein it may be passed directly to the drying drum or drums, otherwise it should first be passed over one or more additional rolls similar to 18 until it is sufficiently free of solvent and then passed to the drying drums. Having attained the degree of dryness desired on the heating drums the sheet or film is collected on the winding roll 20. The sheet or film thus obtained can be further dried or seasoned or treated in any other manner as is well known to those skilled in the art.

The present process is applicable to various dopes and viscous solutions made from or containing a cellulosic base, whether the same is cellulose or one or more of its derivatives, such as, for example, pyroxylin, acetyl cellulose, viscous, ethyl cellulose, etc. The term "cellulose derivatives" as used in the description and claims is used to include the esters and ethers of cellulose as well as cellulose itself, regenrated or otherwise.

The dopes or solutions of the cellulose derivatives employed can be produced by utilizing any suitable solvents or mixtures of solvents for the specific cellulose derivatives or derivatives employed. Where desirable, depending upon the use to which the final product is to be put, the solvent or solvents employed may be modified by suitable restraining agents in the form of selected organic compounds or they may have incorporated therein plastifiers for the particular cellulose derivative used. Also inflamma-

bility reducing agents or fire retardants can be incorporated in the dope where such addition will not interfere with the flowing or feeding of the film onto the mercury surface.

The size of the trough 1, or the mercury bath will vary, depending upon the width and length of the film or sheet desired. Where a thin sheet or film is desired the length of travel on the mercury bed will not have to be as long as it will be for a thick film or sheet. A suitable length for the mercury bath has been found to be 45 feet, permitting the maintenance of a sheet or film of about 40 feet in length on the bath. This length gives the sheet or film ample time to dry and set sufficiently to enable it to be stripped from the mercury bed.

The following is given as an example of a suitable embodiment of our invention for the production of a cellulose acetate film approximately .005 inches thick.

The cellulose acetate dope, utilizing a rapidly drying solvent medium, was poured onto a moving mercury bed of approximately 45 feet in length and 28 inches in width. The rate of travel of the mercury bed was 120 feet per hour and the film in process of deposition and setting was 40 feet long and 22 inches wide. These conditions allow twenty minutes for the setting and drying of the film from the time of its delivery from the hopper to the point of stripping from the mercury bed.

As stated above, the conditions above set out are illustrative only, the dimension of the trough, time of setting, rate of travel, etc., being variable depending upon the size and thickness of the sheet desired, the nature of the solvent employed, the temperature of the bath, etc. Thus where a thicker sheet or film is desired the rate of flow of the mercury can be lower and/or the length of the bed increased.

It will be seen that our invention makes it possible to form films and sheets on plane or substantially flat surfaces in place of wheels, belts, etc. This offers a great advantage, particularly when comparatively thick sheets or films are desired. These thicker sheets or films require more time for setting and drying than is possible to be attained on the curved surface of a wheel. This premature removal of the film support very frequently results in a sagging or distortion of the film or sheet due to insufficient time having been allowed it to set. Although thick sheets or films are usually produced on belts of similar surfaces these also have been found objectionable, because of the tendency of the bath to sag or sway from a level position. These difficulties are all overcome by the use of a mercury or other liquid bath in accordance with our invention for the mercury or other liquid is always level or substantially so. The employment of a liquid or mercury bath has the further advantage that its motion is more smooth and uniform than that of a belt mechanically driven.

The uniform forward motion of the mercury is accomplished, as previously stated, by slightly tilting the trough in the direction of its length and further by providing several draw-offs at the lower end of the trough. To further insure that the liquid or mercury will travel forward uniformly, at least along that part of its surface which is in contact with the film or sheet, the mercury surface should be of sufficient width that there will be at least 3 inches of unused mercury surface on each side of the film. This will minimize the tendency of a higher rate of central flow of the mercury and will supplement the effect of the baffles 2, 2.

The process utilized in accordance with our invention is not limited to moving the mercury bed forward in the manner above set forth. Any means which will not distort or disturb the smooth surface of the mercury can be utilized. For example, the mercury might be carried forward on a traveling belt suitably sectioned to hold the mercury level until it passes beyond the stripping point and also provided with sides to retain the mercury. Also it is possible to impart the forward motion to the mercury by installing propelling devices in the body of the mercury as previously indicated.

Our invention has the further advantage that it not only makes it possible to produce uniform sheets or films of any size but the products obtained are superior to sheets or films obtained as a result of present modes of manufacturing.

Also since it does away with the constant renewal and refinishing of the highly polished surfaces now necessary for film manufacture, it lowers the cost of production considerably. Another decided advantage resulting from our invention is the fact that all thicknesses of sheet or film can be produced by this method, whereas, comparatively thin sheets only can be produced where a wheel is used as the film forming surface.

The terms "sheets" and "films" are used interchangeably since the production of sheeting of various thicknesses by the present process is contemplated. The term "sheets" as used in the claims is therefore to be interpreted as including films as well as sheets. The term "spreading" as used in the claims embraces within its scope any suitable means of depositing the sheet forming solution onto the moving bath, whether the same be by flowing, dropping or spraying.

Having described our invention, what we claim and desire to secure by Letters Patent is:

1. Apparatus for the production of sheets which comprises in combination an inclined trough, a liquid sheet-supporting surface, a reservoir adapted to contain the sheet forming solution and a stripping roll adapted to remove the sheet from the sheet-supporting surface.

2. Apparatus for the production of sheets which comprises in combination an inclined trough, a liquid sheet-supporting surface, a reservoir adapted to contain the sheet forming solution, a stripping roll adapted to remove the sheet from its support, drying means to effect the final drying of the sheet and a roller on which the dried sheet is collected.

3. Apparatus for the production of sheets which comprises in combination an inclined trough provided with an inlet and outlets, a liquid sheet-supporting surface, a reservoir adapted to contain the sheet forming solution and a stripping roll adapted to remove the sheet from the sheet-supporting surface.

4. Apparatus for the production of sheets which comprises in combination an inclined trough provided with an inlet and outlets, a liquid sheet-supporting surface, a reservoir adapted to contain the sheet forming solution, a stripping roll adapted to remove the sheet from the sheet-supporting surface and a pump for receiving the liquid medium from the trough outlet and returning the same to the trough inlet.

5. Apparatus for the production of sheets which comprises in combination an inclined trough provided with baffles and an inlet and outlets, a liquid sheet-supporting surface, a reservoir adapted to contain a sheet forming solution and a stripping roll for removing the sheet from the sheet-support.

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