

Jan. 11, 1955

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2,698,967

PRODUCTION OF REGENERATED CELLULOSE FILMS AND SHEETS

Filed Jan. 19, 1951

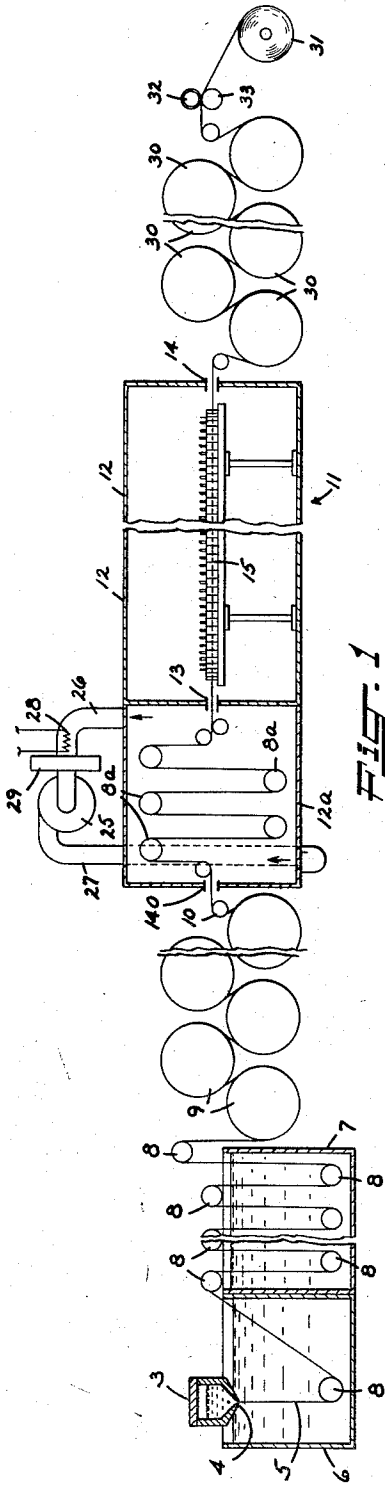


FIG. 1

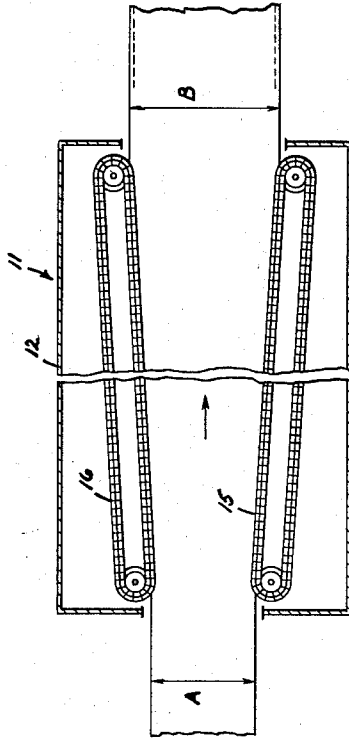


FIG. 2

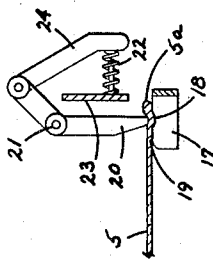


FIG. 3

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PRODUCTION OF REGENERATED CELLULOSE FILMS AND SHEETS

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Application January 19, 1951, Serial No. 206,824

5 Claims. (Cl. 18—57)

This invention relates to the production of regenerated cellulose films, sheets and pellicles and is particularly concerned with the production of pellicles of this type having improved characteristics, especially those of strength, swelling, and shrinkage, both transversely and longitudinally, as well as substantial uniformity in thickness.

In the conventional system for the production of regenerated cellulose pellicles from viscose or other cellulosic solution, such as cuprammonium cellulose, the film-forming solution is extruded into a coagulating and/or regenerating bath through a narrow slot, the width of which in commercial practice is tapered down to an even narrower width at each end in order to substantially prevent the formation of thickened longitudinal edges on the pellicle, commonly referred to as a "bead." The film is drawn from the extrusion slot through a series of treating liquids, generally by the use of suitably disposed guiding rolls, at least some of which are positively driven to draw the pellicle through the system. Some of the rollers are disposed above the baths for transferring the film from one to another of the baths and some are disposed in the baths to provide a zig-zag path of travel for the film through the baths thereby enabling the film to pass a considerable distance through such baths while economizing on space. The nature of the baths depends upon the particular type of film-forming solution used. For example, when it is of viscose, the pellicle may pass from the coagulating and/or regenerating bath into a regenerating bath to substantially complete the regeneration, then to suitable washing, desulfurizing, bleaching, neutralizing, and softening baths which follow one another in sequence in conventional manner. Because of the force exerted upon the film by the driving rollers, the film is tensioned in the machine direction, that is longitudinally, and depending upon the rate of speed through the baths, the number of rollers, the length of travel through the baths, and the particular disposition of the rollers therein, more or less stretching may be effected upon the film. The amount of stretch thus inherently imparted to the film in a longitudinal direction may vary from as low as 5% to as high as 50% or more elongation relative to the initial length of the film. After passing through the liquid treatment baths, the film proceeds in a sinuous path about a series of drying rolls which may be heated internally and/or may be disposed in a closed chamber through which a heated fluid medium is circulated. At least some of these rolls are driven and the tension produced longitudinally in the film prevents any shrinkage thereof longitudinally. However, some transverse shrinkage occurs and it has been found that the extent of transverse shrinkage varies across the width of the film in proportion to the distance from the center thereof, the outer marginal portions shrinking the most. One serious disadvantage of the use of a slot with tapered ends is the fact that the edges are weakened and tear easily. When a tear starts from the edge, it progresses almost instantly across the entire pellicle interrupting the operation of the machine.

The product obtained at the completion of the drying step is found to have distinctly different properties transversely and longitudinally. For example, the marginal areas, especially the outer 3- to 5-inch widths, do not lie perfectly flat relative to the central area. Instead, they have a slight wavy disposition caused by the fact that the central section of the film when measured longitudinally or in the machine direction is shorter than the marginal areas. This is apparently attributable to the fact that the thinner sections near the ends of the material extruded

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set up more quickly than the thicker central section in the coagulating and/or regenerating bath and do not have the opportunity to shrink therein to the same extent as the thicker and more slowly set-up central section. Also, the tapering width of each end portion of the extrusion slot produces edges which are not straight and parallel but have an irregular wavy form. It has also been found that frequent longitudinal ridges or striations are formed in the marginal areas of the pellicle apparently the result of the tapered ends of the extrusion slot.

Furthermore, when the dry film is wet out with water, an irregular swelling occurs in which the transverse dimension may increase as much as 30% whereas the longitudinal dimension may shrink as much as 10%. The marginal portions also have lower tensile strengths and less resistance to rupture or tearing than the central area.

Numerous proposals have been made previously to impart greater uniformity to the regenerated cellulose pellicles, especially to reduce the anisotropic characteristics pointed out hereinabove. Among them are those which suggest transversely stretching the pellicle while it is still in the wet gel condition prior to any drying thereof. These procedures have the disadvantages that the stretching is effected upon the film while it is in a rather weak and delicate condition and unless special care and equipment is used for effecting such transverse stretching, it cannot be satisfactorily and reliably effected upon a continuously travelling film. Furthermore, during the drying, the irregular shrinkage from the center to the edges of the film still occurs and longitudinal tension is unavoidable when dried on a series of heated rollers.

Another process involved transversely tensioning the film throughout the drying between edge-gripping belts. This has the disadvantage of requiring a special drying equipment to provide for properly controlled tracking of the belts therethrough. Otherwise, the lateral shrinkage forces tend to displace the belts axially along the rollers toward the center of the film. Also, up to 6 inches of each edge of the film may be damaged and require removal.

The principal object of the present invention is to provide an improved procedure for reducing the anisotropic properties of the regenerated cellulose film in a novel and improved manner. A further object is to provide a procedure for producing regenerated cellulose pellicles which is accompanied with no sacrifice in strength that is normally derived from the longitudinal tensioning of the film as it proceeds through the machine. A further object is to provide an improved process for producing regenerated cellulose films having improved characteristics which requires relatively simple changes in the equipment conventionally employed for the production of such films. Other objects and advantages of the invention will be apparent from the drawing and the description thereof.

The improved procedure of the present invention is based upon the use of an extrusion slot having a uniform width throughout its length and upon the discovery that at a certain narrowly limited range of moisture content of the film produced from such a slot in an otherwise conventional system as described hereinabove, there apparently occurs a critical balance between the combined tensile strength and thickness factors of the central portion of the pellicle and the tensile strength and thickness factors of the marginal areas. This critical balance, which occurs when the film contains from 12 to 15% moisture (based on the total weight of the humidified cellulose film), is such that the marginal areas of the sheet have a lower resistance to elongation than the central areas so that the major effect of transverse tension at this stage causes an extension of the several unit areas extending widthwise of the sheet which is generally proportional to the distance of the unit areas from the center of the sheet. At this critical stage of moisture content, it has been found that the differential transverse shrinkage produced in the previous drying can be partially or entirely compensated, as desired, by the transverse stretch and the transverse elongation thereby effected substantially remains in the film during the subsequent drying to the moisture content desired in the final product.

The drawing illustrates a system for executing the invention.

In Figure 1, there is shown a diagrammatic side elevation of the system,

Figure 2 shows a plan view of the transverse stretching stage diagrammatically, the extent of stretching being somewhat exaggerated, and

Figure 3 is a detail view showing a form of tenter clip that may be used.

Figure 1 shows a hopper 3 which feeds the film-forming solution, such as viscose, through a slot orifice 4 in the extrusion device disposed at the bottom of the hopper. It is characteristic of the present invention that the width of the slot is constant throughout its length to produce the necessary thickness throughout the width of the film to adapt the film to the subsequent transverse stretching that constitutes another of the vitally important elements of the present invention. Ancillary advantages are also derived from the uniform slot including a greatly reduced frequency of the occurrence of tears and breaks which interrupt operation, and also the substantial elimination of the longitudinal ridges and striations. The film 5 proceeds downwardly through the coagulating and/or regenerating bath in the container 6 and then through a series of treating baths such as that shown contained in the vessel 7. Passage through the various liquid-treating baths is facilitated by means of rollers 8 at least some of which, preferably those above the baths, being positively driven. If desired, stationary rods may replace the rollers disposed in the baths. Generally, the rollers 8 are all driven at substantially the same speed unless it is desired to deliberately introduce longitudinal stretch in addition to that which is inherently produced by the drawing forces exerted by the driven rollers.

From the wet treating stages, the film passes about the drying cans or drums 9, some or all of which are positively driven. The speed of travel of the film about the drying cans and the drying conditions associated therewith are controlled to reduce the moisture of the film to a value of 4 to 15% based on the weight of the cellulose. Generally, it is preferred to dry down to 4 to 8% moisture content, such as that which is ordinarily contained in regenerated cellulose pellicles when exposed to ordinary atmospheric conditions.

When the film is dried to a moisture content of 12 to 15% at this stage, it may pass about a guide roll 10 directly into a transverse stretching stage at 11 which may be contained within the housing 12 having the entrance 13 and the discharge port 14 for the film. Any suitable device for stretching the film transversely may be disposed within the chamber 12. As diagrammatically shown, this device may comprise a clip tenter frame having the edge-gripping clips carried on a pair of oppositely disposed chains 15 and 16. Since tenter frames are conventional, it is not considered necessary to describe the specific details thereof. Essentially, they consist of a series of clips provided on travelling chains or belts which operate above complementary blocks which serve as gripping tracks, that is they are adapted to cooperate with the clips thereabove to grip the edge of the film or sheet therebetween. Figure 3 illustrates diagrammatically, as viewed in the general longitudinal direction of the film, the edge-gripping arrangement. It comprises a block 17 which may have a groove or depression 18 against which the edge 19 of the film is urged by the jaw 20 of the clip which is pivotally mounted on the axis 21 and urged into gripping engagement by the spring 22 acting against the stationary member 23 and the arm 24 extending back from the clip. The bead 5a at the edge of the film 5 assists in the gripping action and gives the necessary protection against tears and breaks, thereby rendering such occurrences infrequent.

Preferably, in the embodiment in which the film contains 12 to 15% moisture content when discharged from the drums 9, it is passed through an entrance slit 140 and through an ante chamber 12a, in which it may travel about rolls 8a, before entering the stretching stage in chamber 12. In chamber 12a, moisture equalization is allowed to occur, that is during passage through this chamber, any inequalities in the moisture distribution in the film are reduced or disappear entirely.

Although it is not absolutely necessary, it is preferred to circulate the moist atmosphere which develops adjacent the film in the chamber 12a. This may be effected by means of the circulating fan 25 connected on its suction side by the inlet duct 26 to the top of the chamber and having its discharge side connected by the conduit 27 to the bottom of the chamber 12a, preferably at the opposite end of the chamber to that where conduit 26 is con-

nected. If desired, instead of merely recirculating the moist air developed by the film in the chamber 12a, such air may be reheated as by means of a coil 28 disposed in either conduit 26 or 27 and if desired further, the reheated air may pass through a humidifying device 29 which may comprise water sprays or the like for the purpose of maintaining the proper humidity in chamber 12a.

From the transverse stretching stage 11, the stretched film passes about the final drying cans 30 and then after attaining a moisture content of approximately 6% or less based on the weight of the cellulose therein, the film proceeds to a take-up, such as a winding device at 31. If desired, the film, on its way to the take-up 31, may pass through the edge-slitting device comprising rotary knives 32 which coact with a cooperating roll 33.

In the preferred system of operation wherein the film discharged from the drying drums 9 has a moisture content below 12% by weight, such as 4 to 8% by weight, the chamber 12a in cooperation with the humidifier 29 serves to re-humidify the film to the desired moisture content of 12% up to 15% before it enters the stretching stage in chamber 12.

The clip chains of the tenter diverge from the point where the film enters and is first gripped to the discharge point where the film is released from the clips. The amount of transverse stretching effected may be varied from a minimum of about 4% wherein the sheet is freed of any wrinkling caused by previous transverse shrinkage to a value which substantially completely compensates or may even overcompensate for the previous transverse shrinkage. This value may vary depending upon the particular thickness and width of the pellicle and its history of manufacture. In a typical embodiment, the film is discharged from drying drums 9 with a normal moisture content of 4 to 8% by weight, at which stage it has been stretched longitudinally but not transversely, and has been allowed no shrinkage longitudinally but has shrunk approximately 10% in width. In chamber 12a, it is humidified to a moisture content of 12% by weight in an atmosphere having a temperature of 165° F. and a humidity of about 95-99% of saturation. In this chamber no longitudinal shrinkage occurs but the film expands transversely about 2 to 3%, thereby partially compensating for the earlier transverse shrinkage during drying. In the chamber 12, the moisture content remains constant at 12% and while neither stretch nor shrinkage occurs longitudinally, a transverse stretch of about 7% is applied, thereby substantially compensating completely for the remainder of the shrinkage during the original drying. During the subsequent drying on drums 30, there is substantially no stretch or shrinkage either longitudinally or transversely. If a transverse shrinkage in the first drying stage amounts to more than 10%, such as 15%, the transverse stretch applied is preferably increased to compensate entirely for this amount of shrinkage after taking into consideration the amount of transverse expansion occurring in chamber 12a.

The final product is characterized by improved strength transversely without any appreciable loss in strength longitudinally. Also, its swelling and stretch characteristics are more nearly alike transversely and longitudinally. The uniformity of gauge is greatly improved, the sheet being substantially uniform in thickness throughout its width except at the very edges where the customary beads occur and may be removed by conventional slitters as mentioned above. Also, the marginal areas lie substantially flat in the same plane as the central area of the sheet and are free of longitudinal ridges or striations in the marginal area. The pellicle exhibits substantially the same resistance to tearing in the marginal areas as in the central portion of the sheet.

It is to be understood that changes and variations may be made without departing from the spirit and scope of the invention as defined in the appended claims.

We claim:

1. A process for producing regenerated cellulose films comprising extruding viscose through a slot having uniform width throughout its length into a liquid coagulating bath, drawing the extruded film through a plurality of liquid baths comprising a regenerating bath, and after drying the liquid-treated regenerated cellulose film to a moisture content of 4 to 8% by weight while preventing longitudinal shrinkage and allowing transverse shrinkage varying in magnitude depending upon the distance from

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the center line of the film, humidifying the film to a moisture content of 12 to 15% by weight, transversely stretching the humidified film between 4 and 7% while preventing longitudinal shrinkage and stretching, and subsequently drying the transversely stretched film to a normal moisture content.

2. A process as defined in claim 1 in which the film is humidified to 12% moisture content and transverse stretching is effected upon the film when it contains approximately 12% by weight moisture.

3. A process as defined in claim 2 in which the film undergoes substantially no transverse shrinkage or stretching and substantially no longitudinal shrinkage or stretching during the final stage of drying.

4. A process for producing regenerated cellulose films comprising extruding viscose through a slot having uniform width throughout its length into a liquid coagulating bath, drawing the extruded film through a plurality of liquid baths comprising a regenerating bath, and after drying the liquid-treated film to a moisture content of 4 to 8% by weight while preventing longitudinal shrinkage

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and allowing transverse shrinkage varying in magnitude depending upon the distance from the center line of the film, humidifying the film to a moisture content of 12 to 15% by weight, effecting moisture equalization in the presence of a circulating humid atmosphere, and then transversely stretching the humidified film between 4 and 7% while preventing longitudinal shrinkage and stretching, and subsequently drying the transversely stretched film to a normal moisture content.

5. A process as defined in claim 4 in which the moisture distributed by the equalization is derived substantially entirely from the film entering the equalization zone.

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