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A. EICHENGRUN

MEANS FOR THE PRODUCTION OF THIN AND VERY THIN FOILS AND
FILM LIKE BANDS FROM SOLUBLE CELLULOSE DERIVATIVES

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Inventor:

Arthur Eichengrun

By: (Signature)
This invention relates to apparatus for the production of endless films from soluble cellulose derivatives.

In practice, film-like bands of solutions of cellulose derivatives such as nitro-cellulose, acetyl-cellulose, alkyd-cellulose, and the like, are manufactured exclusively by pouring solutions of these products onto a rigid base. Such rigid bases may comprise a pouring table or a solid or hollow metal cylinder in which the layer is poured onto the surface or into the interior of the cylinder, or rollers of stone, hard rubber or a similar material having a surface capable of taking up a polish, or a rigid band of copper, nickel, aluminium or the like, which is passed over two or more drums at such a high tension that the band always presents a smooth surface.

Such a method of operation obviously entails the pouring machines working very slowly since it has been found in practice that it is only possible to obtain satisfactory results if the pouring drums have a maximum diameter of 2 to 3 metres and if the overall length of the endless bands amounts to about 12 to 16 metres. In such cases the cellulose layer must be completely dried within the period of one cycle of operations so that in order to be able to ensure stripping of the band of foil, the drying period must be made as long as possible and consequently the speed of the bases must be as slow as possible. In these circumstances an output of only about 40 square metres per hour can be expected in the manufacture of films on a usual pouring machine.

Attempts have often been made to substitute for rigid bases, pliable materials such as impregnated paper, oil cloth, rubberized fabrics or very thin sheets of metal, in order to obtain greater lengths of drying surface. In such cases the bases were, after passing beneath the pourer, over the tables or rollers, conveyed horizontally for long distances until the solutions had dried and could no longer run off laterally. Thereupon they were returned, in accordance with the above described method to the pourer or to a second band apparatus which served mainly for the final drying, or were rolled upon winches where the individual layers were separated.

Apart from the fact that the constructional arrangements for this purpose were very complicated, this method has not proved practicable because after the bases had been in use for some time, they altered owing to the formation of folds, warping, denting and tears at the edges, to such an extent that the applied solutions dried irregularly and that the film bands thus produced were irregular in structure and thickness. Above all however owing to the constant strain, the pliable materials became in time so warped that the edges were more strongly tensioned than the middle. The middle was therefore lifted from the guide surfaces or rollers whilst the edges were applied thereto so that rounded surfaces were produced upon which the poured mass failed to adhere or only adhered in thinner layers than at the edges. This disadvantage was particularly noticeable in the production of very thin films of a thickness of less than 0.1 millimetres since in such cases the reduction of the already very small thickness led to tears and to the production of faulty portions and hitherto it was impossible to employ long band-like bases for the manufacture of thin films.

It has now been found that it is possible to produce not only films but above all also, the very thinnest foils of 0.03 millimetres down to 0.01 millimetres thickness of completely perfect nature, in an extraordinarily rapid operation. Such foils can for example be manufactured in lengths of about 5 metres or more per minute, if instead of using the usual thinly liquid solutions which were applied to the bases by spraying or by a brush or by passing through narrow slots, solutions were used which by virtue of their high concentration, high viscosity, capability of rapidly solidifying, in consequence of the composition of the solvent mixture, for the purpose in question, already solidify or adhere to the base after a short time, so that they no longer run off from the base or are displaced thereupon in such a way that the thickness of the layer varies.
This method may be carried out in the following manner which is given solely by way of example and by the apparatus hereinafter described:

The cellulose solution of as high a concentration and viscosity as possible, is applied by means of a pourer or a scraping device to a base consisting of a long loose band 100 or 200 metres or more long. This band consists of a rigid but pliable material such as for example cardboard, sheet metal, cellulose film, linoleum, rubberized material or the like and is of such a thickness as not to fold, tear or warp after the application of the cellulose layer. If desired, the base may be coated with other materials such as for example gelatine, starch, rubber, albumen or cellulose derivatives to prevent oxidation, or any action of the cellulose derivative solvents or to produce smoother surfaces or vice versa, or to produce a matt or ornamented surface, or to increase the separability of the coating.

The bands are preferably first conveyed over a coating drum or coating table in a horizontal direction in order to give the applied cellulose mass time to solidify or to commence to dry, so that it no longer flows off when the band moves out of the horizontal direction and is thereupon led to a loop-way which enables the band to be suspended in the form of loops. This loop-way differs considerably from the usual drying devices such as employed in the paper industry.

Thus the bands are no longer suspended from rods since they would undergo creasing. Instead of this, they are passed over roller like devices or upon broad edges or discs of a considerable diameter which preferably corresponds to the natural radius of curvature of the bands and which differs with the material from which the bands are produced and their thickness. This measure prevents all creases and dents in the base which would have an unfavourable effect on the foils to be produced.

Moreover, the individual loops are not as hitherto usual, conveyed by being displaced on the rod carriers, but the bands themselves move forward continuously in the form of loops. This is effected by causing the suspending device for example tubular or solid metal rollers to rotate in a fast bearing. The band which is preferably moved forward at both edges by driving wheels, discs or belts, is passed over one guide roller and conveyed in the form of a loop to the next following one. The conveying or guide rollers are driven by means of a belt drive, pinion or worm gearing synchronously with the drive of the pouring device so that the band-like base is moved forward uniformly in all portions of the machine and no shortening or lengthening of the loops can take place.

By means of the apparatus it is possible to arrange a very long length of band in a relatively small space since in working rooms of normal height, loops of about 10 metres length can be arranged so that a length of band of about 200 metres only takes up about 20 metres length of room.

In contradistinction to the usual film-pouring methods where the films must be unrolled when only about 15 metres long, the present apparatus enables long lengths of foil to be poured and dried on their base whilst simultaneously greatly increasing the speed of pouring. This is of particular importance for the production of very thin foils which are produced in entirely insufficient quantities in the usual film pouring machines. In this method of operation it is of particular importance that the foils must be conveyed on their bases in a uniform manner over all portions of the loop-way or drying device.

Whilst a very irregular drying was effected in the usual loop-ways because portions of the band at the upper parts of the loop-way dried more rapidly than the inner and lower portions of the loops where there was practically no movement of air, according to the present invention the bases with the drying foils continually move forward at a uniform speed throughout the whole apparatus so that each portion of the band is dried under the same conditions as any other.

It is moreover possible by means of this continuous advancing movement, to subject the bands to successively different drying conditions, the drying conditions being altered in individual portions by aeration, or by heating or by cooling or aspiration or the like. In particular, it is possible in this manner to aspirate the solvent vapours for recovery, at those places where maximum evaporation takes place because fresh amounts of solvent returning from there beneath the loop-way to the pouring device. The rolling off of the dried film can be effected both at the end of the machine or also at the beginning thereof shortly before the pourer. In order to produce a uniform movement of the band, the individual lower loops, are preferably provided with guide means. These may consist of discs or belts which run in the inner portion of the edges of the bands and which may if desired also be connected together by a shaft or by hollow rollers, gear wheels or by any other suitable devices.

When employing hollow rollers or lateral discs, that is to say devices which only contact with the edges of the band whose centre portion thus remains free also for the suspension of the bands at the upper loops, it is possible to produce two foils simultaneously, one each on the outside and reverse side of the base. For this purpose instead of the pouring table or pouring drum a device is employed, by means of which a cellulose solution is applied to the vertically moving.
It is obviously necessary to employ bases of suitable thickness and strength which are adapted to withstand the mechanical strain imposed thereon by the suspension of the edges. For this purpose thin hard metal bands or thick films of celluloid or acetyl cellulose are suitable which, if desired, may serve as carriers for further base material such as for example for tin foil, prepared papers or fabrics or similar materials upon which the solution is thereafter applied.

This apparatus is suitable also for the production of thick films consisting of several layers of a uniform material and also of such films as consist of several layers of different cellulose derivatives or several compositions in respect of contents in filling materials and softening agents, dyes, pigments and the like. For the purpose of producing such thicker layers, the band is caused to rotate beneath the pouring device continuously, the latter being so arranged that on applying each subsequent layer it is displaced correspondingly. Alternatively a second pouring device and if desired several more of such pouring devices may be arranged at some distance from the pouring device which additional pouring devices are adapted to apply a second and third layer shortly after drying of the previous layer, the composite layers being thereupon dried in the loop-way. It has been found that layers from solutions of the same composition combine firmly together so that films of a greater thickness and particularly of a greater length are produced than was hitherto possible with the usual film-making machines. If solutions of different composition such as for example solutions of nitro-cellulose, cellulose acetate, ethyl cellulose, are superimposed, they dry into a uniform film.

Nevertheless, the individual layers can after drying, be wound up as separate coherent films so that several films of different kinds may be produced simultaneously.

On the other hand also by the addition of suitable substances, especially camphor substitutes, films of various cellulose derivatives differing from each other, such as nitro-cellulose and cellulose acetate may be combined together to produce films which consist of individual layers of different composition, inflammability, rigidity and sensitiveness to water.

This is of special importance because in the production of such double layers, the first layer had hitherto to be produced as a long filament and wound up, whereupon the second layer had to be applied to this film in a separate operation, in which it was difficult to avoid softening and distortion of the first layer.

According to the present invention however the first and as well as all subsequent layers remain firmly connected to the base until the final drying. Any softening or swelling owing to solvents contained in the further layers to be applied has no detrimental effect. It is even possible to effect preliminary preparation and even the emulsioning of the films prior to removing them from the base without any detrimental influence upon the films.

In order more clearly to understand the invention reference is made to the accompanying drawings which illustrate diagrammatically and by way of example, one embodiment of machine constructed in accordance therewith and in which:

Fig. 1 is a side elevation of the apparatus;
Fig. 2 is an end elevation from the right-hand side of Fig. 1, and
Fig. 3 is a side elevation of part of the apparatus showing means for casting films or foils on both sides of the travelling band.

The machine consists of an endless band B of a considerable length of for example 50, 100 or even 200 metres, which passes over a drum A above which is arranged the supply hopper G for the cellulose derivative solution said hopper G may if desired co-operate with scraping devices not shown adapted evenly to distribute the cellulose derivative solution on the travelling band B.

After passing beneath the applying device the band travels horizontally for a short distance in order to prevent the cellulose derivative solution from flowing off the band immediately after application thereto. Thereupon the band moves vertically downwards over a hollow or recessed roll a' rising vertically and passing over a similar hollow or recessed upper roll b' indicated in lateral elevation in dotted lines in Figure 2 of the drawings, and travels in succession over the next lower roll a", upper roll b", lower roll a', upper roll b', finally passing over the lower roll a" and upper roll b" from whence it is conducted over guide rolls c', c", c", c", to the point where the dry film is stripped from the travelling band and wound on roll C.

By virtue of the employment of hollow rolls, the travelling band contacts with the rolls only at its edges so that the film applied to either or both sides of the band is prevented from coming into contact with any solid surface during its drying. It is however obvious that either the series of lower rolls a", a", a", a", or the series of upper rolls b", b", b", b", b", b", b" may be solid if it is desired to apply a coating to only a single side of the band.
In the embodiment illustrated the series of upper rolls \( b', b^2, b^3 \ldots b^n \) are driven in synchronism by an electromotor \( h \) through pulleys \( p \) and bevel gearing \( q \) indicated diagrammatically. The upper rolls \( b', b^2, b^3 \ldots b^n \) are each mounted in separate bearings \( k \) connected to common supports \( l \) whereas the lower idle rolls \( a', a^2, a^3 \ldots a^m \) are mounted in a common frame \( f \).

Any or all of the rolls \( a, b, c \) may be provided with flanges \( m \) adapted to form guides for the travelling band.

Fig. 3 shows means for casting films or foils on both sides of the travelling band \( B \). As shown in this figure, there are provided two vessels or troughs \( t, t' \) which contain a solution of the derivative of cellulose. In these troughs, pick-up rolls \( r, r' \) rotate and take up the solution of the derivative of cellulose from the vessel or trough and transfer it to the rotating rolls \( s, s' \), which in turn apply the solution to the band \( B \) as it comes down from the guide roll \( d \). The films or foils that are formed are stripped from the band and are wound on the rolls \( D, D' \).

I claim:

1. In apparatus for producing continuous film bands of cellulose derivative, the combination of supply means for a solution of cellulose derivative, a travelling band repellant to the said cellulose derivative when solidified and passing beneath said supply means, and means for removing said cellulose derivative solution solidified from said band, said band being arranged in the form of loops uniformly individually positively driven and supported by its borders only.

2. In apparatus for producing continuous film bands of cellulose derivative, the combination of supply means for a solution of cellulose derivative, a travelling band repellant to the said cellulose derivative when solidified and passing beneath said supply means, and means for removing said cellulose derivative solution solidified from said band.

3. In apparatus for producing continuous film bands of cellulose derivative, the combination of supply means for a solution of cellulose derivative, a travelling band repellant to the said cellulose derivative when solidified and passing beneath said supply means, a plurality of alternate upper and lower recessed rolls contacting with said band and means for removing said cellulose derivative solution solidified from said band.

4. In apparatus for producing continuous film bands of cellulose derivative the combination of supply means for a solution of cellulose derivative, a travelling band repellant to the said cellulose derivative when solidified and passing beneath said supply means, a series of recessed rolls contacting with said band at its borders only and in such a manner as to arrange said band in the form of a series of loops and means for removing said cellulose derivative solution solidified from said band.

5. In apparatus for producing continuous film bands of cellulose derivative the combination of supply means for a solution of cellulose derivative, a travelling band repellant to the said cellulose derivative when solidified and passing beneath said supply means, a series of recessed rolls contacting with said band at its borders only coacting with a series of solid rolls in such a manner as to arrange said band in the form of a series of loops and means for removing said cellulose derivative solution solidified from said band.

6. In apparatus for producing continuous film bands of cellulose derivative the combination of supply means for a solution of cellulose derivative, a travelling band repellant to the said cellulose derivative when solidified and passing beneath said supply means, a series of recessed rolls contacting with said band at its borders only coacting with a series of solid rolls in such a manner as to arrange said band in the form of a series of loops and means for removing said cellulose derivative solution solidified from said band.

7. In apparatus for producing continuous film bands of cellulose derivative the combination of supply means for a solution of cellulose derivative, a travelling band comprising metal and a repellant to the said cellulose derivative when solidified and passing beneath said supply means, a plurality of recessed rolls contacting with said band at its borders only and arranged in such a manner that said band forms a series of loops and means for removing said cellulose derivative solution solidified from said band.

8. In apparatus for producing continuous film bands of cellulose derivative the combination of supply means for a solution of cellulose derivative, a travelling band comprising a repellant to the said cellulose derivative when solidified and passing beneath said supply means, a plurality of alternate upper and lower recessed rolls contacting with said band at its borders only and arranged in such a manner that said band forms a series of loops and means for removing said cellulose derivative solution solidified from said band.

9. In apparatus for producing continuous film bands of cellulose derivative the combination of supply means for a solution of cellulose derivative, a travelling band comprising a repellant to the said cellulose derivative when solidified and passing beneath said supply means, a plurality of alternate upper and lower recessed rolls contacting with said band at its borders only and arranged in such a manner that said band forms a series of loops and means for removing the films of said cellulose derivative solution when solidified from said band.

10. In apparatus for producing continuous film bands of cellulose derivative the combination of supply means for a solution of cellulose derivative, a travelling band comprising a repellant to the said cellulose derivative when solidified and passing beneath said supply means, a plurality of alternate upper and lower recessed rolls contacting with said band at its borders only and arranged in such a manner that said band forms a series of loops and means for removing the films of said cellulose derivative solution when solidified from said band.
pellant to the said cellulose derivative when solidified and passing beneath said supply means, a plurality of alternate upper and lower recessed rolls contacting with said band at its borders only and arranged in such a manner that said band forms a series of loops, a support common to the upper rolls, a support common to the lower rolls, means for driving said rolls in synchronism and means for removing the films of said cellulose derivative solution when solidified from said band.

10. In apparatus for producing continuous film bands of cellulose derivative the combination of supply means for a solution of cellulose derivative, a travelling band repellant to the said cellulose derivative when solidified and passing beneath said supply means, a series of alternate upper rolls alternating with a series of lower rolls, one series comprising recessed rolls contacting with said band at its borders only and coacting with the other series comprising solid rolls in such a manner as to arrange said band in the form of a series of loops, a support common to the upper rolls, a support common to the lower rolls and means for removing the films of said cellulose derivative solution when solidified from said band.

11. In apparatus for producing continuous film bands of cellulose derivative the combination of supply means for a solution of cellulose derivative, a travelling band repellant to the said cellulose derivative when solidified and passing beneath said supply means, a series of alternate upper rolls alternating with a series of lower rolls, one series comprising recessed rolls contacting with said band at its borders only and coacting with the other series comprising solid rolls in such a manner as to arrange said band in the form of a series of loops, a support common to the upper rolls, a support common to the lower rolls, means for driving one series of rolls in synchronism and means for removing the films of said cellulose derivative solution when solidified from said band.

12. In apparatus for producing continuous film bands of cellulose derivative the combination of supply means for a solution of cellulose derivative, a travelling band repellant to the said cellulose derivative when solidified and passing beneath said supply means, a series of recessed rolls contacting with said band at its borders only and coacting with a series of solid rolls in such a manner as to arrange said band in the form of a series of loops, a plurality of different drying zones traversed by said band and means for removing said cellulose derivative solution solidified from said band.

13. In apparatus for producing continuous film bands of cellulose derivative the combination of supply means for a solution of cellulose derivatives, a travelling band repellant to the said cellulose derivative when solidified and passing beneath said supply means, a series of recessed rolls contacting with said band at its borders only and coacting with a series of solid rolls in such a manner as to arrange said band in the form of a series of loops, guide means for said band at the edges of said rolls, means for driving one of said sets of rolls in synchronism and means for removing said cellulose derivative solution solidified from said band.

14. In apparatus for producing continuous film bands of cellulose derivative the combination of supply means for a solution of cellulose derivative, a travelling band repellant to the said cellulose derivative when solidified and passing beneath said supply means, a series flanged of recessed rolls contacting with said band at its borders only and coacting with a series of flanged solid rolls in such a manner as to arrange said band in the form of a series of loops, means for driving one of said sets of rolls in synchronism and means for removing said cellulose derivative solution solidified from said band.

In testimony whereof, I affix my signature.

ARTHUR EICHENGRÜN.