

Oct. 15, 1940.

D. F. WINNEK

2,218,227

METHOD FOR EMBOSSING SHEET PLASTIC MATERIAL

Filed April 2, 1938

3 Sheets-Sheet 1

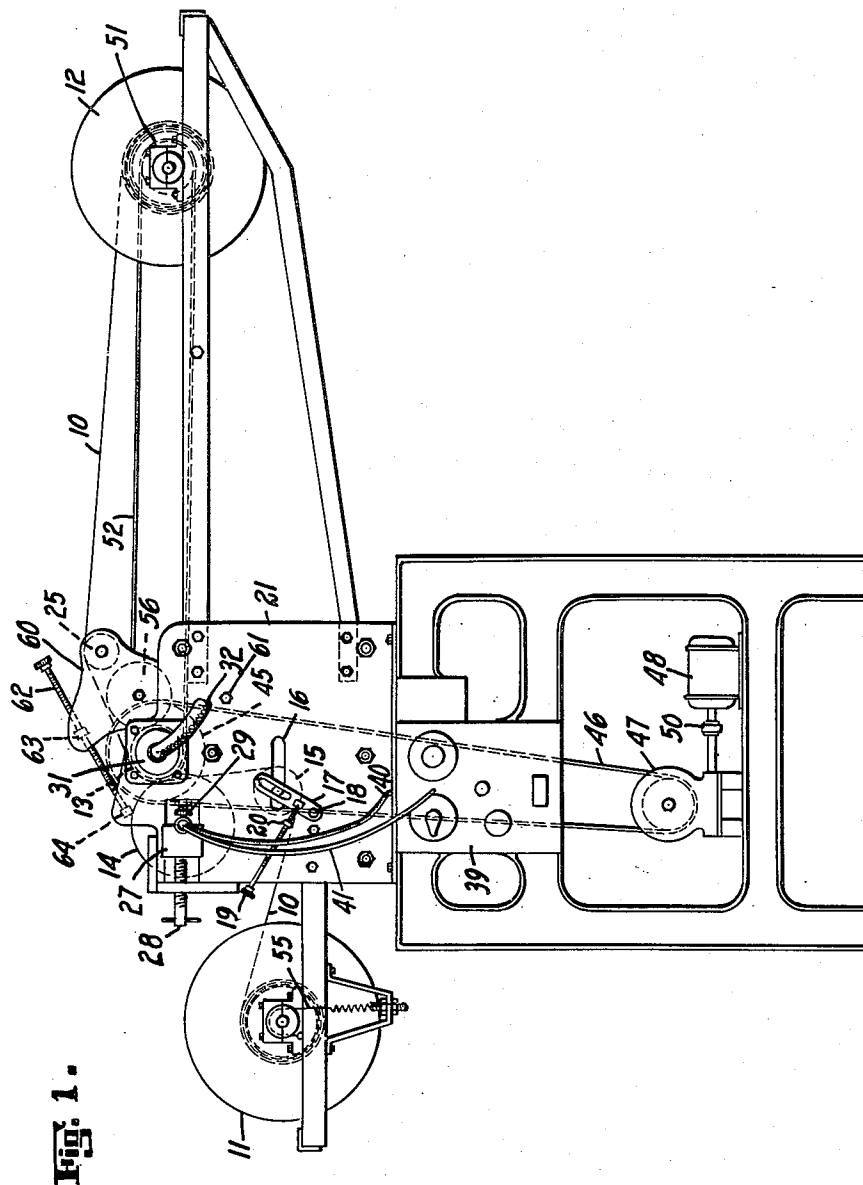


Fig. 1.

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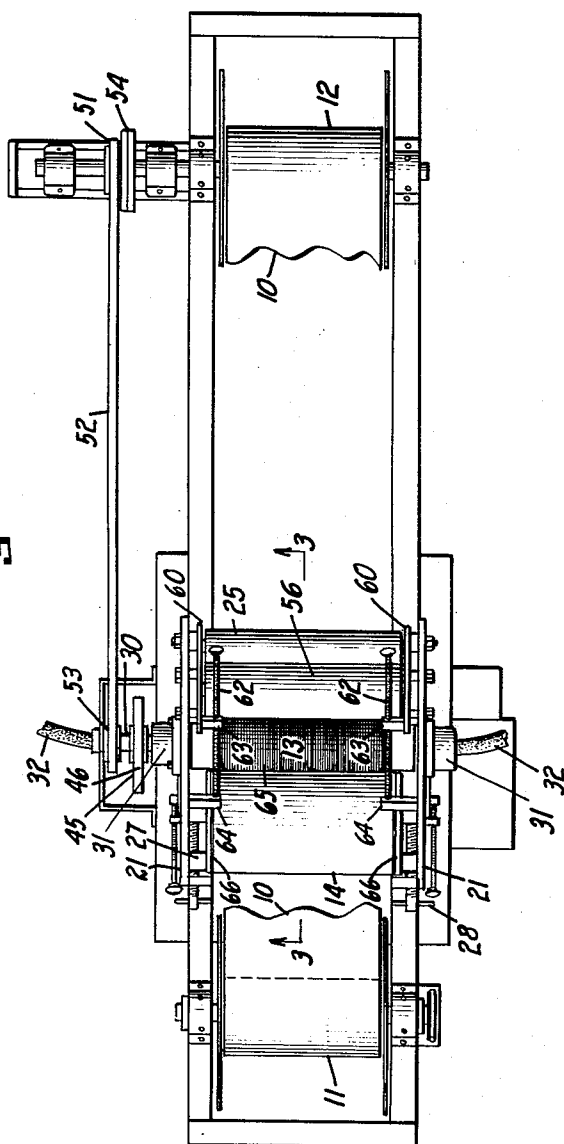
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3 Sheets-Sheet 2

Fig. 2.



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3 Sheets-Sheet 3

Fig. 3.

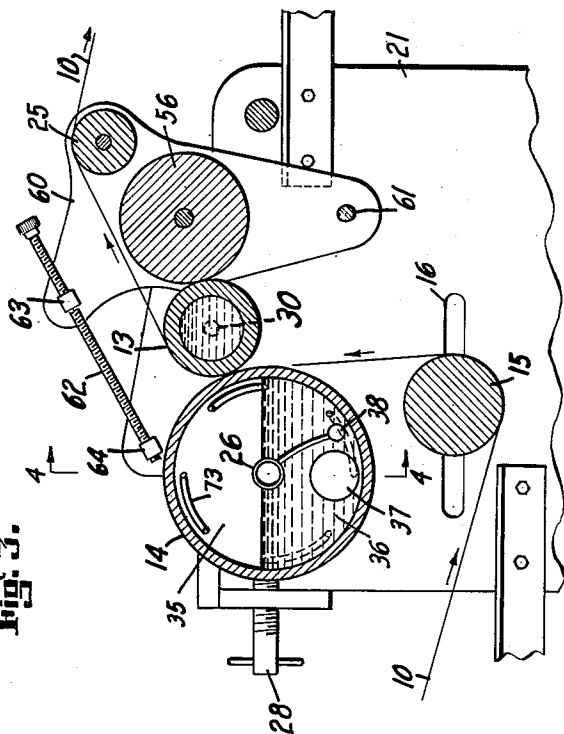


Fig. 4.

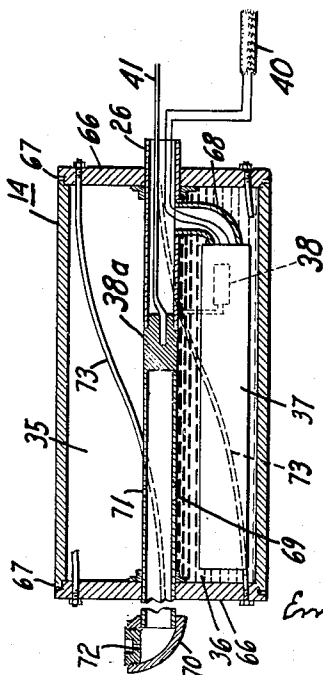
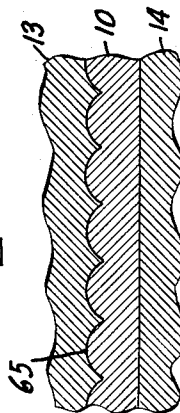


Fig. 5.



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METHOD FOR EMBOSSING SHEET PLASTIC MATERIAL

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7 Claims. (Cl. 18—61)

This invention relates to improvements in methods and apparatus for embossing thermo-plastic sheets, webs or strips used for photographic work, such as films or strips of cellulose acetate or cellulose nitrate. Both of these materials are thermo-plastic like glass and pass gradually from a substantially solid state at normal room temperatures to a viscous or semi-liquid state at elevated temperatures.

It has heretofore been proposed to form lenticulations in these photographic film bases for color or three-dimensional work, the lenticulations usually being very small, for example from 200 to 700 to the inch. But there has been difficulty in forming such small shapes in the sheets in perfect condition; and unless they are perfectly formed the photograph will be distorted.

The plain or smooth sheets are usually cast from a body of material in liquid condition. This liquid "dope", so called, is spread evenly on a casting wheel, belt or the like and solidified by evaporating out its volatile solvents, an operation somewhat analogous to forming a web of paper from liquid pulp. To enable the wet film to dry and set properly before leaving the wheel or belt, even when the apparatus is run at a slow speed, a large wheel or a long belt must be used; so that when the sheets are cast with lenticulations, it is exceedingly difficult, owing to the extensive area of the casting surface of the wheel or belt, to form the very minute grooves accurately and uniformly over the entire surface to produce with the necessary degree of perfection the lenticular matrices. Moreover, there is a tendency for bubbles to form in the sheets unless a high vacuum is maintained on the entire apparatus; and the lenticulations thus formed in the sheets, even under the best conditions, are often impaired by the warping or distortion of the sheets as the solvents dry out.

In an effort to avoid these difficulties and objections in casting lenticulated sheets, it has been proposed to emboss previously formed webs or sheets, but without substantial success so far as I know.

Drawing a preformed web from a reel, heating it to plasticity, embossing it, cooling and causing it to set again and finally rereeling it, could not be practiced with satisfactory results in this art until some means were found for preventing the softened web from being unduly stretched, warped or distorted by such tension as the web is necessarily subjected to in these operations. My invention is based primarily on the discovery I have made that by using a heated counter roll

in juxtaposed contact with an engraved or matrix roll and lapping the web upon the heated roll, as it is drawn from the starting reel, by an amount which is sufficient to impart embossing plasticity to the web just as it reaches the contact zone between the two embossing rolls, but not before, I am able to overcome undue stretching and warping of the web due to the drawing tension produced by the rolls; and that thereafter, by causing the embossed web to lap the relatively cooler embossing roll sufficiently so that the lenticulations will remain in the matrices until hardened or set, I am able to prevent the warping or distortion thereof under the tension of rereeling.

Thus, according to one feature of the present invention, the sheet or web of thermo-plastic material is passed in a regulable arc in contact with a heated roll and is raised to just the right embossing temperature as it reaches the contact zone between the heated roll and the engraved roll which provides the matrices for forming the lenticulations. Thereafter, the embossed sheet is held in engagement with the engraved roll and cooled gradually to set the impressions and is removed from that roll only after it has cooled sufficiently to insure perfect impressions and avoid buckling or distortion of the sheet. The embossed sheet may then be withdrawn from the engraved roll, even while still warm, under sufficient tension to hold it flat and prevent warping or buckling until the sheet has cooled to the point where it will permanently maintain its shape.

In the drawings:

Fig. 1 is a side elevation of a machine which I have devised for practicing my invention;

Fig. 2 is a top plan view of the same;

Fig. 3 is an enlarged vertical section taken approximately on the line 3—3 of Fig. 2;

Fig. 4 is a vertical section taken on the line 4—4 of Fig. 3, showing the internal assembly of the heating cylinder; and

Fig. 5 is a very greatly enlarged cross section through a small width of plastic strip and adjacent portions of the embossing rolls.

In the drawings the numeral 10 designates a strip, web or sheet of plastic material which is fed from a supply reel 11 and after being embossed is wound upon a take-up reel 12. Between the supply and take-up reels the strip passes between the embossing rolls, which, as here shown, comprise a matrix roll 13 and a counter-roll 14.

In passing to the counter roll 14 the sheet 10 moves over an idler roll 15 which may be ad-

justed along the slots 16 to vary the arc of contact of the plastic sheet with the heating roll 14. Any suitable means may be employed for adjusting the roll 15 along the slots 16, that shown in Fig. 1 comprising a slotted arm 17 pivoted at 18 and moved by a hand screw 19 threaded through a fixed boss or bracket 20 carried by the upper frame side plate 21. Identical means may be provided on the opposite side of the machine and, if desired, means may be provided for making the adjustment at both sides of the machine simultaneously.

The sheet 10 after leaving the matrix roll 13 passes over an idler roll 25 in moving to the take-up reel 12. The take-up reel is located a considerable distance from the embossing roll to provide that the sheet be held flat and under tension while cooling to avoid curling, buckling or other distortion.

The counter roll 14, as herein shown, has a smooth and preferably polished surface and is driven only through the action of the plastic sheet. It is mounted for free rotation on a fixed hollow shaft 26. The roll 14 may be separable from the matrix roll 13 for threading the sheet or other purposes and to provide for this, as shown in Fig. 1, the ends of the hollow shaft 26 are mounted partially or wholly in slidable blocks 27 adjusted in suitable ways by hand screws 28. In order to provide a fine working adjustment and the same definite setting each time the roll 14 is closed with the roll 13, adjustable stops 29 which may be locked in adjusted positions are placed on each side of the frame to limit the closing position of the hollow shaft 26. By the setting of the stops and the position of the heating roll relative to the matrix roll, determined by the setting of the stops, the final thickness of the sheet of plastic material may be very accurately controlled.

The matrix roll 13 is positively driven at a very precisely controlled adjustable speed. It is mounted on hollow stub shafts 30 at each end and the cylinder itself is hollow, as shown in Fig. 3, to provide a through passage for cooling fluid such as air or water. The cooling fluid may enter and leave through jackets 31 surrounding the shafts and served by conduit connections 32 associated with the jackets.

The means for heating the counter-roll 14 are shown in detail in Fig. 4. Said roll is formed as a hollow cylinder to provide a sealed chamber 35 within which a body of heat transfer fluid such as oil 36 is placed. The fluid may be heated by an immersed electric heater 37 and the temperature may be regulated by a thermostat controlled cell 38. The thermostat cell may control the supply of electric current to the heater 37 in known manner. A control box 39 is shown in Fig. 1 for housing the various controls, the heater 37 connecting with the box through a current supply cable 40 and the thermostat cell connecting through a tube 41. The box may house relays, thermostat, switches, drive motor rheostat, or other desired control devices.

The matrix roll 13 is the driven roll in the present arrangement. To this end it is provided with a pulley, sprocket, gear or the like 45 driven by a belt 46 from the shaft of a reduction gear unit 47. A motor 48 drives the gear unit. A steady vibrationless drive is desirable and this is provided by placing a mechanical filter 50 between the motor shaft and the gear drive shaft and further by mounting the motor 48 on a vibration absorbing pad. A pad consisting of alternate layers of rub-

ber and sheet cork has proved efficient for this use.

The take-up or rewind reel 12 may be driven by a pulley or sprocket 51 and a belt 52 from a pulley or sprocket 53 secured to the shaft of the matrix roll. Adequate speed of the take-up reel to place tension on the sheet for all sizes of the roll of sheet material on the take-up reel is provided by this drive, and in order to avoid undue tension the shaft of the take-up reel is provided with a suitable slip drive device such as the friction clutch 54.

Proper back tension on the sheet of plastic material issuing from the supply reel 11 may be secured by providing the reel shaft with an adjustable friction brake 55.

Considerable pressure is placed on the film by the embossing rolls 13 and 14 and there is a possibility that the matrix roll 13 might bow in the center and fail to properly emboss the sheet across its entire width. To insure proper pressure throughout the length of the roll 13 it may be backed by a roll 56. The backing roll should be made of softer material than the engraved roll so as to avoid injuring the surface of the latter. Soft rubber has proved to be a satisfactory material for the backing roll. In order to vary the pressure exerted by the backing roll it may be mounted in adjustable plates 60 pivoted at 61. Adjusting movement of the plates 60 may be secured by hand screws 62 threaded through swivelled nuts 63 on the plates 60 and rotatably held in swivelled bearings 64 mounted on the side plates 21 of the main frame. The idler roller 25 may also be mounted on the plates 60. The idler roller may be formed of fairly hard rubber or fabric.

In Fig. 5 the engraved lenticulating grooves 65 of the roll 13 are shown in engagement with the sheet 10 of plastic material. A portion of the heating roll 14 is also shown. Obviously, for purposes of illustration the small lenticulations must be shown greatly out of scale.

The heating roll 14 should have considerable strength and may be made of steel or bronze. The roll is also shown to be of considerable diameter for strength. The periphery of the roll should be very accurately dimensioned. It may be ground to within .0001" tolerance and be electro-plated with a hard surface of chromium or nickel if a smooth high polish is desired on that side of the embossed material.

The matrix roll 13 may be of similar though preferably harder material than the heating cylinder 14. Then if foreign matter should pass between the embossing rolls it will injure only the smooth roll 14, which can readily be resurfaced, rather than the engraved roll 13, which is very expensive to make and resurface.

The internal structure of the heating roll 14 is shown in Fig. 4. The shell or roll proper may be bolted or screwed to the head plates 66 and sealed therewith by washers or gaskets 67. The heater 37 may be suspended by a tubular elbow 68 from the hollow shaft 26 supporting the head plates 66. The mounting joint 38a of the thermostat unit 38 fills the shaft 26 near the middle and oil may be fed at the left end through a hole 69 in the shaft. An upstanding elbow 70 at one end of the shaft provides a filling port for oil. A hole 71 in the top of the shaft 26 and a small hole 72 in the plug in the filling port permit breathing from the air space above the oil inside the roll.

The oil inside the roll may be agitated by spiral rods 73 secured in the head plates 66. The roll 75

14 may be driven by engagement with the sheet of plastic material which in turn is in engagement with the driven matrix roll 13.

The use of the machine for embossing cellulose acetate sheets may be explained as follows:

Cellulose acetate has plastic properties similar to the more familiar material, glass. If glass is heated slowly to red heat or above it gradually becomes softer so it can be reshaped into various forms such as bottles, table glassware and the like. Glass is thermoplastic and upon cooling again hardens without undergoing any chemical changes. It can be softened or melted and reshaped as often as desired but when it again hardens it will permanently retain its new shape. Cellulose acetate plastics have similar properties but do not have to be heated to such a high temperature as glass for reshaping, and at normal temperatures are flexible and enormously stronger and tougher than glass. To change the shape of cellulose acetate it is heated to between 210° F. and 270° F. Then when it cools while held in the new shape it will permanently retain this shape.

To mold it under pressure as contemplated herein it may be subjected to a temperature of between 270° F. and 330° F. But this heat is applied for only a short time due to the fact that the sheet passes through the embossing rolls very rapidly, the result being that the sheet is not melted by the high heat. Nor does any chemical change take place in the cellulose acetate. If cellulose acetate plastics are kept for excessively long times at high temperature they are apt to discolor, the material being organic in nature. In actual practice the continuous embossing machine herein described may run at any desired speed and the embossing temperature and pressure kept at any desired value, so that there is little danger of the material being overheated or discoloring when the machine is adjusted and in normal operation.

Considering actual operating conditions for one material which has been successfully processed by the herein described machine, this was a strip of cellulose acetate known as "Lumarith, L 814." It was received in rolls, the sheet being 10" wide and .010" thick. It fit snugly between the flanges of the supply and take-up reels 11 and 12.

The shell of the heating roll 14 was accurately maintained at approximately 275° F. by the thermostat controlled electrical heating unit immersed in the oil within the roll. The sheet had a lap or arc of contact of approximately 3" with the heating roll, the roll itself having a diameter of approximately 7".

The amount of lap may be adjusted by the setting of the idler roll 15. If too much lap is provided the sheet is overheated and first becomes too soft and with further heating may become hard and brittle. If too little lap is provided the material will not soften enough to take the embossed impressions. While cellulose acetate sheets may be pressure embossed within a fairly wide range of pressures and temperatures, it is found that for a given embossing pressure, an embossing temperature variation no greater than plus or minus 5° F. should be maintained. If pressure is increased the embossing temperature may be correspondingly decreased. The effective working limits are determined by the thermo-characteristics of the particular plastic material to be processed.

The matrix roll 13 is heated but to a temperature low enough to cause the plastic material to

harden. The temperature should be kept uniform by passing water or other cooling fluid at uniform temperature through the roll or by thermo-statically controlling the heating applied to the roll. For the actual operation referred to, the matrix roll was maintained at approximately 175° F., the water being kept within plus or minus 20° F. of the desired temperature.

The embossed material has as much lap on the engraved roll as construction will conveniently permit in order to provide cooling and hardening while the film is mated with the impressions of the roll. This avoids marring the impressions made in the plastic material due to removal from the roll while too hot, and also holds the sheet smooth to avoid buckling and wrinkling. The idler roll 25 also assists in feeding the sheet material in flat fashion to the take-up roll.

The engraved roll was driven at approximately 28.75 R. P. M. giving the sheet a lineal speed of approximately 36 feet per minute, the roll being approximately 3" in diameter.

The pressure maintained on the plastic sheet measured 1704 lbs. across the width of 10". This figures to be approximately 2730 lbs. per square inch. The .010" sheet after embossing measured .0095" thick and this thickness was very uniform over the entire sheet.

With the apparatus described, the speed of the plastic sheet may be quite independent of the temperature of the rolls and the pressure between them. That is to say, the temperature of the rolls and the pressure may be kept at approximately constant values and the sheet may be lapped in varying amounts on the heating and matrix rolls to heat and cool it as required by the speed of travel to provide the desired embossing action. While there is more latitude in the temperature and amount of lap on the matrix roll than in the heating roll, it must be kept in mind that if the matrix roll is too cold the plastic sheet will contort and warp and that if the matrix roll is too hot the impressions in the sheet will not be retained.

Among the advantages which the present invention secures, as compared with the casting method of forming lenticulations, are that a much smaller and less expensive apparatus is required, the necessary engraving is much less extensive and therefore can be done accurately and uniformly with much less difficulty, and finally the process is much more rapid.

While the embodiment of the invention has been described with particularity for purposes of illustration it is to be understood that the invention may have various embodiments within the limits of the prior art and the scope of the subjoined claims:

I claim:

1. The method of embossing sheets of thermoplastic material such as cellulose acetate or the like which comprises, holding a web of the sheet material under tension against an arc of a heating roll, so regulating the arc of contact with relation to the speed of travel of the web as to bring the web to a predetermined temperature as it arrives at the working zone between the heating roll and an engraved roll which is maintained at a temperature enough lower than that of the heating roll to cause the material to begin to harden, and holding the embossed web in an arc of contact with the engraved roll until the engraved impressions have set in the web to the extent that their shape will be perfectly maintained when the web is removed from the roll.

2. The method of embossing a web of plastic sheet material having the characteristics of cellulose acetate by passing it in an arc over a matrix roll while the web is heated to working plasticity, and maintaining the temperature of the matrix
5 high enough to prevent warping of the web during impression and low enough to cause the embossed web to harden before it is separated from the matrix.

10 3. The method of embossing a web of plastic sheet material having the characteristics of cellulose acetate by passing it in an arc over a matrix roll while progressively heating each portion of the web as it approaches said roll so that each
15 portion is gradually heated and brought up to working plasticity when it reaches said roll, and maintaining the temperature of the matrix sufficiently high to prevent warping of the web during impression but low enough to cause the embossed
20 web to harden before it separates from the matrix.

4. The method of embossing a web of plastic sheet material having the characteristics of cellulose acetate, which method comprises, passing the web between a pair of embossing rolls one of
25 which contains the embossed matrix and the other of which is a counter-roll therefor, and both of which are heated, the counter-roll to a temperature sufficient to impart working plasticity to the web, and the matrix roll to a temperature
30 high enough to prevent warping of the web during the impression but low enough to cause a hardening of the web before it leaves the matrix roll.

5. The method of embossing a web of plastic sheet material having the characteristics of cellulose acetate by a matrix roll and a counter-roll therefor, which method comprises, successively heating each portion of the web to working plasticity, impressing each portion with the matrix
5 by passing the web continuously between the rolls while the matrix roll is maintained at a hardening temperature high enough to prevent the warping of the web during impression, and holding each embossed portion of the web on the matrix roll until it commences to harden.
10

6. A method of embossing a web of plastic sheet material having the characteristics of cellulose acetate by a counter-roll heated to a temperature sufficient to impart working plasticity to the web and a matrix roll cooperating therewith and heated to a temperature below that of working plasticity, and in accordance with which the web is first caused to contact the counter-roll, then passed between the two rolls to receive the impression, and then caused to remain in
20 contact with the matrix roll until somewhat hardened.

7. The method of embossing a web of cellulose acetate which comprises, passing the web between a pair of embossing rolls one of which is
25 heated to about 275° F. and the other of which contains the embossing matrix and is heated to about 175° F., and thereafter passing the web over a portion of the matrix roll, whereby the web is heated to working plasticity by contact
30 with the first named roll and after passing through said rolls is cooled and hardened by contact with the matrix roll.

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