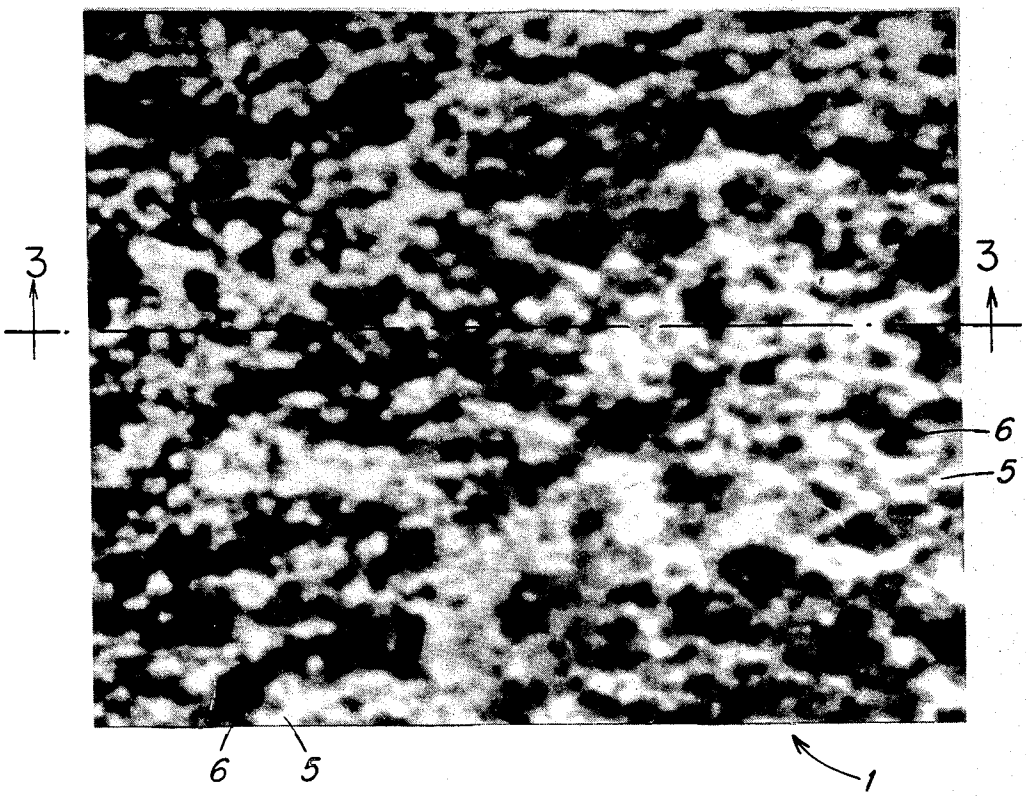
Oct. 25, 1966 S. ROSEN 3,281,257

THERMAL EMBOSSING METHOD

Filed June 10, 1963

FIG. 1



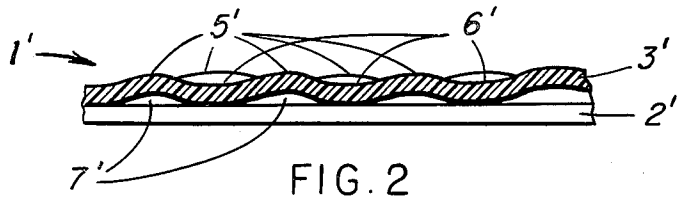


FIG. 2

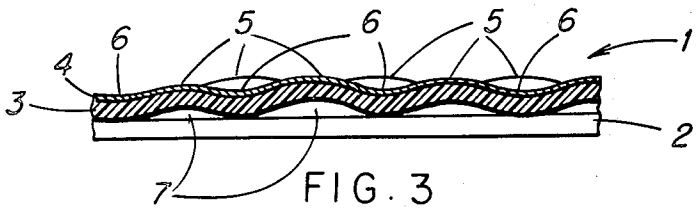


FIG. 3

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THERMAL EMBOSSING METHOD

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This invention relates to a thermal embossing method. More particularly, the invention relates to a method for obtaining an embossed surface without the use of engraving rolls.

It has long been known that paper, such as glassine, sufite papers, kraft paper, paper board and the like, can be embossed by a mechanical process, during which the pattern is applied or engraved by pressure exerted on the surface by rolls upon which a design has been cut. These embossing rolls are not only expensive to make but are also subject to great wear. Accordingly, embossing rolls must be reengraved frequently or must be periodically replaced. In view of the expense, effort and time involved in such reengraving or replacing, this method of embossing has not been completely satisfactory.

In addition to the above-enumerated disadvantages, mechanical embossing also has the following disadvantages: the pressure exerted by the embossing rolls has a tendency to distort the fibers of the paper or other substrate, causing pin hole ruptures. Such ruptures are particularly undesirable when the substrate is to be employed in the packaging of a product and is to serve as a moisture or vapor barrier. In addition, substrates which have been mechanically embossed generally have a surface which does not receive or hold printing inks uniformly.

There have been many attempts to produce embossed or patterned surfaces on substrates by the alteration of coatings placed thereon. For example, in the field of resinous coatings, patterned coatings involving the use "wrinkle" finishes have been employed. Such finishes are obtained by the incorporation of drying oils in the coating, which oils upon aging form irregular films resembling wrinkles. These coatings are not only expensive and difficult to manufacture but also are not capable of producing uniform small patterned embossed finishes. In addition, such finishes do not readily receive or hold printing inks.

It has also been konwn that surfaces which possess a finish somewhat resembling an embossed finish can be produced by spraying a resinous coating in the form of discrete particles on the surface to be coated. However, this method does not provide a satisfactory coat or embossed finish, since the results are not uniform or reproducible.

Another method for obtaining a patterned finish involves coating the substrate with a film forming material and applying thereover a texturing agent, such as an organic solvent, to cause a change in the appearance of the coating. However, this method has the disadvantage that it requires the use of a solvent, thereby adding to the time and cost of making such finishes, as well as involving an additional manipulative step separate and apart from the film forming operation.

It is also known that a textured finish resembling the surface of leather can be obtained by coating the substrate with an alkyd resin and applying over the resulting alkyd resin layer a second coating which comprises a thermoplastic resin and a thermosetting resin and thereafter curing the entire system to obtain a leather like textured finish. This method is not only involved but also is expensive, requiring two coatings to obtain the textured finish. In addition, the textured finish is somewhat large in character and is not adaptable to the finish of a finely textured embossed surface.

In accordance with the present invention the disadvantages of the above-mentioned prior art method for making textured finishes are overcome. The present invention provides a method for the production of an embossed surface which is not only economical but which is also extremely simple to perform. The present invention provides a thermal embossing process by which an improved product can be produced at a cost much lower than that of a product which has been mechanically embossed. Since the process is not dependent upon the application of pressure from rolls, it does not result in distortion or rupture of the substrate. Patterns and combination of patterns of embossing which cannot be achieved with pressure engraving and which cannot be achieved by the above-mentioned methods for texturing surfaces are readily accomplished in accordance with the present process. The present process provides for the embossing of a substrate in a great variety of combinations of colors. The substrate can be printed or otherwise colored prior to the embossing step, without any detrimental result after embossing. Furthermore, the embossed substrates of the present invention readily receive and hold printing ink and the substrates can be printed after embossing as well as prior to embossing. The present invention also provides a method which conditions the surface of the substrate so that an improved sealing bond can be achieved, if desired.

Substrates which are thermally embossed in accordance with the present invention are both decorative and functional and can be used as wrappings for any product that can be enclosed in a mechanically embossed wrapping material. They are particularly valuable for use where the merchandising of a product is dependent on its enhanced visual appearance. For example, thermally embossed papers are excellent as wrappings for cigarettes, candies, soaps, and similar products and can also be used as packagings, as decorative articles such as doilies and gift wrappings and the like.

The present invention comprises applying a film of a thermoplastic material to the surface of the substrate and thereafter heating the coated substrate at a temperature and for a period of time sufficient to cause the formation of nodules or blisters in the coating but not sufficient to darken the substrate or coating.

The substrates which can be embossed in this manner preferably comprise paper, including, for example, glassine, papers other than glassine, for example pouch stock, sulfite paper, kraft paper and the like, as well as paper board and the like. The substrate should have moisture sorbing characteristics and should release moisture under the conditions set forth in accordance with the present invention.

The thermoplastic materials which can be employed as the coating can be thermoplastic materials which have sufficient elongation properties to permit the creation of blisters or bubbles when heated to the desired temperature range. Such materials include low density polyethylene, high density polyethylene, polypropylene and other polyolefins, including copolymers of polyolefins such as ethylene-propylene, ethylene-butylene copolymers, mixtures of polymers, and the like.

The coating can be applied to the substrate by conventional means, including extrusion, dipping, spraying, painting and the like. The coating should be relatively impermeable to moisture vapor and should be sufficiently deformable to form blisters or nodules due to the pressure of vapors which evolve from the substrate under the conditions set forth in accordance with the present invention.

A particularly preferred embodiment of the present invention involves metallizing the coated substrate prior to the heating operation. This can be accomplished by any of the known methods for applying a metal to a coated substrate. Metals which may be employed include aluminum, zinc, silver, cadmium, nickel, chromium, gold and alloys of various kinds, for example tin-copper alloy, and the like. The metal may be applied by vacuum deposition, flame coating and the like or can be applied to the surface in the form of a thin film or foil, suitably laminated to the surface by an adhesive. When thin films of the metal are employed, however, they must be extremely thin to permit the thermoplastic coating to form blisters or bubbles.

After the coating has been applied to the substrate and, if desired, the metal has been applied to the coating, the resulting material is then subjected to controlled heat for a controlled period of time. The controlled heat may be applied by direct flame, by radiation, by direct contact heat or by indirect heating, for example infrared, heated irons or drums, heated air, dielectric heating or a combination of these heating methods. The treatment should be conducted at a temperature of from about 210° F. to about 390° F. and is preferably conducted at a temperature of from about 220° F. to about 275° F. The temperature range at which the desired embossing effect is obtained is dependent upon the particular heat source and heat transmission methods employed, upon the moisture of the substrate, upon the dwell time, i.e. the time of exposure to the heating medium and upon the particular substrate employed. As will be seen from the examples which follow, the dwell time may vary from a few seconds to a few minutes or longer.

The exact conditions to be followed for any particular coated substrate are readily assertable by simple experiment. The desired results can readily be seen as the heating progresses and the coated substrate can be removed from the heating zone when the desired embossed finish can be seen on the surface.

It is important that the rate of heating and the amount of heat supplied to accomplish the desired result be sufficient to accomplish the formation of nodules or blisters in the coating without lowering the moisture content of the substrate or base paper to the point where brittleness or scorching result. If the moisture content of the substrate is lower than about 1% when it is heated at sufficiently rapid rates to produce embossing, the sheet scorches.

The invention is illustrated in the drawings, in which:

FIG. 1 is an enlargd top plan view of an article of manufacture having an embossed effect produced in accordance with one embodiment of the process of the present invention, wherein a metallized coating of thermoplastic material is employed as a coating on a paper substrate, the upper surface of said thermoplastic material having a metallic coating thereon. FIG. 1 is an enlargement (approximately 75 times) of a photograph of the plan view of said article of manufacture.

FIG. 2 is a diagrammatic vertical sectional view of an article of manufacture produced in accordance with a second embodiment of the present invention. The article is similar to that shown in FIG. 1, except that the thermoplastic material does not have a metallic coating on its upper surface.

FIG. 3 is a diagrammatic vertical sectional view, along the line 3—3 of FIG. 1.

As shown in FIGS. 1 and 3 of the drawings, an embossed sheet is comprised of a paper substrate **2**, thermoplastic layer **3**, and metallic layer **4**. As shown in FIG. 2, an embossed sheet **1'** is comprised of paper substrate **2'** and thermoplastic layer **3'**.

The hills **5** and valleys **6** of the thermoplastic layer **3** and metal layer **4** of FIGS. 1 and 3 and the hills **5'** and valleys **6'** of thermoplastic layer **3'** of FIG. 2 can clearly be seen in the drawings. The spaces **7** in FIG. 3 and **7'** in FIG. 2, which are formed during the process of the present invention, can also be clearly seen in the drawings.

The following examples are illustrative:

Example 1

An opaque glassine sheet (25-pound ream weight) on to the surface of which had been extruded a coating of low-density polyethylene (½ mil thickness) was vacuum metallized with about 7 milligrams of aluminum per square foot. When heat from a gas burner was applied with care to the uncoated side of the sheet, the aluminized side of the sheet became speckled with minute "nodules" or blisters, giving the effect of an embossed surface similar to that produced by the use of pressure-type mechanical embossing rolls. The properties of the foil which made it a desirable wrapping material were not adversely affected by this thermal treatment which enhanced its visible appearance.

Example 2

Opaque glassine sheets (30-ream weight) were extrusion-coated with a high-density polyethylene (½ mil thickness) and vacuum metallized with about 7 milligrams of aluminum per square foot were conditioned at 75° F. and 60% R.H. Their moisture content was determined to be about 5%. They were held on a hot plate by a metal grid to insure uniform contact over a large area. The coated side was kept away from the heat source. Heating was performed under the conditions given in Table I below with the following results:

TABLE I

Temperature,° F.	Time	Results
190	2 min., 15 sec.	No embossing effect.
200	do.	Do.
210	do.	Do.
220	40 sec.	Bubbles began to form.
230	6 sec.	Bubbles forming.
230	60 sec.	Well-developed embossing effect.
240	6 sec.	Bubbles formed.
250	1 min., 2 sec.	Bubbles begin to form.
250	5 sec.	Bubbles plainly evident.
250	60 sec.	Embossed pattern well developed.
275	1 sec.	Bubbles formed on contact with hot plate.
275	30 sec.	Definite, well-developed.

Elmendorf tear tests on the sheets heated at 220° to 275° F. for one to 60 seconds showed that their strength had not been materially injured by the thermal treatment. Vapometer cup tests showed that the water vapor transmission rate of the sheets, although somewhat degraded, was superior to that of control sheets which had been mechanically embossed with pressure.

Identical sheets which had been conditioned in a desiccator for 24 hours until they contained less than 1% moisture were held on a hot plate by a metal grid to insure uniform contact, as described above. The results were obtained and are set forth in Table II below:

TABLE II

Temperature,° F.	Time	Results
270	40 sec.	Very slight bubbling noticeable.
270	60 sec.	Some bubbling evident under magnifying glass.
290	12 sec.	Faint trace of bubbling.
290	30 sec.	Slight pattern formed.
390	15 sec.	Bubbling almost immediate with an embossing effect resulting; back of sample scorched.

Example 3

Sheets of 30-ream weight glassine which had been extrusion-coated with a low density polyethylene (½ mil thickness) and metallized with aluminum were run in roll form over a duplex gas flame at a rate of 45 feet per

minute and were then chilled. The embossing effect, an overall speckled pattern, was well developed and showed good reflective properties. The strength of the base paper and the water vapor transmission rates of the sheets were measured with laboratory instruments both before and after the thermal treatment. The data showed that, under carefully controlled conditions of treatment, the thermally embossed sheet had little or no loss in these properties. The test data is given below in Table III.

TABLE III

Tear Strength	Without Thermal Treatment	After Thermal Treatment
Elmendorf Tear Test: [1]		
MD*	22	21
CD**	26	25
Mullen Bursting Test [2]	16.5	16.5
Tensile (Strength), MD* [3]	6.1	6.1
Stretch (Elongation), MD* [4]	1.55%	1.63%

[1] A.S.T.M. D689-44.
[2] A.S.T.M. D774-46.
[3] TAPPI (Technical Association of the Pulp and Paper Industry) T404OS-61.
[4] TAPPI 457m-46.
*Machine direction.
**Cross direction.

Example 4

Semi-opaque sulfite paper which had been coated with polyethylene (¼ mil thickness) was vacuum metallized with aluminum. Samples of the sheets were run over infrared heaters. Bubbles immediately began to form on the coated side, producing a speckled surface which resembled that of a sheet which had been mechanically embossed.

Other sample sheets were treated in a similar manner after steam had been applied to the uncoated side. The embossing effect was more uniform than in the sheets treated without the use of steam and the reflectivity of the sheets was greater. Similar results and distinctive designs were obtained by using a light coating of water on the uncoated side of the sheets and the use of steam or water in this manner represents a preferred method of operation.

The thermally embossed glassine, used as a decorative overwrap for candy bars, served as a moisture and vapor barrier, as demonstrated by the desirable condition of the candy after storage for several weeks.

Example 5

Opaque glassine sheets which had been extrusion coated with high-density polyethylene and vacuum metallized with aluminum were given a coating of varnish and a solid ink overlay. The sheets were then thermally treated by running them in roll form over a duplex gas flame at a rate of 45 feet per minute. The embossing pattern was well developed as a speckled design. The thermal treatment altered the color slightly but not adversely.

Example 6

Dishes made of a metallized high-density polyethylene coated sulfite sheet were floated on molten wax. When the wax was maintained at a temperature of 260° C. or above and the dishes were exposed to the treatment for 5 to 30 seconds, the inside of the dishes became cracked and exhibited unusual and beautiful designs.

Example 7

Flexible sulfite paper which had been coated with polypropylene (½ mil thickness) alone was heat treated as described in Example 2. The embossing effect was achieved but was not as accentuated as in the corresponding samples of Example 2, which had been metallized.

Example 8

Glassine coated with polyethylene (½ mil thickness) and metallized with aluminum was run at a variety of temperatures and speeds through an Inta-Roto laboratory laminator which had a 12-foot oven and hot rolls and cooling rolls 5-inches in diameter.

The results are given in Table IV below:

TABLE IV

Sample	Oven Temp., ° F.	Hot Roll Temp., ° F.	Speed, ft./min.	Results
1	280	270-275	15	Well-developed uniform light pattern of embossing.
2	320	270-275	15	Embossed pattern almost identical with one described above.
3	350	270-275	9	Well-developed heavy embossing pattern.
4	350	270-275	19	Well-developed pattern, light in texture.
5	350	270-275	31	Well-developed uniform light pattern of embossing.
10	380	270-275	21	Well-developed uniform heavy pattern of embossing.
11	385	270-275	50	Well-developed uniform light pattern of embossing.
12	385	270-275	60	Well-developed uniform light pattern.
13	385	270-275	65	Well-developed uniform light pattern.

From the data above, it can be seen that the embossing effect is dependent upon the temperature at which the paper is run and upon the time of heating, measured in this case by the speed of the machine. A heavy embossing can be made by applying high temperatures and slow speeds. A light embossing can be obtained by high temperatures and high speeds.

Samples 1, 3 and 4 were tested by the Standard Mullen Test which is A.S.T.M. D774-46.

The results are given below:

Mullen:
No. 1 (Standard Mullen Test), p.s.i. ---------- 28.7±1.5 (S.D.)
No. 3 ---------- 29.1±2.1 (S.D.)
No. 4 ---------- 27.3±3.0 (S.D.)

(Conclusion: No significant difference)

Samples 1, 3 and 4 were also tested for tensile and elongation in accordance with TAPPI T404 OS-61 and TAPPI 457m-46.

The results are given below:

[10 cm. gage length—Strain rate, 5 cm./min.]

Tensile and Elongation	Tensile, kg./in. of width	Percent Elongation
No. 1	8.59±0.38 (S.D.)	2.40±0.32 (S.D.).
No. 3	8.78±0.87 (S.D.)	2.6±0.35 (S.D.).
No. 4	8.32±0.94 (S.D.)	2.46±0.38 (S.D.).

Example 9

Glassine paper (30-ream weight) which had been extrusion-coated with polyethylene (½ mil thickness) was aluminized by vacuum deposition. The resulting sheet was run in two different experiments over rolls heated at 220° F. and 275° F. respectively. A speed of 9 feet per minute was used in each instance. The embossing effect was apparent but was not as pronounced as that obtained under the conditions used in Example 8.

Example 10

As in Example 8, a polyethylene coated and aluminized sheet of glassine was run through an oven at 350° F., over rolls heated at 275° F., and over chilling rolls at a speed of 9 feet per minute. The embossing effect was apparent but the sheet had a grayish finish which was not wholly desirable.

Example 11

Glassine coated with polyethylene and metallized with zinc was thermally treated as described in Example 2.

Nodules or bubbles were formed immediately upon contact with the heat, producing an embossing effect similar to that described in the preceding examples.

I claim:

1. A process for producing an embossed effect which comprises heating a coated substrate, said substrate comprising paper having a moisture content of at least 1% by weight and being coated with a solid, substantially continuous coating of thermoplastic material, until said coating is softened and moisture in said substrate is vaporized to cause sufficient pressure due to moisture vapor to distort the surface of the softened coating, whereby an embossed effect is obtained.

2. The process of claim 1 wherein said heating is conducted at a temperature of from about 210° F. to about 390° F.

3. The process of claim 1 wherein said coating is coated on the side away from the paper with a metal.

4. The process of claim 1 wherein said thermoplastic material is a polyolefin.

5. The process of claim 1 wherein said plastic material is polyethylene.

6. The process of claim 1 wherein said coating is polyethylene and wherein said coating is coated on the side away from the paper with aluminum.

7. A process for producing an embossed effect which comprises heating a coated substrate, said substrate comprising paper having a moisture content of at least 5% by weight and being coated with a solid, substantially continuous coating of thermoplastic material, until said coating is softened and moisture in said substrate is vaporized to cause sufficient pressure due to moisture vapor to distort the surface of the softened coating, whereby an embossed effect is obtained, said heating being terminated while the moisture content of said substrate is retained at a value above about 1% by weight.

8. The process of claim 7 wherein said heating is conducted at a temperature of from about 210° F. to about 390° F.

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