ENGRAVED ROLL APPLICATION OF SEALING COMPOUNDS

Filed April 10, 1961 2 Sheets-Sheet 1

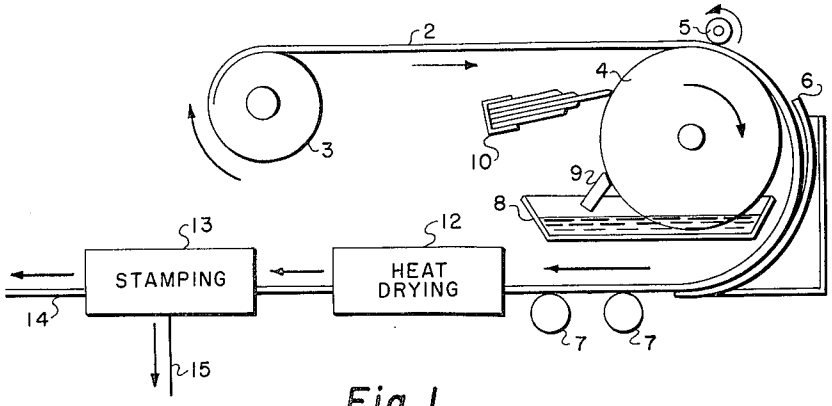


Fig. 1

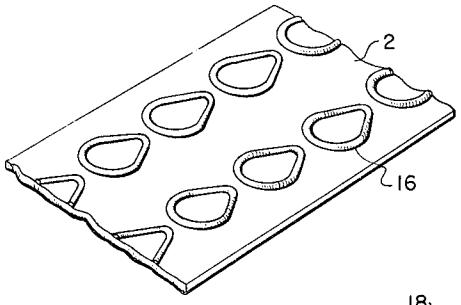


Fig. 2

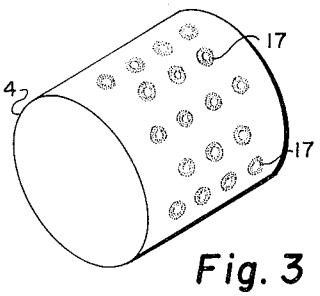


Fig. 3

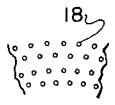


Fig. 4

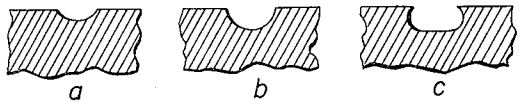


Fig. 5

ENGRAVED ROLL APPLICATION OF SEALING COMPOUNDS

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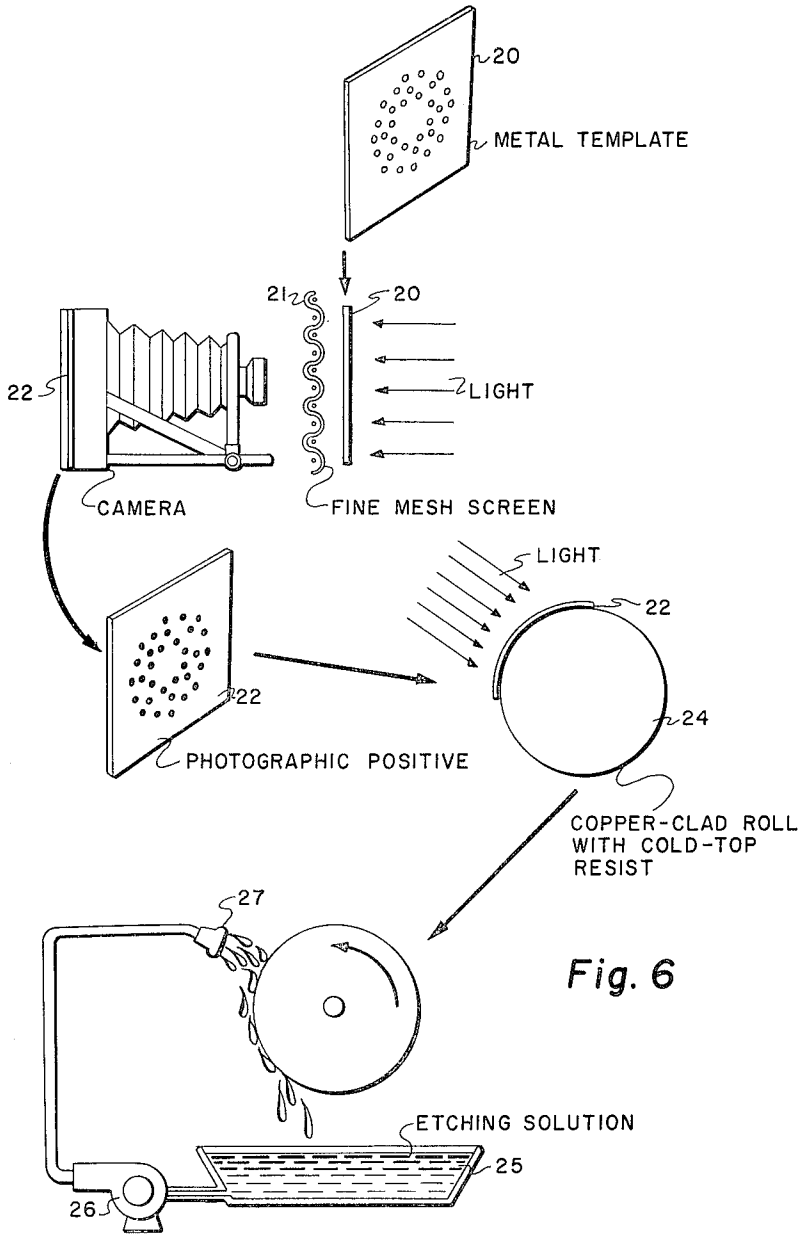


Fig. 6

United States Patent Office 3,198,111 Patented Aug. 3, 1965

3,198,111

ENGRAVED ROLL APPLICATION OF SEALING COMPOUNDS

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Filed Apr. 10, 1961, Ser. No. 102,021
6 Claims. (Cl. 101—170)

This invention pertains to a method and apparatus for applying sealing or gasketing compound in the manufacture of container closures and the like. More particularly, it is directed to a method of forming can end gaskets on flat stock from which gasketed can ends can then be fabricated.

Can end gaskets have been formed on punched can ends by nozzle lining. Nozzle lining involves applying a fluid gasket-forming compound through a nozzle to the edge of a can end, usually while spinning the can end if it is round. This is followed by drying, fluxing, or curing of the compound. This method is mechanically complex and is not well suited to the lining of irregular shaped ends such as rectangular or oval shapes. It has been proposed to form container gaskets by a method akin to silk-screen printing wherein the gaskets are formed on flat stock and the closures with the gaskets are subsequently stamped therefrom. The traditional screen printing method, however, is inherently intermittent because the metal sheet must be stationary when printed. The improvements of the silk-screen method that have been suggested for making the method continuous are usually mechanically complex and are generally unsatisfactory. Also, experimental work has shown that uniform gasket thicknesses and weights are difficult to achieve by this method.

In brief compass, the method of this invention comprises the continuous rotary "printing" of a fluid or liquid gasket-forming composition of the shape desired on metal sheet followed by conversion of the composition so printed to form-stable gaskets. The metal sheet is thereafter cut or stamped into can ends, crown closures, lug caps and the like in a conventional manner.

The essence of this invention resides in effecting the "printing" through the use of a cylindrical printing surface having the desired design or gasket shape in intaglio. The design is composed of a multiplicity of small independent cavities formed by drilling, engraving, etching or similar methods. The configuration of the cavities and the rheological properties of the liquid gasket-forming composition are important determinants to the obtention of (1) proper film thicknesses, (2) adequate transfer of the fluid composition to the metal sheet, and (3) uniformity in film weights in a single design and between designs, at commercially acceptable speeds.

Dry film thicknesses in the order of 0.025 to 1 millimeter are generally required for the types of can-sealing gaskets contemplated and it has been established that the process of this invention is capable of depositing films of this thickness in a single step. The present invention is particularly suited to the making of gaskets of 0.050 to 0.250 millimeter thickness, which thickness encompasses a majority of the can-sealing applications. The individual band widths for conventional can gaskets will usually be in the range of 2 to 8 millimeters. The method of this invention is particularly suited to the printing of gaskets which have two or more bands. It permits placement of dual or multi-band gaskets with a precision that is difficult to achieve by other methods.

The composition transferred to the metal sheet in the manner of this invention is initially in the form of small individual liquid dots which, depending on the rheology

of the composition, may immediately flow together or may be made to flow together thereafter, as by heating, to form a continuous film. In some applications, of course, it may not be necessary for the individual dots to coalesce.

The fluid gasket-forming composition can be applied to the printing wheel during each revolution in any conventional manner, such as by a bath, squeegeeing or spraying. Another important determinant to the successful practicing of this invention is the mechanical doctoring of excess compound from the background of the printing surface. This is done by the use of a rigid, usually metallic, doctoring knife or edge mounted at an angle with respect to the printing surface which, while scraping away excess composition from the background, does not appreciably cause the composition to be pulled from or scooped out of the cavities of the intaglio design. The configuration and placement of the cavities also affect the doctoring action. The cavities by and large must be independent, i.e., not interconnected, to provide a lattice or framework which supports the doctor blade and they must not be too large because the edge of the blade will flex into an overly large cavity and scoop out compound.

Under the proper conditions and with the proper intaglio design, 15 to 90 volume percent of the material in a cavity will transfer to the receiving surface, and the cavities after refilling and doctoring but prior to transfer will be 95 to 105 percent filled with the composition. Dry weight variations in any one design, and between designs, are normally less than ± 5 percent, and are usually within ± 2 percent. This precision is secured while printing or laying down relatively large amounts of material, generally over 1 milligram per square centimeter of the band (dry film weight).

While this invention is particularly directed to the manufacture of can end gaskets, it will be appreciated by those skilled in the art that the present invention can be usefully applied in any situation where it is desired to place a repeating pattern of a fluid polymer-containing system such as a dispersion, solution, melt, or emulsion on a receptive form-stable substratum. Thus, crown closures can be made by the method of this invention as well as pregasketed electrical conduit junction box covers. Masonite panels decorated with a relatively thick design of an elastomer and useful in the manufacture of glass top tables can also be made.

The nature and scope of this invention will become clear from the following discussion and examples made with reference to the drawings attached to and forming a part of this specification.

In the drawings:

FIGURE 1 schematically illustrates the gasket printing process of this invention;

FIGURE 2 shows a portion of the printed metal sheet with the gaskets thereon;

FIGURE 3 is a perspective view of the printing cylinder having a 307 can end design in intaglio;

FIGURE 4 is an enlarged view of a portion of the particular 307 can end intaglio design on the cylinder of FIGURE 3;

FIGURE 5 depicts a much enlarged cross-sectional view of different shapes the individual cavities making up the intaglio design may have; and

FIGURE 6 schematically illustrates a method of forming an intaglio design in the printing wheel by etching.

Like parts have the same number in the drawings.

Referring to FIGURE 1, the substratum to receive the elastomer gasket-forming compound can be, for example, a sheet 2 of 90 pound tin plate delivered from unwind roll 3. Any weight sheet desired can be used, and dimensionally or form-stable materials other than tin plate, e.g.,

aluminum, iron, steel and plastic are satisfactory, of course. The sheet is passed over printing roll **4** and underneath pressure roll **5**, receiving the compound in the pattern desired on its underside. The sheet passes around with the roll **4** until guided by curve guide **6** horizontally and compound side up over table rolls **7**. It is thereafter given whatever additional processing or treatment is desired.

While the drawing illustrates delivery of the printed sheet compound side up, which is preferred, the sheet does not need to bend around the roll and can be printed on the underside, while remaining substantially flat.

The printing speed can be as high as 3 linear meters per second or higher. Roll **4** can be heated or cooled as required by the nature of the compound. For example, a hollow roll can be used and hot or cold water or other suitable liquid can be circulated therein, or the roll can be electrically heated.

The compound is applied to the roll by passing the roll through a bath **8** maintained beneath the roll. Excess compound is then grossly removed, as the roll rotates, by a rough doctor or squeegee knife **9**. This is followed by a precision knife-edge doctor blade **10** which is used to remove substantially the last traces of compound from the background. The under, flat side of the doctor blade **10** is set at an angle of 30 to 60 degrees from the tangent at the point of contact. The blade is preferably oscillated by known mechanical means, e.g., with an air cylinder.

The compound on the printed sheet at the point of table roll **7**, as illustrated in the drawing, is still fluid and may or may not be coalesced. The printed compound is thereafter set to form-stable shapes by any convenient method, e.g. chemical curing, heat drying and curing, heat fluxing or irradiation. As shown in FIGURE 1, the printed sheet is heat cured in oven **12** and then passed to step **13**, when each gasket is stamped out of the repeated pattern in a conventional manner to form the can ends. The perforated scrap is removed at **14**, and the can ends at **15**.

FIGURE 2 illustrates for purposes of clarity the appearance of a sheet after printing of the compound and heat curing. The metal sheet contains a repeating pattern of a plurality of can end gaskets **16**, in this case, pear-shaped gasket for 709 x 1011 ham can ends ($7\frac{9}{16}$ x $10\frac{11}{16}$ inches, outside dimensions, after double seaming).

FIGURE 3 shows the printing surface of roll **4**. As illustrated, it has a plurality of intaglio can end gasket designs **17** for a 307 can end (can end size for United States standard Number 2 can—$3\frac{7}{16}$ inches, outside diameter, after double seaming). In some cases, roll **4** may have only one design per revolution.

FIGURE 4 shows a 45-degree arc of one of the 307 can end designs **17** in enlarged detail. It is composed of a multiplicity of small cavities **18** having the desired volume, configuration and spacing. While the cavity openings illustrated are round, they may also be square, triangular, ovoid and the like. Generally speaking, the depths of the cavities used in the method of this invention are considerably greater than those encountered in conventional rotogravure printing. The cavities normally have a depth over 0.120 millimeter, usually over 0.250 millimeter. It is preferred to use at least two rows of cavities across the width of the band.

FIGURE 5 shows in cross-section three different shapes the individual cavities may have. FIGURE *5a* is a shallow dish-shape formed by drilling with a ball tipped drill or cutter and is the preferred design. FIGURE *5b* shows the same type of cavity but drilled to a greater depth. FIGURE *5c* shows the type of cavity which is obtained by acid etching. When acid etching is carried out, there is usually some undercutting and thus the cavity bulges in cross-section. When etching is used, it is desirable in some instances to machine a few thousandths off the surface of the roll after etching to open up the mouth of the cavity. A preferred method of forming the cavities by etching will be described in greater detail hereafter. Besides acid etching, electrolytic and electron beam etching can be used as well.

Experimental work has shown that the fraction or percent of compound transferred from a cavity is principally a function of the cavity shape and the rheology of the compound, but is largely unaffected by the size of the cavity. A shallow cavity, to a limit, transfers a larger fraction of its material than a deep cavity. It is to be understood, however, that for two cavities of the same diameter, but materially different depths, the deeper cavity will transfer the largest total amount of compound because it contains more, although the percentage transfer will be less than that for the shallow cavity. Stated somewhat differently, for a given cavity depth, the quantity of material deposited is a linear function of the diameter of the cavity, or approximately so, if the cavity volumes being compared contain the same percentage of compound, i.e., filling and doctoring has been equal. For a given cavity diameter, the quantity of material transferred is a second order function of the depth and approximates a parabolic function.

While the shape of the cavity opening is not too material, it can be seen that the relationship between the surface area encompassed by the cavity opening to the volume of the cavity is important to the efficient transferral of compound in the heavy film weights desired. There is a limit on the maximum size and on the spacing of the cavities imposed by the doctoring step. If the cavity openings are too large, the doctor blades will scoop or draw compound out of the cavities. Cavity spacing is determined by the need to have the printed dots close enough to permit coalescence while still maintaining a lattice-work, i.e., cavity independence, of sufficient strength to support the doctor blade without deflection and undue mechanical wear.

In general, it is preferred to use 18 to 75 cavities per square centimeter of the intaglio design, and to have the ratio of the surface area encompassed by the opening of a cavity to its volume in the range of 5:1 to 500:1, preferably 20:1 to 80:1 centimeters^{-1} (volume measured without considering undercutting). The distance between the edges of the cavities is preferably not further than 0.250 millimeter apart in any direction in order to obtain coalescence, and the lattice-work between the cavities should not be less than 0.025 millimeter thick at any point. It is also preferred that the area encompassed by the cavity openings be in the range of 40 to 80 percent of the total area included in the intaglio design.

It has been found that a shallow disc-shaped design as illustrated in FIGURE *5a* as opposed, for example, to a square or a truncated spheroid design in cross-section is most efficient and is preferred. The depth to radius ratio of the disc-shaped cavity is preferably in the range of 1:3 to 1:8. The radius of the cavity is preferably less than 1 millimeter.

As noted before, the rheology of the fluid gasket-forming compound is significant. While its useful properties may vary somewhat with the printing speed, film thickness desired, doctor blade angle, temperature, and the like, certain of the attributes that the compound must have for successful transfer can be generally described. The compound must fill the cavities without too much of a meniscus and at a rate consistent with the speed being used. Generally, this means that the compound has a relatively low viscosity as compared to compounds used in nozzle-lining operations. It must adequately wet the surface of the sheet being printed to permit transfer. The internal cohesiveness must be sufficient to permit cavitation [1] and transfer of a reasonable volume percent

[1] See Eirich, Rheology, volume III, pages 145 to 187, Academic Press, New York (1960).

from the cavity to the surface of the sheet. Its solids content, i.e., the ratio of dry film weight to wet film weight, must be relatively high in order to secure adequate film weights with a single printing, and in the case of heterogeneous polymer systems, to avoid syneritic squeeze, i.e., compressive removal of liquid phase. The solids content of the compounds used is greater than 40, preferably greater than 70 weight percent.

The viscosity-shear characteristic of the compound is perhaps its most important property. The compound can range from a slightly dilatant through a Newtonian to a pseudo-plastic liquid. This can be more precisely expressed by saying that its PIRV [2] slope is within the range of 0.70 to 1.05. The Precision Interchemical Rotary Viscometer measures the shear stress of a compound over a range of shear rates. The PIRV slope is the logarithmic rate of change of the shear stress with the shear rate as determined by plotting on log-log paper the shear stress in dynes per square centimeter against the shear rate in reciprocal seconds.

The viscoelastic flow property of the compound is also a useful guide. A viscoelastic flow valve can be obtained by inserting the tip of a 1.016 millimeter diameter wire (American S & W music wire, 18 gage) into a drop of the compound and withdrawing it at about 50 centimeters per minute using an Instron tester. While various withdrawal rates can be used, the results obtained at 50 centimeters per minute are particularly significant. During the withdrawal of the wire from the sample, the viscoelastic elongation (stringing) is recorded with a movie camera and the corresponding strain is taken from the Instron recorder. Correlations of the measured viscoelastic flow and the observed strain with the ability of a compound to print indicate that values in excess of 12 millimeters at 200 milligrams strain are most satisfactory.

The compound should wet the surface of the plate being printed, i.e., a 3 to 6 millimeter diameter drop of compound on the surface should have no tendency for withdrawal. A slight enlargement of the drop is preferred. The wetting of the receptive surface can be improved by suitable means such as coating it with a thin adhesive or lacquer. The Brookfield viscosity (model LVF5X, No. 4 spindle, 60 r.p.m., 27° C.) is in the range of 1,500 to 250,000 centipoises, preferably 1,500 to 60,000 centipoises. Internal cohesiveness as measured by doctoring a 0.025 millimeter film of the compound on a 6.45 square centimeter amooth surface of a metal block, wetted as defined above by the compound, compressing it between a like surface and then pulling the surfaces apart at a rate of 50 millimeters per minute should give initial forces in the range of 420 to 2100 grams per square centimeter. Cavitation will be obtained with forces above about 1050 grams per square centimeter.

[2] Precision Interchemical Rotary Viscometer, see: "Precision Scientific Company Instruction Manual, cat. #64945," W. B. Barish, issued 6–14–55, Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

EXAMPLE I

Cavity design.—Experimental work supporting the conclusions, supra, about the effects of cavity configuration and spacing, and compound rheology, on the transfer of compound will be but briefly described.

The work was carried out on a bench model, hand-operated machine with 20.3 centimeter diameter magnesium printing wheel. Sixteen intaglio designs were drilled in the wheel perpendicular to the tangent using 4 sizes of spherical cutters (1.59, 2.38, 3.18 and 3.97 millimeters diameters) run into 4 different depths (0.254, 0.381, 0.508 and 0.635 millimeter). Each design was a 72 degree arc of a 307 can end. The band width was 4 millimeters. With the smallest cutters, the circular spacing between holes was 2 degrees and 3 rows were used for a total of 107 holes per arc, and the arc spacing was uniformly increased up to 4 degrees for the largest cutter with 2 rows being used for a total of 37 holes per arc.

Three different compounds were evaluated during this series of tests.

Table I

Compound	A	B	C
Type	Polyvinyl-chloride plastisol.	Neoprene in aromatic solvent with small amount of filler.	Low molecular weight peptized neoprene.[1]
Flow properties	Cohesive, pseudo-plastic.	Pseudo-plastic (intermediate cohesiveness).	Mildly cohesive, pseudo-plastic.
Viscoelastic flow, millimeters	14.2	16.0	18.5.
PIRV slope	0.86	0.85	0.78.
Solids content, weight percent	100	82	100.
Brookfield viscosity (LVF5X):			
Spindle number	3	4	5.
Temperature	38° C	27° C	28° C.
6 r.p.m., centipoises	7,500	25,000	66,000.
60 r.p.m., centipoises	3,500	20,750	35,500.

[1] See United States Patent 2,456,972.

After adjusting the machine to obtain uniform transfers, 15.2 centimeters wide strips of 90 pound tin plate were printed on their underside at a speed of 25.4 centimeters per second. The wheel rotated through a bath of the compound being tested, and excess compound was doctored from the wheel prior to the wheel contacting the strip at the top of its revolution. The strip almost linearly contacted the wheel under the impression roll with very little bending.

An average of 10 weighings were made on each of the 16 designs to obtain the average volume of compound transferred per pass. Percentage transfers ranged from 22 to 60 percent, based on the amount of compound a design should contain when full as determined from calculations of the cavity volumes. The majority of the data fell in the range of 30 to 45 percent transfer. Reproducibilities for any one design and compound, i.e., deviation of any one run from average (in milligrams), were within ±2.0 percent, except for one run which was ±5 percent. The data predominately fell in the range of ±1 percent. The wet film weights varied from 6.7 to 38.8 milligrams per 72 degree arc, with the majority falling in the range of 15 to 30 milligrams.

EXAMPLE II

Properties of compound.—These experiments were carried out on a motor driven bench model printer equipped with an adjustable knife-edged doctor blade and a 20.3 centimeter outside diameter "wrap around" zinc plate designed to print the proper film volume (0.050 to 0.070 cubic centimeter, dry basis) for a 307 can end. The internal diameters of the bands were 87 millimeters and the outside diameters were 96 millimeters. Four can

ends designs in intaglio were placed on the plate using a ball or spherical cutter. Table II gives additional details:

Table II

Circle number	1	2	3	4
Cutter diameter, millimeters	1.59	1.59	1.98	3.18
Depth, millimeters	0.305	0.381	0.381	0.381
Dot Spacing, degrees (alt.)[1]	2	2	2.5	3
Number of rows	4	3	3	2
Total number of holes	720	540	432	240

[1] Between centers of dots in alternate rows.

Compound was placed on the roll by a bath maintained beneath the roll. Excess compound was doctored off using two blade angles, 30 degrees and 60 degrees from the tangent. Operating speeds were 10.7 and 15.2 linear meters per minute. 90 pound tin plate strips 15.2 centimeters wide were printed with the compound by being contacted with the upper portion of the printing roll using a pressure roll to force it down against the printing roll. Ten weighings were made on each ring printed at each angle and for each compound.

Several different types of compounds were evaluated. Table III lists the physical properties of five of these compounds by way of example. The variety of compound types used establish that the compound system or chemical constituents can vary widely, it only being important that the compounds have the proper rheological properties for printing.

3 of the intaglio designs, while printing consistently, printed underweight from what was expected. A photographic study showed the ring to have been incorrectly machined.

A study of these data and data obtained from other experiments established that extremely plastic materials or extremely dilatant materials will not print satisfactorily. The ideal rheological operating range is slightly on either side of Newtonian, i.e., slightly dilatant, Newtonian or pseudo-plastic. It is difficult to print a compound whose PIRV slope is outside the range of 0.70 to 1.05. At lower values, the extreme plasticity of the compound prevents filling of the cavities and coalescence. The dilatancy of a compound having a higher value prevents clean doctoring of the background and also causes poor percentage transfers.

At constant speed and with the proper cavity configuration and compound rheology, the quantity of material transferred from the intaglio design to the metal sheet can be made to be as high as 80 percent by decreasing the doctor blade angle. It appears to be desirable in some instances to design or pitch the doctor blade such that a hydraulic pressure is created under (and in advance of) the blade which causes a small amount of compound to flow back within the cavity underneath the blade, to the extent perhaps of creating a slight minuscus or overfilling of the cavity with some compounds. In this connection some benefit can be obtained by pitching the cavities with respect to the tangent, i.e., while the cavities in the roll of this example were drilled perpendicularly to the tangent,

Table III

Compound	D	E	F	G	H
Type	Modified G-RS in solution.	Rubber latex	Thermosetting polyvinyl chloride plastisol.	Low molecular weight neoprene.	Polyvinyl chloride plastisol.
PIRV slope	0.77	0.82	0.83	0.87	1.02.
Total solids, percent	75	50	100	100	100.
Brookfield vis., centipoises (LVF5X):					
Spindle No	4	4	3	4	3.
Temperature, ° C	25.6	26.1	43.5	27	43.5.
6 r.p.m	10,000	4,500	14,000	45,000	3,500.
60 r.p.m	4,750	1,400	6,600	31,000	1,500.

Compound D was a butadiene-styrene-acrylonitrile terpolymer dispersion carried in a paraffinic solvent. A large amount of clay filler was used in this compound.

Compound E was a butadiene-styrene copolymer dispersion in water modified with a primarily zinc oxide filler and a relatively large amount of ester gum resins.

Compound F was a dispersion of polyvinyl chloride and an imidazoline crosslinking agent modified with a moderate amount of a primary plasticizer blend.

Compound G was a highly mechanically and chemically peptized neoprene formulation modified principally with inorganic fillers and mixed hydrocarbon plasticizers.

Compound H consisted of 55 weight percent of a dispersion grade polyvinyl chloride resin admixed with 35 percent of di-2-ethylhexylphthalate, 6.5 percent titanium dioxide, 0.25 percent activated carbon black, and 2.5 percent of a refined paraffin wax. The composition was prepared by first melting the wax in about ⅓ of the plasticizer at 66° C. and then blending the remaining ingredients in at about 50° C., followed by immediate cooling. This compound had a specific gravity of 1.27. It was developed specifically for use on vinyl lacquered tinplate. A 2.5 millimeter thick film of this compound can be fused in one minute at 195° C.

Compounds D through H printed successfully although there were variations in the film weights as a result of compound characteristics, and changes in speed and doctor blade angle. Compound E had the tendency to dry out and form deposits in the cavities. This can be overcome by proper humidification of the atmosphere. Ring the cavities may be drilled 0 to 45 degrees from the perpendicular.

It was also found that with the more plastic solvent containing compounds, it is desirable to relieve the pressure of the impression roll to avoid syneretic squeeze and obtain a more definite print.

In general, less compound is transferred at the higher speeds. This is not true, however, with compounds having a considerable "intrinsic" viscosity.

Table IV summarizes the data obtained with Compound D for purposes of illustration.

Table IV

RESULTS WITH COMPOUND D

[75 weight percent total solids—15.2 meters per minute]

Circle number	1	2	3	4
Theoretical dry weight contained in cavities, milligrams	127	142	[1] 146	137
Percent transfer:				
30° blade angle	66	82.5	43	79.5
60° blade angle	50	71	26	43.5

[1] Not accurate—cavities improperly drilled, consistency between runs is significant.

Table V more clearly shows the effect of doctor blade angle on the percentage transfer of compound.

Table V

PERCENT TRANSFER VS. BLADE ANGLE

[15.2 meters per minute]

Compound	Percent Transfer	
	30° angle	60° angle
A	60	48
D	82.5	71
E	53	41
F	59	51
G	62.5	51

EXAMPLE III

Preparation of etched intaglio design.—Six intaglio 307 can end designs were prepared on a 0.508 millimeter copper clad, 20.3 centimeter diameter steel roll. Two were acid etched and four were machined as previously described with the exception that the layout for the machining was carried out with the template in the same manner as will be described for the acid etched designs. The etched designs were to duplicate two of the machined designs.

Table VI sets out the pertinent information on the designs:

Table IV

Circle number	1-M	2-M	3-M	4-M	3-E	4-E
Cutter diameter, millimeters	1.19	1.59	1.98	1.98		
Dot diameter millimeters (est)	1.03	1.27	1.52	1.58	1.52	1.58
Dot depth, millimeters	0.381–0.405	0.355–0.381	0.381–0.405	0.381–0.405	0.381–0.405	0.381–0.405
Dot spacing, degrees (alt.)	2	2	2.5	2.5	2.5	2.5
Number of rows	4	3	3	4	3	4
Total number of holes	720	540	432	576	432	576
Circle diameter, millimeters:						
Internal	87	87	87	83	87	83
Outside	96	96	96	96	97	96

With reference to FIGURE 6, brass templates **20** were prepared with the cavities of the design drilled approximately 0.381 millimeter undersize. This reduction in cavity diameter allows for the horizontal etching that occurs during the vertical etching, which is extensive as compared to the mild etching used to prepare rotogravure plates. Any form-stable material such as a plastic or aluminum can be used as the blank from which the template is prepared.

Each brass template was used as a photographic negative to produce a positive film by photographing the template image through a fine mesh (150 line) screen **21**, using a Cronar type of film **22**, which is dimensionally stable. The screen was superimposed on the template to reduce undercutting during the etching. The use of the screen resulted in the photographic positive **22** of the template dots being composed of a regular pattern of very minute dots. The positive was developed in a conventional manner.

The copper clad roll **24** was treated with a photosensitive resist, Kodak Photo Resist (Eastman-Kodak Company, catalog C., 1959), and the image of the positive was transferred thereto using carbon arc light through the positive. When developed in a conventional manner, the "black" areas of the positive, i.e., the screen grid or framework, became the "white" etchable areas on the roll. The images were then incrementally etched in a conventional manner using an iron perchlorate solution and until the desired depths were reached. The iron perchlorate solution was sprayed onto the roll while rotating the roll. The solution was collected in drip pan **25** and recycled by pump **26** and spray nozzle **27**.

It can be seen that with both the machining and etching methods of preparing the printing wheel, the intaglio design in the surface of the wheel is composed of a multiplicity of minute independent recessed cavities with the surrounding continuous lattice-work being formed from the original surface of the wheel, i.e., the lattice-work of the design is on level with the surrounding surface or background of the wheel, and serves to support the doctor blade. In the preferred embodiment, directed to the manufacture of can ends, the cavities have substantially identical dimensions and there is no intentional variation either in the spacing of the cavities within the design or in the depth, volume or width of opening of the cavities. This helps to assure that uniform film weights will be secured. In other applications, of course, it may be desirable to have some gradation.

The etching preparation procedure can also be used to prepare thin flat or curved perforated plates useful in compound printing processes similar to silk-screen printing. In this arrangement, the holes go through the metal sheet, and compound is forced through the holes from the reverse side by a squeegee on to the plate being printed.

Having described this invention, what is sought to be protected by Letters Patent is succinctly set forth in the following claims:

What is claimed is:

1. A method of printing a repeating pattern of a liquid polymeric composition on a form stable sheet comprising

(1) passing said sheet under an impression roll and uniformly and evenly placing a surface thereof in contact with a portion of a rotatable cylindrical printing surface having an intaglio design of the desired configuration,

(a) said intaglio design comprising a multiplicity of minute independent cavities ranging from 18 to 75 per square centimeter,

(1) said cavities having a depth of at least 0.120 millimeter and

(2) an enclosed surface area to volume ratio in the range of 5:1 to 500:1 centimeters^{-1},

(a) said enclosed surface composing 40 to 80% of the surface area encompassed by said design,

(2) filling said cavities with a liquid gasket-forming polymeric composition

(a) having a PIRV slope in the range of 0.70 to 1.05,

(b) a viscoelastic flow value greater than 12 millimeters,

(c) a solids content greater than 40 weight percent and

(d) is capable of wetting the surface of said sheet,

(3) removing excess composition from the background of said design, and then

(4) transferring a portion of the composition in said cavities to the surface of said sheet,

all while rotating said printing surface to produce a repeating pattern of said design.

2. A method according to claim **1** wherein said cavities are disc-shaped with a ratio of the depth to the radius of the open end thereof being in the range of 1:3 to 1:8, said radius being less than one millimeter.

3. A method according to claim 1 wherein said design is a can end and the pattern is thereafter set to coalesced form-stable, the dry weight variation between the designs of said pattern being less than ±5%.

4. A method of printing a sheet metal blank with a plurality of uniformly spaced elastomeric shapes having a dried film thickness in the range of 0.050 to 0.250 millimeter, a dry film weight greater than 1 milligram per square centimeter and suited for stamping into gasketed closures comprising

(1) passing a sheet metal blank under an impression roll and uniformly and evenly placing the under surface thereof in contact with a portion of a rotating cylindrical printing surface having a plurality of intaglio designs therein of the desired configuration,
  (a) each of said designs being filled with a liquid gasket-forming polymeric composition
    (1) having a PIRV slope in the range of 0.70 to 1.05,
    (2) a viscoelastic flow value greater than 12 millimeters,
    (3) a solids content greater than 40 weight weight percent and
    (4) is capable of wetting the surface of said metal blank,
  (b) each of said intaglio designs comprising a multiplicity of independent minute cavities
    (1) having a depth of at least 0.120 millimeter and
    (2) an enclosed surface area to volume ratio in the range of 5:1 to 500:1 centimeters^{-1},
      (a) said enclosed surface composing 40 to 80% of the surface area encompassed by said design,
(2) transferring liquid composition from said cavities to the surface of said metal blank,
(3) continuing rotation of said printing surface,
(4) refilling said cavities with said liquid compositon,
(5) removng excess composition from the background of said printing surface and repeating the printing cycle,
(6) and thereafter converting the comoposition so transferred to the surface of said metal blank to an elastomeric state.

5. A process according to claim 4 wherein said shapes are can end gaskets having a band width in the range of 2 to 8 millimeters, there being at least two rows of cavities across the width of the band, and wherein the dry weight variation between the shapes is within ±5%.

6. In the manufacture of gasketed can ends wherein a repeating pattern of can end gaskets having dried film weights greater than 1 milligram per square centimeter and a band width in the range of 2 to 8 millimeters are formed on a metal sheet and gasket can ends are subsequently formed therefrom, an improved method of forming said repeating pattern comprising the steps of

(1) printing said metal sheets with said repeating pattern by contacting said sheet with a rotating cylinder having said pattern incised therein in intaglio,
  (a) the intaglio pattern being composed of a multiplicity of independent cavities
    (1) having a depth greater than 0.120 millimeter and
    (2) an enclosed surface area to volume ratio in the range of 5:1 to 500:1 centimeters^{-1},
      (a) said enclosed surface composing 40 to 80% of the surface area encompassed by said design,
    (3) there being in the range of 18 to 75 of said cavities per square centimeter of said band,
    (4) said cavities at the time of contact with said metal sheet being in the range of 95 to 105% filled with
  (b) a liquid gasket-forming polymeric composition having
    (1) a PIRV slope in the range of 0.70 to 1.05,
    (2) a viscoelastic flow value greater than 12 millimeters,
    (3) a solids content greater than 40 weight percent and
    (4) is capable of wetting the surface of said metal sheet,
(2) transferring in the range of 15 to 50% of said composition to said metal sheet on contact,
(3) continuing rotation of said cylinder,
(4) refilling said cavities with said composition,
(5) removing excess composition from the background of said pattern by doctoring and
(6) repeating the cycle.

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