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(54) **SILK-SCREEN PRINTABLE FOAM PRODUCT**

division of application No. 08/734,900, filed on Oct. 22, 1996, now Pat. No. 5,736,075.

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(57) **ABSTRACT**

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**Related U.S. Application Data**

(60) Continuation of application No. 08/929,938, filed on Sep. 15, 1997, now Pat. No. 6,586,074, which is a

A molded product is made comprising a low-density product having a porous volume including cells and an essentially non-porous layer adjacent an external surface of the product. Essentially none of the cells are exposed at the external surface. The external surface is sufficiently tough, smooth, strong and durable to be suitable as a substrate for silk-screen printing.

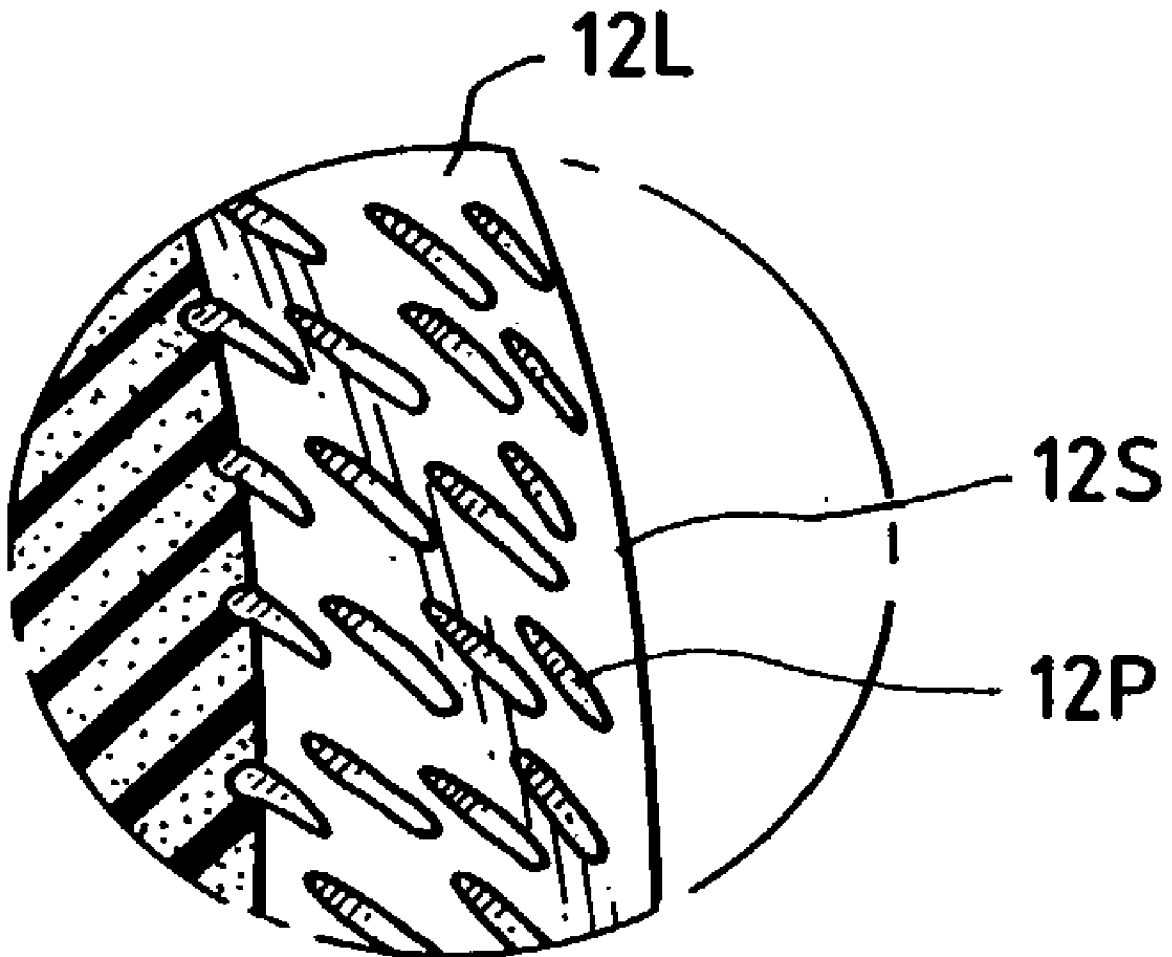


FIG. 1

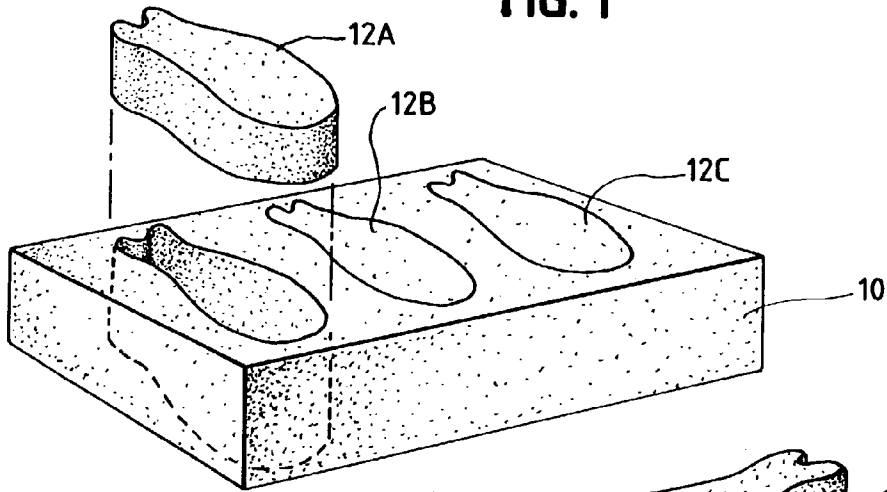


FIG. 2

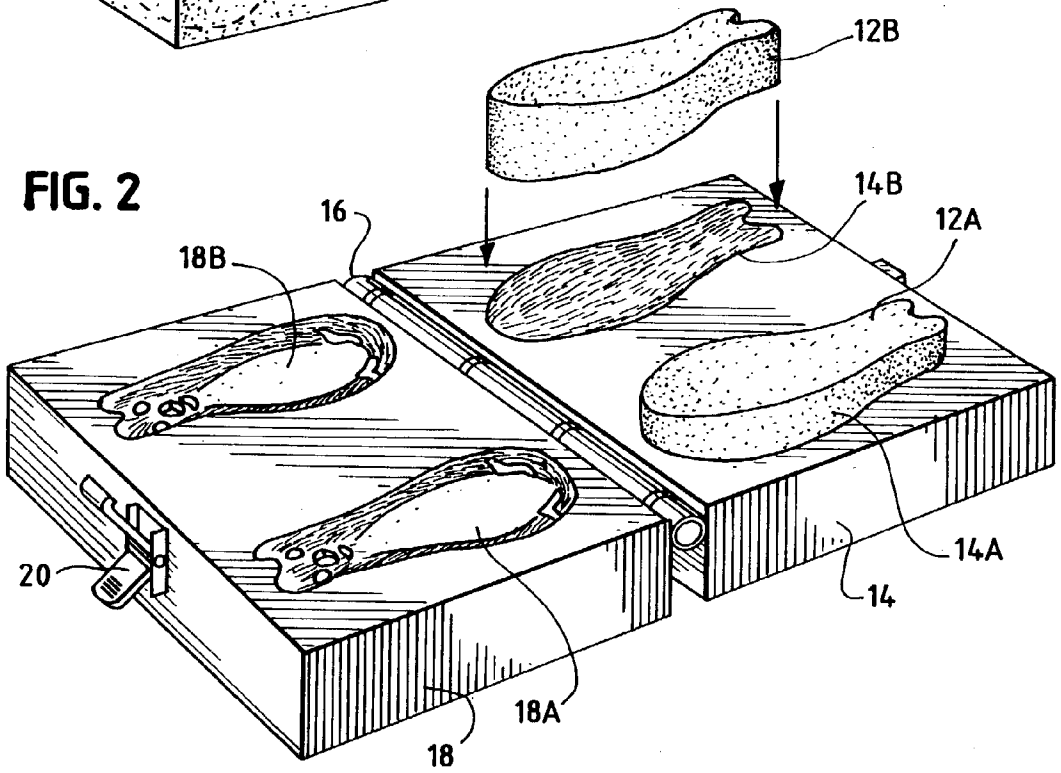


FIG. 3

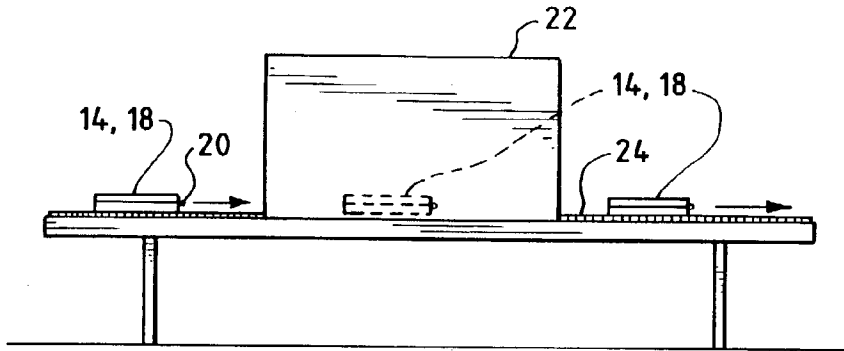


FIG. 4

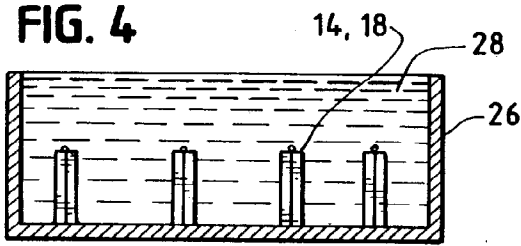


FIG. 5

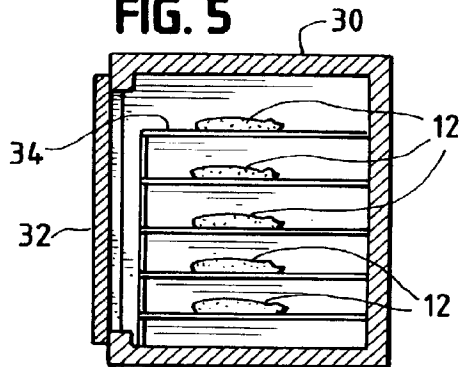


FIG. 6

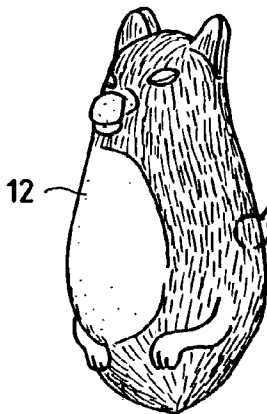


FIG. 7

FIG. 7

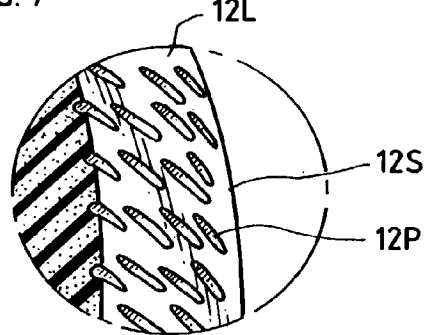


FIG. 8

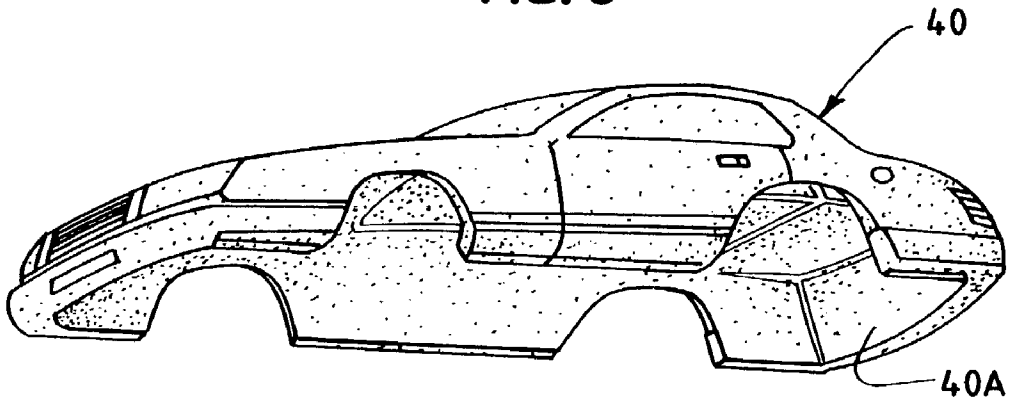


FIG. 9

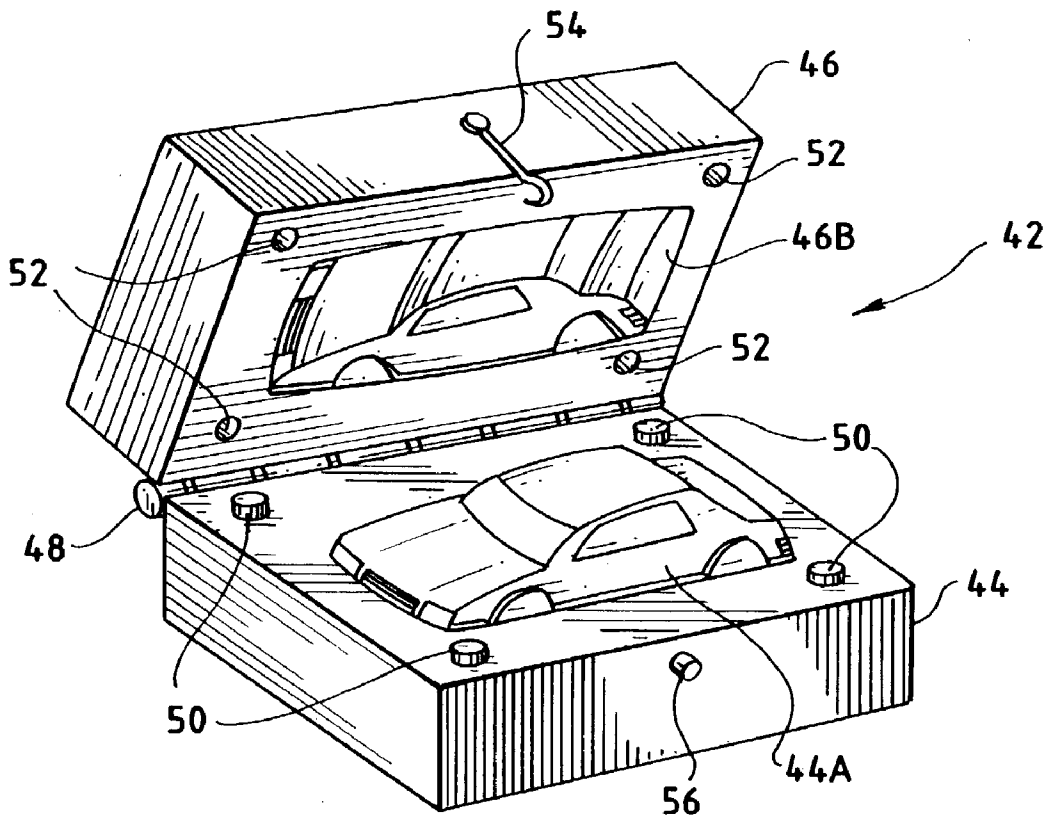


FIG. 10

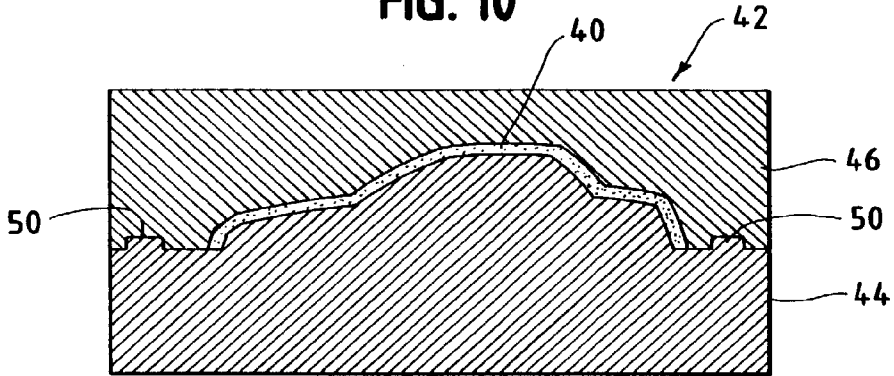
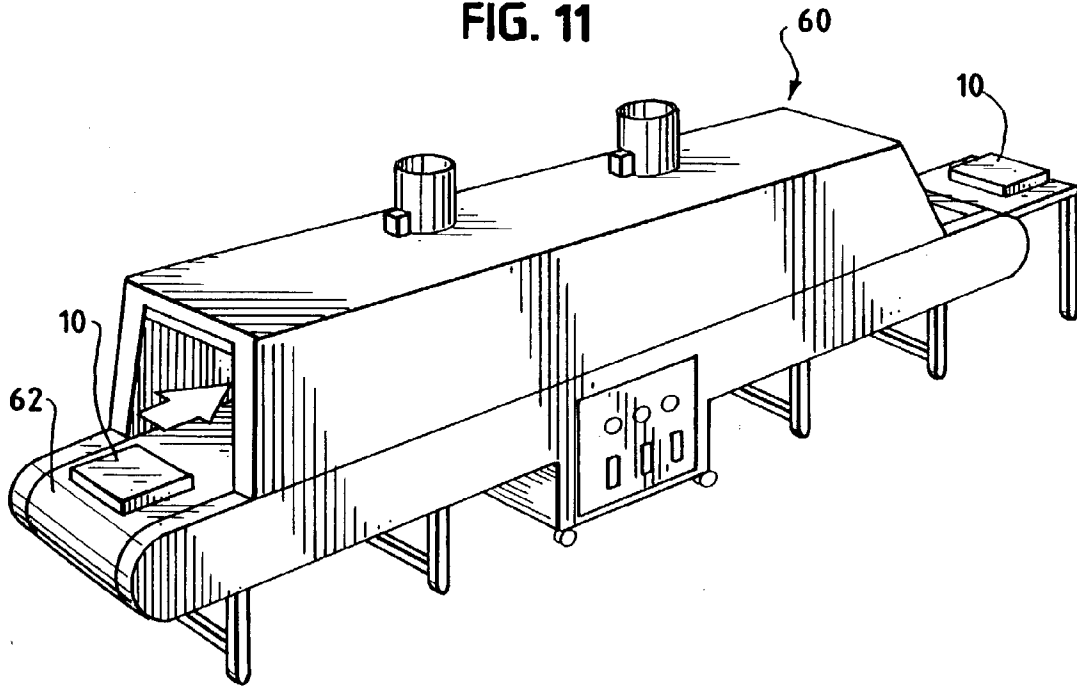


FIG. 11



### SILK-SCREEN PRINTABLE FOAM PRODUCT

[0001] This patent application is a continuation of U.S. application Ser. No. 08/929,938, filed Sep. 15, 1997 and now allowed, which is a divisional of U.S. application Ser. No. 08/734,900, filed Oct. 22, 1996 and now U.S. Pat. No. 5,736,075.

### TECHNICAL FIELD

[0002] This invention relates generally to molded objects and methods of molding. It particularly concerns an object molded of foam material which has many of the characteristics of a solid molded object, and molding methods for achieving such characteristics.

### BACKGROUND OF THE INVENTION

[0003] Toys and other objects which are fabricated from porous materials such as foamed plastics have certain advantages: they are light in weight, owing to their low density; and they are safe for children, owing to their compressibility. Such lightness, safety and compressibility makes these materials especially suitable for bouncing balls, flying toys such as gliders, and throw-toys such as darts. But these materials have not generally produced very good results when used for other types of toys and other products.

[0004] In the past it has been difficult or impossible to fabricate such materials in a form which is acceptable to the marketplace. Foam materials are usually supplied in sheet form, making it difficult to fabricate them into objects of non-uniform thickness. By comparison, injection-molded plastic objects can be made in a wide variety of shapes of non-uniform thickness. Injection molding also has been favored for the inclusion of molded-in-place inserts of various types. Historically, foam materials have not held such inserts well.

[0005] In addition, the toy marketplace favors objects with a shiny surface, preferably decorated with a variety of bright colors. Foam materials have heretofore had a dull, porous surface which is unsuitable for finishing with brightly colored paints, silk screens, tampo printing and decals. Such surfaces are also unsuitable for the molding of fine surface detail, which lends a desirable realism to toy objects. Another problem encountered with foam objects of the prior art is their vulnerability to tearing because of the softness of the surface layer.

[0006] The present invention, however, contemplates the molding of toys and other objects from foam materials, yet provides such objects with a tough, smooth, shiny surface which is similar to that which results from insert molding. As a result, the molded foam objects of this invention combine foam's advantages of lightness, safety and compressibility with a superior ability to hold molded-in-place inserts and to accept various types of surface decorations, preferably brightly colored, plus fine surface detail. The molded foam objects of the invention are also more durable, because the tough surface layer resists tearing.

### BRIEF SUMMARY OF THE INVENTION

[0007] These desirable results are achieved by a method of molding a low-density object having an impermeable surface, from porous material, comprising the steps of preparing a mold having a cavity the outline of which defines the

outline of the object, stamping from the porous material a blank having substantially the outline of the object, inserting the blank into the cavity with the outline of the blank substantially congruent with the outline of the cavity, heating the mold with the blank therein to form the blank permanently into a product, and then removing from the mold and freezing the product, the durations and temperatures of the heating and freezing steps being chosen such that an impermeable surface is permanently formed on the product, whereby the product has the appearance of having been formed from non-porous material.

[0008] In a most preferred form of the invention, after heating the mold is quenched in cold water, after which the molded product is removed and subjected to freezing.

[0009] The result of this molding method is a low-density product having an impermeable surface and a foam interior integral with the impermeable surface.

### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[0010] FIG. 1 is an exploded perspective view of a sheet of foam plastic material, from which a number of mold blanks have been cut and removed;

[0011] FIG. 2 is a perspective view of a double mold designed to receive two of said blanks;

[0012] FIG. 3 is an elevational view of a heating chamber through which a number of said molds are passed, thereby molding the blanks into desired objects;

[0013] FIG. 4 is a vertical sectional view of a cold-water-filled quenching chamber used for subsequent rapid chilling of said molds with the molded products therein;

[0014] FIG. 5 is a vertical sectional view of a freezer used for subsequently freezing the molded products;

[0015] FIG. 6 is a front elevational view of one of the finished molded products;

[0016] FIG. 7 is an enlarged sectional view of a portion of the surface layer of the finished molded product.

[0017] FIG. 8 is a perspective view of another type of finished product which can be made in accordance with the present invention, which is in the form of a hollow shell;

[0018] FIG. 9 is a perspective view of a mold used for making the product of FIG. 8 in accordance with this invention;

[0019] FIG. 10 is a vertical sectional view of the mold of FIG. 9; and

[0020] FIG. 11 is a perspective of a conveyer oven used in making the product of FIG. 8.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] The molding process of this invention begins with conventional plastic material formed of foamed poly-ethylene (PE) or foamed poly-ethylene vinyl acetate (EVA), both of which are commercially supplied in the form of a flat sheet 10 of uniform thickness (i.e., in the vertical direction, as seen in FIG. 1). The standard commercially available sheet size is 100 cm. by 200 cm.; and the available thick-

nesses range from 3 to 100 mm., the thickness being substantially uniform across the length and breadth of any particular sheet. The density of such materials is comparable to that of rubber at ordinary ambient temperatures.

[0022] The objective of the process is to produce a toy or other end product **12** (FIG. 6) which in general has a non-uniform thickness in all dimensions, notwithstanding the uniform thickness of the commercially available sheet stock.

[0023] The first step in the process is to die-stamp from the foam sheet **10** one or more mold blanks **12A, B, C**, etc. which have an outline roughly congruent with the intended outline of the final product **12**. Because the stamping die cuts through the entire thickness (in the vertical direction) of the foam sheet **10**, no flash or parting line results from the die-cutting process. In FIG. 1 the first blank **12A** is shown after having been lifted out of the foam sheet **10**. At this stage of the process, the blanks **12A, B**, etc. have the same uniform thickness (in the vertical direction) as the sheet **10** from which they came.

[0024] The next step is to put one or more blanks **12A, B**; etc. into suitable half cavities such as **14A, B** formed in the lower half **14** of a metal mold. Connected to the lower half **14** by hinge **16** is an upper half **18** of the metal mold, which is formed with complementary half cavities **18A, B**. After the foam blanks **12A, B**, etc. are inserted into the lower cavities **14A, B**, the upper half **18** is rotated about the hinge **16** to close the mold, and the mold is then clamped closed by means of a conventional clamping mechanism, part of which is visible at **20**.

[0025] When the mold is closed, the upper half cavities **18A, B** cooperate with the lower half cavities **14A, B** to form complete molding cavities which completely enclose the foam blanks **12A, B**, etc. The outlines of the upper and lower half cavities are congruent with each other, and with the desired outline of the final product **12**.

[0026] The concave surfaces of the half cavities have the external surface shapes of the upper and lower portions respectively of the desired final product, and thus serve to mold the blanks **12A, B** into products **12** of the desired final shape. That shape will generally have a non-uniform thickness, even though the foam blanks previously were of uniform thickness, like the foam sheet **10** from which they were stamped. In addition, the concave surfaces of the half cavities are engraved with fine surface relief detail which is to be impressed upon the surface of the final product **12**.

[0027] The closed mold **14, 18**, with the foam blanks **12A, B**, etc. inside the cavities **14A, 18A** and **14B, 18B** is then passed through an oven **22** mounted on a table **24**. Movement of the molds through the oven may be either intermittent or continuous, and may be accomplished either manually or by means of a conventional automatic conveyer mounted on the table **24**. The temperature inside the oven **22** is in the range from 200 to 300° C., and the duration of exposure to the oven temperature is in the range from about 5 to about 15 minutes.

[0028] After emerging from the oven, the molds **14, 18**, with the foam blanks **12A, B**, etc. still inside, are immersed in a vat **26** of cold water **28** for the purpose of quickly chilling the surface of the foam blanks where they contact the concave surfaces of the cavities **14A, 18A** and **14B, 18B**.

The relatively high heat conductance of the metal mold **14, 18** facilitates rapid cooling of the surface layer of the mold blanks **12** where they contact the mold. The temperature of the cooling water is in the range from about 5 to about 20° C., and the duration of exposure to the chilling water is from about 5 to about 15 minutes.

[0029] Subsequently the molds **14, 18** are removed from the water bath **28**, opened by releasing the clamps **20** and rotating the upper mold half **18** away from the lower mold half **14** about hinge **16**, and the molded objects **12** are then removed from the molds and placed in a freezing compartment **30** by inserting the objects **12** through a door **32** and placing them on shelves **34** inside the compartment **30**, after which the door **32** is closed. The freezer temperature is from about -5 to about -15° C., and the duration of exposure to the freezing temperature is in the range from about 30 to about 45 minutes.

[0030] The EVA foam starting material used in the present invention is classified as "closed cell," which means only that the cells do not connect with each other; the cells do, however, open through the external surface of the sheet **10**, making the surface dull-looking and porous. The PE starting material is classified as "open cell," and also has a dull and porous external appearance because of the fact that the cells open through the surface.

[0031] The process of this invention produces a substantially lower reject rate than prior processes for molding foam products, which have tended to suffer from irregularities in shape and finish, and incorrect and inconsistent control of softness and density. In addition, prior art products molded from foam materials were characterized by dull and porous surfaces which have defied efforts to apply bright and colorful finishes; those finishes which were applied tended to peel off easily and did not achieve a bright, shiny or colorful effect. The surface detail was also poor. But, as seen in FIG. 7, the result of the successive hot molding, cold quenching and freezing steps of this invention is to create a layer **12L** at the surface of the final product **12** in which the cells or pores **12P** are sealed and do not open up through the surface of the final product **12**. Indeed, the surface now consists of a tough, smooth, impermeable skin **12S**, which has substantially the same characteristics as the surface of an injection-molded product: i.e., it is tough, smooth, shiny, durable, and able to receive and hold various types of decorative finishes.

[0032] The finished product **12** is also better able to hold molded-in-place inserts, and is less likely to be torn in use. The surface **12S** also has a smooth, shiny finish which is inherently more attractive than the dull, porous look of untreated foam materials; which holds fine detail in a way which has not previously been accomplished with foam materials; and which also lends itself to various finishing processes involving bright and decorative colors.

[0033] In particular, the finishing processes which have been found to work well in the method of this invention are color die spraying, tampo printing, silk-screening, and the use of a non-porous PE film pre-printed with graphics or a solid color and laminated with a glue which causes the films to adhere to the surface of the product **12**. It is a particular feature of the invention that such films can be applied to the mold blank **12** before the heating step of FIG. 3, in which case the film is permanently molded in place on the surface of the product **12**.

[0034] At the same time, the bulk of the product 12, below the surface layer 12L, retains the original porosity and hence the low density of the original foam sheet 10. As a result, the final product remains soft, light, flexible, and therefore safe for use as a glider, dart toy, bouncing ball, or the like. In addition, the final product 12 can have any desired non-uniform thickness, despite having been formed from a sheet 10 of uniform thickness.

[0035] In accordance with an additional aspect of this invention, it is suitable for molding shapes having the general configuration of a hollow shell, such as the toy car body 40 illustrated in FIG. 8, which features a hollowed-out interior space 40A. This type of configuration is produced by means of the mold 42, which has a lower mold half 44 formed with a convex core 44A and an upper mold half 46 formed with a complementary cavity 46B. A hinge 48, guide pins 50 on the lower mold half 44, complementary guide holes 52 on the upper mold half 46, and a latching mechanism 54, 56 complete the mold assembly.

[0036] The sectional view of FIG. 10 illustrates the hollow shell-like shape 40 being formed within the closed mold 42. In order to permit a bulky mass of foam material cut from the sheet 10 to be more easily compressed between the core 44A and cavity 46A for molding purposes, it is preferable to heat the foam material at a temperature of about 200° C. for about 3 to about 5 minutes in order to soften the material before beginning the molding process. For this purpose, an oven 60 (FIG. 11) is provided, and is equipped with a conveyor belt 62 which transports sheets of foam material 10 through the oven prior to their undergoing the process steps described above. Alternatively, this pre-heating procedure may be performed on the foam blanks after they are stamped from the sheet 10; but the stamping is facilitated if the pre-heating step is done first, so that the sheet material 10 is softer at the time the blanks are stamped out.

[0037] The ability to mold hollow shell-like configurations as just described opens up the possibility of using the process of this invention to manufacture a wider variety of products, not all of which are toys. For example, inexpensive soft-sided luggage-like containers with attractive exterior finishes may be manufactured in this manner, as well as protective shock-absorbing housings, cases or covers for small electronic appliances, books, and a wide variety of other objects.

[0038] Despite somewhat higher raw material costs, the present invention achieves certain significant economies as compared to other molding processes. First, the molds employed in injection molding processes are very expensive. In order to withstand the high temperatures employed in injection molding, the molds must be made of expensive steel; whereas in the present process a much less expensive aluminum alloy material is adequate. In addition, injection molding requires numerous conduits and fittings to conduct the molten plastic resin into the mold cavity; all of which is unnecessary with the process of this invention.

[0039] As a result, the mold cost, which can run around \$40,000 per cavity for an injection mold, is reduced to the neighborhood of only \$2,500 per cavity. This permits the construction of a greater variety of molds for a given cost; which is advantageous generally, but particularly in the toy field because it permits a manufacturer to satisfy consumer desires for greater product variety.

[0040] Second, the fact that products manufactured in accordance with this invention can be finished with multi-colored pre-printed PVC film offers a significant saving over other finishing processes requiring more individualized attention to each manufactured piece.

[0041] Accordingly, the present invention, in both its process and product aspects, economically produces a flexible, light, shiny, brightly and colorfully finished, durable product of any desired cross-sectional shape. While these features and advantages of the invention have been described in connection with a preferred illustrative embodiment, the scope of protection to which the invention is entitled is to be determined by the appended claims, interpreted in light of the novel principles disclosed herein.

That which is claimed is:

1. A low-density product, which comprises:

a porous volume including cells; and

an essentially non-porous layer adjacent an external surface of the product, essentially none of the cells being exposed at the external surface.

2. The product of claim 1 in which the porous volume and the essentially non-porous layer have been formed from the same body of material.

3. The product of claim 1, which has the appearance of having been formed from non-porous material.

4. The product of claim 1, which has a non-uniform thickness, the porous volume and the essentially non-porous layer having been formed from the same sheet of foam of substantially uniform thickness.

5. The product of claim 1 in which the porous volume and the essentially non-porous layer are integral with each other.

6. The product of claim 1, which has a non-uniform thickness and in which the porous volume and the essentially non-porous layer are integral with each other.

7. The product of claim 1, which has a decorative coating on the external surface, the coating formed by applying a liquid material to the external surface.

8. The product of claim 1, which has a decorative, silk-screen print on the external surface.

9. The product of claim 1, which is composed essentially of polyethylene or ethylene vinyl acetate copolymer.

10. The product of claim 1, wherein the porous volume is composed essentially of a resiliently deformable foam material.

11. A low-density product, which comprises:

a porous volume including cells; and

an essentially non-porous layer adjacent an external surface of the product, the external surface being sufficiently tough, smooth, strong and durable to be suitable as a substrate for silk-screen printing.

12. The product of claim 11 in which the porous volume and the essentially non-porous layer have been formed from the same body of material.

13. The product of claim 11, which has the appearance of having been formed from non-porous material.

14. The product of claim 11, which has a non-uniform thickness, the porous volume and the essentially non-porous layer having been formed from the same sheet of foam of substantially uniform thickness.



**15.** The product of claim 11 in which the porous volume and the essentially non-porous layer are integral with each other.

**16.** The product of claim 11, which has a non-uniform thickness and in which the porous volume and the essentially non-porous layer are integral with each other.

**17.** The product of claim 11, which has a decorative coating on the external surface, the coating formed by applying a liquid material to the external surface.

**18.** The product of claim 11, which has a decorative, silk-screen print on the external surface.

**19.** The product of claim 11, which is composed essentially of polyethylene or ethylene vinyl acetate copolymer.

**20.** The product of claim 11, wherein the porous volume is composed essentially of a resiliently deformable foam material.

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