July 3, 1962 N. R. PETERSON 3,042,562

PRODUCT AND METHOD FOR PRODUCTION OF ARTICLES HAVING COMPOUND CURVES

Filed May 4, 1959

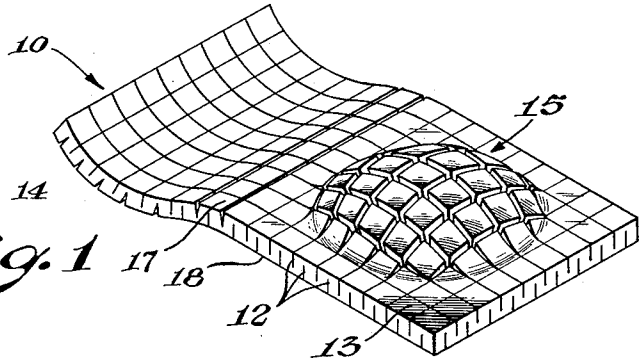


Fig. 1

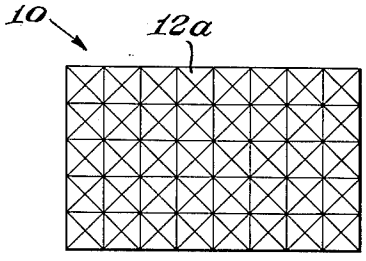


Fig. 2

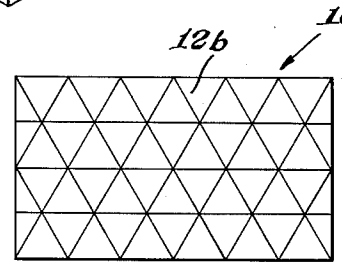


Fig. 3

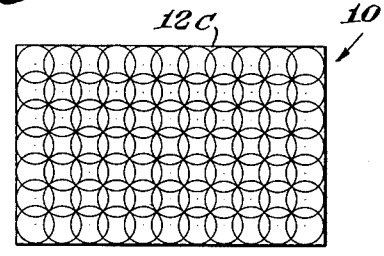


Fig. 4

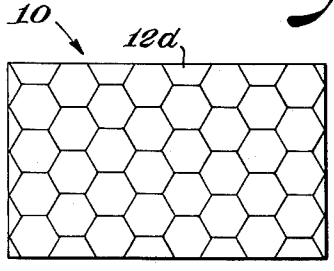


Fig. 5

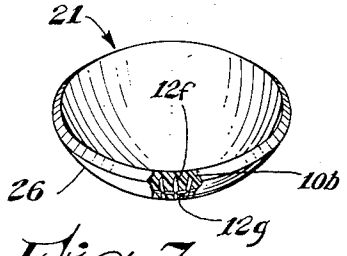


Fig. 7

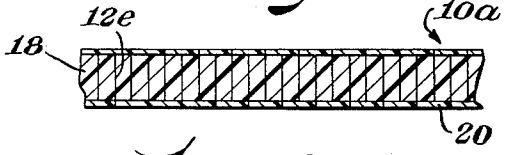


Fig. 6

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PRODUCT AND METHOD FOR PRODUCTION OF ARTICLES HAVING COMPOUND CURVES

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This invention relates to a product and method for production of articles having compound curved surfaces. More specifically, it relates to a particular variety of grooved sheet and a method for producing articles having compound curved surfaces therefrom.

In the fabrication of articles having compound curves which have been developed from a substantially rigid sheet material, it has ordinarily been necessary to fabricate the sheet material, usually while it is in a plastic form, to attain such curvature. Alternatively, the desired complex surface may be built up in the article from a number of plane-surfaced smaller pieces which are provided therein to result in a rough pre-form that may then be shaped to the desired dimensions. These approaches generally require either a substantial investment in equipment or an excessive amount of labor involving arduous fitting and finishing work.

It would be advantageous to have available a sheet or board material which could be readily formed into a wide variety of compound curved shapes without the application of expensive equipment or arduous manual labor.

It would be particularly advantageous if such a material could be formed into shapes having compound curves without applying undue stress to the sheet or board.

It would be additionally advantageous if such a sheet could be formed into complex curves without the use of excessive mechanical force and if, by the application of a suitable grout, cement, adhesive, or other hardenable material, an article of permanent form could be thus obtained.

These and other advantages and purposive results may be obtained by practice of the present invention.

A product in accordance with the invention, in general, is a substantially homaloidal sheet of sufficient thickness to be rigid, said sheet having at least two generally opposite surfaces; a plurality of slits extending into said sheet to a depth greater than one half thickness of said sheet; the slits originating from any one surface defining a plurality of adjacent columns, with slits originating from opposite surfaces being interdigitated between one another. This arrangement of slits allows the sheet material to be formed into a wide variety of complex shapes without employing excessive mechanical force. The sheet material may readily be permanently set in this form by the application of hardenable material to the surfaces that are exposed while the sheet is in the desired form.

Sheet or board material slit or grooved in accordance with the invention is formed to a desired compound curve and the grooves or slits are filled with a hardenable material. Thus, when the hardenable filler material becomes rigid, a self-supporting article is obtained having compound curvature.

The term "rigid," as employed herein, refers to a board or sheet of material which will rupture if bent at an angle of 90° and the ratio of thickness to the radius of bend is 1:12 or greater.

The term "hardenable material" is utilized herein to refer to cements, grouts, polymerizable resin compositions and the like which may be applied to a sheet or board

suitable for the practice of the invention without causing rapid deterioration of said sheet or board.

Further features and advantages of the invention will be more apparent in the following description and specification, taken in connection with the drawing wherein:

FIGURE 1 is an isometric representation of a sheet of rigid material formed in accordance with the invention;

FIGURES 2, 3, 4 and 5 illustrate some of the alternate arrangements of slits which may be employed in accordance with the invention;

FIGURE 6 illustrates a cross sectional view of a laminated sheet having thin outer surfaces of a flexible material; and

FIGURE 7 illustrates a view of a finished article prepared from slit sheet stock and coated with hardenable material.

The present invention may be practice readily with all rigid materials which may be obtained as or formed into a slab, sheet, board or other similar configuration having two generally plane surfaces separated by an appreciable thickness of the material.

A column of material having both ends fixed will deflect when placed in shear by movement of one end in a direction substantially normal to the longitudinal axis of said column. The magnitude of its deflection, in general, is dependent upon the relative thickness of the particular piece of material being considered. Silicate glass, for example, is generally considered to be a relatively rigid material. Despite this, when it is in a thin section or filamentary form it is readily deformable.

Thus, the simplest embodiment of the invention comprises a plurality of columns, each having a height greater than one half and less than the total thickness of the sheet from which they are formed, with each column being arranged side by side. Each pair of adjacent columns has one pair of adjacent ends joined, with opposite ends of the pair of columns each forming one member of two other pairs. As further columns are added in this manner, two dimensional growth will take place to provide a sheet having a thickness equal to the height of the columns and limited only by the number of columns employed. On flexing a sheet so formed, the fiber stress, appearing in a column for a given deflection of the sheet, is greatly below that which would occur in a single sheet of material having similar dimensions and deflected in a similar manner.

Materials ranging from foamed plastic material to sheets of cellular glass or laminated sheets having flexible surface lamination may be employed in accordance with the invention. However, the invention is more advantageously employed when used with foamed or expanded materials. These include, for example, such materials as expanded polystyrene, expanded polyurethane, expanded polyethylene, expanded polypropylene, foamed glass and the like synthetic thermoplastic or thermoset (and thermosettable) expanded resinous materials.

In FIGURE 1, there is illustrated a sheet 10 in accordance with the invention having therein a plurality of slits 12 which are so arranged as to form a plurality of adjacent columns 13. The slits 12 terminate on the surfaces 17 and 18. A similar pattern of cuts or slits 12 has been made on both surfaces. The slits 12 on the surface 18 have been displaced approximately midway between the slits 12 originating on surface 17. This, in effect, provides a sheet that is continuous and very flexible.

On distortion of the flat sheet 10, crevices 15 are formed therein. The radius of curvature of surface 17 is greater than that of surface 18 in the area of the compound curve, whereas the radius of the curvature of the surface 17 is less than the curvature of surface 18 and the general area of the cylindrical curve designated by the numeral 14. Thus, such a sheet 10 is readily formed into

a wide variety of complex shapes. The slits 12 placed in the sheet 10 of FIGURE 1 comprise two sets of parallel slits 12 which are disposed substantially at right angles to each other. This, as has been mentioned, is an embodiment of the invention in its most simple form.

Alternate arrangements of the slits 12*a* may be employed such as that shown in FIGURE 2, wherein four sets of slits 12*a* are utilized, each set being formed at an angle of about 45° from the previously formed slits.

The increased number of slits 12*a* obtained in this manner provides improved flexibility where relatively small radii of curvature are to be employed.

In FIGURE 3, there is shown three sets of slits 12*b* being successively formed at about 60° to each other. This gives a degree of flexibility intermediate between the arrangement of FIGURE 1 and FIGURE 2.

In FIGURE 4 there is shown an embodiment having overlapped circular slits 12*c* that have been formed in the sheet 10. Such an arrangement is particularly advantageous if a relatively small portion of a large sheet is required to have a compound curvature. Thus, only the portion involved in the curvature need have slits formed in it.

In FIGURE 5, there is shown an embodiment having a hexagonal arrangement of slits 12*d* employed therein, which slits 12*d* have similar utility to those illustrated in FIGURE 4.

FIGURE 6 illustrates a laminated sheet, indicated generally by the reference numeral 10*a*, having a core 18 and a flexible surface lamination 20 and slits or grooves 12*e*. In this alternative construction, flexibiilty of the core material is not utilized when the sheet material is formed into compound curved shape. Any rigid material may be used in the core 18. Likewise, any of a wide variety of flexible sheet material may form the outer surface 20, such as, sheet metals, flexible plastic sheet, fabrics, rubbers, papers, and the like.

FIGURE 7 illustrates a view of a shaped article generally indicated by the reference numeral 21 and fabricated in accordance with the invention. The shaped article 21 comprises a base sheet 10B having therein a plurality of slits 12F and 12G. The sheet 12 is formed into a generally concave structure and the sheet and slits 12F and 12G are filled with a hardenable material 25. The entire article 21 is covered with a coating 26. The completed article 21 is rigid and self-supporting.

Depending upon the material selected for forming, various modes of cutting are employed to form the slits or curves, such sawing, grinding, slitting with a sharp instrument, hot wire cutting, and the like. If the material is relatively rigid, as might be encountered in foamed glass, sawing is advantageously employed. Longitudinal straight slits are readily formed in a sheet of foamed glass material using a conventional cut-off wheel or circular saw, or by means of a saw having its teeth arranged in a linear fashion. If such materials as foamed plastic boards or sheets are utilized, similar means are employed or, frequently and advantageously, a heated wire is used to form the slits somewhat in the manner of a brick cutter. A sharp-edged cutting instrument, such as a manually operated knife or power driven knife, is also found satisfactory. For the insertion of circular slits, a conventional hole saw with pilot removed has been found to give an adequate performance.

The slits may be formed by simple slicing of the material, as with a knife. This involves no removal of the material. The slits can also be formed as V-shaped grooves with either straight, convex or concave sides.

Grooves having a generally V-shape are usually employed when the radii of curvatures of the surfaces desired are relatively small in relation to the thickness of the material employed and a relatively non-deformable sheet material is being used.

The depth of the slit in the sheet is also dependent on the amount of deformation desired and the inherent rigidity of the material being employed. Generally, the thinner the section, the greater angular deflection can be obtained for any specific length of such material. Therefore, when employing radii of curvature that are relatively small in relation to thickness of material, it is preferable that the slits or grooves extend as far into the material as practicable. For the purposes of the invention, it has been found that grooves or slits cut to a depth less than one-half thickness of the sheet or board do not lend an appreciable amount of flexibility to the board formed in this manner. This is for the reason that a change in the radii of curvature of the opposite faces then requires compression of the board or sheet toward the face having the shorter radii. Therefore, in order to take the most advantage of stretching and bending characteristics of the material, slits are employed which extend a greater distance into the board than half its thickness. In this way, little compression of the material is required adjacent to the surface having the shorter radius.

A board that has been slit or grooved in accordance with the present invention may be readily formed into a wide variety of complex shapes, such as boat hulls, domes, insulating jackets, and the like.

In order to make a self-supporting object, a hardenable cement, grout, or filler may be applied to the article so that the grooves or slits opened by flexure thereof are filled. This material, upon hardening or setting, then provides a permanent means of supporting the board in the formed shape. If a maximum of physical strength is required, the slits or grooves of the sheet may be filled with adhesive material prior to forming, thus forming a structure without discontinuities.

Further applications, or a sufficiently large application of cement, grout, adhesive, filler or similar material will serve to give a complex shaped article in substantially a one step operation.

By way of further illustration, articles in accordance with the invention, such as boat hulls, are readily fabricated by temporarily supporting sheets of board polystyrene, slit in accordance with the invention, on a suitable form; coating the sheets with a sufficient quantity of polyester resin wood-flour mixture or epoxy resin-wood flour mixture to fill the fissures; and then applying a layer of fibrous glass fabric to the outer surface. When the resin is cured, the temporary support is removed and a similar coating is applied to the inner surface. Thus, a strong, light hull is advantageously constructed without the necessity of the usual precise fitting required for boat hull manufacture.

Similar articles are readily prepared by employing various sheet materials cut in accordance with the invention, as, for example, polyurethane foams, foamed glass, particle board, and the like.

As is apparent from the foregoing specification, the apparatus and method of the present invention are susceptible of being embodied with various alterations and modifications which may differ particularly from those that have been described in the preceding specification and description. For this reason, it is to be fully understood that all of the foregoing is intended to be merely illustrative and not to be construed or interpreted as being restrictive or otherwise limiting of the present invention, excepting as it is set forth and defined in the hereto appended claims.

What is claimed is:

1. A substantially homaloidal sheet of sufficient thickness to be rigid and having at least two generally opposite surfaces; a plurality of slits extending into said sheet to a depth greater than one-half the thickness of said sheet; the slits that originate from any one surface defining a plurality of adjacent columns, and the slits from opposite surfaces being interdigitated with one another; said sheet having formed therein at least one compound curve, and at least the slits formed in said curve being filled with a hardenable material.

2. The sheet of claim 1, wherein the slits on any one surface are arranged in two groups substantially at right angles to each other.

3. The sheet of claim 1, wherein the slits are arranged in four groups, each successive group being disposed at about 45° and multiples thereof from the previously formed slits.

4. The sheet of claim 1, wherein the plurality of columns have a hexagonal shape.

5. The sheet of claim 1, wherein the columns are triangular in cross-section.

6. The sheet of claim 1, wherein the columns are formed by overlapping circular slits.

7. The sheet of claim 1, wherein said sheet comprises an expanded styrene polymer.

8. The sheet of claim 1, wherein said sheet comprises an expanded propylene copolymer.

9. The sheet of claim 1, wherein said sheet comprises foamed glass.

10. A substantially homaloidal, laminated sheet having at least two generally opposed flexible laminations and a rigid core material; a plurality of slits extending into said sheet to a depth substantially equal to the thickness of the core material plus one of said flexible laminations; said slits originating from opposite surfaces being interdigitated with one another; said sheet having formed therein at least one compound curve and at least the slits formed in said curve being filled with a hardenable material.

11. A method of forming self-supporting shaped articles having at least one compound curved surface, the steps of which method comprise: providing in one surface of a substantially homaloidal sheet having sufficient thickness to be rigid, a plurality of slits extending to a depth of from about one-half to less than the total thickness of said sheet, said slits forming a plurality of adjacent columns; slitting the opposite surface of said sheet in a similar manner with a plurality of slits originating on the first mentioned surface; then forming the slit sheet into a shape having at least one compound curved surface and adding to the fissures formed when said sheet is bent a hardenable material.

12. The method of claim 11, wherein said sheet comprises an expanded styrene polymer.

13. The method of claim 11, wherein said sheet comprises an expanded propylene copolymer.

14. The method of claim 11, wherein said sheet comprises foamed glass.

15. The method of claim 11, wherein said hardenable material is a polyester resin.

16. The method of claim 11, wherein said hardenable material is a mortar.

17. The method of claim 11, wherein said hardenable material is an epoxy resin.

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