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Langfeldt

[11] **3,762,977**

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[54] **METHOD OF MAKING WORKPIECES FROM A KNITTED FIBER REINFORCED HARDENABLE SYNTHETIC MATERIAL, AND FIBER REINFORCEMENT FOR CARRYING OUT SAID METHOD**

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[52] **U.S. Cl.** ..... **156/229,** 28/72.5 R, 28/75 R, 66/200, 156/148, 161/89, 161/92

[51] **Int. Cl.** **B29c 13/00**

[58] **Field of Search** ..... 28/72.5 R, 75 R; 156/148, 229; 66/200; 161/89, 92

[56] **References Cited**

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[57] **ABSTRACT**

An article containing hardenable synthetic material and a method of making the article, particularly a laminated article in which the core of the article is formed of a deformable textile member having protuberant portions which diminish in height when the textile member is stretched. While the member is stretched, it is impregnated with synthetic material and is then permitted to return to its original shape. One or more cover layers are applied to the member and bonded thereto by hardening the synthetic material.

3 Claims, 12 Drawing Figures

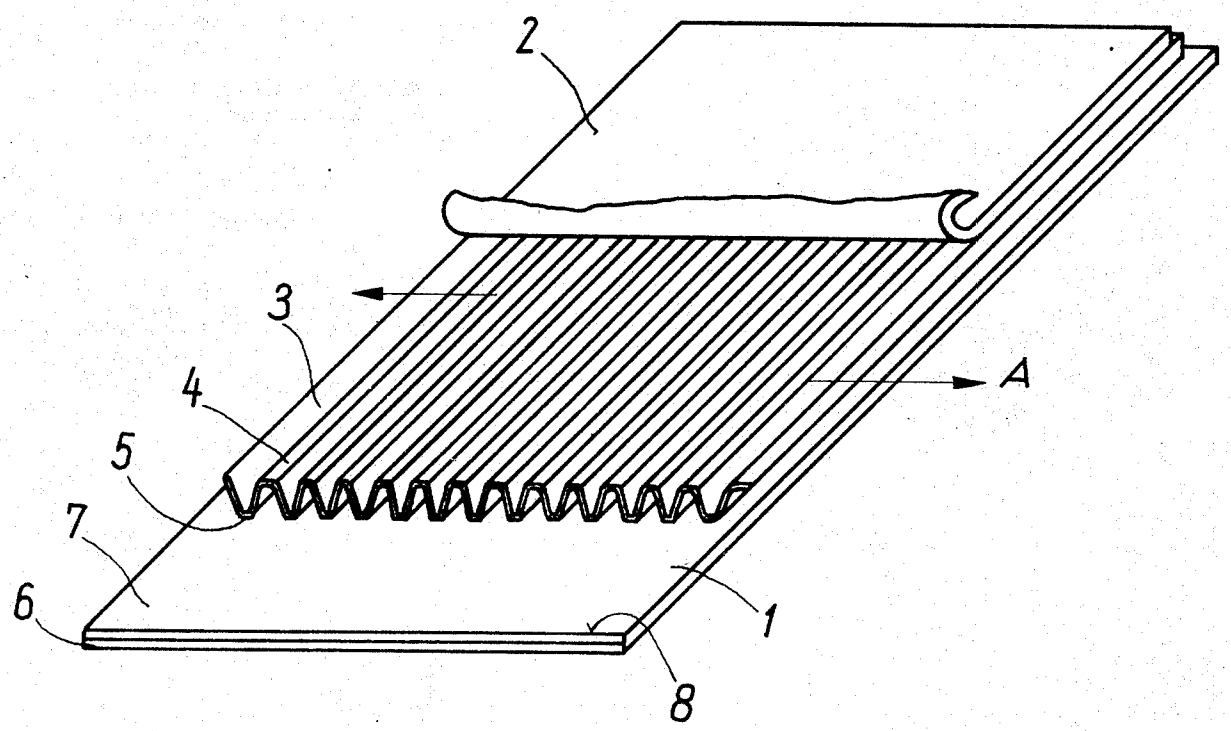


Fig. 1

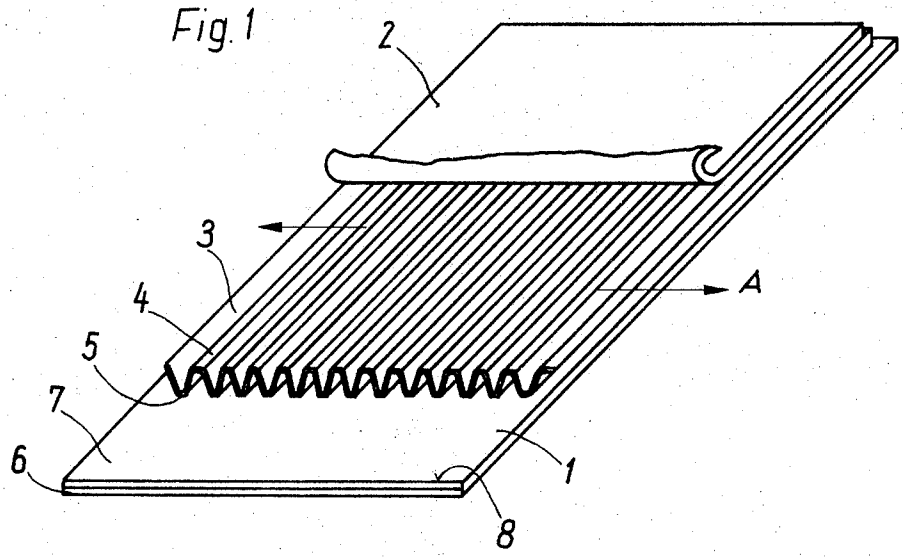


Fig. 2

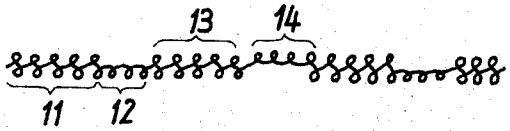


Fig. 3

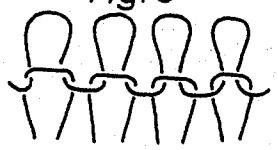


Fig. 4

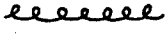


Fig. 5

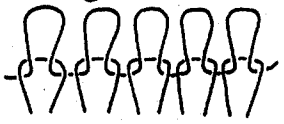


Fig. 6

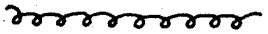
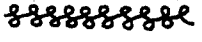


Fig. 7



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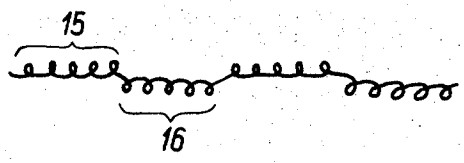


Fig. 8

Fig. 9

Fig. 10

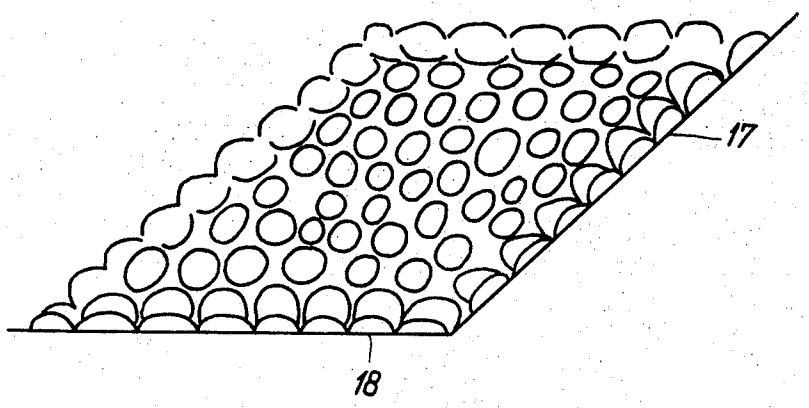


Fig. 11

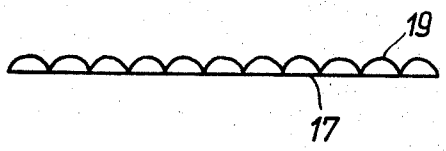
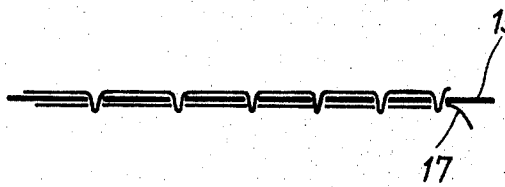


Fig. 12



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METHOD OF MAKING WORKPIECES FROM A KNITTED FIBER REINFORCED HARDENABLE SYNTHETIC MATERIAL, AND FIBER REINFORCEMENT FOR CARRYING OUT SAID METHOD

The present invention relates to a method of making workpieces from a hardenable synthetic material which is elastic in its starting position and which is provided with a knitted fiber reinforcement. When making pressed pieces, it has been suggested heretofore to employ flat material such as tricot material, crepe fabrics, and the like, which can meet the required conditions in all directions without losing its tension strength. Such material has, for instance, been impregnated with a plastic organic substance, as for instance, phenol formaldehyde synthetic resin and has then, in a matrix, been pressed to form profiled workpieces.

It is also known to produce compound materials or substances, especially for the construction industry in the form of plates, or the like, which have a prefabricated core, for instance, of corrugated cardboard, of prefabricated honeycombs, of glass fiber fabric, or the like, which core has one or both sides covered with one or more, for instance, symthetic material impregnated glass fiber layers forming cover layers, in such a way that a solid compound body is formed. The drawback of such methods and materials is seen, however, in the fact that the same always require a special core as central layer and that this core has to be produced in a separate method. Consequently, it is not possible with these methods to produce the substance as a unit in a single working operation. Moreover, all heretofore known compound substances are not homogeneous, so that a special connection between the cover layers and the core layer is necessary.

Furthermore, synthetic materials have become known such as polyesters employed, for instance, in the building of boats, which likewise employ inserts, for instance, glass fibers or glass fiber fabrics and permit a substantially uniform structure. Such structure is, as a rule, formed by a plurality of layers of glass fiber fabrics or glass fiber mats which are permeated with the hardening synthetic material. When processing glass fiber reinforced synthetic materials, it is the endeavor so to arrange the individual layers tightly one upon each other so that no air bubbles will be enclosed or other hollow spaces will be formed. This method, however, has the drawback that materials produced in this way have too high a specific weight so that they are useable and employable only in a limited way.

It is, therefore, an object of the present invention to provide a method of producing workpieces of hardenable synthetic material with a knitted fiber reinforcement, which will overcome the above mentioned drawbacks of heretofore known methods.

It is another object of this invention to provide a method as set forth in the preceding paragraph which will result in a homogeneous workpiece of high stability and which can be produced preferably in one working operation without the employment of pressure.

It is still another object of this invention to provide a workpiece along the above mentioned lines which will be useful for various purposes of employment, for instance, as building plate or as a thin-walled cup-shaped structural element which may have an optimum three-dimensional shape suitable for the respective purpose of employment.

A still further object of this invention consists in the provision of a compound workpiece which over heretofore known glass fiber reinforced workpieces of synthetic material will have a low specific weight while nevertheless having at least the same strength as said heretofore known workpieces while the same wall thicknesses of the workpieces are obtainable.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

FIG. 1 illustrates an isometric view, partially in section of a plate of synthetic material made according to the invention.

FIG. 2 represents a simplified illustration of a knitted structure for use in the central layer of the plate of FIG. 1.

FIGS. 3 to 12 respectively illustrate modifications for a fiber reinforcement with high expansion elasticity for use in an article as shown in FIG. 1.

The method according to the present invention is characterized primarily in that a fiber reinforcement which has protrusions protruding from the main plane of said fiber reinforcement is deformed in at least one direction, is permeated with synthetic material, and is subsequently formed to the desired shape while decreasing said protrusions, and is held in said desired shape during the hardening of the synthetic material.

According to a further development of the method of the invention, the fiber reinforcement is stretched in the longitudinal direction or transverse thereto and in this condition is permeated with synthetic material and then prior to the hardening of the synthetic material is allowed to relax while the protrusions decrease. For instance, for purposes of making building plates, according to a further feature of the invention, the fiber reinforcement may be provided with at least one cover layer.

For permeating the basic body, duroplasts such as polyesters, thermoplastic synthetic materials such as polyethylene polyvinylchloride, or polyurethane, or other suitable synthetic materials may be employed. The method according to the invention makes it possible to produce workpieces of any desired three-dimensional shape, especially also articles of a spherical shape, in a rather simple manner. For the macrological structure obtainable by the present invention, it is important that the knitted structure, or the like, be permeated or wetted only with such quantity of synthetic material which will remain below the suction limit, and that this fiber reinforcement which forms the basic body will, as soon as it is permeated and the pulling forces acting thereupon have subsided be left to itself and due to its own elasticity will return to its starting position.

While the fiber reinforcement serving as starting material, when in expanded position covers a larger surface and has a shorter cross-sectional height, the fiber reinforcement will, in permeated and relaxed condition which at least nearly applies to its starting position, have a form according to which it will have a greater cross section, i.e., a greater thickness whereas it covers a surface which is considerably less than the surface covered in extended position.

According to the method of the present invention, a considerable quantity of air is stored as basic body in the fiber reinforcement serving as starting material and

is absorbed by said basic body. The particular advantage of this provision is seen in that the quantity of air is distributed into a great number of hollow chambers which are surrounded by the nearly arc-shaped protrusions of the basic body, said hollow chambers being determined by the starting structure of the fiber reinforcement. Thus, a regularly and uniformly distributed storing of air enclosures occurs with which not only the specific weight of the finished workpiece, but also with sufficient cross-sectional height of the relaxed body, a considerable increase in strength can be obtained. With the method according to the invention, it is possible to influence or control the pressure and bending strength by selecting the structure of the knitted fiber reinforcement serving as starting material.

Particularly favorable mechanical properties are obtained with the workpiece prepared according to the method of the invention, when the knitted fiber reinforcement is at its top or bottom side, preferably on both sides, provided with a cover layer which consists of hardened synthetic material and is considerably thinner than the thickness of the fiber reinforcement. Such cover layer can advantageously obtain a reinforcement of flatly located fibers, especially glass fibers which without being mutually interlocked are located in planes approximately parallel to each other and adapted to insert upon the cover layer an elasticity which is considerably less than the elasticity of the permeated and hardened basic body.

The fiber reinforcement employed in connection with the method according to the invention is characterized primarily in that it comprises projections extending transverse to the length and/or transverse direction and is deformable at will in all directions and can be reshaped back after the deforming forces have been eliminated. A particularly advantageous embodiment of this knitted fibers reinforcement serving as basic body is as to its cross section designed at least approximately in a corrugated manner, in a zig zag manner, and in a meander-like manner.

The basic body serving as fiber reinforcement may consist of knitted material which comprises fibers of organic or synthetic material. It is particularly advantageous when the knitted material for purposes of forming the projections contains alternate groups of left and right meshes.

Referring now to the drawings in detail, the workpiece shown in FIG. **1** is particularly well suitable for use as building plate. The said workpiece comprises primarily a lower cover layer **1** and an upper cover layer **2,** as well as a fiber reinforcement located between said two cover layers and spacing the same from each other. The said fiber reinforcement comprises a textile knitted fabric which has numerous longitudinal ribs **4, 5,** which are parallel to each other and in the illustrated cross section merge with each other in a corrugated manner.

For purposes of making the lower cover layer **1,** first a non-illustrated layer of insulating material is placed on a work plate (not shown), the top side of which is plane for the illustrated embodiment. This insulating layer is provided to facilitate the later lifting off of the finished plate of synthetic material. First by means of a roller or a spray pistol, a thin layer **6** of synthetic material, for instance, of polyester is deposited which depending on the employment of the workpiece to be made may have a thickness of from 0.3 to 0.5 millimeters. The layer **6** is in FIG. **1** not shown enlarged to scale. The said synthetic layer **6** is reinforced by means of a glass fiber fabric **7** in which the individual non-illustrated glass fibers are at least approximately parallel to the plane of the layer **6** and are adapted to oppose considerable pulling forces exerted in this plane.

For purposes of preparing the fiber reinforcement **3** between the two cover layers **1** and **2,** a knitted textile material is employed, the binding diagram of which is shown in FIG. **2.** This knitted fabric has in the cross section shown in FIG. **1,** a sequence of different groups of knitted meshes while in the illustrated embodiment a first mesh group **11** has five right-hand and five left-hand meshes individually following the right-hand meshes. This group is followed by a group of right-hand meshes which in FIG. **5** are shown on a considerably enlarged scale and are shown in FIG. **6** in a simplified illustration. These two groups form together the second group of meshes **12.** The group **13** of meshes following the just mentioned groups, similar to the group **11** of meshes comprises each five right-hand and five left-hand meshes which alternate in a left, right, left sequence. This group is followed by a further group **14** composed of left-hand meshes directly following each other. Adjacent the group **14** of meshes, the described sequence of meshes **11, 12, 13,** is repeated so that the cross section of the textile fiber reinforcement shown in FIG. **1** is obtained with which in relaxed condition, in spite of an only slight thickness of the material, in view of the highly corrugated course, a considerable thickness of the fabric is obtained between the top and bottom side defining the upper crests **4** and lower crests **5.**

Such knitted fabric which contains protrusions toward the upper and lower surface side is, during the further manufacturing process strongly wetted with synthetic material by means of a synthetic material permeated roller. Said wetting is such that the synthetic material will surround the individual textile fibers in a substantially uniform manner but nowhere will the adhesion ability of the textile fabric be exceeded. In view of the application of the synthetic material by means of a roller it will be assured that the absorbed quantity of synthetic material remains far below the suction limit. For purposes of absorbing the synthetic material the fiber reinforcement **3** is considerably stretched in the direction of the arrow A and is then wetted or moistened by means of the roller. Thereupon, the pulling forces acting in the direction of the arrow A are eliminated so that the fabric can relax and can retract to its illustrated starting position in which between the individual ribs **4, 5,** which assume the original corrugated shape, narrow but substantially uniform hollow spaces remain which following the hardening of the synthetic material will assure a low specific weight. In order to assure that the fiber reinforcement **3** will be adapted to withstand symmetric bending stresses, the upper cover layer **2** will, in not yet hardened condition, be placed directly upon the synthetic material impregnated fiber reinforcement **3.** The upper cover layer **2** will, similar to the lower cover layer **1,** obtain as reinforcing layer a glass fiber mat which will assure the desired pull resistance. This reinforcing layer will, due to the synthetic layer on its bottom side, undergo an intimate connection with the synthetic material impregnated fiber reinforcement **3.** During the subsequent hardening step, the two cover layers combine intimately with the inter-

mediate layer formed by the fiber reinforcement **3** while the distance between the upper and lower cover layers may amount to a few millimeters. In this way, a considerable mechanical strength of the structural element of synthetic material will be obtained while its weight will be relatively low.

FIG. **3** illustrates a sequence of left meshes provided in the mesh group **14** while FIG. **4** shows a simplified illustration thereof similar to the simplified showing of FIG. **2.** In FIG. **5,** right-hand meshes of a knitted fabric are illustrated, the simplified illustration of which is shown in FIG. **6.** FIGS. **2** and **13** illustrate in the mesh groups **11** and **13** a binding sequence of five right-hand meshes alternating with five left-hand meshes illustrated in FIG. **7** in simplified form. In contradistinction to the binding illustrated in FIG. **2,** also knitted fabric with a textile knitted structure may be obtained which is manufactured in conformity with the binding diagrammatically shown in FIG. **8.** In this instance, a group of five left meshes designated with the reference numeral **15** alternates with a group of meshes **16** which latter comprises five right-hand meshes of the type illustrated in FIGS. **5** and **6.** The alternating sequence of the mesh groups **15** and **16** will then result in the fiber reinforcement **3** illustrated in FIG. **9** and having the structure shown in FIG. **1,** according to which the reshaped stiffness may be selected particularly high if for the manufacture of the knitted fabric threads or yarns are employed which otherwise have a highly undesired stiffness for textiles. The threads or yarns referred to above may consist of synthetic fibers of a relatively coarse thickness. Since for the arrangement according to the invention a high reshaping stiffness is necessary, there exists the possibility for purposes of preparing the fiber reinforcement **3,** to employ inexpensive synthetic fibers forming rejects, especially glass fibers.

FIGS. **10, 11,** and **12** illustrate a material which is useable as fiber reinforcement while FIG. **12** shows in cross section the condition of the material in isometric view and in section. The material is, by means of elastic threads **17** and **18,** provided with a seam while during this step, the said threads are under considerable pull stresses and in relaxed condition which they will assume also after the permeating operation shortens considerably so that bubble-shaped protrusions of generally non-elastic or slightly elastic fabric **19** are obtained. The particular advantage of a workpiece prepared according to the invention consists in that by application of the expandable base body forming the reinforcement, if desired, three-dimensional shape can be obtained while it is completely sufficient that only one outer or one inner form is provided as support for the deposit or application, whereas with heretofore known customary production methods, as a rule an outer and an inner form were necessary. In view of the flexibility of the base body assured by the arced protrusions, also three-dimensional shapes with short radii of curvature can be obtained without the structure of the base body being interrupted by gusset-shaped cuts, or the like. Thus, even with very complicated three-dimensional shapes a better adaptability of the workpiece to the model form can be obtained which cannot be realized by the heretofore customary sandwich structure. Depending on the purpose of employment of the new material, the cover layer may have any desired thickness and a corresponding shape or form. Thus, in addition to cover layers with glass fibers, also cover layers may be employed according to which flat knitted fabrics, fleece, endless or finite fibers or threads may be employed for forming the cover layer. These inserts for the cover layer may be employed in one layer or more layers, or they may also cross each other or be provided layer-wise. With inserts, for instance, in the form of threads or fibers, they may be arranged parallel or cross-wise or at random, or in any other manner serving the structural purpose. Also, cover layer inserts of metals, wood, for instance, veneer may be employed.

It is furthermore possible to design the fiber reinforcement **3** in conformity with the respective requirements. The fiber reinforcement may, for instance, additionally contain stiffening inserts in the form of fabrics, fleece, or additional reinforcements, such as wires, cables, and the like, which are inserted, for instance, in free hollow spaces and serve for bracing or connecting the plate when the wires protrude. Moreover, the cross-sectional changes in the reinforcements, for instance, the yarn or fabric thickness may be obtained by the provision of larger or smaller meshes. It is also possible to preload such additionally inserted wires. The fiber reinforcement itself is, in conformity with the respective structure and material designed in conformity with the requirements to be met by the plate or the formed body. Thus, a body may be of a definite, for instance, a cylinder cube or any irregular shape. The thickness of the layer, for instance, the quantity of the synthetic mass will be determined to a major extent by the structure of the fiber reinforcement and their possible reinforcement by other substances, and also by the thickness of the fiber and the type of the fiber as well as by the size of the meshes. The insertion of the synthetic material can be effected by permeation, dipping, rolling, injecting, casting, spraying, and pressing, depending on the employed mass of synthetic material.

It is, of course, to be understood that the present invention is, by no means, limited to the particular showing in the drawings, but also comprises any modifications within the scope of the appended claims.

What is claimed is:

1. A method of making an article comprising hardenable synthetic material in which a layer is provided in the form of a textile member having protuberances projecting from the plane of the member, said method including steps of: deforming the textile member longitudinally to reduce the height of said protuberances, permeating the member while deformed with a synthetic material, restoring the member to the original shape thereof, and hardening the synthetic material to form hollow air chambers inside the synthetic material enclosed for light weight rigidity thereof.

2. A method according to claim **1** in which the textile member is stretchable and is stretched in at least one direction to effect the said deforming of the member prior to the said permeation thereof with synthetic material.

3. A method according to claim **1** which includes applying at least one cover layer to one side of said member and bonding the cover layer form-stiff to said member.

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