Dec. 14, 1965 R. E. EVANS ETAL 3,223,576

FIBROUS PANELS IMPREGNATED WITH FOAM PLASTIC

Filed Aug. 11, 1961

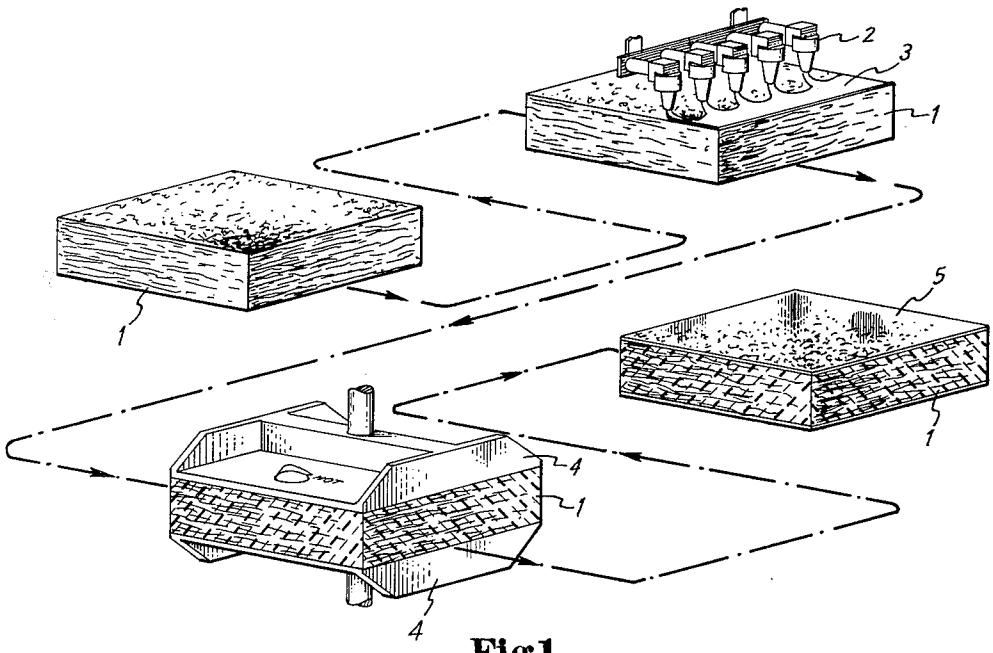

Fig 1

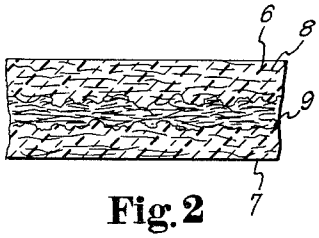

Fig. 2

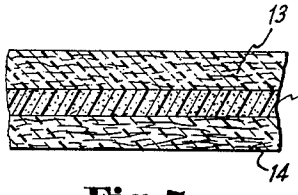

Fig. 5

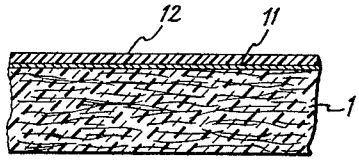

Fig. 4

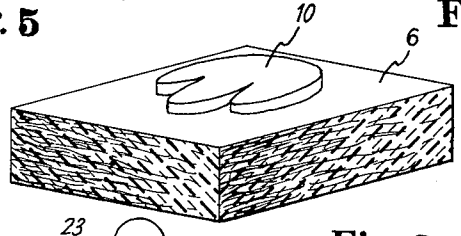

Fig. 3

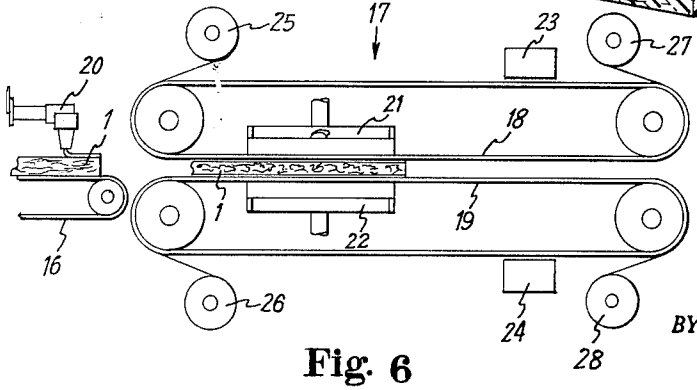

Fig. 6

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United States Patent Office

3,223,576

Patented Dec. 14, 1965

3,223,576

FIBROUS PANELS IMPREGNATED WITH FOAM PLASTIC

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Filed Aug. 11, 1961, Ser. No. 130,846
4 Claims. (Cl. 161—84)

This invention relates to the manufacture of structural and/or decorative building material in the form of fibrous panels, and relates more particularly to the impregnation with a foam plastic of a preformed fibrous board composed of wood wool or excelsior and a magnesium cement binder.

Fibrous board composed of wood wool and a magnesium cement binder has been commercially manufactured in this country for a number of years, the preferred practice being to form the wood wool into a loose mat which is then thoroughly coated with the cementitious binder, whereupon the mat is fed into a compacting press which compresses the mat to the desired thickness and at the same time heats the binder to accelerate its exothermic reaction and thereby set the fiber-binder mass in the compacted condition. A process for forming such wood wool panels is taught in Collins Patent 2,655,458, and an improved process employing steam as a setting medium is taught in Prior et al. Patent 2,944,291. In accordance with the teachings of the latter patent, excelsior is preferred as the fibrous material, although other fibers may be used, inclusive of bagasse, straw, synthetics and the like. The binder is preferably composed of magnesium oxide and a gauging solution of water and magnesium sulphate. The fiber-binder composition preferably has a binder to fiber ratio of 55 parts binder to 45 parts fiber, the parts being by weight, although this ratio may be varied depending upon the fibers employed. Similarly, the magnesium oxide to magnesium sulphate ratio is preferably 65 parts oxide to 35 parts sulphate, although here again the ratio may vary widely. Normally, the gauging liquid consists of a 26% magnesium sulphate solution. In preparing the binder, the gauging solution is prepared by adding the magnesium sulphate crystals to water, whereupon the magnesium oxide is added to the gauging solution and thoroughly mixed. After mixing, the binder is sprayed over the fibers which are then agitated, as by means of picker rolls, to thoroughly coat each fiber with the binder. The binder coated fibers are then introduced into the compacting press, compressed to the desired thickness, and heated to effect setting of the binder.

For most uses the preferred density of the standard fiber-binder board is in the range of 15 lbs. per cubic foot to 26 lbs. per cubic foot, with board having a density of 21 lbs. per cubic foot ideally suited for construction purposes. Such board is normally manufactured in thickness of one inch, two inches, and three inches, depending upon its intended use. In most installations the exposed surfaces of the panels are either used in their initial whitish-brown condition or painted. The random arrangement of the fibers provides a surface which, while essentially flat, is nonetheless irregular or mottled, being characterized by grain-like patterns defined by the fibers, with adjoining depressions and voids. In fact, the board

is characterized by a multiplicity of interstices and passageways giving it a cellular quality. While, as already indicated, the board surfaces may be used as such or suitably painted, ther are many potential uses for board of this character which require more elaborate decorative treatment.

Accordingly, a principal object of the instant invention is the provision of board structures composed of wood wool and cementitious binder which have been additionally treated with foamed plastics, thereby producing unusual and beautiful decorative effects. For example, it has been found that a preformed mat of the fibrous material can be saturated with a foam plastic, such as a polyurethane which, upon reaction and expansion, migrates throughout the fibrous mat filling the interstices and passageways therein. By maintaining the mat between platen members during the resin reaction, surface effects can be obtained which resemble marble in appearance.

A further object of the invention is the provision of low density fibrous panels composed of a compacted mass of fibers bonded together with a cementitious binder, the mat so formed being treated with a foam plastic which becomes an integral part of the board structure and, in addition to the decorative effects obtained, materially enhances the physical properties of the composite board.

Still a further object of the instant invention is the provision of composite boards in which a foam plastic material is caused to unite with one or more panels composed of compressed and bonded mats of fibers, with the foam plastic intimately associated with the fibrous material to form composite structures having enhanced physical properties.

Still a further object of the instant invention is the provision of procedures and techniques of manufacture by means of which fibrous panels and foam plastics may be united into composite bodies, which techniques include the provision of surface designs and other special decorative effects.

Still another object of the instant invention is the provision of procedures whereby fibrous panels of the character under consideration may be united with foam plastics to form composite structural panels in a continuous mechanized operation.

The foregoing, together with other objects which will appear hereinafter or which will be apparent to the skilled worker in the art upon reading this specification, are accomplished by those constructions and arrangements of parts and by those procedures and techniques of which certain exemplary embodiments shall now be described.

Reference is made to the accompanying drawings wherein:

FIGURE 1 is a diagrammatic representation of the successive steps in the conversion of a fiber-binder panel into a composite structure impregnated with a foam plastic.

FIGURE 2 is an enlarged fragmentary sectional view taken through a panel provided with foam plastic surface skins produced in accordance with the instant invention.

FIGURE 3 is a fragmentary perspective view illustrating the formation of a surface relief design in a foam skin panel structure.

FIGURE 4 is an enlarged fragmentary sectional view illustrating a composite panel incorporating a porous veil composed of a plastic permeable material.

FIGURE 5 is an enlarged fragmentary sectional view

illustrating the use of a foam plastic core to bond together a pair of fibrous panels.

FIGURE 6 is a diagrammatic side elevational view of a continuous press mechanism by means of which composite panels may be formed.

In making up composite structures in accordance with the instant invention, it is preferred to employ as the base material a fiber-binder board having a density on the order of 10 lbs. per cubic foot. It will be understood, of course, that the density of the board may be varied to suit the conditions of use, although it may be stated that where the base board is to be impregnated with the foam plastic, more uniform impregnation results where the board density is on the order of 10 lbs. per cubic foot as opposed to a standard board having a density on the order of 21 lbs. per cubic foot. The essential prerequisites of the board are that it be highly porous and yet sufficiently rigid to withstand the forces exerted by the plastic as it expands and migrates throughout the cell-like structure of the board.

Of the various known foam plastics, urethane has been found to be the most satisfactory, although as will be pointed out hereinafter other foam resins, such as epoxy, polystyrene beads and phenolic microballoons may be employed. Essentially, a urethane is a generic term describing amine or nitrogen bearing compounds with specific chemical bonding

(C—C=O and NC O linkage)

Isocyanates contain N—C—O reaction sites which, when reacted with polyhydroxyl groups (—OH), form the NCO urethane group. Under proper conditions, the urethane molecule will react together and form polyurethanes. Since the reaction rates, length of the molecular chains and reaction sites can be controlled chemically, it is possible to produce a range of polyurethanes from very flexible to very rigid.

In order to produce foams, it is necessary to add a blowing agent. At present "Freon" [11] (trichlorol mono fluoro methane) is used, since it volatilizes at 75° F. and is relatively noninflammable. This solvent, under the heat of reaction generated during polymerization of the resin, volatilizes, expands, and causes foaming to occur. Generally speaking, there are three classifications of urethane foam: rigid, semi-rigid and flexible. Essentially, the manufacture of any of these foams is very much the same, the differences in rigidity being effected by changing the reaction sites in the polyurethanes—the greater the number of reaction points the more cross linking occurs and a more rigid resin is formed. Normally, such resins are provided as two components: A—the polyether resin or polyol and blowing agent, and B—the isocyanate and emulsifier and catalyst. These two materials (A and B), which are intimately admixed immediately prior to use, react almost immediately to produce a foam which will expand as much as thirty (30) times the combined volume of the initial ingredients.

As already indicated, urethane foam appears to be the most desirable due to its versatility and ability to be made in all degrees of rigidity. There are, however, other forms of foam plastics which can be employed. For example, polystyrene beads containing N-heptane dissolved under pressure will expand and adhere to one another when heated to a temperature of 212° F. However, such beads are of a higher density than polyurethane and require steam injection in order to react. Microballoons, which are tiny spheres of phenolic resin, also may be employed, as may the phenolic resin foams, although the latter tend to be weak and brittle in the densities most useful for structural panels. It is recognized, however, that the technology of the so-called foam plastics or foaming resins is rapidly advancing and undoubtedly new and improved resins will appear which will be free from the defects noted. Consequently, while a preference is currently expressed for the polyurethanes, it is to be understood that the principles of the instant invention will be equally applicable to any resinous material possessing the ability to expand or foam as an incident of heating or of its polymerization.

In the production of impregnated board, i.e. a fiber-binder board which is fully impregnated with resin, the preferred procedure is diagrammatically illustrated in FIGURE 1 of the drawings. As seen therein, the basic board **1**, which is composed of a compacted mat of excelsior bonded together with a cementitious binder, is first subjected to the action of a series of mixing heads **2** which act to deposit a metered quantity of the admixed foam plastic material **3** onto at least one surface of the basic board **1**. The urethane mixing equipment may be similar to that shown in Hoppe et al. Patent Re. 25,514, dated August 12, 1958.

The viscosity of the resin is such that it will readily penetrate into the mat, flowing along the interstices and passageways therein. For the use described the viscosity of the admixed resin should be of the order of 300–500 centipoise. Of course, as the polymerization of the resin takes place, the heat of reaction causes expansion, and accelerates the migration of the material throughout the board. The quantity of resin employed will be sufficient to provide complete saturation of the board. For example, a "Freon" blown polyether resin cross-linked with tolylene diisocyanate can be formulated to produce a 2 lb. per cubic foot rigid polyurethane foam. Due to inherent resistance of the wood fibers to the rise of the foam, the resultant foam has an average density of about 3 to 4 lbs. per cubic foot and hence, where a 10 lbs. per cubic foot density board is employed, the resultant product has a composite density of from 13 to 14 lbs. per cubic foot with considerably higher density at the resin-fiber interface. Such board contains from 30% to 40% resin as foam. Preferably, a rigid foam is employed in place of semi-rigid or flexible foams due to the high percentage (95%) of closed cells and better overall physical characteristics.

In order to produce more uniform saturation of the board with the resin, the board is preferably placed between caul plates or platen members **4** which serve not only to direct the foaming plastic toward the center of the board but additionally provide cast foam surfaces **5**, as seen in the rightmost portion of FIGURE 1. As the foam expands, exerting approximately 7 p.s.i. pressure, against the plates, the plates act as casting surfaces, imparting to the foam the general surface characteristics of the plates. For example, if the plates have a smooth, polished surface, the foam cast thereagainst will have a comparable surface. Preferably, the plates will be treated with wax or other substance capable of effecting release of the plastic surface from the plates. Alternatively, the plates may be covered with sheets of release paper or similar material having good release properties.

It is to be understood that the procedure just outlined may be varied without departing from the spirit and purpose of the invention. For example, while a preference has been expressed for discharging the admixed resin directly onto the board, the foam resin may be applied directly to the caul plates or platen members and the plates thereafter juxtaposed to the opposite sides of the board. In order to accelerate the polymerization and setting of the resin, either or both of the plates may be heated.

The composite board produced by completely impregnating the base fiber-binder board with urethane foam produces a marked improvement in the strength to weight ratio of the composite board, together with improved decorative, fire resistive, thermal and acoustical values. For example, in order for urethane foam as such to be fire retardant a fire retardant additive is required. However, it has been found that comparable resistance to burning is achieved in the composite material without

the added fire retardant. The following chart is illustrative of improved properties of the composite board as compared with the base materials standing alone and compared with standard 21 lbs. per cubic foot fiber-binder board.

	Flexure str. (MOR, p.s.i.)	Strength-to-wgt. ratio (MOR/dens.)	Swelling (percent)	K-factor thermal conduct
Urethane, 4 lbs./ft.^{3} foam	40	10–1	0	.16
10 lbs./ft.^{3} base dens. board	70	7–1	4.5	----------
14 lbs./ft.^{3} composite foam-board	417	30–1	0	.26
21 lbs./ft.^{3} base dens. std. board	400	19–1	2.5–3.0	.5–.6

The basic procedures for producing composite board may be varied to provide special effects and obtain specific physical properties. Thus, soluble colors may be added to the resin and/or the underlying fibers may be painted or suitably tinted in whole or in part, thereby providing a wide range of decorative effects. Instead of completely impregnating the base board, the quantity of resin employed may be limited to provide only partial impregnation of the board. Then, by raising the caul plates or platen members about ⅛ to ¼ inch from the surfaces of the board, as by using spacers, a board having foamed skin surfaces results. Such board is illustrated in FIGURE 2 wherein it will be seen that the skins **6** and **7** project well beyond the surfaces of the base board **1**, with the foam skins interlocked with the base board in the areas **8** and **9**.

Such skins greatly enhance the thermal insulation properties of the board and, being wholly devoid of fibers adjacent the surfaces of the skins, render such surfaces wholly water proof. The skin provides excellent design and decorative possibilities either through the use of soluble colors in the resin mix or by the embossing or carving of designs in the skin surfaces. FIGURE 3 is illustrative of a bas-relief design **10** formed in the skin **6**. This may be conveniently done by providing the plate or platen member with a cavity of the desired configuration into which the foam will flow as it expands. It will be understood, of course, that the design could be of intaglio character, in which event the plate would have the design projecting outwardly from its foam contacting surface. Of course, if desired, the design could be cut or otherwise carved into the skin after formation.

For many uses of such foam surfaced board, whether it be of the composite or skin surfaced type, it is desirable to increase the impact strength of the foam surfaces. It has been found that a tough surface skin can be created by incorporating a porous veil in the foam surfaces as they are formed. Essentially, such porous veil may comprise any sheet-like material having sufficient porosity to be effectively saturated with the resin. For example, a 10 mil glass fiber mat has been found to be highly effective. Similarly, absorptive paper sheets, cloth and woven materials may be employed. The porous veil is placed on the basic board prior to the expansion of the foam plastic and hence is saturated by the plastic material as it expands. Such material is illustrated in FIGURE 4 wherein the basic board **1** is provided with a porous veil **11** which lies immediately beneath the foam surface **12**. In addition to greatly enhancing the impact strength of the foam surface **12**, the veil **11** provides unlimited decorative effects in that any design, pattern, or decorative effect inherent in the material of the veil will be visible through the overlying foam surface.

Similarly, due to the inherent adhesive properties of polyurethane resins, imperforate skin surfaces (such as aluminum foil, steel sheets, plastics sheets, and the like), can be applied to the surface after placing the resin and prior to pressing. As the foam rises it will adhere to the skin surface which becomes firmly bonded to the composite structure after the foam resin has become cured.

It has also been found that the impact strength of the foam surfaces as such can be effectively toughened or strengthened by altering the density of the foam. That is, by cutting the quantity of blowing agent employed to expand the polymerizing resin, a much higher density and hence tougher foam can be produced. The use of cold caul plates or platen members has also been found advantageous in the formation of tough surface skins.

The instant invention is also applicable to the production of a foamed core board sandwich. For example, and as seen in FIGURE 5, two standard fiiber-binder boards **13** and **14** may be adhered together with a foam core **15**, thereby providing a laminated board structure having greatly enhanced thermal values and improved acoustical properties. Such board structures may be formed in a number of ways. If the foam is to be utilized solely as a core material, standard density basic boards (21 lbs. per cubic foot) may be arranged in spaced apart relation and held by spacers and clamps, whereupon the liquid foam resin may be introduced into the cavity between the boards. It will be evident, however, that by using basic boards of lesser density the boards may be wholly or partially impregnated and/or surfaced in the manner taught herein in conjunction with composite and foam skin boards.

FIGURE 6 diagrammatically illustrates continuous press mechanism capable of producing board structures of the character taught herein. As illustrated, the lengths of the basic fiber-binder board **1** may be advanced on a conveyor **16** for introduction into a compacting press **17** composed of upper and lower traveling belts **18** and **19**, respectively, between which the basic board is engaged and advanced. Preferably, the belts **18** and **19** will be formed of stainless steel, and they will be suitably supported to provide essentially planar plate-like pressing surfaces. It will be understood that the basic board will have been treated with the foam plastic prior to entry into the press, as by means of nozzles **20** positioned to apply the resin immediately prior to the entry of the board into the press. Suitable heating and/or cooling means **21** and **22** may be provided to effectively heat or cool the board as it is advanced through the press. Suitable applicator means, indicated diagrammatically at **23** and **24**, will be provided to treat the surfaces of the belts with a suitable release agent. Alternatively, if it is desired to employ a release paper or similar material, such material may be conveniently fed from supply rolls **25** and **26** and collected on rewind rolls **27** and **28**. If a porous veil is to be incorporated in the board surfaces, it too may be continuously applied from supply rolls **25** and **26** or form additional rolls arranged to deliver such material to the inlet end of the press.

As should now be apparent, board structures produced in accordance with the instant invention will find a multitude of uses as wall paneling, structural ceiling panels or tiles, and as decorative panels capable of wide and diverse usage for building purposes. Where the foam surfaces are of sufficiently high impact strength the boards may be used as light-weight table tops, counter tops and the like. While the instant disclosure has been directed primarily to the utilization of rigid foams, it is also within the spirit and purpose of the invention to employ semi-rigid and flexible foams to produce board structures particularly suited as vibration dampeners or where a cushioning effect is desired.

Having thus described the invention in certain exemplary embodiment, and with the undestanding that modification may be made therein without departing from its spirit and purpose, what it is desired to secure and protect by Letters Patent is:

1. A structural building panel consisting essentially of a rigid fibrous board composed of a network of fila-

mentary material bonded together in sheet form by means of an inorganic cementitious binder and characterized by a multiplicity of passageways and interstices extending inwardly from the exposed surfaces of the board throughout the entire thickness thereof, the passageways and interstices in said fibrous board being filled and closed by an essentially rigid foamed plastic material characterized by having been foamed in situ, said foamed plastic material additionally defining an integral foam plastic layer covering and sealing at least one face of said fibrous board, said layer having a cast foam surface.

2. The structural building panel claimed in claim 1 wherein said fibrous board is composed of wood wool fibers bonded together by means of a magnesium cement binder.

3. The structural building panel claimed in claim 2 wherein said fibrous board has a density of approximately 10 lbs. per cubic foot, and wherein said foamed plastic comprises polyurethane foam having a density, in the foamed condition, of approximately 3 to 4 lbs. per cubic foot.

4. A structural building panel consisting essentially of a rigid fibrous board composed of a network of filamentary material bonded together in sheet form by means

of an inorganic cementitious binder and characterized by a multiplicity of passageways and interstices extending inwardly from the exposed surfaces of the board throughout the entire thickness thereof, the passageways and interstices in said fibrous board being filled and closed by an essentially rigid foamed plastic material characterized by having been foamed in situ, said foamed plastic material additionally defining an integral foam plastic layer covering and sealing at least one face of said fibrous board, said foam plastic layer having a cast foam surface, and a porous veil lying immediately beneath said cast foam surface and wholly enclosed within said foam plastic layer, said porous veil serving to enhance the impact strength of said foam surface.

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