July 23, 1935. E. M. JENKINS 2,008,718

STRUCTURAL MATERIAL AND METHOD OF MAKING THE SAME

Filed July 23, 1932

Fig. 1.

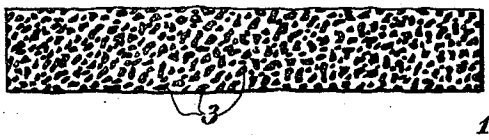


Fig. 3.



Fig. 2.

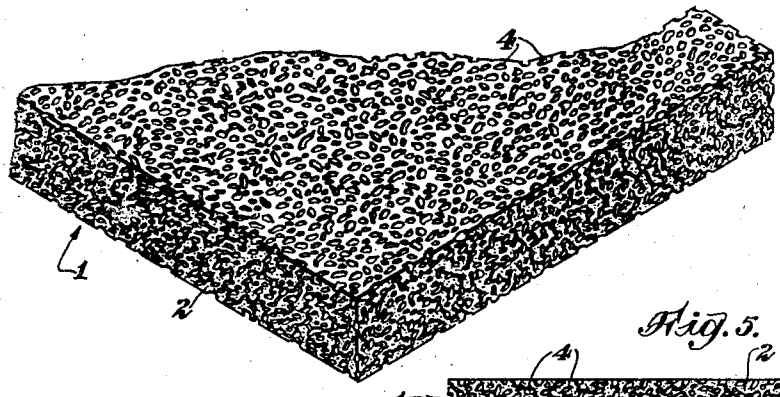


Fig. 5.

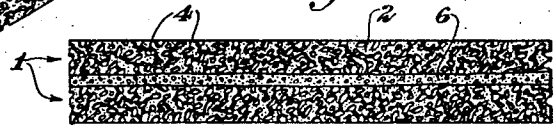
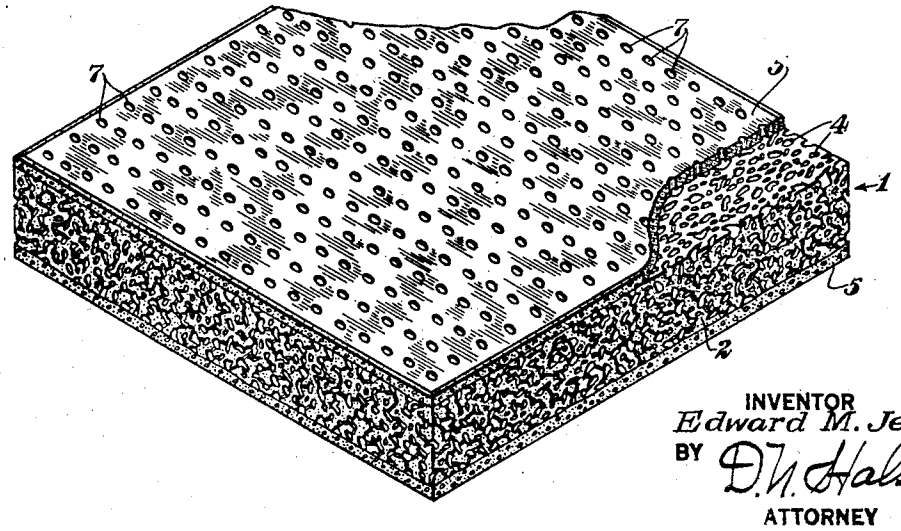


Fig. 4.



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2,008,718

STRUCTURAL MATERIAL AND METHOD OF MAKING THE SAME

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Application July 23, 1932, Serial No. 624,295

17 Claims. (Cl. 154—2)

This invention relates to a structural material and method of making the same, and particularly to a compressed and densified, reenforced cementitious composition provided with a multiplicity of cells. In a preferred embodiment of the invention the cellular composition is integrally united to a dense non-cellular portion containing the same kinds of materials as the cellular composition.

There has been made, heretofore, a cellular cementitious product. Thus, granular naphthalene has been mixed with Portland cement, sand and water, the mixture cast and allowed to harden, and the naphthalene removed by melting and volatilization. Attempts to produce thus a product containing a high proportion of voids cause weakness or susceptibility of the product to breakage.

It is an object of the present invention to provide a structural material and a method of making it in preformed units that are light in weight but sufficiently strong to withstand heavy loading, even when supported in the form of large units at positions several feet apart, that are fire-proof and also heat-resistant, that are thermal insulating, and that may be also sound-absorbing.

Other objects and advantages of the invention will appear as the description thereof progresses.

The invention is illustrated in the drawing in which

Fig. 1 shows a side view of a unit containing a compressed and densified, reenforced cementitious composition including particles of a density-lowering filler material.

Fig. 2 shows a perspective view of an insulating or sound-absorbing material containing a multiplicity of cells resulting from the removal of the filler material from the structure shown in Fig. 1.

Fig. 3 shows a side view of a unit comprising a cellular core of the kind illustrated in Fig. 2 and dense facing layers integrally united to opposite sides of the core.

Fig. 4 shows a perspective view of an embodiment of the invention in which a dense, integrally united facing layer is perforated in a manner adapted to admit incident sound to a cellular sound-absorbing core material of type shown in Fig. 2.

Fig. 5 is a side view of a modification of the invention, comprising a layer of dense material and units of cellular material, of the type illustrated in Fig. 2, united to each side of the dense layer.

In the various figures like reference characters denote like parts.

Thus, 1 denotes a cellular structure or material, suitably in the form of a sheet, comprising a compressed and densified mixture 2, of a cementitious and a reenforcing fibrous material. The cementitious material as used originally, is one adapted to be hardened at atmospheric temperature and suitably is a hydraulic cement. Materials that may be used include magnesium oxychloride cement, calcium aluminate cement (sometimes called cement fondu or Lumnite cement), and Portland cement. The latter is the cementitious material preferred at this time.

The fibrous material should be incombustible and also heat-resistant, that is, not susceptible to decomposition, by charring or otherwise, when subjected to moderately high temperatures, such as 350 to 400° C. The fibers are preferably inorganic and of the type of asbestos. I prefer asbestos fibers, particularly because they are adapted to become interlocked with the cement, originally forced thereinto under strong compression, and to facilitate the later removal of filler in fluid form, as will be described later. When used in the structure of the present invention, asbestos shows no harmful action and no corrosion. I have used to advantage chrysotile asbestos from Canadian mines. One grade used consisted of short fibers and showed 100 per cent through a 4-mesh screen and 57 per cent through an 8-mesh screen, in a standard screening test.

Distributed throughout the cementitious and fibrous composition in the modification shown in Fig. 1 are discrete particles of a density-lowering filler material 3, that, in the preferred embodiment of the invention, are subsequently removed to give a finished product provided with a multiplicity of cells 4 corresponding to the space initially occupied by the particles of filler material. These cells may be distributed more or less uniformly throughout the structure. They may be individually relatively small, that is, so small as to be effective in thermal insulation. Also, they may intercommunicate, as by means of narrow capillaries, in such manner as to make the structure sound-absorbing. They may correspond in size and shape to the granules of filler material originally used. By using filler material in various shapes, such as pellets, crystals, rods, or the like, corresponding shapes of voids may be obtained.

The density-reducing material is suitably a solid that may be reduced to the form of granules or pellets and that is compression-resistant (not adapted to undergo pronounced change of form or volume under compression). The material should not seriously stain or otherwise injure the finished product. For use in making cellular sound-absorbing compositions, the filler material should be adapted to be removed without weakening the structure in which it is embedded. Thus, the filler should be removable by fusion and/or volatilization at a temperature below that which would cause excessive weakening of the rest of

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the structure. Removable filler materials that may be used are granular naphthalene, paraffin, and para-dichlorbenzol. These materials melt and also are volatile in steam. If the density-lowering filler material is to be left in the finished product, in a modification of the invention, the filler should be one that is incombustible and heat-resistant and of low apparent density, such as granular pumice or diatomaceous earth.

The light-weight structure comprising either the density-lowering material or cells, resulting from the removal of the density-lowering material, may be provided with a dense facing layer 5. This facing layer may consist of the same kind of materials, but not necessarily in exactly the same proportions to each other, as found in the light-weight structure. In the modification illustrated in Fig. 5, there may be centrally spaced dense layer 6 of material of the same kind, integrally united on either side to two sheets of the light-weight structure.

The facing layer may be provided with perforations 7 adapted to admit incident sound. Thus, there may be provided a multiplicity of perforations of diameter $\frac{3}{16}$ inch, spaced on ½ inch centers, for example.

The method of making the improved products of the present invention involves the use of certain apparatus that is conventional in making sheet material comprising a compressed and densified and then hardened mixture of Portland cement and asbestos fibers. In making such a product, Portland cement may be mixed with asbestos fibers, say, in approximately equal proportions by weight, and sufficient water to form a freely flowing slurry. This slurry may then be poured into the bed of a hydraulic press provided with a filtering bottom and constituting a mold. The mold may have removable sides. Then, a plate connected suitably to the plunger of the press is brought down on top of the slurry. The slurry is shaped into a sheet; excess water is removed therefrom and forced through the filtering bottom in the bed of the press; and the composition is strongly compressed, to densify and strengthen it. The resulting densified sheet is then removed from the press. It may be so removed by taking away the sides of the mold, raising the die plate to which the sheet normally adheres through suction effect, then breaking the suction at an edge of the sheet, as by stripping over a small area, and allowing the sheet to be received upon a support. The sheet is then allowed to set and harden.

This process may be modified in such manner as to produce the products of the present invention, as illustrated in the following examples:

Example I

In this example, and elsewhere in the specification and claims, all proportions are expressed as parts by weight.

When sound-absorption properties are desired, a material of the type illustrated in Fig. 1 may be formed of a mixture of 25 parts of asbestos fibers, 75 parts of Portland cement, and 186 parts granular pumice filler material (corresponding to 65%, approximately, of the weight of the total dry mixture), and sufficient water to give a freely flowing slurry. The slurry is then poured into the bed of a hydraulic press with a filtering bottom. The amount of slurry poured into the press should be sufficient to give a finished sheet of the desired thickness. Pressure is then applied to the layer of material in the bed of the press, as, for example, by means of a steel die plate. As the pressure is applied, the slurry is shaped and compressed, with the elimination of water. The pressure is increased until, at the end, it is very high, say approximately 2000 pounds per square inch. At this stage, the sheet is highly compressed and densified; it may have approximately a third the thickness of the layer of slurry before compression.

The densified sheet is removed from the press and allowed to stand until the cement hardens, say for thirty days. The resulting hard sheets may be trimmed to exact size desired.

Example II

In making a sound-absorbing element constituting the preferred embodiment of the invention, a sheet is made as described under Example I, except that 186 parts of granular naphthalene are substituted, as the filler material, for the pumice and that the resulting densified sheet is subjected to treatment to remove the naphthalene after the cement in the sheet has taken its initial set.

The removal of the filler material may be accomplished by subjecting the sheet to an elevated temperature to melt and/or volatilize the said material. Thus, the naphthalene may be removed by maintaining the sheet at a temperature somewhat above the melting point of naphthalene, until much of the naphthalene has flowed or dripped from the sheet, and then raising the temperature of the sheet to a point at which the remaining naphthalene volatilizes rapidly. For example, the naphthalene may be volatilized by heating in a stream of saturated steam at 100 pounds pressure, with attendant accelerated hardening of the cement in the sheet, or in a stream of superheated steam, flue gas, or the like. The use of saturated steam is preferred as its use minimizes the evaporation of water before the cement sets.

Example III

There is made a mixture of Portland cement and asbestos fibers, suitably in equal proportions by weight, with water to form a freely flowing slurry. This slurry is placed as a layer in the bed of a hydraulic press with filtering bottom, as described above. The layer is covered by a screen wire or provided with other vacuum breaking means, for a purpose that will appear later. The layer is then compressed, as by a die plate of the type described above, to a more or less compact sheet, say one so firm that it may be indented with the finger with difficulty. Pressing is then discontinued. The pressure, up to this point, may be of the order of 50 to 100 pounds per square inch. With such moderate compression, there is formed a sheet that is adapted to filter water in subsequent operations.

The die plate is then removed, as by being raised, during which operation the screen breaks the vacuum between the sheet and the die plate and causes the sheet to remain in position in the bed of the press. The wire screen or vacuum breaking means is then removed from the surface of the sheet.

Over this sheet there is then applied a layer of material containing a density-lowering filler material, preferably, of the type of the filler described under Example II. This layer may be in the form of a freely flowing slurry containing 75 parts of Portland cement, 25 of asbestos fibers, 186 of naphthalene, and water in amount to give the consistency desired. Since the cementi-

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tious material in the original sheet and also in the layer of material applied thereto is the same, the cementitious material in the layer is miscible with that in the sheet, and becomes integral therewith. On the other hand, the sheet first formed is sufficiently compact and firm to retain its shape when the layer of additional material is placed over the sheet.

Pressure is then applied, as before, except that the pressure may now be built up to the full limit of, say 2000 pounds per square inch.

When the filtration of water from the composite layer and sheet has practically ceased, the product is removed from the press and allowed to set, that is, stand until the cement therein has taken its initial set, say for a half day or longer. It is then submitted to a treatment such as described in Example II and including steaming, for removing the volatile filler material and hardening the cement in the composition.

Example IV

The procedure of Example III is followed, with the exception of certain modifications which permit the fabrication of a product having a dense facing layer united to each side of a porous core material.

There is formed at moderate compression an initial sheet of asbestos fibers, Portland cement and water, and there is pressed onto this sheet a layer of Portland cement, asbestos fibers, naphthalene and water, all as described in Example III, with the exception that a wire gauze, disposed next to the die plate, as vacuum-breaking means, is used in pressing the second layer as well as the initial sheet, and the final compression of the two layers is made in such manner as to maintain the composite in condition for filtering water, say by compression at 50 to 100 pounds per square inch. The die plate is removed, and also the wire screen. There is then applied over the top of the layer containing naphthalene a slurry like that used in making the initial sheet of the composite, namely, a wet mixture of Portland cement and asbestos fibers, say in approximately equal proportions. The whole is then compressed at a final pressure of, say, 2000 pounds per square inch, to remove excess water and give a strongly compressed and densified composited article.

When the compression is completed, the composited article is allowed to set to develop initial strength, after which it is subjected to treatment to remove the naphthalene, as, for example, as described under Example II. Thus, the composited article may be maintained at a temperature above the melting point of naphthalene. This causes a large proportion, frequently about two-thirds of the total naphthalene used, to flow in liquid form from the article. When the recovery of naphthalene in liquid form becomes very slow, the temperature is raised to volatilize the remaining naphthalene. For this purpose there may be used to advantage a stream of saturated steam, as at 100 pounds pressure or higher.

When the naphthalene has been removed, there remains a structural material or unit comprising a cellular portion or core and dense and strong facing material integrally united to opposite faces thereof. Since all parts of the unit contain the same kinds of material, the various parts are adapted to adhere to each other over a wide range of conditions, in spite of the rigidity of the core and facing material.

Example V

A composited article, adapted to absorb sound incident upon either of its two faces but not to transmit it, of the type illustrated in Fig. 5, is made by a method somewhat similar to that described under Example IV, except that the outer layers are made with a removable filler material, that is later removed, while the inwardly disposed or core layer is made of material that remains dense and impermeable to air-borne sound in the finished product.

A slurry comprising Portland cement, asbestos fibers, naphthalene and water is moderately compressed in the bed of a press and formed into a sheet. Over this sheet is then moderately compressed and united a layer of a composition of Portland cement, asbestos fibers, and water. Then there is formed, over this layer, a sheet like the first, containing naphthalene. The whole is then strongly compressed and densified, and then subjected to treatment as previously described, to cause hardening and also the removal of the naphthalene.

Such a product may be provided with integrally united outer facing layers, say of Portland cement and asbestos fibers. These faces may be imperforate, if sound absorption is not desired, or perforated, if the sound-absorbing properties of the product are to be utilized.

Example VI

In this modification of the invention, a dense facing layer, united to the material containing inter-communicating cells, is made permeable to sound. Thus, the dense facing layer may be provided with small, closely spaced perforations 7 (Fig. 4). Such holes may be formed by drilling or cutting through the facing layer after the composite has been set or hardened, or in other suitable manner.

It will be understood that various types of openings adapted to admit sound may be used, as, for example, openings arranged in the form of ornamental patterns or designs.

The products of the present invention have certain features in addition to those that have been mentioned.

The dense facing layers, in a typical product, weigh about 120 pounds per cubic foot and have a modulus of rupture of about 4000 pounds per square inch. They may be sanded to a hard, smooth surface that is susceptible to decoration, as, for example, by paint or lacquer.

The cellular material made, as described, by the use of and subsequent removal of filler of the type of granular naphthalene, is strong and rigid in spite of the presence of cells corresponding to more than half, say 75 to 90 per cent, of the total volume of such material, and of a density that may be as low at 18 to 30 pounds per cubic foot. The compressive strength may be approximately 100 to 500 pounds per square inch. The exact figures as to strength, percentage of cell volume, and density depend in part upon the proportion of removable filler material used initially. The cellular and/or the dense facing material may be colored by the incorporation of pigment into the original compositions before being shaped into sheets.

It is not necessary to use an adhesive or to leave substantial amounts of organic material in the finished article. Therefore, the finished article may be not only incombustible but also heat-resistant up to relatively high temperatures.

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The material can be sawed, nailed and worked by a number of conventional methods.

The properties will depend quantitatively, in part, upon the details of the method of preparation and upon the proportions of materials.

Thus, the size of the particles of the removable filler incorporated initially into the mixture and later removed has a bearing. With a given proportion of naphthalene used, for example, smallness of size of particles favors increased thermal insulating power, but decreased strength of the product. On the other hand, less effective insulation and greater strength are obtained when the naphthalene particles are larger. With these facts in mind, one may choose a graduation of size of naphthalene particles that suits the particular requirement. In order to avoid making a porous material of pronounced capillarity for water and weakness, the particles of naphthalene should be large enough to leave individual cells of substantial size when the particles are removed from the composition. To make such cells, I have used to advantage particles of naphthalene of which more than half by weight was finer than 10-mesh. The results of a standard screening test of a granular naphthalene that I have used, follows:

Mesh of Screen	Retained
Openings per linear inch	*Percent by weight*
On 14	21
On 20	17
On 40	37
On 60	12
On 80	5
On 100	3
Through 100	5

Also, the proportions of the filler material may be varied. Thus, there may be used in making the cellular or core material 25 to 85 parts and preferably about 50 to 75 parts by weight of naphthalene to each 100 parts dry weight of mixture including the naphthalene, Portland cement, and fiber.

The proportion of removable filler used has a decided effect upon the properties of the product from which the filler is finally removed. Thus, the proportion of naphthalene used initially affects the sound-absorption properties. With a material made as described under Example II, the following data on sound absorption has been obtained:

Percent of naphthalene used	Thickness of cellular material in inches	Sound absorption, percent, at frequency of 500–1000 cycles
55	0.5	34
65	0.7	50
75	1.0	62

The strength of the product with the dense facing layers is very high and is outstanding in proportion to the overall density of the material. Also, the thermal insulating properties are very satisfactory, as illustrated quantitatively by the data for a preformed structural unit made as described in Example IV. The unit included a core of cellular material and two dense facing layers, each approximately $\frac{3}{16}$ inch thick, containing 50 parts of Portland cement to 50 of asbestos fibers. The core was 0.93 inch thick and contained 75 parts of Portland cement to 25 of asbestos fibers, and was made with the use initially of 65 parts of naphthalene to 100 of total dry mixture in the core layer. The unit weighed approximately 51 pounds per cubic foot, had an overall thermal conductance at atmospheric temperature of approximately 0.5 to 0.6 British thermal units per square foot of area, per hour, calculated for a temperature gradient of 1° F. Also, this product, when supported in units 42 inches wide, on beams 7 feet apart, broke, under concentrated center loading at 1,266 pounds. It will be seen that the material, even when made in large units, can support heavy loads over long spans.

When such a unit is subjected to heavy loading, there is slight flexing before the unit breaks. This slight flexing is accomplished by compression of the facing layer on which the load bears and tension on the opposite facing material. Since compositions consisting of Portland cement and asbestos fibers are stronger under compression than under tension, the facing layer under tension in the unit will usually break before the other facing layer breaks. To offset this greater susceptibility to breaking under tension, the preformed unit may be made with a layer of facing material that may be two to five times as thick on the side that is to be subjected to tension, when the unit is loaded, as on the other side. However, it is desirable from the standpoint of minimizing warpage of the unit under varying conditions, such as varying humidity of air in contact therewith, to have the oppositely disposed facing layers of the same thickness, as well as of identical compositions.

The proportions of fibrous to cementitious material may be varied within limits. Thus, the proportion of fiber in the core or light-weight material may be 20 to 75 per cent, say 25 to 40 per cent, of the weight of the mixture of fiber and cement. For the facing layers, which are dense and very strong, there has been used a somewhat higher proportion of fibers, say 40 to 75 per cent, advantageously about 50 per cent, of the weight of the mixture of fiber and cement.

The units may be made of various dimensions or sizes. Thus, the light-weight or cellular material may be made of thickness greater than ½ inch, say up to about 5 inches. The faces may be made of thickness greater than $\frac{3}{16}$ inch. The units may be made in very large shapes, say 3½ x 11 feet on the face. Such units, particularly when faced on both sides, are admirably adapted for use in floors, walls, partitions or roofs of buildings.

While the invention is not limited to any theory or explanation of the results obtained, the pressure filtration of water through the composition, during the fabrication, as illustrated in Examples I–VI, has a very important bearing. This filtration makes possible the use initially of very wet and easily shaped slurries and facilitates the integral union of the adjacent layers. Also, the filtration may carry fine particles of cement from one layer into pores in another, with the substantial elimination of boundary planes between the cement in one layer and that in the next and blending in the zone of contact. Further, the rapid removal of water from the composition by filtration may open small passages from the interior to an exterior surface and thus provide avenues of escape for the filler during its subsequent removal.

With these considerations in mind, a modification of the filtration process as described in the

examples may be used. Thus, the products may be fabricated by a process using a wet or millboard type of machine. In this process, there is provided a paper making stock comprising Portland cement and asbestos fibers, for example, suspended in a large volume of water. The cement and fibers are then collected in the form of a felt and the felt transferred continuously to the collecting drum of a millboard or wet machine, in conventional manner. When the felt on the drum reaches the desired thickness, it is composited with a similarly formed felt made from a stock containing a removable filler, such as naphthalene, in addition to the above ingredients. Also, there may be applied a third layer, like the first, to give a composite comprising core material containing naphthalene (or other removable filler) and facing layers containing no such filler. The whole may then be strongly compressed, as at 2,000 pounds per square inch, to weld the several layers together, densify them, and remove excess water by filtration. The product may be hardened and subjected to treatment to remove the naphthalene.

The various layers may be composited either on the drum of the millboard machine, as by changing the character of the stock furnished to the machine, or after the individual layers are removed from the drum and straightened into slabs.

Also, layers separately formed by filtration in the hydraulic press equipment, as described in Examples I–VI, may be composited. Thus, separately formed and pressed sheets, one or more with and one or more without filler, may be placed together in mating relationship, before the sheets are hardened, and then pressed together strongly, suitably at a pressure substantially higher than used initially in forming the individual sheets. The adhesive or cementing material, used between the separately formed and compressed sheets in making the composite, may be a material suitable for the purpose, as, for example, a Portland cement mortar.

During the filtration step of the process of manufacture, the asbestos fibers facilitate the filtration. Compacted, finely ground Portland cement alone does not filter water readily. Mixed with asbestos fibers, as in the facing layers, the cement composition filters water rapidly and makes possible the removal of excess water at a rate that may open up passages associated with the fibers through which a volatile filler may later be removed.

A similar effect of the asbestos in the compositions and method described is the provision of wick-action or otherwise facilitating ready removal of the filler of the type of naphthalene by melting or vaporizing, as described above. In spite of the strong compression and densification of the facing layers of the unit comprising, for example, dense layers on both sides of the naphthalene-containing core layer, raising the composite to a temperature above the melting point of naphthalene causes a rapid flow of naphthalene therethrough. This result is particularly surprising in view of the campactness and relative freedom from porosity of the surface layer and is to be explained as due in part to the action of the asbestos fibers present.

In the finished product, the asbestos fibers have a strong reenforcing and toughening action which, with the effect of compression and densification and knitting together of the structure by the pressure filtration, offsets in large measure the weakening effect of voids corresponding to particles of initially incorporated and then removed filler.

It will be understood that the details that have been given are for the purpose of illustration and not restriction, and that many variations therefrom may be made without departing from the spirit and scope of the invention.

What I claim is:

1. An article of manufacture comprising a strongly compressed and densified mixture of a cementitious material adapted to be hardened at atmospheric temperature, reenforcing fibers of the type of asbestos, and a density-lowering material that is readily volatile in superheated steam at a temperature below that which causes weakening of the bond in the cementitious material.

2. An article of manufacture provided with cells intercommunicating with each other and with an outer surface of the article by means of fluid-escape channels and comprising a compressed, densified, and then hardened mixture of a hydraulic cementitious material and reenforcing fibers, of the type of asbestos, embedded and interlocked therein.

3. A rigid, strong, incombustible structural unit consisting largely of hydraulic cementitious material and reenforcing fibers distributed therethroughout, and adapted to absorb sound incident upon opposite faces and to prevent the transmission of such sound, said unit comprising outer layers of sound-absorbing material integrally united to a centrally disposed sheet of material that is impermeable to air-borne sound.

4. A structural unit consisting largely of a hydraulic cementitious material and reenforcing fibers, containing the same materials throughout and comprising a cellular portion and a dense portion, the said portions being in the condition of having been integrally united one to the other by filtration, compressed and densified, and then hardened.

5. A structural material provided with a multiplicity of cells and comprising a hardened mixture of asbestos fibers and Portland cement in the proportion of approximately 20 to 75 parts of asbestos to 100 parts of total weight of mixed asbestos and cement, the said cells corresponding approximately to the volume originally occupied by a removable filler of the type of naphthalene initially incorporated, in the proportion of not less than 25 parts of filler to 100 parts by weight of total dry material, and subsequently removed.

6. A preformed, sound-absorbing structure consisting throughout largely of a compressed and densified and hardened mixture of a hydraulic cementitious material and reenforcing material and comprising a cellular layer provided with intercommunicating cells adapted to absorb sound, and a dense, perforated facing layer adapted to admit incident sound, the said cellular and facing layers being integrally united to each other to give a strong, rigid, washable unit adapted to absorb more than 40 per cent of incident sound of frequency ranging from 500 to 1000 cycles per second.

7. A strong, light-weight, preformed structural unit comprising a cellular core and dense facing layers integrally united to opposite faces of the core, the said core and facing layers containing each a compressed and hardened mixture of a hydraulic cementitious material and reenforcing fiber and the core being provided with intercommunicating voids corresponding to the space resulting from the initial incorporation and sub-

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sequent removal of granular filler of the type of naphthalene in proportion equal to approximately 55 to 75 parts by weight of the filler to 100 parts dry weight of all materials used.

8. A strong, light-weight, preformed structural unit comprising a cellular core and dense facing layers integrally united to opposite faces of the core, the said core and facing layers containing a hardened mixture of Portland cement and asbestos fibers.

9. In the manufacture of a cellular composition, the method which comprises making a mixture of a hydraulic cementitious material, reenforcing fibers of the type of asbestos, a volatile density-lowering material, and water, forming the mixture into a sheet, strongly compressing the sheet to densify and strengthen it, setting and hardening the compressed sheet, and removing the density-lowering agent therefrom by a treatment including volatilization.

10. In the manufacture of a cellular composition, the method which comprises making a mixture of Portland cement, asbestos fibers, granular naphthalene containing more than half by weight of particles finer than 10-mesh, and water, forming the mixture into a sheet, strongly compressing the sheet to densify and strengthen it, setting and hardening the compressed sheet, and removing the naphthalene therefrom.

11. In the manufacture of a cellular composition, the method which comprises making a mixture of Portland cement, asbestos fibers, granular naphthalene, in proportion equal to at least 55% of the dry weight of the mixture, and water, forming the mixture into a sheet, strongly compressing the sheet to densify and strengthen it, allowing the cement in the compressed sheet to take its initial set, and then simultaneously hardening the product and removing naphthalene therefrom by subjecting the product to a temperature above the melting point of naphthalene and below the temperature of substantial weakening of the cement.

12. In the manufacture of a cellular composition, the method which comprises making a mixture of Portland cement, asbestos fibers, granular naphthalene, and water, forming the mixture into a sheet, strongly compressing the sheet to densify and strengthen it, allowing the cement in the compressed sheet to take its initial set, and then simultaneously hardening the product and removing naphthalene therefrom by subjecting the product to saturated steam at a temperature substantially above 100° C., whereby melting and volatilization of the naphthalene are produced.

13. In the manufacture of a structural unit comprising a portion of low density and a dense portion, the method which includes shaping and moderately compressing a wet mixture of a hydraulic cement and reenforcing fibers, to form a sheet adapted to filter water, then applying over the sheet a layer of a wet mixture of a hydraulic cement, reenforcing fibers, and a density-lowering material, shaping the layer and compositing it and integrally uniting it to the said sheet by moderate compression, strongly compressing the resulting composite to remove water therefrom, to densify and strengthen it, and to cause blending in the zone of contact between the said sheet and layer, and then hardening the product.

14. In the manufacture of a structural unit comprising a portion of low density and a dense portion, the method which includes shaping and moderately compressing a wet mixture of a hydraulic cement and reenforcing fibers of the type of asbestos, to form a sheet adapted to filter water, then applying over the sheet a layer of a wet mixture of a hydraulic cement and reenforcing fibers of the type of asbestos containing an admixed removable density-lowering material, shaping the layer and compositing it and integrally uniting it to the said sheet by moderate compression, strongly compressing the resulting composite to remove water therefrom and to densify and strengthen it, and then hardening the product and removing the density-lowering material therefrom, to form intercommunicating voids.

15. In the manufacture of a structural unit comprising a portion of low density and a dense portion, the method which includes shaping and moderately compressing a wet mixture of a hydraulic cement and reenforcing fibers of the type of asbestos, to form a sheet adapted to filter water, then applying over the sheet a layer of a wet mixture of a hydraulic cement and reenforcing fibers of the type of asbestos containing an admixed density-lowering material, shaping the layer and integrally uniting it to the said sheet by moderate compression, forming a second sheet like the first mentioned sheet over the layer containing the density-lowering material, then strongly compressing the composited article to remove water therefrom to densify and strengthen it, and hardening the strongly compressed product to give a unit containing a core of low density and dense facing layers integrally united to opposite faces of the core.

16. In the manufacture of a structural unit comprising a portion of low density and a dense portion, the method which includes shaping and moderately compressing a wet mixture of a hydraulic cement and reenforcing fibers of the type of asbestos, to form a sheet adapted to filter water, then applying over the sheet a layer of a wet mixture of a hydraulic cement, reenforcing fibers of the type of asbestos, and a removable density-lowering material, shaping the layer and integrally uniting it to the said sheet by moderate compression, forming a second sheet like the first mentioned sheet over the layer containing the density-lowering material, then strongly compressing the composited article to remove water therefrom to densify and strengthen it, hardening the strongly compressed product, and removing the density-lowering material therefrom, to produce a unit containing a cellular core and dense facing layers integrally united to opposite faces of the core.

17. In the manufacture of a structural unit comprising a portion of low density and a dense portion, the method which includes shaping and moderately compressing a wet mixture of a hydraulic cement and reenforcing fibers of the type of asbestos, to form a sheet adapted to filter water, forming a similar sheet containing particles of filler material in addition to the ingredients stated, placing the two sheets together face to face, then uniting them and simultaneously filtering water from the united sheets by subjection to pressure in excess of that originally used in moderately compressing them, and then hardening the united sheets.

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