May 16, 1961 F. O. BRISLEY ET AL 2,984,312

ACOUSTICAL WALL BOARD

Filed April 24, 1959 3 Sheets-Sheet 1

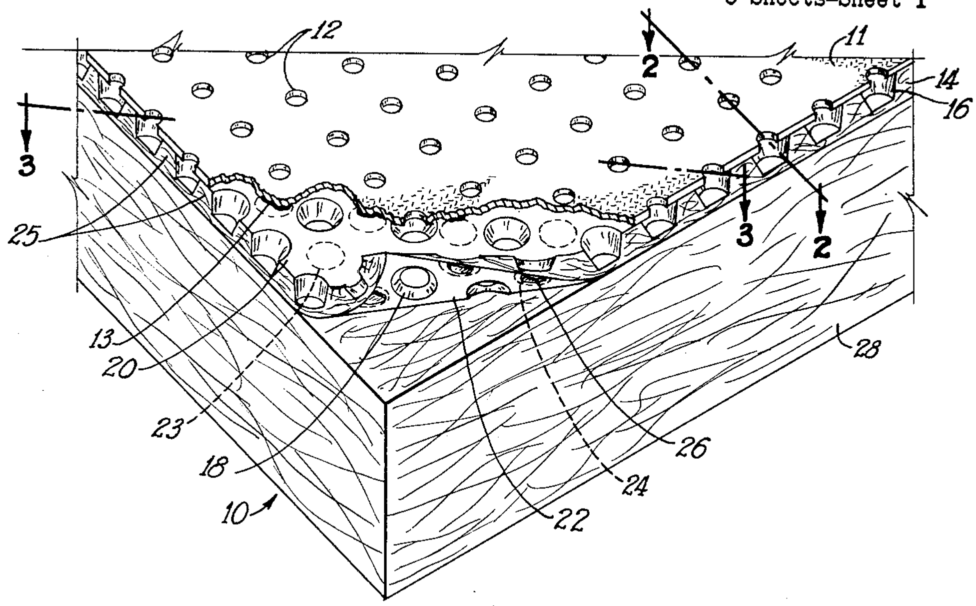

Fig. 1

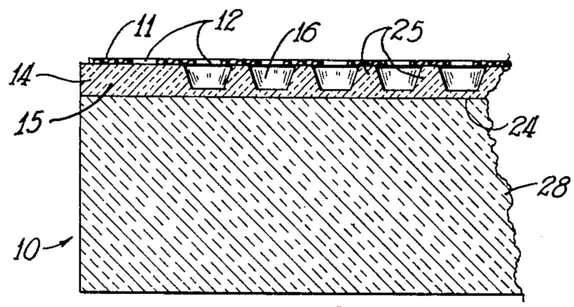

Fig. 2

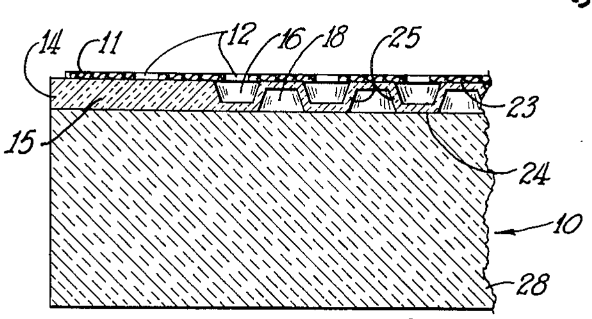

Fig. 3

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ACOUSTICAL WALL BOARD

Filed April 24, 1959 3 Sheets-Sheet 2

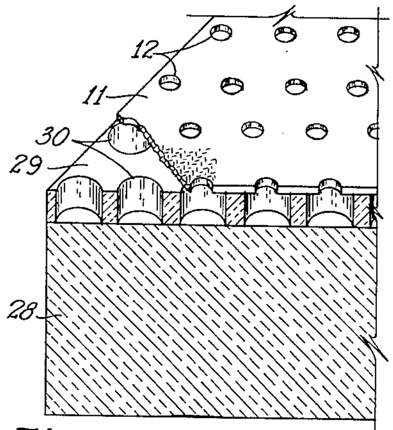

Fig. 4

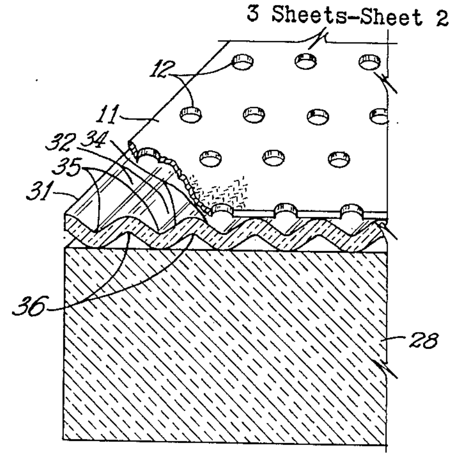

Fig. 5

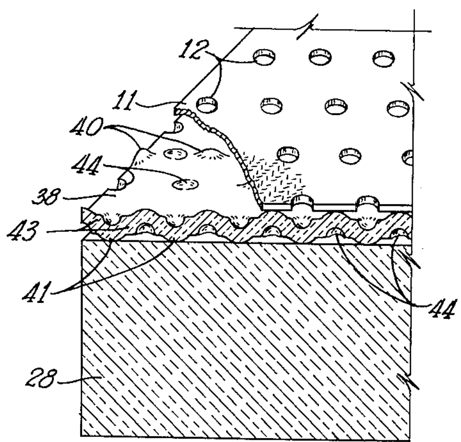

Fig. 6

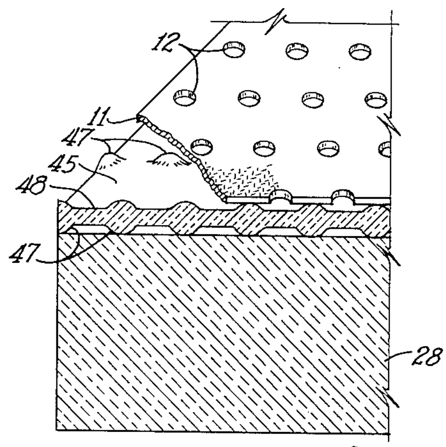

Fig. 7

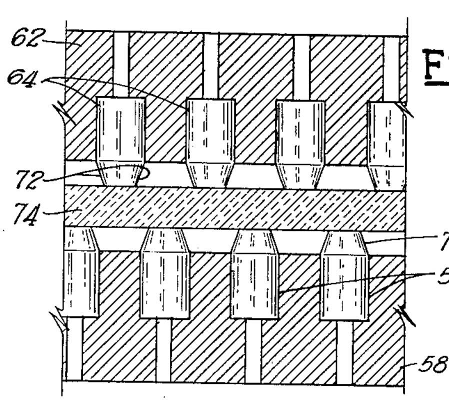

Fig. 9

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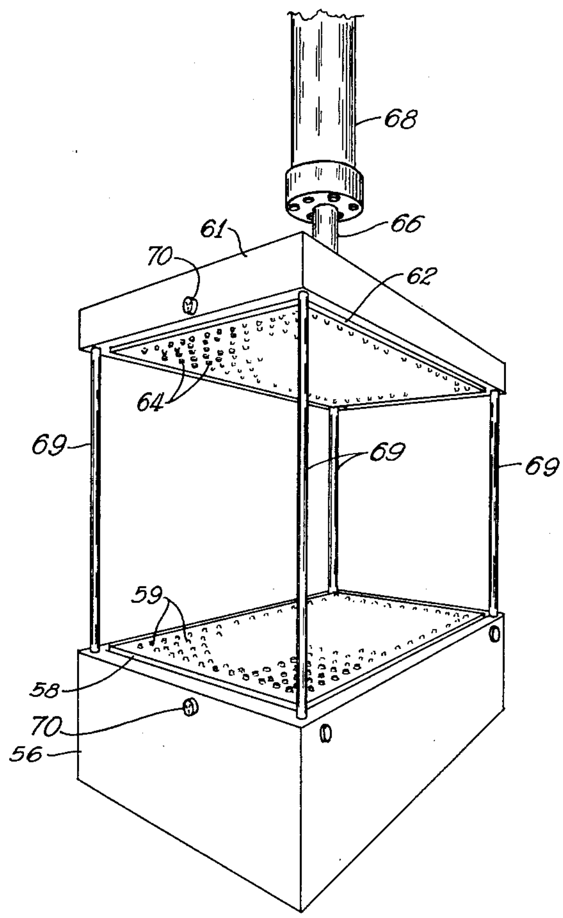

Fig. 8

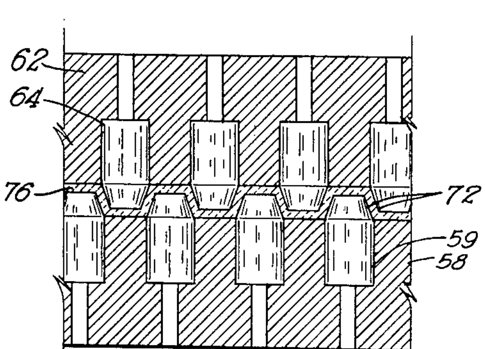

Fig. 10

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United States Patent Office

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ACOUSTICAL WALL BOARD

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Filed Apr. 24, 1959, Ser. No. 808,647

17 Claims. (Cl. 181—33)

This invention relates to a panel for installation in abutting series as a wall or ceiling structure or covering. More particularly, this invention pertains to an acoustical and thermal insulating board preferably composed of glass fibers or of other comparable mineral fibers.

Porous, low density bodies of fibrous glass are most effective in noise abatement due to the capacity of the myriad, minute communicating air cells in the maze of fibers to baffle and absorb sound waves. The tiny pockets of static air are also responsible for the high thermal insulating power of such fibrous masses.

Because of their inherent porosity and lightness, acoustical and insulating boards of glass fibers are necessarily rather deficient in strength and rigidity. As a consequence, their installation is usually restricted to exposed areas where they are not apt to be submitted to physical abuse, or alternately to locations behind more sturdy protective shields.

In line with this general practice, semi-rigid acoustical tile may be placed upon ceilings; insulating blankets are positioned between studdings or rafters and enclosed behind wall plaster or paneling; and pads of acoustical wool are placed within metal pans. Such pans are rigidly mounted and are perforated to permit sound waves to pass through and reach the shielded sound absorbing, fibrous pad.

The pans and special hangers are additional elements of the cost of such acoustical installations. Besides the extra expense they involve, pans are also objectionable since they may be dented and permanently disfigured.

Because of the indicated limitations in prior products of this type it is a prime purpose of this invention to provide an integrated composite board which not only has high acoustical and thermal insulating properties but also has a rugged resiliently supported, surfacing able to cushion blows and sharp impingements without fracture. A board of this invention accordingly has no need of extra protective sheathing and may be employed where requirements are most severe, for example, in ships of the navy or merchant marine.

In such sea craft heat conservation, and sound suppression are of great importance. At the same time wall surfacing material must be of a sturdy character to withstand just the ordinary day-to-day activities. Also, neat and well painted surroundings aboard ship are highly regarded for morale and efficiency reasons.

In regard to this high standard of neatness, it is another object of this invention to provide an acoustical wall board which may be easily washed and repeatedly painted without loss of effectiveness frequently arising from such treatment of acoustical panels.

A further object of the invention is to provide an acoustical board which does not release loose fibers.

Another important purpose of this invention is the provision of a wall board of glass fibers which is unaffected by fire, moisture and heat, and is light in weight and dimensionally stable.

A still further aim is to furnish a wall board which is reasonable in cost and inexpensive to install.

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The objects and advantages recited above, and as brought out hereafter in connection with the description of the invention, are preferably attained through the provision of an integrated wall board having first, a cover of stiff, sturdy sheeting, most desirably of fibrous glass, with spaced perforations therein for the passage of sound pulsations; secondly, a reinforcing, intermediate densified body of glass fibers shaped to provide cavities beneath the perforations of the cover with the breadth of the cavities greater than the diameters of the perforations; and lastly, an underlying, thick blanket of a more porous mass of bonded fibrous glass of high acoustical and thermal insulating capacity.

In this preferred embodiment the cover fabric is a plastic impregnated woven cloth, while the interlayer has compacted portions constituting strong supporting bases to which the cover is adhesively secured. The interlayer also has depressions on both surfaces and internal, porous sections for the dampening and transmission of sound waves to the main underlying body, the latter serving as the principal heat insulating and sound suppression portion of the board.

Various other alternate embodiments of the invention may be utilized with retention of many, if not all, of the benefits secured through the above preferred structure. Such modifications include a two-piece assembly incorporating a sheeting cover attached directly to a main body of insulating material with depressions in the surface of the main body beneath perforations in the cover. Further variations encompass the use of materials other than glass fibers for the facing sheet, the interlayer or spacer and the main insulating body.

The invention will be more fully explained hereafter with reference to the drawings in which:

Figure 1 is a perspective view of a portion of a wall board embodying a preferred form of the invention;

Figure 2 is a fragmentary vertical section of the wall board of Figure 1 taken on the line 2—2 thereof;

Figure 3 is a similar vertical section taken on the line 3—3 of Figure 1;

Figure 4 is a fragmentary sectional and perspective illustration of a wall board incorporating an alternate form of interlayer from that in the embodiment of the preceding figures;

Figures 5, 6 and 7 are similar views of wall boards having still different types of interlayers;

Figure 8 is a perspective view of a hot press adapted to mold an interlayer for the board depicted in Figures 1–3;

Figure 9 is an enlarged section of the mold portion of the press of Figure 8 with a blank of glass fibers in place to be compressed; and

Figure 10 is a similar view of the mold in closed position shaping the blank into the interlayer.

Referring to the drawings in more detail, a wall board **10** embodying this invention in a favored form is shown in Figure 1. This board, which may be of any conventional size such as two by three feet, has a covering sheet **11** woven of fibrous glass yarn. This sheet is desirably a resin impregnated cloth of a crowfoot satin weave having a weight between seventeen and twenty ounces per square yard and a thickness of approximately seventeen thousandths of an inch. It is estimated that a sheet so fabricated has a break strength of over four hundred pounds in a one-inch strip.

This woven glass cloth is a conventional product. The glass fibers utilized are of continuous filament form with a typical diameter of around thirty-eight hundred thousandths of an inch. These filaments in number from one to two hundred are gathered together in strands which are wound upon mandrels below the furnace bushings from which the filaments are drawn. The strands are subsequently plied and twisted to build the yarn of the weight and strength required.

The yarn is then woven into the type of cloth most suitable for its ultimate purpose. For the subject wall board a satin weave is chosen as it possesses strength in all directions and presents an even and decorative surface.

According to the recommended practice of this invention the basic cloth is impregnated with a fire-retardant, vinyl-melamine thermosetting resin in a quantity from one to one and a half ounces per square yard. This resin fills the interstices of the cloth thereby sealing and smoothing the surface and making it less inclined to hold dirt and more readily washed without injury. The resin also reinforces the glass stock. Such a glass cloth is quite incombustible, since inert glass fibers amount to approximately eighty percent of the material, and the lesser component of the vinyl-melamine impregnant has high fire resistant properties.

While tough and strong, the facing sheet is somewhat flexible and will give under pressure to counter and lessen the effect of blows apt to cause punctures. Under the resilience of the underlying interlayer and backing insulation the facing sheet is restored and maintained in proper position.

Being sealed by the impregnant and hence generally impervious to sound waves the sheet is punched to form perforations for the passage of such acoustical pulsations to the absorbing material in the main portion of the board. The sheet **11** has rows of the circular perforations **12** which, in this example, are .218 of an inch in diameter with their centers spaced one-half inch apart. With such dimensions the apertures **12** account for about fifteen percent of the area of the sheet **11**. They may constitute between six and twenty percent of the area as far as the recommended practice of this invention is concerned.

While variously lacking in strength, freedom from denting, fire resistance, low cost, or lightness, other facing materials may be utilized in creating wall boards of this invention. One of the more practical alternate materials for the facing sheet is an unwoven mat of glass fibers. The use of such a mat, however, entails quite a lessening in strength which would not be acceptable in many situations. Also, as more of an organic binder is required in a mat, the fire protection would be decreased. Other possible substitutes are metal or plastic sheeting, masonite, cloth of organic fibers, or of other inorganic fibers such as asbestos, paper, and cardboard. The deficiencies of such alternate facing elements are believed self-evident when taking their known characteristics into consideration.

A flame-proof vinyl adhesive **13** is finally applied to the sheet in an amount of three to four ounces per square yard. This serves as the attaching agent for joining the sheet to the adjacent intervlayer **14**.

The particular interlayer forming a part of the board illustrated in Figures 1, 2 and 3 has a recommended overall thickness of one-quarter of an inch; and is of a waffle appearance having regularly spaced inverted frusto-conical depressions **16** on its upper face and like upwardly extending indentations **18** on its lower side. The depressions **16** are centered below the perforations **12** in the cover **11**, and since the depressions taper from a top diameter of .375 of an inch to a base diameter of .239 they reach under the edges of the perforations, the latter being only .218 of an inch in diameter.

The interlayer or spacer **14** is preferably a compressed, bonded pad of fibrous glass. From the standpoint of lightness, acoustical effectiveness, and thermal insulation, glass fibers of a diameter in the range of twelve to twenty-two hundred thousandths would serve most satisfactorily. Fibers of still small diameters enhance some properties of the product, while fibers of large diameters, up to more than seventy hundred thousandths, give quite adequate results and may be more practical for commercial purposes.

The size of fibers is determined by the type and control of the forming equipment utilized. Regardless of the particular fiber producing process involved, for creating the spacer of this invention the fibers are collected in blanket form with an uncured binder component dispersed therethrough.

The binder must provide permanent, rigid ties between fibers at the cross over contact points and should not support combustion. A combination of melamine and phenol formaldehydes, in a proportion of roughly one to two, successfully meets these requirements. The amount of binder may run between nine to twenty-six percent by weight of the finished spacer, depending upon the balance desired between strength and fire protection in the product. Twenty percent is a preferred maximum where the fire hazard is high.

The interlayer **14** is so molded that the upper and lower surface lands **20** and **22** have circular areas **23** and **24** diametrically between the depressions **16** on the upper surface, and between the indentations **18** on the lower surface. These areas are compacted to a thickness of .0625 of an inch and to a hard density between sixteen and thirty-two pounds per cubic foot. The location of the circular areas **23** and **24** is indicated in Figures 1, 2 and 3. The partitioning portions **25** of the interlayer disposed between the depressions **16** and the indentations **18** preferably have a much lower density, about one-half of that of the compressed land areas, or between eight and sixteen pounds per cubic foot.

The land areas **23** present a firm base for the adhesive attachment of the interlayer **14** with the cover **11** while the porous walls **25** afford easily penetrated paths to the absorptive main body **28** of the wall board for sound waves traveling through the perforations **12**.

The solid land areas **24** on the underside of the interlayer provide effective attaching portions for the integration of the interlayer and main body **28**, while the lower indentations **18** afford an unencumbered space for the sound waves traveling through the walls **25** toward the body **28**. The latter, in the favored product, is a porous mass of bonded glass fibers with the fibers in lengths averaging an inch or more and with diameters preferably in a range between fifteen and thirty-five hundred thousands.

However, from an economic standpoint it may be more feasible to utilize fibers with diameters up to seventy or more hundred thousandths. These, however, would not contribute the sound absorbing qualities and lightness secured with the finer fibers.

In a manner similar to that followed in creating the blank of fibers for the interlayer **14**, the fibers for the main body **28** are gathered in a thick web below a forming hood. The binder impregnated mass is then held compressed to the selected thickness while the binder is heat cured.

The binder component should be as fire resisting as possible and for this reason the same melamine-phenol formaldehyde resin as employed in building the interlayer **14** is recommended. A constituent of binder between nine and twenty-six percent by weight of the combined glass and resin mass is held best for all around performance.

For a high value of insulating capacity the body **28** should have a thickness of at least one and a half to two inches and a density of only two to three pounds per cubic foot. The body would then have a thermal conductance of roughly twenty-two hundredths of a B.t.u. per square foot, per hour, per inch of thickness for each Fahrenheit degree difference. In situations where further insulating effectiveness is desired the body **28** may have a thickness of four to six inches.

While a waffle shape of interlayer has characteristics making it particularly suitable for incorporating in boards of this invention, other forms are serviceable without severe loss of function.

For example, a compressed pad with holes arranged to lie beneath the perforations **12** of the covering sheet **11** provides paths for sound waves into the main body **28** and also permits painting of the sheet **11** without harm to the sound dampening capability of the wall board. A section of a board with such an interlayer is shown in Figure 4, in which the interlayer is designated as **29** and the holes therethrough as **30**. Such a board should be molded as loose fibers result from a hole punching operation.

Similarly an interlayer of corrugated formation as indicated at **31** in the section presented in Figure 5 will serve fairly adequately. The valleys **32** of the configuration of such a board are positioned below the perforations of the covering sheet to permit painting of the sheet without the coating material reaching the spacer surface. The inclined sides **34** of the corrugations, as well as the bottoms **35** thereof and the valleys **36** on the underside provide paths for the sound waves to the insulating and sound absorbing backing. Such a corrugated interlayer, however, has less strength than the waffle design unless a heavier fibrous glass mass is utilized.

The board pictured in Figure 6 has an interlayer **38** with round knobs **40** and **41** impressed upwardly and downwardly, respectively, from a central planar section **43**. Beneath the knobs are spherical cavities **44**. The side walls of the knobs as well as areas of the central section **43** between the knobs provide paths for the sound waves. The top of the knobs act as contact and attaching spots to join the interlayer with the top sheet **11**, and with the main insulating body **28**.

A still different design of interlayer **45** is incorporated in the board illustrated in Figure 7. In this form the knobs **47** are solid and in opposed relation. Not being as compacted as the contact areas of the interlayers shown in the previous figures they are not as strong, but have compensatingly more cushioning effect.

In Figures 8, 9 and 10 the press for molding the preferred form of interlayer **14** is illustrated. With reference first to Figure 8, the press is depicted as having a base **56** upon which the lower mold **58** is mounted. Ends of pins **59**, for forming the indentations **18** in the lower side of the interlayer **14**, project upwardly from the main surface of the mold **58**.

Fixed to the upper platen **61** of the press is upper mold **62**. Pins **64**, similar to pins **59** but in staggered relation thereto, extend downwardly from the planar face of mold **62**. The press ram **66** is motivated by cylinder **68** to drive the upper platen **61** and upper mold **62** downwardly on guide rods **69**.

The upper and lower mold sections are heated to a temperature of around four hundred degrees Fahrenheit for setting the binder in the glass fiber stock. Steam may be utilized for this purpose but electrical elements are preferred for reasons of safety and the inclusion of such elements is indicated in Figure 8 by the electrical supply attachments **70**.

In the enlarged sectional view of Figure 9 the mold is shown approaching its closed position. As may be noted the pins **59** and **64** have protruding tapered ends **72** for impressing the depressions **16** and **18** in the blank **74** of the interlayer to be shaped. This blank **74** is previously cut to dimensions to fit the mold from a binder impregnated fibrous glass web of the desired specifications.

In Figure 10 the mold members **58** and **62** have been brought together compressing the blank **74** into waffle configuration. The pressure applied may be on the order of fifteen tons for an interlayer unit three feet long and two feet wide. The binder component generally requires three to five minutes to cure at the temperature of four hundred degrees Fahrenheit.

Being thus molded and resin bonded, the fibers of the formed blank **76** are smoothly held in place with no proclivity to shed. This contrasts with the loose pieces of fibers left in like porous bodies of fibrous glass when punched or cut to shape.

In integrating the covering sheet **11**, the interlayer **14** and the main insulating body **28** into the composite wall board panel **10**, the first step in the presently favored procedure is to join the interlayer **14** to the body **28**. This is accomplished by applying a solvent type, rubber base adhesive **26** to the under side of the interlayer. Care must be taken that the adhesive does not enter the indentations **18** and seal the surfaces thereof as this would block the route of the sound waves to the body **28**. The interlayer is then held with pressure but without heat against the backing body **28** until sufficient solvent has evaporated to set the adhesive.

The combination of the backing body **28** and interlayer **14** is then secured to the covering sheet **11** under heat and pressure. The heat fuses the vinyl adhesive **13**, previously applied to the sheet **11**, making it effective in seizing the upper lands **20** of the interlayer. It is important to have the sheet carefully positioned for this adhering step in order that the perforations **12** be centered over the frusto-conical depressions **16**.

The edge of the finished board **10** is closed due to the unshaped margin **15** left on the interlayer in the molding operation. Such plain edges of the interlayer may be seen in Figures 2 and 3.

The completed wall board unit is preferably two feet wide and three feet long. With an insulating body **28** two inches thick and a one quarter inch interlayer, the board has a thickness of approximately two and five sixteenths inches and a weight of about five pounds.

The lightness and rigidity of the boards make them easily manipulated for installation. When applied to bulkheads or other steel partitions or frame work in naval craft, the recommended attaching procedure involves the welding of nail-like stud members to the metal backing structure. The board is forced against the stud members which pierce the board and project slightly for receipt of spring clips or washers.

The exposed points of the studs and surrounding washers may be painted or covered with a glass cloth tape such as is applied over the seams between adjoining boards. Where there are no steel wall elements or when it is not desired to use the studs for some other reason, the boards may be attached with an adhesive such as one having a rubber base.

For fitting around pipes or other obstructions or filling in narrow strips at corners, the wall board may be cut easily with a knife to the required outline or dimensions.

The board of this invention combines in a single unit properties of strength, sound dampening and thermal insulation approached in the past only by assemblies of separate elements. The subject wall board presents a resilient, puncture proof facing which may be readily washed or painted without detracting from the acoustical and insulating functions of the product. Other desirable qualities possessed by the board are moisture and fine resistance, light weight, reasonable cost and ease of installation.

Features of this invention which are responsible for these superior properties include the tough, resin saturated, covering sheet of woven fibrous glass; the perforations in the covering sheet coupled with cavities of broader dimensions below the perforations; an interlayer with hard attaching areas and depressions on both the upper and lower faces thereof and with more porous portions in its center section; and finally, under the protection of the covering sheet and interlayer, a backing composed of a thick, low density mass of bonded glass fibers capable of top performance in sound deadening and thermal insulation.

As previously mentioned, features of the invention may be incorporated in wall boards with integrated covering sheets of materials other than a fabric of glass fibers. Likewise, structure concepts of the invention may be retained in interlayers and main insulating bodies of different compositions and shapes than those so far disclosed. Also, certain benefits of the arrangement of depressions or cavities of greater width placed below perforations in a covering sheet may be secured through the use of a single body member directly attached to the sheet, without an intervening spacer or interlayer.

A structure of this design may, for example, be created by blasting cavities at spaced points in the surface of a plain fibrous glass insulating board before joining the board to a perforated protective sheet. To minimize release of loose fibers from a panel so constructed, a light coating of a binding agent, such as a melamine, neoprene or phenolic resin, should be applied to the surface fibers of the cavities.

Where cheapness is the main concern or where the superior qualities of glass fibers are not demanded, the interlayer, main body or a combination of the two elements may be composed of shaped masses of various natural, or synthetic fibers, or of a foamed plastic such as polystyrene, polyurethane, cellulose acetate, phenol formaldehyde and polyvinyl chloride. For retention of acoustical properties the foams should be open or communicating cell form.

There are other compositions which may be substituted for the preferred melamine-phenol formaldehyde as a binder in the bodies of glass fibers. A few of these possible alternate materials are epoxy, urea, and polyester resins.

It must be expected in practising the invention with alternate materials or with different quantities than recommended in the preferred embodiment that there will be a weakening of performance in the resulting product in at least some respects. Accordingly, it should be understood that the modifications have been presented not as structures fully equivalent to the preferred form created principally of glass fibers, but to indicate the broad scope of the invention, especially as defined in the following claims.

We claim:

1. An acoustical wall board having an air pervious, main body member of high sound absorbing and thermal insulating capacity, a tough surfacing sheet with spaced perforations therein, and an intermediate member with cavities below the perforations in the surfacing sheet for receipt of sound waves passing through the perforations and said intermediate member being air pervious for transmission of the sound waves to the main, underlying body member, said body member being considerably thicker and much lower in density than the intermediate member, and the latter being considerably thicker and much lower in density than the surfacing sheet.

2. An acoustical wall board according to claim 1 in which the main body member is a bonded mass of glass fibers.

3. An acoustical wall board according to claim 1 in which the surfacing sheet is a fibrous glass fabric with a resin impregnant.

4. An acoustical wall board according to claim 1 in which the intermediate member is a molded mass of glass fibers, and varies in thickness.

5. An acoustical wall board according to claim 1 in which the intermediate member has other cavities in its under surface adjoining the main body member, said cavities being laterally offset in position from the position of the cavities in the opposite surface of the intermediate member which are below the perforations in the covering sheet.

6. An acoustical wall board according to claim 5 in which there are densified areas on the surfaces of the intermediate member by which the intermediate member is adhesively attached to the surfacing sheet and the main body member and the intermediate member has internal portions of less density than said areas.

7. An acoustical wall board according to claim 1 in which the main surfaces of the intermediate member are generally planar and parallel, and the cavities are confined between the main surfaces.

8. An acoustical wall board according to claim 1 in which the intermediate member is corrugated in section with valleys of the corrugations positioned below the perforations in the surfacing sheets.

9. An acoustical wall board comprising a covering fabric of glass fibers, there being perforations in the covering fabric, an intermediate, considerably thicker element firmly adhered to the covering fabric, said element being a molded, bonded mass of glass fibers and having depressions in its upper surface positioned immediately below the perforations in the covering sheet, and a main body attached to the intermediate element, said main body being a porous, bonded mass of glass fibers and having high sound absorbing and thermal insulating capacity, said main body being considerably thicker than the intermediate element.

10. An acoustical wall board according to claim 9 in which the unperforated portion of the covering fabric is sealed with an impregnation of resin.

11. An acoustical wall board according to claim 9 in which the intermediate element has an average density in the region of sixteen pounds per cubic foot and the density of the main body is between two and three pounds per cubic foot.

12. An acoustical wall board according to claim 9 in which the intermediate element has a fire resisting binder component between nine to twenty-six percent by weight of said element.

13. An acoustical wall board according to claim 9 in which the intermediate element has hard land areas by which it is adhered to the covering sheet and the main body.

14. An acoustical wall board according to claim 9 in which the intermediate element is approximately one quarter inch thick and the main body has a thickness between one and a half, and six inches.

15. An acoustical wall board comprising a tough surfacing sheet with perforations therethrough; a cushioning and strengthening intermediate element, considerably thicker than the surfacing sheet and having cavities and densified land areas upon both its upper and lower surfaces and internal porous portions; and a low density, sound absorbing and thermal insulating mass of bonded fibers below the intermediate element; said intermediate element being firmly adhered through the densified land areas to the surfacing sheet and to the mass of bonded fibers, and said cavities and said internal porous portions of the intermediate element together serving as paths for acoustical waves from the perforations in the surfacing sheet to the mass of bonded fibers.

16. An acoustical wall board according to claim 5 in which the surfacing sheet is a woven fabric of glass fibers and the intermediate element is a molded, bonded pad of glass fibers of greater density than said mass of bonded fibers.

17. An acoustical wall board comprising a tough surfacing sheet composed of a woven fabric of glass fibers and a considerably thicker, porous body member of bonded fibrous glass, said surfacing sheet having perforations therein and said body member having cavities positioned immediately below said perforations, and said body member having highly densified areas at the base of said cavities and internal portions of comparatively low density extending between the cavities.

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