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GLASS FIBER FISSURED ACOUSTICAL BOARD

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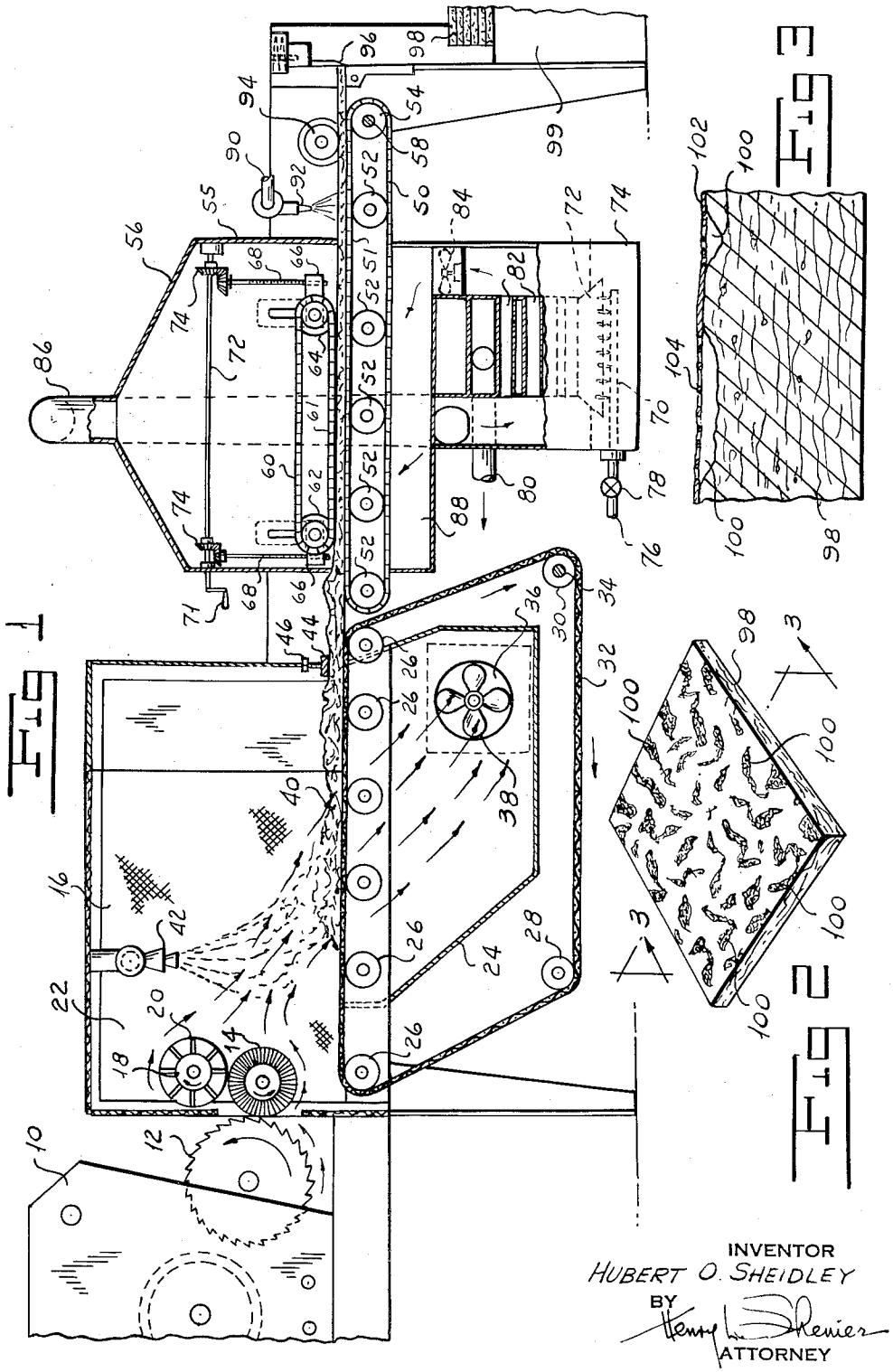


FIG. 1

FIG. 3

FIG. 2

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GLASS FIBER FISSURED ACOUSTICAL BOARD

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My invention relates to a glass fiber fissured acoustical board and more particularly to a sound-absorption material formed of glass fibers bonded together with a resin and compressed to a predetermined density in such a manner as to give a fissured effect. The fissured surface is then coated with a paint which will not impair the sound-absorption properties of the material.

The psychological disadvantage of noise in offices, banks, corridors, and the like, has long been known and architects have provided sound-absorption materials for rendering such spaces more quiet. When a sound strikes a surface the energy may be divided into three portions; namely, the incident energy, the reflected energy and the absorbed energy. A sound-absorption material is designed to convert a large proportion of the incident energy into heat and thus reduce the reflected energy to a small volume. Most manufactured acoustical materials depend largely on their porosity. For their acoustical absorption sound waves are propagated into and through the interstices of the material. Small fibers of the material are sent into vibration. The panel itself takes part in flexural vibration. The energy of sound is thus converted in part into heat.

The average value of the sound-absorption coefficients varies with frequency. Tests are usually conducted at frequencies of 125 cycles, 250 cycles, 500 cycles, 1,000 cycles, 2,000 cycles and 4,000 cycles. This corresponds roughly to the note C of the third, fourth, fifth, sixth, seventh and eighth octaves of a piano. In comparing materials which are used for noise reduction purposes it is convenient to employ a single figure called the noise reduction coefficient (abbreviated NRC). This is the average of the absorption coefficients at 250, 500, 1,000 and 2,000 cycles per second to the nearest multiple of 0.05. An efficient sound-absorption material is an acoustical tile formed of regularly perforated cellulose fiber. A tile of this material three-quarters of an inch in thickness would have a typical NRC of about 0.75. A fissured mineral tile thirteen-sixteenths of an inch in thickness would have an NRC of approximately the same order. Cellulose fiber tile has a density of between seven pounds and nine pounds per cubic foot. A fissured mineral tile has a density of about eighteen pounds per cubic foot. Both materials are inflexible and hence hard to install. They are also chippable.

Owing to their high density they require considerable structural support. If cemented on to the ceiling they require a considerable amount of and a strong adhesive. If they are mounted on furring the furring must be sufficiently strong. This is true too of a suspension system adapted to suspend the tile at a distance removed from the overhead. Such tiles are usually manufactured in squares of a foot on the side. This requires the handling of a large number of tiles which results in increased labor costs.

The cellulose fiber acoustical tile and the fissured mineral tile come in unattractive natural colors. If it is attempted to paint such tiles they lose their sound-absorption qualities. That is, their noise reduction coefficients are sharply reduced.

While the mineral acoustical tile is fireproof, the perforated cellulose fiber acoustical tile is not.

One object of my invention is to provide a springy, low density, fireproof acoustical tile which may be conveniently painted any desired color or group of colors.

Another object of my invention is to provide an acoustical tile which may be readily manufactured, shipped and handled in large panels so that it may be easily installed with a minimum of labor.

Another object of my invention is to provide an acoustical tile which is sufficiently springy to be readily snapped into and removed from an opening in a suspension system.

Another object of my invention is to provide an acoustical tile having a high noise reduction coefficient with respect to the weight of the material employed.

Another object of my invention is to provide an acoustical tile formed of glass fibers impregnated with a resin and compressed to a predetermined density and painted with a fireproof short paint which has a surface appearance resembling travertine.

A further object of my invention is to provide a method of manufacturing a glass fiber fissured acoustical board.

Other and further objects of my invention will appear from the following description.

In the accompanying drawings which form part of the instant specification and which are to be read in conjunction therewith and in which like reference numerals are used to indicate like parts in the various views:

FIGURE 1 is a diagrammatic view of an apparatus capable of carrying out the method of my invention and making my glass fiber fissured acoustical board.

FIGURE 2 is a perspective view showing a panel of my glass fiber fissured acoustical board.

FIGURE 3 is a fragmentary sectional view drawn on a large scale taken along the line 3—3 of FIGURE 2.

In general my invention contemplates the formation of a glass fiber mat or batt with its upper surface hummocked or billowed to present an irregularly undulating surface. This glass fiber mat or batt is impregnated with a heat-reactive resin. The thickness of the mat should be such that when it is compressed to give a product of the desired density and cured while in compressed condition the surface of the mat will present a number of fissures of varying depth and length and of random orientation. These fissures contribute to an attractive and decorative appearance aesthetically and serve a useful function of increasing the average noise reduction coefficient. After the mat is cured it is coated with a fireproof flexible coating which has a high degree of light reflectance, is durable and will not bridge or hide the fissures.

More particularly referring now to the drawings, an apparatus capable of forming the glass fiber mat or batt is shown in my Patent No. 2,619,151, dated November 25, 1952, granted for "Method and Apparatus for Manufacturing Fibrous Mats."

Glass fibers from any suitable source are cut into any appropriate lengths. A chopping machine is adapted to cut glass fibers into lengths averaging between three-quarters of an inch and five inches. If the averagle length of the fibers is less than three-quarters of an inch the fibers will not mat properly and will tend to sift out. If the average length of the fibers is longer than five inches the fibers will tend to orient themselves in a fore and aft direction, that is, along the direction of travel of the air stream, and destroy the random orientation of the desired fissures.

The fibers must be fine enough to be conveniently air-floated. A fiiber diameter of less than twenty microns should be employed. I have found that an optimum fiber diameter is in the vicinity of ten microns. If the fiber diameter is in excess of twenty microns difficulty will be encountered in air-floating the fibers and having them billow and hummock properly.

The chopped fibers travel through a garnett machine, a portion of which is diagrammatically indicated by the

reference numeral 10, and are picked up by a doffer roll 12. A brush roll 14 is adapted to remove the fibers from the doffer roll and project them into an enclosure 16. It will be noted that the rotary brush 14 revolves in the same direction as the doffer roll 12. A wind roll 18 is provided with veins 20 and is driven at a speed higher than that at which the rotary brush 14 revolves. The arrows in FIGURE 1 show the path of air currents created by the rotary brush and the wind roll 18. The enclosure 16 is defined by screen panels 22. A suction hood 24 is positioned below the enclosure 16. Below the suction hood I mount a plurality of rolls 26, a roll 28 and a driving roll 30.

Disposed around the supporting rolls 26, the lower roll 28 and the driving roll 30 I position an articulated foraminous conveyor 32. A shaft 34 is driven by any suitable driving means (not shown) to move the conveyor in the direction of the arrows. Within the suction hood 24 I provide an exit opening 36 in which is positioned an exhaust fan 38. The fan draws the air stream and the floated glass fibers over the surface of the travelling conveyor and deposits them thereon. Owing to the turbulence of the merging air streams from the rotary brush 14 and the wind roll 18 the airborne glass fibers will mill around in random directions. The speed of the exhaust fan 38 is adjusted to ensure that the surface of the mat or batt 40 being deposited upon the conveyor 32 is irregularly billowed or hummocked.

If the exhaust fan speed is too high there is a tendency for the surface of the mat to become smooth. If the speed of the exhaust fan is too low the humocks or billows become too great. The process is such that the glass fibers are deposited upon the moving conveyor 32 to provide an irregularly undulating or billowing surface.

As the glass fibers fall to the surface of the conveyor 32 they are subjected to a plurality of jets or sprays 42 adapted to disperse either a dry or a liquid bonding material throughout the turbulent airborne glass fibers. The bonding material may be any heat-reactive resin such as a phenol formaldehyde condensation product, a melamine formaldehyde condensation product, a melamine-urea formaldehyde condensation product, or the like. The function of the resin is that when it is set the glass fibers will be randomly bonded to each other. The amount of resin may vary from five percent by weight of the finished product to thirty percent by weight of the finished product. The optimum quantity of resin I have found to be in the vicinity of twenty percent by weight of the finished product.

The thickness of the mat or batt 40 being deposited on the conveyor 32 is governed by the speed at which the driving roll 30 rotates. If the conveyor moves slowly the mat will be thicker than if it moves more rapidly. I control the thickness of the mat so that when it is compressed to approximately three-quarters of an inch in thickness it will give a product having a density between one and one-half pounds per cubic foot and eight pounds per cubic foot. If the density is much below one and one-half pounds per cubic foot the board cannot be manufactured in large panels since it will tend to sag or flex too much. Besides this, the sound-absorption properties will be materially reduced. If the density of the mat is much over eight pounds per cubic foot it tends to become boardy and relatively inflexible or nonspringy. One of the salient advantages of my acoustical board is that it is springy. It can be inserted into a flanged opening by flexing the board and letting it spring into the opening. It may be removed from the opening in a similar manner. The destruction of this flexibility defeats one of the purposes and main objects of my invention. Besides this, a density of over eight pounds per cubic foot will require a supporting structure which is heavy and expensive. It is one of the advantages of my acoustical material that it can be supported readily from a very light and inexpensive supporting structure. An optimum density is three pounds per cubic foot.

A wiper bar 44 which may be adjusted vertically by means of an adjusting nut 46 is adapted to be positioned roughly to dimension the thickness of the mat. This wiper bar does not destroy the undulating or billowing surface of the mat which in the uncured state will move downwardly readily and then resume its undulating form.

The green impregnated mat is then passed to a second foraminous conveyor 50 which passes around a plurality of supporting rolls 52 and a driving roll 54. The articulated conveyor 50 is adapted to receive the green mat and carry it through a curing oven 56. The conveyor 50 is driven at the same linear velocity as the conveyor 32. This is ensured by rotating the drive shaft 53 of the driving roll 54 at the same speed as the drive means for the shaft 34 and having the roll 54 of the same diameter as the roll 30.

Mounted within the oven 56 I provide a compression belt 60. This compression belt may be an endless articulated foraminous member. It is carried by a pair of rolls 62 and 64 mounted on brackets 66. The brackets are adapted to be moved upwardly and downwardly by screws 68. The screws may be rotated in unison by crank 71 acting through shaft 72 and bevel gears 74. The arrangement is such that the crank 71 will move the compression belt 60 upwardly and downwardly when it is rotated. When the lower flight 61 of the belt which engages the upper surface of the resin-impregnated batt within the oven moves downwardly it compresses the batt between itself and the upper flight 51 of the conveyor belt 50. The compression belt 60 may be covered with a comparatively fine-mesh wire screen (not shown) to ensure that the lines of articulation of the compression member will not leave imprints upon the mat, the resin of which is being cured in the oven 56.

A burner 70 in the combustion chamber 72 of a furnace 74 is supplied with a fuel through pipe 76 under the control of valve 78. The products of combustion pass upwardly through the combustion chamber 72 and are removed through flue pipe 80. A plurality of heat exchange tubes 82 pass through the combustion chamber. An air-circulating fan 84 takes suction from recirculation duct 86 at the top of the oven 56 and pulls air downwardly for passage through the heat exchange tubes 82. The air thus becomes heated and is discharged by the fan 84 into the hot air distribution chamber 88 below the oven. The hot air then passes upwardly through the resin-impregnated batt positioned between the upper flight 51 of the conveyor 52 and the lower flight 61 of the pressure belt 60. It is to be understood, of course, that the crank 71 has been adjusted to compress the green resin-impregnated batt to give the desired pattern.

This compression is quite important. Too little compression leaves the fissures insufficiently defined and an unsatisfactory product both from appearance and sound-absorption standpoint is obtained. It will be recalled that the speed of the conveyor 32 in the forming section of the machine was so adjusted as to give a mat of the desired thickness so that when compressed to form an acoustical board it would have the desired density. At this density the fissures are properly defined and the product has a sufficiently high noise reduction coefficient. If too little pressure is exerted during the curing step not only will the fissures be insufficiently defined but the product will have too low a density. A low density product will not be springy enough to be self-supporting in large sizes and will have a reduced noise reduction coefficient. If, on the other hand, the crank 71 is operated to compress the resin-impregnated mat being cured too much the fissures will be virtually erased and the noise reduction coefficient will be materially reduced. Besides this, the attractive appearance of random fissure will be lost and the product will be so boardy as to lose its springiness.

The product, furthermore, will be too thin, that is, much less than the desired thickness of three-quarters of an inch.

The temperature of the recirculating heated air which is used to cure the resin depends, of course, on the particular resin being used as a binder. With phenol formaldehyde resins a temperature between 400° F. and 475° F. will produce good results. With melamine formaldehyde resins a somewhat lower temperature of between 275° F. and 330° F. may be employed. It will be understood, of course, that the binder resins and the temperatures are given by way of illustration and not by way of limitation.

The cured board moving past the oven wall **55** will be brownish in color (owing to the cured resin color), and the fissured surface will not stand out with the desired clarity. This board would not be considered outstandingly attractive for installation in offices, banks, places of business, homes and the like. Besides this, the brownish color does not reflect sufficient light since acoustical tile is usually installed on the ceilings of the spaces fitted with it and it is important, therefore, that the tile have a high degree of light reflectance. After the tile has been in place for some years it becomes necessary to clean it. This is done by washing and an unsurfaced acoustical tile leaving the oven **55** cannot be readily washed.

In order to produce a commercial product, therefore, it is necessary to coat the product leaving the oven wall **55** to produce the finished acoustical tile. This coating must, of course, provide a high degree of light reflectance. It must qualify for fireproof rating in order not to destroy the fireproof qualities of the glass fiber acoustical tile. The coating must have sufficient flexibility and strength to resist cracking and chipping in the packaging, transportation, installation and other handling of the tile as well as while the tile is in service. The coating must also be washable and have sufficient toughness to resist the washing operation. More important still, the paint must not form a sufficiently tenuous film to bridge the fissures or the fine matting or webbing which will be found to cover the fissures. Then too, the coating must not cause warping of the finished board and the coating should too retain its properties over an appreciable period of life since the board cannot be painted with ordinary paint owing to the fact that to do so would minimize the noise reduction coefficient of the acoustical board. The coating must be readily applicable. Preferably it should have such viscosity that it may be sprayed on to the surface of the cured resin-impregnated board and yet not penetrate or strike in the surface too deeply. At the same time, the viscosity cannot be so high that it will bridge the fissures.

I have found that a "short" aqueous vehicle paint may be employed. By a "short" paint I mean one in which a mineral pigment is employed. The viscosity may be adjusted by use of colloidal clay properly thickened. By way of illustration and not by way of limitation, the following is a paint which may be employed in carrying out the process of my invention and produce the acoustical board of my invention.

Ingredient:	Percentage by weight
Water	25.15
Dispersing agent	1.00
Antifroth agent	.01
Thickener	.40
Colloidal silica	5.50
Flame retardant	5.03
Binder resin	8.05
Inorganic pigment	40.25
Colloidal clay	8.05
Titanium dioxide whitener	6.56

Any appropriate dispersing agent may be employed as, for example, desulfonated sodium lignosulfonate. A suitable antifoaming agent, for example, would be propylene glycol ricinoleate. A thickener adapted to raise the shear rate which may be used conveniently is methyl cellulose. An appropriate flame retardant is ammonium sulfonate. An appropriate binder resin would be an acrylic emulsion, or polyvinyl acetate. Calcium carbonate, preferably water-ground, forms an excellent inorganic pigment. This may be whitened by titanium dioxide. It is understood, of course, that any other coloring inorganic pigment may be employed if other shades are desired. The colloidal clay may be aluminum silicate clay.

The paint from any suitable container is passed through pipe **90** through a plurality of spray nozzles **92** and sprayed upon the cured acoustical tile as will be well understood by those skilled in the art. The viscosity of the paint is properly adjusted so that it will cover the tile without bridging the fissures and without striking in past the surface of the tile too deeply. This short paint will not impair the noise reduction coefficient of the acoustical tile and will have the desirable properties outlined above.

A pair of rotary knives **94** trim the moving painted acoustical board to the desired width and a cutter blade **96** is adapted to be reciprocated (by any appropriate means, not shown) to cut the trimmed board in desired lengths. The dimension of the apparatus is such that boards having dimensions of 2 ft. x 2 ft., 2 ft. x 4 ft., 3 ft. x 4 ft. and 4 ft. x 4 ft. may readily be obtained. A board of a dimension 2 ft. x 4 ft. forms a panel of easily handled size. I have made tile a foot square and I have made large panels running as long as 20 ft. in length. The finished panels **98** are collected upon a platform **99**.

A finished panel **98** is shown in FIGURE 2. Its surface will have a plurality of random fissures **100** which are readily seen in FIGURE 3. The fissures **100** are reentrant and increase the noise reduction coefficient value of the acoustical tile. A random oriented layer of fibers is stretched over the fissures. The upper surface of the acoustical tile **98** is coated with a coating **102** described above as a result of the drying of the paint spray. The fibers **104** bridging the fissures **100** will be coated with the paint but there will be no bridging of the fibers. One may see through and sound may pass through the interstices between the fibers.

The tile presents an attractive appearance and is quite light. A fissured mineral tile having a density on the order of eighteen pounds per cubic foot would weigh six times as much as my material having a density of about three pounds per cubic foot. A tile, for example, 1 ft. x 1 ft. in area and three-quarters of an inch in thickness will weigh about four ounces. A tile of the same dimensions made of fissured mineral material will weigh one and one-half pounds. It will readily be seen that the structural assembly to hold the tile of the prior art must be much more rugged and expensive than the structure which holds my novel glass fiber fissured acoustical board.

Comparatively light T-bar suspensions may be arranged on the ceiling and acoustical board of my invention in panels of 2 x 4 ft. may be readily, conveniently and expeditiously installed by flexing the material and having it spring back into place. This has an outstanding advantage since the suspension system may be so arranged as to space the surface of my acoustical board from the ceiling. The leaving of a dead area space behind the acoustical board increases the noise reduction coefficient. Access to electrical outlets, air-conditioning conduits, and the like, may readily be had by the simple expedient of removing a panel. Besides this, the panels may be completely removed, washed or otherwise cleaned without difficulty and again reinserted without damage.

Owing to the fact that comparatively large panels may be installed a large area may be quickly covered with my acoustical board. This represents a distinct saving.

My glass fiber fissured acoustical board has a surface of high light reflection and may be readily washed or cleaned. Other acoustical tile cannot be painted without destroying the noise reduction coefficient.

As pointed out above the noise reduction coefficient of a much heavier material is in the order of 0.75. Tests on my material in Mounting #7 show a noise reduction coefficient of .85. When one considers that the density of my material is less by a factor of six compared to mineral tile and less by a factor of three compared to perforated cellulose fiber tile it will be appreciated that my acoustical tile is remarkably efficient in its sound absorption qualities.

It will be seen that I have accomplished the objects of my invention. I have provided a springy, low density, fireproof acoustical tile which may be conveniently painted any desired color. My acoustical board may be readily manufactured, shipped and handled in large panels so that it may be easily installed with a minimum of labor. It is sufficiently springy to be readily snapped into and removed from an opening in a T-bar or other similar suspension systems. My acoustical tile has a high noise reduction coefficient with respect to the weight of the material employed. The surface of my acoustical tile presents a fissured appearance resembling travertine which is quite attractive and suitable for installation in offices, corridors, auditoriums and the like. I have provided a novel method of manufacturing glass fiber fissured acoustical board.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of my claims. It is further obvious that various changes may be made in details within the scope of my claims without departing from the spirit of my invention. It is therefore to be understood that my invention is not to be limited to the specific details shown and described.

Having thus described my invention, what I claim is:

1. A sound-absorbing acoustical board formed of glass fibers bonded by a resin, said board having a surface formed with a multiplicity of fissures of random orientation and of various lengths and depths, said surface being coated with a light-reflecting coating deposited to leave the fissures unbridged by said coating, said board being deformable and springy.

2. A sound-absorbing acoustical board formed of glass fibers having an average length between three-quarters of an inch and five inches, said fibers being bonded by a heat-reactive resin, said board having a surface formed with a multiplicity of fissures of random orientation and of various lengths and depths, said surface being coated with a light-reflecting paint being deposited to leave the fissures unbridged by said paint, said board being deformable and springy.

3. A sound-absorbing acoustical board formed of glass fibers having an average length between three-quarters of an inch and five inches and an average diameter of less than twenty microns, said fibers being bonded by a heat-reactive resin, said board having a surface formed with a multiplicity of fissures of random orientation and of various lengths and depths, said surface being coated with a light-reflecting paint deposited to leave the fissures unbridged by said paint, said board being deformable and springy.

4. A sound-absorbing acoustical board formed of glass fibers having an average length between three-quarters of an inch and five inches and an average fiber diameter of less than twenty microns, said fibers being bonded by a heat-reactive resin in an amount between five percent and thirty percent of the board by weight, said board having a surface formed with a multiplicity of fissures of random orientation and of various lengths and depths, said surface being coated with a light-reflecting paint deposited to leave the fissures unbridged by said paint, said board being deformable and springy.

5. A sound-absorbing acoustical board formed of glass fibers having an average length between three-quarters of an inch and five inches and an average fiber diameter of less than twenty microns, said fibers being bonded by a heat-reactive resin in an amount between five percent and thirty percent of the board by weight, said board having a density of between one and one-half pounds per cubic foot and eight pounds per cubic foot, said board having a surface formed with a multiplicity of fissures of random orientation and of varying lengths and depths, said surface being coated with a light-reflecting paint deposited to leave the fissures unbridged by said paint, said board being deformable and springy.

6. A sound-absorbing acoustical board formed of glass fibers having an average length between three-quarters of an inch and five inches and an average fiber diameter of less than twenty microns, said fibers being bonded by a heat-reactive resin in an amount between five percent and thirty percent of the board by weight, said board having a density of between one and one-half pounds per cubic foot and eight pounds per cubic foot, said board having a surface formed with a multiplicity of fissures of random orientation and of varying lengths and depths, said surface being coated with a light-reflecting short, aqueous vehicle fireproof paint deposited to leave the fissures unbridged by said paint, said board being deformable and springy.

7. A method of making fissured acoustical board including the steps of air-floating short lengths of glass fibers onto a moving foraminous conveyor together with a binder, controlling the air-floating step to form a hummocked mat of glass fibers, compressing the hummocked mat to form the desired fissured surface, maintaining the mat in a compressed state while setting the binder and then coating the fissured surface with a desired light-reflecting paint and controlling the coating step to leave the fissures unbridged by the paint.

8. A sound-absorbing acoustical board formed of glass fibers bonded by a resin, said board having a surface formed with a multiplicity of fissures of random orientation and of various lengths and depths, said fissures being bridged by a random orientated layer of fibers, said surface being coated with a light-reflecting coating to leave the fissures unbridged by said coating, said board being deformable and springy.

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