Sept. 10, 1963 R. F. COTTS 3,103,444

FIRE RETARDANT ACOUSTICAL TILE

Filed Dec. 30, 1960

Fig. 1.

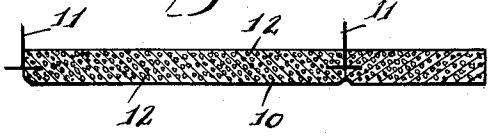
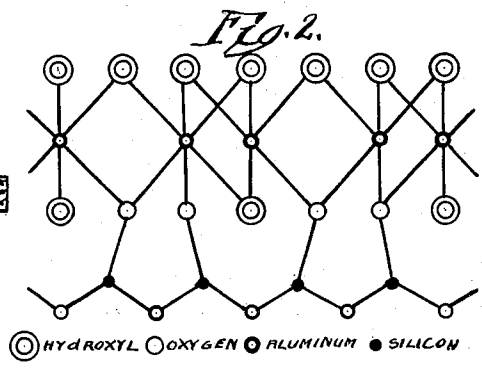


Fig. 2.



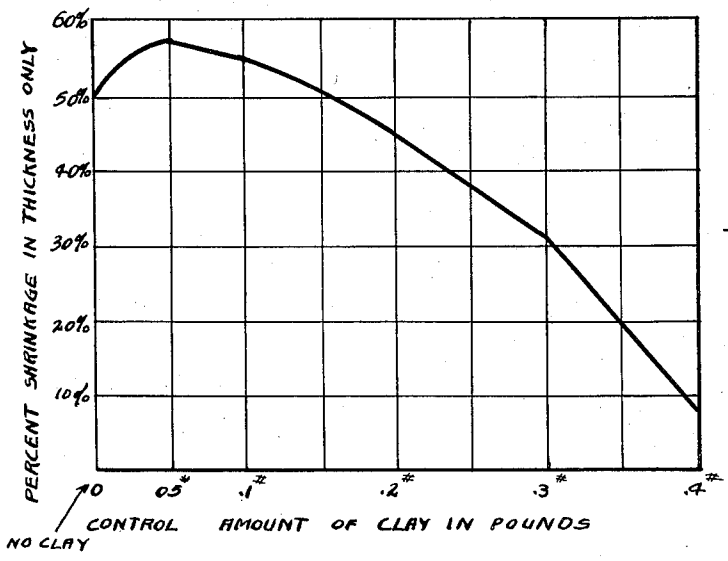


Fig. 3.

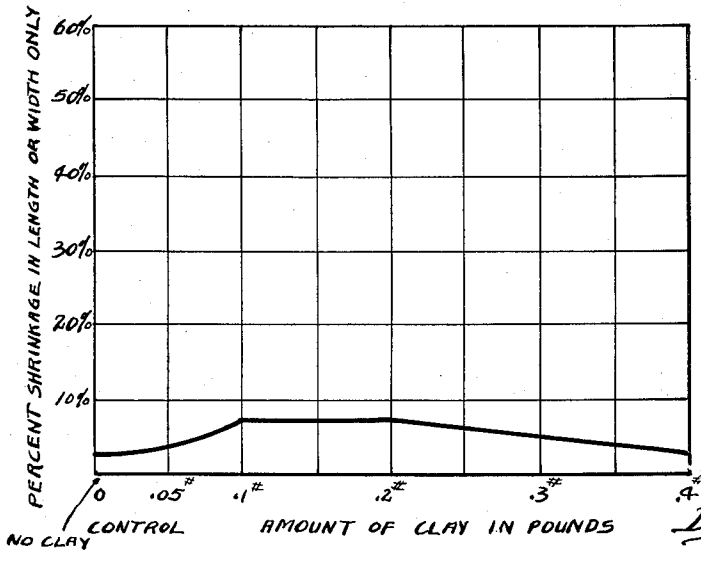


Fig. 4.

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FIRE RETARDANT ACOUSTICAL TILE

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This invention concerns an acoustical ceiling tile and more particularly, a fire retardant acoustical ceiling tile.

In contemporary residential, industrial, commercial, and particularly institutional construction, it is necessary to obviate the hazards to life and property caused by the ravages of fire. To this end, in those installations wherein acoustical or sound absorbing ceiling tile is installed, it is necessary to insure that the ceiling tile be fire resistant so as to reduce the risk of fire damage.

In the course of installing acoustical tile, a suspension system of some type must be employed. In many installations, the usual type of suspension system involves the use of a number of individual ceiling tiles kerfed on four sides and the insertion of conventional T-splines in the kerfs. The T-splines are supported from a surface above the ceiling. It is apparent that if the individual tiles shrink excessively because of the heat generated in a fire, they may fall out of the suspension system and permit flame or hot gases to penetrate to the area above the ceiling. In addition, the internal bonds which hold the individual ascoustical tiles together are weakened by fire and the tiles become crumbly and fall out of the suspension system.

A particular type of ascoustical tile, and the type to which this invention pertains, is made of granular mineral fibers with a binder. Granular mineral fibers may be defined as mineral wool or glass wool in the form of granules or separate tufts which are in contradistinction to felted or interlaced mineral wool. The conventional mineral fiber tile made of granular mineral wool with a starch binder shrinks substantially in thickness when subjected to a high temperature condition, such as that occurring during a fire. The tile does not shrink appreciably in length or width. It is thought that the action of the granular mineral fiber tile in shrinking greatly in thickness and not appreciably in length or width is due to the minimum level of interconnecting fibers between granules and the large ratio of granule diameter to the thickness. When heated sufficiently, the fibers soften and tend to shrink and coalesce, and the fiber granules are readily distorted from spheres to oblate spheroids by the gravitational forces in the vertical direction. In becoming oblate spheroids, the granules tend to bulge outwardly in the horizontal plane and thus the shrinkage in length and width is negligible. However, in the vertical plane the shrinkage of the tile is appreciable.

In order to strengthen the acoustical tile against such shrinkage, the addition of certain types of clay or clay-like material to the binder formulation in the manner of the present invention has been found to be effective. The clay particles have a minimal effect in strengthening the granules and binder until the tile is heated or fired by the rise in temperature due to a fire. Under these latter conditions, the clay particles inhibit shrinkage by raising the fusing point of the mineral fibers. The clay bonds the glass mineral fiber pellets together and also prevents shrinkage of the individual granules.

It is, therefore, an object of the present invention to provide a granular mineral fiber acoustical tile which has greater bonded strength when subjected to fire than conventional acoustical tile.

It is another object of the present invention to provide a granular mineral fiber tile which remains in place in a suspension system under conditions of extreme heat.

It is yet another object of the present invention to set forth a method for making an improved granular mineral fiber acoustical tile.

Other and further objects and advantages of the invention will be apparent on reading the following specification in conjunction with the accompanying drawings, in which:

FIGURE 1 is a cross-section of a tile made in accordance with the invention;

FIGURE 2 is a molecular diagram of an ingredient suitable for the invention, and

FIGURES 3 and 4 are graphical representations useful in explaining the invention.

Referring now to FIGURE 1, there is shown an acoustical tile **10** suspended by means of T-splines **11**. Granules **12** of mineral wool are shown interspersed within tile **10**. The granules **12** are held in place by a binder, such as starch, in which particles of clay are suspended. Additionally, the clay particles adhere to the individual fibers of the mineral wool.

In considering the types of clay which may be used in the binder, non-swelling clays of the kaolin or non-swelling type are especially preferred. These clays are widely available, relatively low in cost, and easily procured in commercial quantities. Their non-swelling characteristics prevent problems of undue thickening of the binder which occurs with the swelling type of clay.

Montmorillonites, including bentonite and particularly sodium bentonite, are of the swelling type of clay and they hold large quantities of bound water. Thus, the drying problems in the manufacture of the fire resistant acoustical tile of the invention are increased. In addition, the addition of the swelling type of clay does not produce the high temperature bonding characteristics of the non-swelling type, and has proved to be definitely inferior thereto in the reduction of shrinkage of the tile.

The kaolin clays are multi-layer in molecular structure. In the case of Kaolex D–6, the thickness of each layer is about 7.15 angstrom units.

All kaolin minerals are composed of identical layers of composition $Al_2O_3.2SiO_2.2H_2O$ and differ only in the way the layers are arranged with respect to each other. The chemical representation of a kaolin layer is

$$(Si_2O_5)Al_2(OH)_4$$

implying sheets of $n(Si_2O_5)^{2-}$ linked to sheets of $n(Al_2(OH)_4)^{2+}$ units. This unit is of indefinite length in two directions along the a and b crystallographic axes.

Kaolin contains many layers stacked above each other to give extension along the c-axis. Thus, with reference to FIGURE 2, the single layer along the c-axis may be represented as therein shown.

In practicing the invention, the clay is pulverized so that the plates are several hundred layers in thickness and are preferably about 300 to 800 times the thickness of the single layer. The area of the plate, as pulverized, is such that its length and width are about 10 times the thickness or about 21,000 to 57,000 angstrom units, or about 2.14 to 5.72 microns.

Other minerals which contain magnesium ions in single layer silicate structure are also useful in supplying the fire retardant feature of the present invention. Such a mineral is chrysotile which is a common constituent of asbestos minerals. However, again it is important to note that the chrysotile plates used in the present invention are not of the long fibrous filamentary type of asbestos, but must be pulverized to the fineness of the kaolin. Thus, the chrysotile layers must be about 21,000 to 60,000 angstrom units in length and width and about 7.33 angstrom units thick.

Talc or similar type of kaolin clay, a major component

of soapstone, if finely ground, may also be used. Ball clay may also be used.

The diameter of the mineral fiber filaments is in the order of 2 to 12 microns, so that the length of the clay plate in any direction is less than the diameter of the filament. The purpose of this preferred relationship between the diameter of the mineral fiber filament and the length of the clay plate in any direction proves to be the most efficient since clay layers of larger area result in the use of excess clay. The effect of excess of the length of the clay plate is apparently lost because the excess area overhangs the filament and the overhung portion does not aid or enhance the strengthening of the fiber filament attributable to the clap plate.

GRANULAR MINERAL WOOL

The mineral fiber acoustical tile of the present invention is made by making mineral fiber granules. These may be made by any conventional process known to those skilled in the art.

For a clear understanding of the general procedure of the formation of mineral or glass wool by blowing with the collection of blown wool as a loose blanket, and for an illustration of a procedure for tearing tufts or agglomerates therefrom, as has above been referred to, reference is made to the patent to Coss, 2,375,284. This patent schematically shows a cupola or melting furnace, the jet or blast for blowing the molten material into fiber, and a wool room in which the fiber settles as a blanket on a conveyor running across the bottom of the wool room. This patent also shows what is termed a stationary rack and a rotatable paddle rack which might be termed complementing combs which serve, as the paddle rack or rotatable comb revolves, to tear small granules or tufts of fibers from the blanket of fibers and deposit them on a conveyor.

BINDER

A typical binder formulation is:

	Pounds	Percentage Dry Basis
Starch	31.0	35.8
Boric Acid	6.0	6.9
Paraffin wax	4.5	5.2
Calgon	0.1	
Kaolex D-6 clay	45.0	52.0
Total	86.6	99.9

If desired, the binder may be formulated with the addition thereto of a filler in an amount of about 8% by weight of dry solids. The filler preferably consists of pulverized dust from reject acoustical tile made according to the method set forth herein. The addition of the filler tends to thicken the binder somewhat, and as a consequence the amount of tufted mineral wool fibers may be slightly reduced.

METHOD OF MAKING TILE

The procedure for mixing and cooking the binder per batch is as follows:

150 gallons of water at a temperature of 145–150° F. are placed in a large tank. An agitator, which may be any commercial electrically operated stirrer, is adjusted to cause agitation of the water. The Calgon, boric acid and starch are added slowly while agitation is continued for at least five minutes after all materials have been added. Following this step, 400 gallons of water at 205° are added to a cooking vessel. While the water in the cooking vessel is agitated vigorously, the wax is added thereto. After the wax has been dissolved, the mixture of water, Calgon, boric acid, clay and starch is added to the cooking vessel and the remainder of the hot water at 210° F. The agitator is continued at high speed through a 10 minute cooking period, whereupon the agitator is then switched to low speed. The cooking vessel is heated until the temperature of the mixture is 185° and until the viscosity of the gel mixture is 1000/2000 centipoises as measured by a Brookfield viscosimeter at 170° F. After the cooking step, the gel is stored in the cooker tank wherein the temperature of the gel may be allowed to decrease to 170° F.

The method of forming the acoustical tile comprises mixing together approximately 200 pounds of mineral wool fiber in granulated form and about 116 gallons of the binder as prepared in the previously described manner. The binder is pumped into a tank until 116 gallons are measured therein and the mineral wool fiber is delivered to the tank by a conveyor belt. The binder and mineral wool fibers are then thoroughly mixed by an suitable mixing device so that a complete inter-mixture of the binder and mineral wool is achieved.

Following this mixing operation, the totally mixed mineral wool fiber and binder is then fed onto paper-lined platens and leveled to the desired thickness by a reciprocating screed bar. The purpose of the screed bar is to produce fissures in the surface of the tile so as to aid in increasing the sound absorption efficiency thereof.

Following the molding of the tile, the molded slabs are air-dried in the open air before being placed in the drying oven. Approximately one hour air-drying temperature has been found to be desirable. Following the air-drying, the molded slabs are placed in ovens for a drying cycle of from 12 to 13 hours for ¾" thick slabs. The drying oven is divided into four zones in which the temperatures of the respective zones for ¾" thick tile are as follows:

	Zone 1	Zone 2	Zone 3	Zone 4
°F	290	310	325	315

During the drying cycles approximately the same amount of time is spent in each of the four zones. After the slabs have been dried in the oven, they are then planed to thickness, cut to size, edge fabricated, painted, inspected, and packed.

For a further description of the materials used in the manufacture of the acoustical tile, the following table of definitions is presented:

Calgon: Sodium hexametaphosphate, a commercial grade.
Boric acid: Granular, technical grade.
Paraffin wax: Fully refined paraffin—133–135° F. M.P.
Starch: Commerical grade.

As has been indicated herein before, different types of non-swelling clay may be used in the manufacture of the acoustical tile. To illustrate the shrinkage of acoustical tiles made with similar amounts of different clay minerals, reference may be had to the following table:

Table I

	Percent Shrinkage in Length	Percent Shrinkage in Thickness
Control Board (no clay)	2.1	50.0
Tile with 0.5 pound of kaolin (Kaolex D-6)	2.4	3.2
Tile with 0.5 pound pulverized chrysotile	2.2	0.8
Tile with 0.5 pound magnesium silicate (talc)	1.9	2.5

From Table I it is seen that the addition of the kaolin type clay, which in the examples given represents about 25% by weight of the granulated mineral wool, results in a remarkable reduction in the amount of shrinkage in thickness. The maximum amount of shrinkage is 3.2% as compared to the 50% shrinkage of the control board which contained no clay. In Table I the amount of clay is given for an acoustical tile ⅝" thick and 12" x

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12" in area. Here the amount of clay is approximately 25% by weight of the amount of mineral wool, and is consistent with the formulation given thereinbefore.

To illustrate the improvement in the percent shrinkage in thickness in terms of the amount of clay added, reference may be had to the graph of FIGURE 3, wherein the percent shrinkage in thickness is plotted as the ordinate axis of the amount of clay as abscissa.

It may be seen that as the amount of clay is increased from 0 pounds to 0.05 pound, the percent shrinkage increases. As the amount of clay is increased from 0.05 pound to 0.4 pound, the percent shrinkage in thickness unexpectedly decreases rapidly to about 8%. The curve has not been extended because this amount of clay is the amount preferred for actual production.

However, reference to Table I shows that an increase of clay to 0.5 pound again reduces the percent shrinkage to 3.2%. This latter figure is consistent with the graph of FIGURE 3.

Referring now to FIGURE 4, there is therein shown the relationship between the amount of kaolin clay added and the percentage of shrinkage in length of the acoustical tile. It may be seen that as clay is added up to about 0.1 pound for an acoustical tile 5/8" thick and 12" x 12" in area, the percentage of shrinkage increases. Then, for the addition of kaolin clay from 0.1 pound to 0.2 pound, the percentage of shrinkage remains high. For the addition of clay from about 0.2 pound to 0.4 pound, the shrinkage in length unexpectedly decreases. Consequently, it is seen that in considering the shrinkage in either thickness or length, the amount of clay to be added should be about 25% by weight of the amount of mineral wool and not less than about 12% by weight.

In summary, there has been set forth a new and novel acoustical tile made of granulated mineral fiber which, by the addition of non-swelling clay particles to its binder, has a remarkable resistance to shrinkage in thickness. Such tile affords added protection from fire damage.

While there has been set forth and described embodiments of the novel fire resistant acoustical tile of the invention, other modifications and changes may occur to those skilled in the art, and it is intended to include such modifications and changes in the scope of the appended claims.

I claim:

1. An acoustical tile consisting essentially of tufts of mineral fibers, and a binder in which said tufts of mineral fibers are uniformly dispersed, said binder consisting essentially of starch, wax, boric acid and a finely ground non-swelling silicate mineral selected from the group consisting of kaolinite, talc, ball clay and chrysotile plates, said silicate mineral being in an amount not less than 12% by weight of the mineral fibers.

2. An acoustical tile consisting essentially of tufts of mineral fibers, said fibers having a diameter of between 2 and 12 microns and a binder in which said tufts of mineral fibers are uniformly dispersed, said binder consisting essentially of starch, wax, boric acid and finely ground particles of a non-swelling silicate mineral selected from the group consisting of kaolinite, chrysotile plates, ball clay and talc, said particles being in an amount not less than 12% by weight of the mineral fibers.

3. An acoustical tile consisting essentially of tufts of mineral fibers, said fibers having a diameter of between 2 and 12 microns and a binder in which said tufts of mineral fibers are uniformly dispersed, said binder consisting essentially of starch, wax, boric acid and finely ground particles of a non-swelling silicate mineral selected from the group consisting of kaolinite, chrysotile plates, ball clay and talc, wherein said particles of silicate mineral are less in any dimension than said diameter of said mineral fibers and in an amount not less than 12% by weight of the mineral fibers.

4. An acoustical tile consisting essentially of tufts of mineral fibers, said fibers, having a diameter of 2 to 12 microns and a binder in which said tufts of mineral fibers are uniformly dispersed, said binder consisting essentially of starch, wax, boric acid, and finely ground discrete particles of non-swelling silicate mineral, said particles being in the form of between 300 and 800 layers of sheets of Si_2O_5 linked to $(Al_2(OH)_4)$ units, said particles having at least one dimension normaal to said layers of a length about 10 times the total thickness of said layers, said particles being in an amount not less than 12% by weight of the mineral fibers.

5. An acoustical tile consisting essentially of tufts of mineral fibers and a binder in which said tufts of mineral fibers are uniformly dispersed, said binder consisting essentially of starch, wax, boric acid, and finely ground discrete particles of non-swelling silicate mineral selected from the group consisting of kaolinite, chrysotile plates, ball clay and talc, in an amount substantially one-fourth by weight of said mineral fiber in said tile.

6. A binder composition for an acoustical tile consisting essentially of 36 percent of starch, 7 percent of boric acid, 5 percent of paraffin wax, a minute amount of sodium hexametaphosphate, and 52 percent of finely ground particles of non-swelling silicate mineral from the group consisting of kaolinite, talc, ball clay and chrysotile plates, wherein said particles of silicate mineral are less in any dimension than 7 microns.

7. A binder composition for an acoustical tile consisting essentially of 36 percent of starch, 7 percent of boric acid, 5 percent of paraffin wax, and 52 percent of finely ground particles of non-swelling silicate mineral selected from the group consisting of kaolinite, chrysolite plates, ball clay and talc, wherein said particles of silicate mineral are less in any dimension than 7 microns.

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