

Nov. 30, 1965

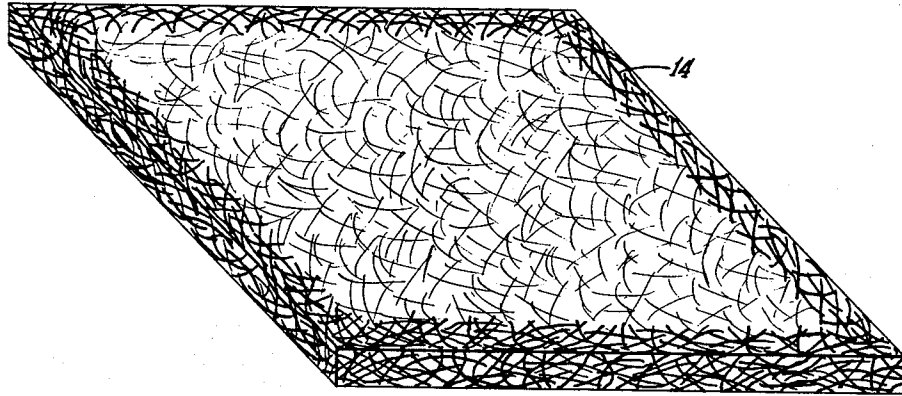
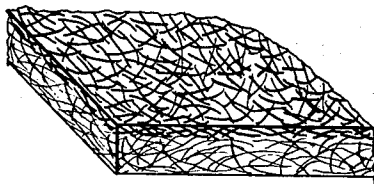
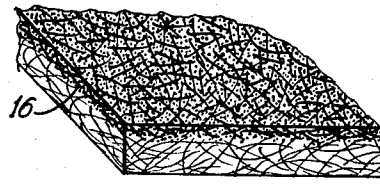
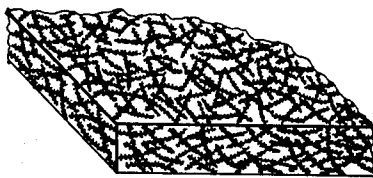
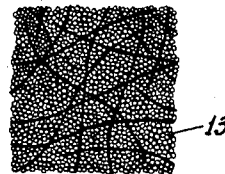
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3,220,915

STRUCTURES COMPRISING VITRIFIED AND DEVITRIFIED MINERAL FIBERS

Filed Aug. 5, 1960

2 Sheets-Sheet 1

Fig. 1Fig. 2Fig. 3Fig. 4Fig. 5Fig. 6Fig. 7

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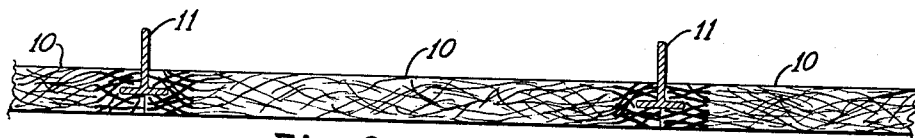


Fig. 8

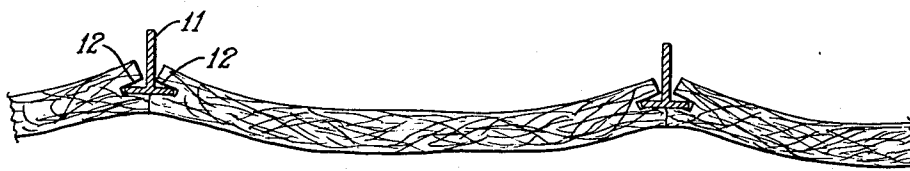


Fig. 9

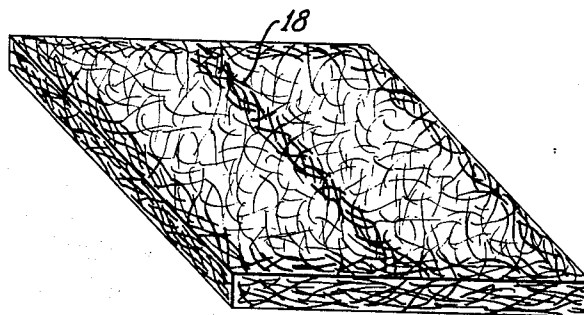


Fig. 10

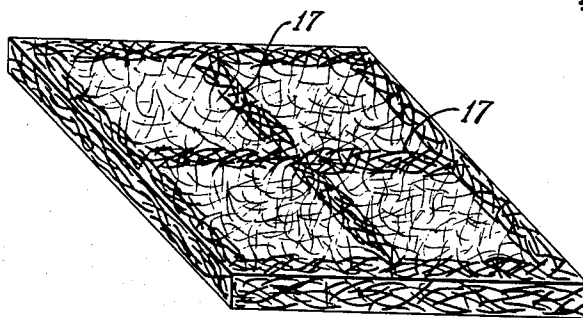


Fig. 11



Fig. 12



Fig. 13

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STRUCTURES COMPRISING VITRIFIED AND DEVITRIFIED MINERAL FIBERS

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9 Claims. (Cl. 161-149)

This invention relates to fibrous products and especially to treatments for fibers which provide improved strength and high temperature resistance.

Fibers such as those of glass have become well-known in their many applications wherein they exhibit resistance to high temperature, chemical attack and mechanical working and shock. Many new uses of fibers in various forms are made as man exhibits his ingenuity and resourcefulness in fulfilling the needs and requirements of a progressing world. The need for improved resistance to high temperatures in structural panels, ceiling boards and various other fibrous structures is a particular subject of the present invention.

It is an object to provide an unusually high-temperature resistant fiber.

It is an object of this invention to improve the high temperature resistance of fibrous articles.

It is an object to provide assemblages of fibers treated to provide dimensional stability at elevated temperatures and a method therefor.

It is also an object to increase the temperature which a fibrous board can withstand before it slumps or loses its integrity and shape.

It is a further object to provide high strength panels capable of withstanding extremely high temperatures without undue loss of dimensional stability.

Other objects will become apparent from the complete disclosure which follows.

The objects are attained by selecting proper compositions from which the fibers are produced, treating these fibers to produce a crystalline structure and thereby improve their temperature resistance and combining these improved fibers with treating compositions in a panel or structure to enhance further their resistance to high temperature. The treating composition is one which can withstand high temperature and thereby enhances the heat resistance of the fibers or one which forms an insulating wall or barrier when heated to reduce heat transfer through the fiber structure.

The invention will be better understood by reference to the drawings, wherein:

FIGURE 1 is a perspective view of a panel of fibers having a reinforcing border of fibers having a material thereon which increases further their temperature resistance;

FIGURE 2 is a view of a panel of crystalline fibers having a face of treated crystalline fibers;

FIGURE 3 is a view of a panel of high-temperature resistant fibers, one face of the panel having a foamed intumescent coating thereon;

FIGURE 4 is a view of a panel comprising high-temperature resistant fibers having an inorganic binder throughout the panel;

FIGURE 5 is an enlarged view of fibers treated with a high-temperature resistant inorganic cement;

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FIGURE 6 is an enlarged view of fibers treated with an intumescent material;

FIGURE 7 is an enlarged view of fibers and an intumescent material after heating;

FIGURE 8 is a cross-sectional view of abutted panels of fibers supported on metal rails;

FIGURE 9 is a sectional view of conventional fibrous boards which failed when exposed to high temperature;

FIGURE 10 is a perspective view of a panel of high-temperature resistant fibers having a reinforcing border and a transverse strip of high-temperature resistant fibers treated to increase further their temperature resistance;

FIGURE 11 is a similar view of a panel having multiple transverse reinforcements;

FIGURE 12 is a greatly magnified view of a mineral fiber; and

FIGURE 13 is a similar view of a crystallized, mineral composition fiber.

Various fibers can be used as the starting material from which a pack, mat, board, sheet, panel or other fiber arrangement can be formed. The fibers can be collected as they are being formed or they can be already formed fibers which are arranged in the desired manner by directing them upon a suitable collection device. The fibers can be compressed or molded into a sheet-like panel or into any desired configuration. The fibers may be asbestos, glass, slag, rock wool or any suitable mineral fiber composition. It has been found preferable to utilize fibers of a mineral composition which crystallizes upon application of heat to the fibers. Such a fiber resists slumping and loss of dimensional stability even though subjected to greatly elevated temperatures. Partial crystallization to provide semicrystalline, ceramic bodies is enough to provide the desired improvement in heat resistance. Views of amorphous fibers and crystalline fibers fashioned after actual photomicrographs are shown in FIGURES 12 and 13, respectively. Suitable compositions for the purposes of this invention are illustrated by the following compositions:

Example 1

Ingredient:	Percent by weight
SiO ₂ -----	60
Al ₂ O ₃ -----	20
CaO -----	12
MgO -----	8

Example 2

Ingredient:	Percent by weight
SiO ₂ -----	45
Al ₂ O ₃ -----	15
CaO -----	35
MgO -----	5

Example 3

Ingredient:	Percent by weight
SiO ₂ -----	45.0
Al ₂ O ₃ -----	13.7
CaO -----	33.5
MgO -----	5.0
K ₂ O -----	0.8
Na ₂ O -----	0.1
Fe ₂ O ₃ -----	0.6
MnO -----	0.5
TiO ₂ -----	0.8

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Example 4

Ingredient:	Percent by weight
SiO ₂ -----	42.5
Al ₂ O ₃ -----	18.2
CaO -----	30.2
MgO -----	5.4
Na ₂ O -----	0.6
K ₂ O -----	1.4
Fe ₂ O ₃ -----	1.7

Example 5

Ingredient:	Percent by weight
SiO ₂ -----	45
Al ₂ O ₃ -----	10
CaO -----	35
MgO -----	10

These compositions include oxides of group II elements which have been found to promote devitrification upon heat treatment. Calcia and/or magnesia are added to promote devitrification. Devitrification is also promoted by nucleation; for instance, surface irregularities, inhomogeneities within the composition, small crystalline particles and any points from which crystals can grow, promote the desired high-temperature resistant compositions.

Compositions comprising from 42-60% by weight SiO₂, from 10-20% Al₂O₃, from 10-35% CaO, and from 5-10% MgO may be used. These compositions are merely illustrative, however, and the invention is not limited thereto. The above compositions are melted and formed into fibers which are then collected in the form of a board such as an acoustical tile or ceiling board. Staple length fibers can also be collected into textile products by conventional means in the form of roving or yarn and these woven into fabric. The fibers are produced by preparing a melt in a cupola and fiberizing a stream flowing from the cupola by directing attenuating forces onto the stream or by any conventional fiber forming process. These boards exhibit unusual dimensional stability when exposed to elevated temperatures such as those encountered during a fire. Whereas, most ceiling boards either burn, melt or slump and then fall from the ceiling when exposed to fire conditions, these boards comprising fibers of compositions of Examples 1 to 5 with or without further treatments to enhance heat-resistance withstand fire temperatures without failure. The mechanical strength of the fibers increases upon application of sufficient heat to cause crystallization.

Such mineral fibers are normally bonded together by a binder composition such as one comprising a water dispersion of a phenolic resin. Various latices also have been used either alone or in combination with resinous materials as binder compositions. Although bonded fiber products have very good properties for many uses, it is oftentimes desirable to provide improved physical properties such as high strengths, higher temperature resistance, increased slump resistance, improved dimensional stability, and the like. Urea borate has been added to phenolic binder compositions to provide punk resistance and various other attempts have been made to raise the temperature resistance of bonded fiber boards.

In the present invention, further, treatment of the bonded fibers is carried out to provide the unusually high heat resistance now made possible. When utilizing mineral compositions which devitrify upon heating, it may or may not be necessary to provide a further application of a treating composition that further enhances heat resistance. For instance, when a mineral composition such as those set forth in the examples is utilized in preparing the fibers, a board made of these fibers will be found to resist slumping at high temperature for extended lengths of time even though they are exposed to fire conditions. It has been found that fibers of a composition which crystallizes upon heating will not slump at temperatures normally met during a fire within a building. As a result,

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ceiling boards 10 or panels produced from these fibers are not likely to fall from the suspension system due to slumping. When conventional fibrous glass boards are suspended by members 11 that fit into the kerf 12 of the board or by a T section suspension system upon which the boards rest, it has been found that during a fire the boards will slump at the metal strip used in suspending the acoustical tile and, as a result of the slumping, will fall from the suspension system, see FIGURE 9. When the high temperature fibers herein disclosed are used throughout the panels or at least in reinforcing portions of the panels, temperatures of from 300° to 900° F. higher than those normally withstood by glass fiber products can be met without failure. Fibers of a composition which crystallizes upon heating can be further treated to enhance further their already greatly improved heat resistance.

The treatments used may comprise the application of any of several intumescent materials which foam during heating to provide an insulating wall that reduces heat transfer and thereby heat buildup within the fibrous glass structure. Intumescent coatings in the form of paints and the like can be applied to one or more surfaces of the fiber board or mat. For instance, a dilute solution of dibasic ammonium phosphate, starch or dextrine, and urea formaldehyde resin is applied by vacuum impregnation and then dried upon the fibrous ceiling boards. If desirable, only the edges of the board are treated and then dried. When treated boards are exposed to heat, the intumescent material 13 foams and fills the interstices of the board, see FIGURE 7, with the result that further transfer of heat is retarded and failure of the board does not occur.

A typical water solution is prepared and applied to fibrous panels as follows. An acoustical panel, which was one foot square in dimension, was treated with 80 grams of an intumescent solution having the following composition. Two hundred (200) parts of ammonium phosphate, one hundred (100) parts of dextrine, one hundred ninety-six (196) parts of urea-formaldehyde resin (Urac 180) and two thousand (2000) parts of water were combined to form the solution. The solution was applied to the panel by placing the panel in a flat pan containing the solution. After saturation the panel was removed and placed in a vacuum tank at 20 inches of mercury for 3 minutes to replace the air in the tile with the solution. Any excess material was removed by means of a suction box. The tile was then dried at 200° F. When a panel having a dried deposit of this solution on its fibers is heated during a fire endurance test, the panel becomes blackened and an intumescent foam is formed over the entire treated surface of the panel. The tile successfully withstands temperatures encountered under fire conditions, since a heat transfer barrier is formed which protects the fibers and which substantially reduces heat transfer to the suspension system and concrete slab above the tile.

In FIGURE 1, a panel comprising high-temperature resistance fibers with a border treatment is illustrated. The fibers are held together in an intermeshed pack by a phenolic binder to form an integral board. The border fibers 14 are then treated to impart extremely high temperature resistance thereto. The mineral fiber composition disclosed devitrify when heated to a temperature within about 150° of their liquidus temperature to form stiff, high-temperature resistant fibrous masses; therefore, the edges of the boards may be pre-heated to the required temperature to form a "picture-frame" reinforcement for the structure. Alternatively or in addition to such heat treatment of the fibers within the fibrous structure, a treating composition is applied to all or a portion of the fibers within the panel or board. For instance, an intumescent paint is applied as explained above, or, alternatively, by flooding the entire board with the paint or by immersing the edges of the board in the paint so that the fibers in

the treated portions become substantially impregnated with the intumescent material. This treatment is then dried to form a deposit 15 which remains on the fibers and foams only in case of a fire, see FIGURES 6 and 7. When the material foams or expands, a protective, carbonaceous insulating material is formed throughout the borders of the panel or wherever applied, so that heat buildup, which would normally cause slumping and failure of the ceiling, does not occur.

Other treating compositions may be applied to the borders of the structure shown in FIGURE 1. For instance, an inorganic cement is applied by dipping the board in a slurry of the cement to effect substantially complete impregnation of these border fibers. This cement is then dried to form a "picture-frame" reinforcement which is able to withstand extremely high temperatures and provides the necessary strength to the structure so that it does not slump when exposed to fire conditions. An inorganic cement slurry can be applied to one or more surfaces of a board so that it coats and impregnates at least the surface fibers, see FIGURE 2. Inorganic cements such as magnesium oxysulfate slurries can be applied by saturating the entire board, see FIGURES 4 and 5.

Intumescent materials may also be applied to a major face of the board in a like manner. In FIGURE 3 a panel having an intumescent material on one major face of the board is shown after the board has been exposed to high temperature and the intumescent material has foamed to form a carbonaceous protective layer 16. This board does not slump nor fall from its supports during the fire test. Ceiling boards are conventionally suspended by T bars inserted into kerfs at sides of the boards as shown in FIGURES 8 and 9. Untreated boards and boards of low temperature fibers slump and fall from the suspension system, see FIGURE 9, but boards having border fibers treated with inorganic cements remain dimensionally stable as shown in FIGURE 8.

Inorganic cements which can be used include magnesium oxysulfate, magnesium oxychloride, magnesium oxide with silicic acid or sodium silicate, chromium oxide with silicic acid or sodium silicate, clay and silicic acid, hydraulic cements, Alumnite cement, sillimanite or any other cement which will remain heat stable for the required two hour period. These materials are applied by conventional means as slurries to the fibrous product and then dried to provide a high-temperature resistant board such as shown in FIGURES 4, 8, 10 and 11. The fibers have a relatively thick coating of dried cement on their surfaces as shown in FIGURE 5.

Various other structures can be produced utilizing the concept of providing high-temperature resistant reinforcing strips or borders for panels. Cross strips 17, 17 or transverse strips 18 of treated fibers can be used as shown in FIGURES 10 and 11. The structures disclosed have been found to withstand 1850° F. for two hours when tested as ceiling panels. Conventional glass fibers fail when exposed to temperatures of about 1000° F. The two hour fire test utilized herein simulated the full scale room test designated ASTM E119-58. In accordance with this test procedure, ceiling panels are supported on a steel bar joist assembly with a two inch concrete slab thereover to simulate an actual roof construction. The furnace temperature under this ceiling follows the standard (Columbia) time-temperature curve for control of fire tests set forth by the ASTM procedure. The test is continued until the tile fails by slumping and falling from the suspension system, until the concrete slab temperature exceeds 325° F. above the starting temperature or the steel temperature average exceeds 1000° F., or until two hours have passed.

The structures disclosed have acceptable noise-reduction characteristics and are decorative in addition to exhibiting the unusual resistance to high temperature described. They are particularly suited for use as ceiling boards, acoustical panels, structural panels, fire doors, 75

roof insulation, marine panels and the like. The high temperature treatments may be applied to the lower or upper sides of the ceiling boards or may be applied to the border fibers of the panel as described. Additional coatings of paint or other surface coatings can be applied for aesthetic or decorative effects. It should be understood that strength at high temperature can be imparted to panels by utilization of reinforcing elements which comprise high temperature fibers with or without treatments that enhance their inherent strength at high temperature or by treatments applied to surface fibers or all the fibers within a panel.

Other uses include form board, ceiling tile, acoustical tile, pipe insulation, block insulation, roof insulation, aircraft insulation, automotive insulation, and textile uses such as draperies and fire curtains.

Although specific embodiments of the invention have been set forth, it is not intended that the invention be limited thereto but rather to include all obvious variations and modifications within the spirit and scope of the appended claims.

I claim:

1. A mineral fiber structure comprising vitrified and devitrified fibers bonded together in the form of a generally rectangular board, said vitrified and devitrified fibers consisting essentially of, by weight, from 42-60% silica, 10-20% alumina, 10-35% calcia and 5-10% magnesia, said structure having exceptional resistance to sag imparted by reinforcing elements which comprise at least a part of the total structure and which comprise fibers that have been devitrified by heat treatment.

2. The structure of claim 1 wherein the devitrified fibers are located at the borders of the generally rectangular boards to form a reinforcing frame.

3. The structure of claim 1 wherein the reinforcing elements are located at the borders of the structure and in at least one transverse strip across the structure.

4. A mineral fiber structure comprising vitrified and devitrified fibers bonded together in the form of a generally rectangular board, said vitrified and devitrified fibers consisting essentially of, by weight, from 42-60% silica, 10-20% alumina, 10-35% calcia and 5-10% magnesia, said structure having exceptional resistance to sag imparted by a border of reinforcing elements comprising integral, bonded devitrified fibers of said rectangular board which have been treated with a fire-retardant composition that imparts extreme heat resistance thereto.

5. The mineral fiber structure of claim 4 wherein the fire-retardant composition comprises a heat-foamable material.

6. The mineral fiber structure of claim 4 wherein the fire-retardant composition comprises an inorganic cement.

7. A fibrous structure comprising haphazardly arranged mineral fibers bonded together into an integral board, said mineral fibers consisting essentially of, by weight, from 42-60% silica, 10-20% alumina, 10-35% calcia and 5-10% magnesia, at least a portion of said fibers comprising a composition which has become crystalline upon heating to form high-temperature resistant fibers, and upon the high temperature resistant fibers a treating material that further enhances their heat resistance.

8. The fibrous structure of claim 7 wherein the treating material comprises a heat-foamable material.

9. The fibrous structure of claim 7 wherein the treating material comprises an inorganic cement.

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EARL M. BERGER, *Primary Examiner*.CARL F. KRAFFT, *Examiner*.