Sept. 9, 1969 F. W. CURTIS 3,466,222

FIRE RETARDANT INSULATIVE STRUCTURE AND ROOF DECK CONSTRUCTION COMPRISING THE SAME

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FIG. 1

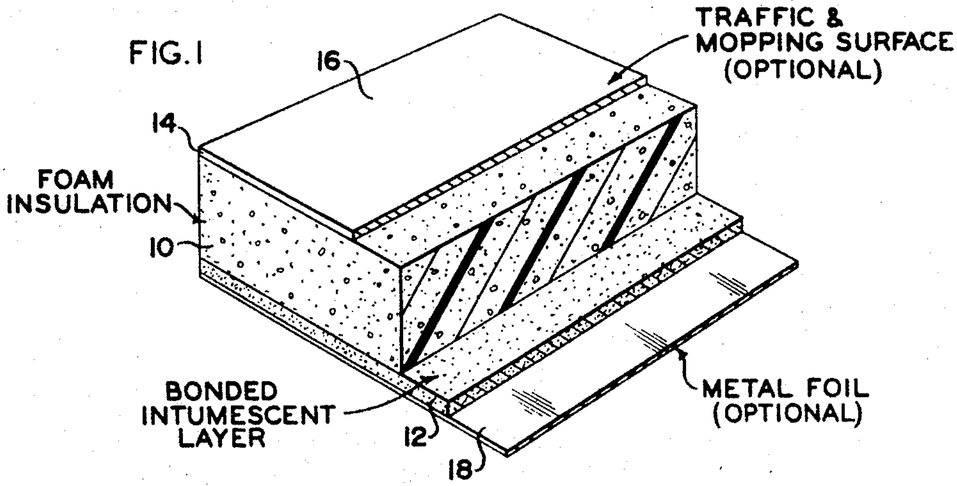
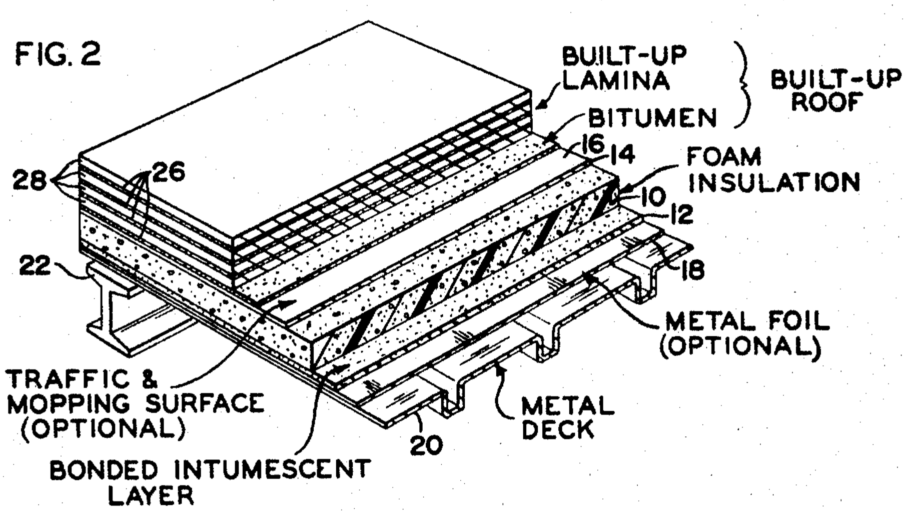


FIG. 2



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ABSTRACT OF THE DISCLOSURE

As a fire retardant insulative structure, a substantially rigid body of synthetic, organic polymeric foam, and a lamina on one surface of the body formed of a particulate, inorganic material and a binder, wherein at least about 50 wt. percent of the inorganic material is unexpanded vermiculite.

This invention relates to the insulation art and more particularly to an improved fire retardant insulative structure and to a roof deck construction comprising the same.

The fire retardant insulative structure of the present invention is particularly applicable for use as a component in a roof deck construction, and more especially a metal roof deck construction, and will be described with particular reference thereto. However, it will be appreciated that the invention has broader aspects and may be used in other applications where improved thermal insulation and fire retardance are important criteria.

As described in U.S. Patent 2,861,525, a conventional metal roof deck construction contains large quantities of combustible bituminous materials such as asphalt, coal tar pitch, and the like. It has been found that notwithstanding the heat shielding and fire resistant properties of the metal roof deck itself these combustible materials can and do contribute to the spread of a fire in a building under a metal roof deck construction.

It appears that the heat generated by a fire within the building, is transmitted at such a rapid rate through the metal roof deck to the combustible materials above, that the combustile material closest to the roof deck will actually begin to vaporize while the combustible material further from the roof deck remains "skinned over" presenting a generally impermeable barrier to the upward escape of vapors. As a consequence, the path of least resistance for these vapors is downwardly through the joints and the sections of sheet metal forming the metal roof deck. As the vapors of combustible material seep through the joints in the metal deck, they are ignited by the flames of the fire within the building and thereby contribute to the conflagration.

This is one of the problems to which the present invention is addressed, and the problem is solved by the provision of a fire retardant, insulative structure which is capable of reducing the rate of heat transfer from a fire below, through a roof deck, to combustible materials above, to such a degree, that the combustible material is heated gradually and substantially uniformly through its thickness. Thus, by the time the combustible material closest to the roof deck has reached a vapor generating temperature, the combustible material further from the roof deck has at least softened to a point which permits the escape of vapors upwardly therethrough.

Another problem to which the present invention is addressed concerns the provision of a fire retardant, insulative structure, suitable for use in roof deck construction, which comprises a substantially rigid body of synthetic, organic polymeric foam. Such foams are well known for their outstanding thermal insulating properties. However, their exploitation to date has generally been limited to applications where the foams are exposed to ambient or low temperature conditions, since organic foams decompose at elevated temperatures.

As applied to a roof deck construction, an organic foam would provide a very satisfactory thermal insulating service at ambient temperatures but would disintegrate rapidly when exposed to the heat generated by a fire within a building under a metal roof deck construction. This deficiency is overcome by combining the organic foam with a high temperature thermal barrier lamina formed of a particulate, inorganic material and a binder, wherein at least about 50 wt. percent of the inorganic material is unexpanded vermiculite.

In accordance with another aspect of the invention, there is provided a fire retardant, insulative structure, comprising a laminate having a core formed of a substantially rigid body of synthetic, organic, polymeric foam, and a lamina on one surface of the core formed of a particulate, inorganic material and a binder therefor, wherein at least about 50 wt. percent of the inorganic material is unexpanded vermiculite.

In accordance with another aspect of the invention, there is provided a fire retardant, insulative structure of the type described, in combination with a metal roof deck.

The fire retardant, insulative structure of the present invention is unique in that it is composed of materials which, individually, are deficient in one or more properties required for use with a roof deck construction. Thus, for instance, the organic foam core is unsuitable for use by itself, since it melts at relatively low temperatures and consequently would not maintain its structural integrity during a fire. Similarly, the lamina of bonded particulate inorganic material while having very satisfactory structural and high temperature thermal barrier properties does not, prior to expansion of the vermiculite, have the strength or thermal insulative properties to provide satisfactory performance by itself, at ambient temperatures.

The fire retardant, insulative structure of the present invention has the additional advantage of being a unitary structure, which can be fabricated by any one of a number of conventional techniques, and installed on a metal roof deck quite simply and efficiently, without resort to any special installation techniques.

It is therefore an object of the invention to provide an improved fire retardant, insulative structure.

A further object of the invention is to provide a fire retardant, insulative structure which overcomes certain disadvantages of the prior art.

A further object of the invention is to provide a metal roof deck construction comprising a fire retardant, insulative structure in accordance with the present invention.

Yet another object of the invention is to provide an improved fire retardant, insulative structure which has excellent thermal insulative properties at ambient temperatures, and which in the event of a fire, retards the rate of heat transfer to combustible components thereof, permitting vapors generated from such components to escape without contributing to the spread of the fire.

A still further object of the invention is to provide a fire retardant, insulative structure, which can be readily prefabricated, and then installed on a metal roof deck quickly and efficiently without resort to special installation techniques.

These and other objects and advantages will become apparent from the following detailed description of a preferred embodiment of the invention when read in connection with the accompanying drawings, in which:

FIGURE 1 is a schematic, pictorial view of a preferred embodiment of a fire retardant, insulative structure of the present invention; and

FIGURE 2 is a diagrammatic, pictorial view of a section of metal roof deck construction comprising a fire retardant, insulative structure of the present invention.

Referring now to the drawings wherein the showings are for purposes of illustrating a preferred embodiment of the invention only, and not for the purpose of limiting the same, FIGURE 1 shows a fire retardant, insulative structure comprising a laminate having a core **10**, formed of a substantially rigid body of synthetic, organic, polymeric foam; a lamina **12** on one surface of the core **10**, formed of a particulate, inorganic material and a binder therefor; and an optional lamina **14** on the opposite surface of core **10**, providing a traffic and mopping surface 16.

If desired, the laminate may be provided with a thin sheet of metal foil **18**, adhered to the exposed surface of lamina **12**. Metal foil **18** serves a useful function in the fabrication of the fire retardant, insulative structure, as will be described presently.

Core **10** may be formed from a variety of synthetic organic polymeric materials, all of which produce low density, lightweight, low heat transmission, substantially rigid foams. Without limitation on the generality of useful materials, the foam may be formed of a polyurethane resin, a vinyl resin (e.g., polyvinyl chloride, copolymers of polyvinyl chloride and polyvinyl acetate), epoxy resins, phenolic resins (e.g., phenol formaldehyde), polyethylene resins, silicone resins, urea formaldehyde resines, polystyrene, acrylic resins, synthetic rubber, and the like.

A particularly suitable core is one formed of a foam having closed cells. This provides a core having extremely low permeability to moisture. However, cores formed of foam having open cells may also be used.

The thickness of the core can vary over wide limits, depending on the environment in which the insulative structure is to be used, the density of the foam, the nature of the synthetic organic polymeric material forming the foam, and the insulation requirements of the particular application for the insulative structure. In general, however, the thickness of the core for most applications will be within the range of about ½ inch to about 2 inches or more. In the case of an insulative structure intended for use as a component in a metal roof deck construction, a core formed of polyurethane foam will satisfy most commercial specifications if the core has a thickness within the range of about ½ to about 2 inches. This is based on the fact that a polyurethane foam having a K-factor [thermal conductivity expressed in B.t.u./(hr.) (sq. ft.) (deg. F./in.)] of approximately 0.15 will have commercially recommended C values [thermal conductance expressed in B.t.u./(hr.) (sq. ft.) (deg. F.)] in the range of about 0.06 to about 0.36.

Lamina **12** is formed of a particulate, inorganic material and a binder, wherien at least about 50 wt. percent of the inorganic material is unexpanded vermiculite, the remainder, if any, being any other natural or synthetic inorganic, preferably low density, insulative material, such as expanded vermiculite, perlite, shale or the like. Laminae containing higher concentrations, of unexpanded vermiculite are generally preferred, and in some circumstances laminae containing 100% unexpanded vermiculite as the particulate inorganic material are especially preferred.

The advantages of unexpanded vermiculite are manifold. It is readily available at low cost, in a wide variety of sizes or grades. In addition, vermiculite expands at temperatures of about 300° F. and above, which means that the lamina **12** begins to expand and protect core **10** at temperatures below those which will begin to degrade the polymeric foam from which the core is formed. Another advantage of vermiculite, is that it releases water vapor upon expansion or exfoliation, and the latent heat of vaporization absorbed in the process of converting water to water vapor, helps to slow the rise of temperature in the vicinity of core **10**.

The binder for the particulate, inorganic material may take the form of an inorganic adhesive such as sodium silicate, or an organic resinous material such as a urea formaldehyde or phenol formaldehyde resin. In general, organic binders are preferred because of their ease of handling and mixing with the particulate, inorganic material, and the speed with which they set-up.

Preferably, the amount of binder used is kept at a minimum, since it serves no other useful function than to bond the particles of inorganic material to each other to form a cohesive lamina. Thus, the binder may represent as little as about 1% by weight of the inorganic material, up to about 5% by weight. In general, concentrations of binder in excess of 10% by weight of inorganic material cannot be economically justified.

Vermiculite ore (unexpanded vermiculite) is commercially available in a number of grades, having particle sizes within the range of 3 to 40 mesh (U.S. series), and any of the commercially available grades may be used. Preferably, however, commercial grade No. 3, having particles within the range of 12–14 mesh (U.S. series) is used.

The thickness of the bonded lamina of particulate inorganic material where 100% unexpanded vermiculite is used, may range from about 1/32 of an inch to about ¼ inch, and preferably within the range of 3/32 of an inch to ⅛ inch. Thicker laminae may be used, but generally cannot be economically justified, since a ⅛ inch lamina of unexpanded vermiculite, will expand to a thickness of about 1 inch, which is generally adequate for most applications contemplated by the present invention.

It will be understood that where the particulate inorganic material is a mixture of unexpanded vermiculite and some other inorganic material, the thickness of lamina **12** will increase proportionately as the weight percent of unexpanded vermiculite decreases. As the concentration of unexpanded vermiculite approaches 50 wt. percent, lamina thicknesses on the order of ¾ inch to 1 inch are satisfactory for most applications contemplated by the present invention.

Lamina **14**, providing traffic and mopping surface **16**, may be formed from a variety of materials, such as pressed hardboard, asbestos-cement sheet, and a sheet of synthetic elastomeric material, such as butadiene rubber. From the standpoint of economics, lamina **14** is preferably formed of a conventional roofing felt, which may be a cellulosic or synthetic fibrous body saturated with a bituminous material, as is well known in the art.

The fire retardant, insulative structure of the present invention may be fabriacted by any one of a number of procedures, as will readily suggest themselves to one skilled in the art. Thus, for instance, core **10**, lamina **12**, and optional lamina **14**, may each be formed separately, either in a continuous manner, or in batch fashion, and then fabriacted into a laminate by the use of suitable adhesives. If the core and laminae are formed on a continuous basis, the lamination step may be effected either before or after the components are cut into suitable size blocks.

As an alternative fabricating technique, the fire retardant, insulative structure may be formed and laminated in situ. This can be accomplished either on a continuous basis, or in individual molds suitably dimensioned to provide easily handled blocks. For example, such molds may be constructed to form blocks measuring 2 ft. by 4 ft. by about 1 inch thick.

In accordance with one convenient practice, the bottom of the mold may be spread with a mixture of a particulate inorganic material and a binder, and this lamina cured in the mold. Thereafter, a mixture of a synthetic, organic, polymeric material, and a foaming agent may be placed in the mold, and if desired covered with a lamina, such as roofing felt, providing a traffic and mopping surface. Thereafter, the mold can be closed, and heated if necessary, to initiate and/or accelerate the foaming of the synthetic organic polymeric material. Curing of the foam core in contact with the top and bottom laminae, will develop a bond between the core and and the laminae so that no separate lamination step is required.

In some instances, it may be desirable to line the bottom of the mold with a sheet of metal foil, or a sheet of paper having a metal foil facing, before spreading a layer of inorganic material and a binder across the bottom of the mold. Curing of the binder will cause the metal foil or metal foil faced paper, to adhere to the bonded layer of inorganic material, whereby the metal foil becomes an integral part of the fire retardant, insulative structure. The metal foil interface between the structure and the mold facilitates the removal of the cured laminate from the mold.

The production of fire retardant, insulative structures in individual molds has the advantage of providing blocks of insulation which are uniform in size and true in rectilinearity. Consequently, these blocks fit together quite well when assembled as for instance on a metal roof deck.

Referring to FIGURE 2, there will be seen a fire retardant insulative structure of the present invention, incorporated in a metal roof deck construction. Roof deck **20**, is of conventional design, and is formed of a plurality of panels which are interlocked in any suitable fashion, and are supported by structural members forming a part of the building, such as purlin **22**.

Roof deck **20** may be formed from a variety of metals such as steel and galvanized steel.

The fire retardant, insulative structure may be secured to metal roof deck **20** by any suitable means such as adhesives or metal fasteners (not shown). It will be noted that the fire retardant, insulative structure is placed on metal roof deck **20** so that lamina **12**, formed of a particulate inorganic material and a binder, or metal foil **18**, if such is used, is positioned between the metal roof deck and foam core **10**.

The metal roof deck construction is completed by applying to core **10**, or to traffic and mopping surface **16** of lamina **14** if such is included in the structure, a "built-up roof" which comprises at least one covering of weather resistant which may be a rubbery substance applied as a coating or sheet, but in the embodiment illustrated, is a coating of bituminous material **26**, and preferably a plurality of such coatings separated by built-up lamina **28**, which may be formed from a variety of materials, but which in accordance with the preferred embodiment of the invention are formed of roofing felt.

In general, the built-up roof portion of the metal roof deck construction is formed by mopping a bituminous material on the traffic and mopping surface, applying a layer of roofing felt, and alternating this procedure until 3 or 4 plies of roof felt have been built-up. The top layer is usually a coating of bituminous material, which may have embedded in its granules of a conventional mineral material, such as gravel, marble chips, volcanic rock or the like.

For purposes of this disclosure, the term "bituminous material" is intended to embrace a variety of hydrocarbonaceous materials such as asphalt, coal tar, sand tar, shale oil residue, and high boiling byproducts of petroleum refining processes, such as treated (e.g., solvent extracted) and untreated residues of catalytic cracking and hydrocracking operations.

The fire retardant, insulative structure of the present invention provides excellent thermal insulation at ambient temperatures and superior fire retardance at extreme temperature conditions. Should a fire develop in a building under a metal roof deck comprising a fire retardant insulative structure of the present invention, the following would occur. At temperatures well below those necessary to vaporize and/or liquefy the combustible material forming a part of the built-up roof portion of the metal roof deck construction, the unexpanded vermiculite in the lamina of particulate inorganic material, expands with the release of water vapor. This provides a substantial body of heat insulative material between the metal roof deck and the organic foam core. The expanded lamina together with moisture vapor released during the expansion of the vermiculite both would serve to protect the organic foam from heat degrading temperatures and slow the rate of heat transfer to the combustible material. Since the foam itself has low heat transmission properties, as long as it maintains its structural integrity, the foam in turn helps to slow the rate of heat transfer to the combustible material. In this manner, additional time is provided to bring the fire within the building under control before the combustible material vaporizes and/or melts, and thereby contributes to the spread of the fire along the under surface of the metal roof deck. Should some vaporiaztion and/or melting of the combustible material take place before the fire within the building is brought under control, the slow rate of heating of the combustible material would have by this time softened the entire mass of combustible material permitting the vapors to escape upwardly, so that they would not contribute to the spreading of the fire.

The present invention has been described in conjunction with certain compositions and structural embodiments; however, it is to be appreciated that various structural and/or compositional changes may be made in the illustrated embodiments without departing from the intended scope and spirit of the present invention as defined in the appended claims.

Having thus described my invention, I claim:

1. In combination with a metal roof deck, a fire retardant, insulative structure comprising a substantially rigid core of synthetic, organic, polymeric foam, a lamina on one surface of said core and in contact with said metal roof deck, formed of a particulate, inorganic material and a binder therefor, said inorganic material comprising at least about 50 wt. percent of unexpanded vermiculite, and a covering on the opposite surface of said core of a weather resistant combustible material.

2. The combination as defined in claim **1**, wherein said covering is a lamina providing traffic and mopping surface.

3. The combination as defined in claim **2**, wherein said traffic and mopping surface is provided with a built-up roof comprising a plurality of laminae of roofing felt, each separated from the next by a coating of weather resistant combustible material.

4. A fire retardant, insulative structure comprising a substantially rigid body of synthetic organic, polymeric foam, a lamina on one surface of said body formed of a particulate, inorganic material and a binder therefor, said inorganic material comprising at least about 50 wt. percent of unexpanded vermiculite, and a lamina on the opposite surface of said body comprising metal foil.

5. A fire retardant, insulating structure comprising a substantially rigid body of synthetic organic, polymeric foam, a lamina on one surface of said body formed of a particulate, inorganic material and a binder therefor, said inorganic material comprising at least about 50 wt. percent of unexpanded vermiculite, and a lamina on the opposite surface of said body comprising bituminized roofing felt.

6. A fire retardant, insulating structure comprising a substantially rigid body of synthetic organic, polymeric foam, a lamina on one surface of said body formed of a particulate, inorganic material and a binder therefor, said inorganic material comprising at least about 50 wt.

percent of unexpanded vermiculite, and a lamina on the opposite surface of said body comprising roofing felt.

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JOHN E. MURTAGH, Primary Examiner

U.S. Cl. X.R.

52—232, 309, 408; 161—403