April 2, 1957 L. D. SOUBIER ET AL 2,787,345

FIRE RESISTANT STRUCTURAL UNITS

Filed Nov. 19, 1952 2 Sheets-Sheet 1

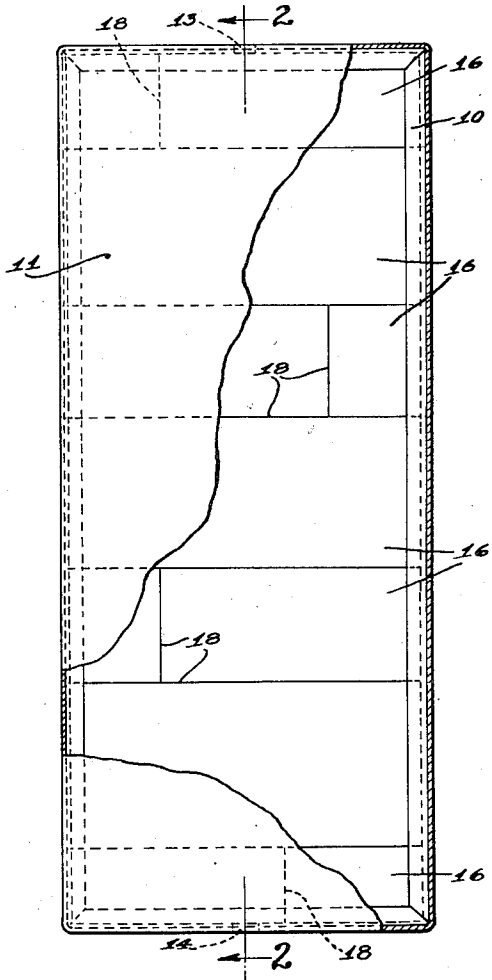


Fig. 1.

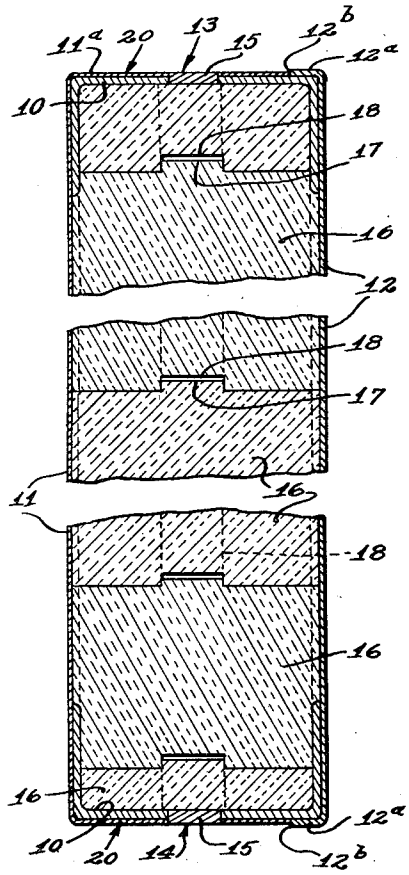


Fig. 2.

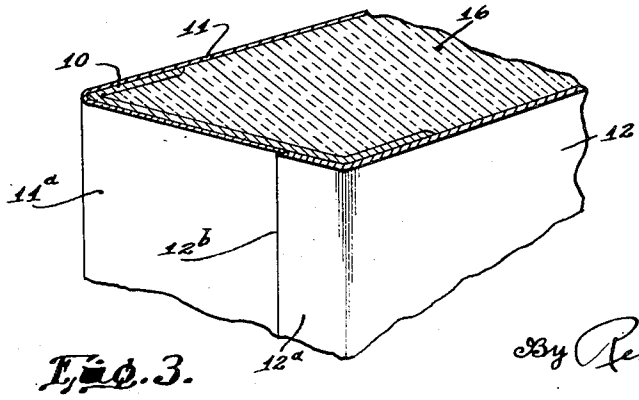


Fig. 3.

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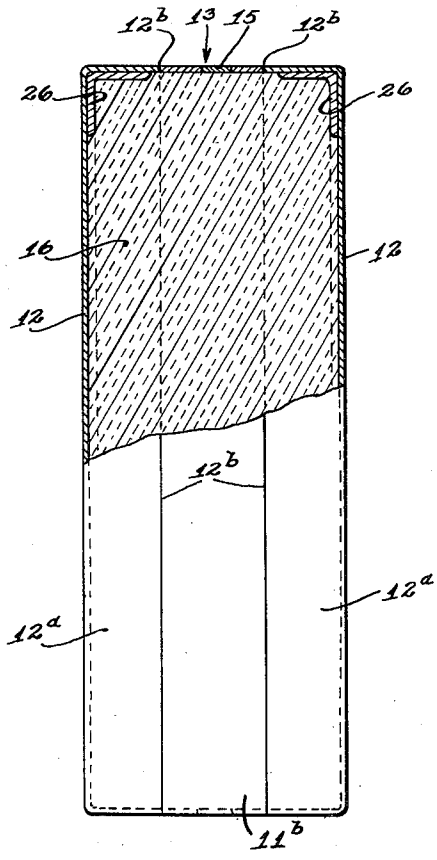


Fig. 4.

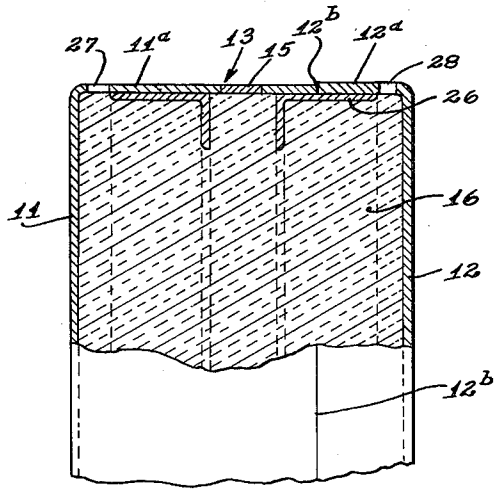


Fig. 5.

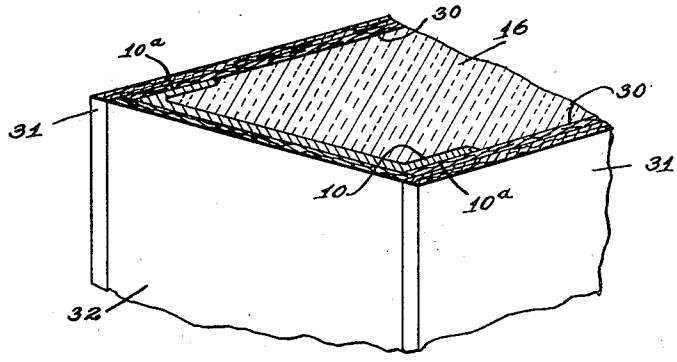


Fig. 6.

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FIRE RESISTANT STRUCTURAL UNITS

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4 Claims. (Cl. 189—34)

This invention relates to the production of structural units, such as firedoors, and in particular to a type of unit having an initially high resistance to heat and fire and which resistance increases with a rise in temperature and reaches a maximum under actual subjection to fire and/or high temperatures.

In most fire resistant units, whether wood or steel clad, the structure and core material utilized will provide a maximum temperature resistance before break down and without any change or conversion of the material which will increase that maximum temperature.

This present invention has for its primary object the production of a firedoor, or other fire-proof or fire resistant units for various end uses under high temperature conditions, provided with a core material and core structure and other structural features which will provide in that unit, at or upon installation, a particular temperature resistance range and which material when subjected to higher temperatures above this particular range will undergo a physical and/or chemical change which increases its resistance through still a higher temperature resistance range.

One such material is synthetic xonotlite which when subjected to temperatures in excess of 1200° F. undergoes a physical and/or chemical change which increases its maximum temperature resistance to at least 2000° F.

A xonotlite material undergoes a transformation at a temperature of approximately 1400° F., and since in standard fire tests temperatures of 1000° F. are reached in five minutes, and continue upward on a curved line to 1700° F. in an hour, and thereafter up to 2000° F. at four hours, such transformation point advances progressively deeper into the core material. While with a core made up of individual sections the shrinkage when break-down occurs is less than with a monolithic core there comes a time in the long fire test in which the element or core break-down due to shrinkage becomes a factor.

It is important to note that with fire on only one side of the firedoor or other structure, the progressive break-down of the core material does not produce a major structural break-down of the structure as a whole until a substantial length of time has passed. This break-down occurs in present commercial firedoors in which a type of core material is used that can resist only about 1300° F. and yet is able to get a fire rating of one hour when for most of the time the fire temperature is above 1300° F. The slow rate at which the break-down occurs progressively through the particular silicate core used in present commercial firedoors means that the over-all structural unit, even though one face is burned away, is still a fire barrier. It is only after this progression of the break-down, due to loss of water from the core, has occurred to a substantial or considerable depth that the structural strength is reduced to a point of virtual failure. In present firedoors this occurs sometime after one hour.

In the case of a xonotlite core firedoor, or panel, the subject of this present invention, the integrated core of

synthetic xonotlite would go through the ±1400° F. transformation to Wollastonite and then present to the fire a material which is capable of resisting temperatures up to at least 2000° F. As a result of this transformation such a door will not show any significant physical, chemical or structural weakness insofar as the core is concerned for at least four hours.

The rate of deterioration due to the shrinkage, after say 2100° F. has been passed, as it progresses through the core is quite slow and the significant point is that even though so-called maximum working temperatures of the core material are exceeded, there is a time delay for any possible failure of the structural unit, because the progress of break-down or physical disintegration through the core is very slow.

Since the maximum temperature of a standard fire test is 2300° at eight hours in which the temperature has progressed at 75° per hour after the 2000° F. at four hours, the door with a synthetic xonotlite core will withstand a standard fire test for a period longer than 4 hours insofar as the core is concerned. This would mean that with metals that do not change appreciably in these high temperature ranges that the integrated xonotlite core should give a fire barrier for a very appreciably extended length of time. This would also mean that units can be made for services where high temperatures are encountered over and above the mere protection against accidental fire.

Other objects of our invention will be apparent from the following specification and accompanying drawings.

In the drawings:

Fig. 1 is a face view of a structural unit which may serve as a door or panel, portions of the surface covering or envelope being broken away;

Fig. 2 is a sectional elevational view at the line 2—2 on Fig. 1, but on a larger scale and with parts broken away, illustrating the sectional structure of the core and the venting arrangement of the envelope;

Fig. 3 is a fragmentary sectional view showing the core restraining channel and the enclosing envelope;

Fig. 4 is a part sectional elevational view of a structural unit provided with a monolithic core;

Fig. 5 is a fragmentary sectional view of another monolithic structure; and

Fig. 6 is a fragmentary sectional view of a structure wherein the envelope is comprised of adhered veneers of fire-proofed material.

In practicing our invention there are several practical ways of making structural units, such as doors, partitions, etc., capable of high temperature heat or fire resistance wherein the enveloping material is metal or other materials highly resistant to fire and/or high temperatures and the core material consists essentially of a silicate compound in integrated form.

For example, a metal case may be provided which is entirely closed, with the exception of a filling opening and an air vent, and which may be filled with a lime, silica, asbestos or aggregate and water slurry capable of being converted to an integrated crystalline structure wherein the crystals have the chemical formula $5CaO.5SiO_2.H_2O$. Upon induration of the slurry and drying of the product the fill opening is sealed with a low melting point material and the air vent is permanently sealed. Thus, a structural element is provided having a metal enclosure and a monolithic crystalline structure core of synthetic xonotlite which is unaffected insofar as chemical composition is concerned by temperature less than approximately 1400° F.

Secondly, a metal case may be provided and a preindurated and dried xonotlite monolithic core inserted therein and sealed. Also this preindurated core may be inserted into the metal case in sections with these sections abutting in vertical and horizontal planes and with the

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abutting edges having articulation, such as a tongue and groove or the like.

Prefabricated pieces or articulated sections of synthetic Wollastonite may be inserted and sealed into a metal case. However, we have discovered that the preconversion of xonotlite slabs or blocks to Wollastonite is, from the commercial viewpoint, not a simple matter. For example, it requires heating oven equipment capable of providing temperatures of at least 1400° F. and adapted for regulable control of the drop of temperature to room temperature over an extended period of time. Without such controls the conversion becomes a risky commercial endeavor because of the stress and strain occuring in the slabs which result in breakage of a type which lessens the efficiency of the core in its resistance to the transmission of flame or gases.

Consequently it is the more desirable procedure to retain the core in its unconverted form, xonotlite, in the completed article, so that conversion will only occur while the core is enclosed in the door or panel structure and while being subjected to the high temperatures such for example, as those incident a fire. In the majority of instances such high temperatures is applied to only one side of the structure and the progression of the conversion from xonotlite to Wollastonite will require an extended time interval.

Conversion of the xonotlite core to Wollastonite while confined in a retaining enclosure will lengthen fire resisting time interval by that length of time which is required to eliminate the predetermined amount of free water contained in the highly porous xonotlite plus the time intervals required to eliminate the combined water and produce the necessary atomic rearrangement of the crystals in the change from Wollastonite to pseudowollastonite at approximately 2100° F.

In addition to the above the application of temperatures in excess of 2100° F. will require a time interval of some length before the core will reach a point of structural break-down such as to lose its efficiency as a firedoor.

Such delaying of the conversion also reacts to extend the life of the structural unit in that its final progression to a structural breakdown of the core is greatly delayed.

A preferred structure is one wherein articulated tongued and grooved sections of molded synthetic xonotlite are sealed within a metal case and wherein the xonotlite has been dried to about 30% at about 300° F. Under such conditions the xonotlite would have both free and combined water to lose when subjected to high temperature and the procedure of conversion to Wollastonite accordingly would be less abrupt through the mass.

Further, the tongue and groove construction of such articulated sections gives a protection against leakage of gases or flame due to warpage, which protection is not possible with a monolithic structure when it cracks due to warpage or for any other reason.

In Figs. 1 and 2 there is shown one form of a metallic casing structure which may be utilized for producing structural units, panels or doors having either a monolithic or articulated core structure. In this particular structure, a channel member **10** extends completely around the periphery of the core **16**. One of the major or face surfaces of the door unit is formed by a sheet or stainless steel or similar alloy **11** covering the side of the door and the opposite side is formed with a carbon steel face **12**. However, both faces may be of the same material as shown in Fig. 4 and be interconnected by a metal strip **11b** and seam welded at **12b**.

The sheet **11** has its marginal portions **11a** turned inwardly in the form of flanges which overlie the channel **10** and form the major portion of the edge surfaces **20** of the door. The face plate **12** is formed with marginal flanges **12a** which complete the edge surfaces **20** and abut the flanges **11a** along the weld line **12b**.

Vents **13** and **14** are provided respectively in the top

and bottom surfaces of the door and are normally sealed with plugs **15** of low melting point material, such as, some metal which will melt at or below the boiling point of water, for example, Cerra Matrix Metal. The purpose of sealing the vents **13** and **14** is to prevent the core **16**, after being formed or placed in the steel casing, from picking up additional moisture, although where conditions make it desirable the vents may be left open to deliberately permit the porous integrated core **16** to pick up additional moisture. In any event the ultimate purpose of the vents is to permit the escape of steam vapors when the door is subjected to high temperatures.

In the preferred form as mentioned above, the core **16** is preferably initially formed of the crystalline compound xonotlite, in integrated porous form having a density of approximately 10 p. c. f. to about 35 p. c. f. or to greater or lesser densities as the end use may dictate, and that said core is in sections having tongue **17** and groove **18** articulations with each other extending horizontally and if necessary also vertically.

Such a core **16** when subjected to sufficiently high temperatures loses both its free and combined water. When the door is in use and a fire occurs by which it is subjected to such high temperature, the heat usually being applied mainly to one side of the door, there is a strong tendency to warpage and resultant cracking of the core material. The articulation being of the tongue and groove type prevents such cracking and the resultant leakage of heat and gases through the thickness of the door. Such leakage could not ordinarily be prevented in a monolithic structure when it cracks.

In this type of firedoor, regardless of whether the core **16** is of the monolithic or articulated type, it is necessary to make provision in the structure to offset the shrinkage which will occur when the synthetic xonotlite core is subjected to these high temperatures. For example, if the door is subjected to a temperature sufficiently high to cause the xonotlite to convert to synthetic Wollastonite, there will be an over-all shrinkage in the length, width and thickness of the core. By providing a heat retarding element such as the channel structure **10** around the periphery of the core **16** or some similar means vacant space due to any such shrinkage will automatically remain enclosed and a barrier to the transmission of heat provided.

With respect to the tongue **17** and groove **18** portions, these are of such depth and width that it would be necessary for all three legs or splines thereof to be broken off in order to permit the excessive passage of heat, etc. The total shrinkage in a door of usual width will be approximately ¼" and with the channel **10** extending completely around the door there will be no possibility of direct leakage of excessive heat or flame. However, it is possible to control this shrinkage factor to some considerable extent by providing the proper combination of porosity or density in the core as well as the thickness of the core to suit particular or specific conditions of heat exposure.

Earlier in this disclosure it was mentioned that one side of this door is faced with a stainless steel facing **11** and that this facing extends over the major portion of the edges **20** of the door. There is nothing unique in this in itself but it has significance in connection with the rest of the construction. The sheet on the inside, or "cold" side in a fire test, is a 24 gauge carbon steel sheet **12**. The stainless steel sheet **11** may be approximately .008" in thickness.

The stainless steel sheet **11** has a lower conductivity than a carbon steel sheet of the same thickness, is made of a thinner gauge sheet and the thinner gauge lower conductivity sheet covers most of the edge. Most important, steel angles or channels **10** (Figs. 1 and 2) and steel angles **26** (Figs. 4 and 5) are built into the panel to approach close to the stainless steel sheet **11**. Their conductivity is also higher than that of the stainless steel sheet **11** (per cross sectional area). These angles **10**

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and **26** are in intimate contact with the carbon steel sheet **12** on the reverse side. It is presumed that the amount of heat that can be conducted by the stainless steel sheet **11** at the temperatures reached will be distributed rather rapidly through the greater mass of steel designed on the inside of these panels and through them will be fed rather rapidly to the carbon steel sheet **12** on the inside. The emissivity of a black carbon steel sheet is high.

The basic feature herein disclosed comprises the building of a firedoor or other unit having a core **16** which is normally resistant to specific temperatures, namely, approximately 1200° F., and which when subjected to higher temperatures will inherently increase its resistance to a much higher range of temperatures due to the change in physical and/or chemical form and/or the atomic rearrangement of the crystals forming the porous integrated core **16**.

A monolithic form of core **16** as shown in Figs. 4 and 5 may also be made and utilized as follows:

A hollow firedoor case **25**, made of a carbon or other steel or other metals or combinations thereof, with a melting point of from 1800° F. to 2500° F., is so designed as to encompass all surfaces of the door, and is formed with a fill opening **13** in one of the edge surfaces **20**, through which a xonotlite slurry is poured to fill said case. Vents **27** and **28** are also provided to obviate air entrapment and these are welded closed after induration of the slurry.

This filled case is then placed in an indurator, with the pouring opening **13** still open, and is subjected to a pressure and temperature and for a time interval sufficient to convert the slurry to an integrated monolithic structure of a crystalline compound, the crystals of which have the formula $5CaO.5SiO_2.H_2O$. This door is then placed in a drier and the free water is evaporated, for example, down to approximately 30% @ 300° F. The pouring opening **13** in the door may, if desired, be then sealed with a slug **15** such as lead or other low melting point material to prevent any moisture pick-up by the xonotlite core. We now have a steel firedoor in which the core **16** (xonotlite) has a normal fire resistance up to approximately 1400° F. without any structural change either chemically or physically. However, by maintaining exposure to a somewhat higher temperature the xonotlite will convert to synthetic Wollastonite at approximately 1400° F. (760° C.) and then be chemically unaffected up to approximately 2100° F. As the temperature is further increased beyond 1400° F., the Wollastonite will become pseudowollastonite at approximately 2100° F. (1150° C.). From this point on the effect of further temperature increase upon the core **16** is that it may begin a gradual structural break-down and finally melt when the temperature reaches 2800° F. (1540° C.). The above structural changes take place whether the core be monolithic or of articulated sections. Angle shaped members **26** extend around the inside of the case **25** to act as barriers to the heat transfer when the core **16** shrinks.

From the preceding it should be quite apparent that a firedoor has been produced the core **16** of which, at its initial production, has a potential fire resistance in the proximity of at least 1200° F. without structural change, but when subjected to actual fire or high temperature conditions the resistance of said core **16** progressively increases at least another 1000° F. and has a final potential resistance at a temperature of at least 2100° F. but probably not greater than 2800° F. except for short intervals of time. During the above procedure of temperature change the crystals of the core structure **16** will change their chemical formula from

$$5CaO.5SiO_2.H_2O$$

to

$$CaO.SiO_2$$

Many ferrous or non-ferrous metals or combinations thereof may be used as the envelope for the core and possibly some non-metallic materials such as fireproofed wood veneers, etc.

The core materials to be utilized in carrying out this invention are to be of the crystalline compound form having the formula $5CaO.5SiO_2.H_2O$ and to be in integrated form and having a density always substantially less than that of the natural mineral xonotlite. The density of the product will of course be always dictated by the specific temperature condition to be coped with in any specific installation.

The lath-like microcrystalline structure utilized in this invention is of great value as insulation in the high temperature field and tests to determine its applicability indicate it will withstand excessively high temperatures for long periods of time without breaking or disintegrating.

For example, this material at 20# density, was subjected to a series of tests wherein the surface temperature, from direct flame application, reached approximately 2000° F. and after two hours of exposure thereto was subjected to a stream of cold water under pressure without shattering and with only superficial surface cracking.

The shrinkage of this material is extremely low when compared to other lime-silica products and its hardness of 6.5 according to Mohs scale, together with its quality of withstanding extreme thermal shock upon quenching makes it a most desirable product for many purposes and in particular for fire resistant structures. Such a product, because of its rigid structure lends itself to various forms or methods of finishing, such as shaping, cutting and sawing as well as the polishing of its surfaces to very smooth finish.

In Fig. 6 there is illustrated a structure wherein the channel **10** which may be metal or any fire resistant material, such as, fireproofed wood, and which extends entirely around the core **16** to thereby function both as a retaining element for the core **16** and a heat barrier as the core shrinks when subjected to high temperatures. Actually the member **10** may be of various shapes and forms provided it supplies the desirable barrier feature.

The core **16** may be of either monolithic in form or comprised of sections either in abutting or articulated arrangement. A fireproofed veneer crossband **30** is adhered to both faces of the core **16** and those edges **10a** of the channel **10** which are parallel with the faces of the core **16**. This assembly is covered over with a finishing veneer of fireproofed wood **31** adhered to crossband **30**. A facing **32** of fireproofed wood veneer may extend completely around the outer edges **20** of the structure as a finishing means or covering.

Modifications may be resorted to within the spirit and scope of the appended claims.

What we claim is:

1. A structural unit having a high resistance to fire and heat at a temperature of approximately 1200° F. comprising an outer fireproof envelope having a vent on the surface thereof sealed with a substance having a low melting point, and a highly porous integrated core completely filling said envelope, said core being a hydrous calcium silicate crystalline compound whose crystals have the formula $5CaO.5SiO_2.H_2O$, said core having free water therein, said structural unit having the property of increasing its resistance to fire and heat to at least 2000° F. upon being subjected to a temperature of approximately 1400° F., said vent being opened when the sealing substance therein is heated above its melting temperature to permit water vapor to escape through said vent, said core being converted to Wollastonite at a temperature of approximately 1400° F., said Wollastonite having the property of increasing the resistance of said structural unit to a temperature of at least 2000° F.

2. The structural unit defined in claim 1, wherein the

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outer fireproof envelope is of metal and the substance sealing the vent is lead.

3. The structural unit defined in claim 1, wherein said core consists of articulated tongued and grooved sections, each section being in interlocked relationship with each adjacent section.

4. A structural unit having a high resistance to fire and heat at a temperature of approximately 1200° F. comprising an outer fireproof envelope having a vent on the surface thereof sealed with a substance having a low melting point and a highly integrated core in sectional form filling said envelope, each of said sections of said core being a hydrous calcium silicate crystalline compound whose crystals have the formula $5CaO.5SiO_2.H_2O$, said core having free water therein, a heat barrier channel member in abutting relation with and completely surrounding the peripheral edges of said core, said structural unit having the property of increasing its resistance to fire and heat to at least 2000° F. upon being subjected to a temperature of approximately 1400° F., said vent being opened when the sealing substance therein is heated above its melting temperature to permit water vapor to escape through said vent, said core being converted to Wollastonite at a temperature of approximately 1400° F., said Wollastonite having the property of increasing the resistance of said structural unit to a temperature of at least 2000° F.

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