March 8, 1966 L. D. SOUBIER 3,238,677

FIRE-RESISTANT STRUCTURAL ELEMENT

Original Filed March 1, 1957

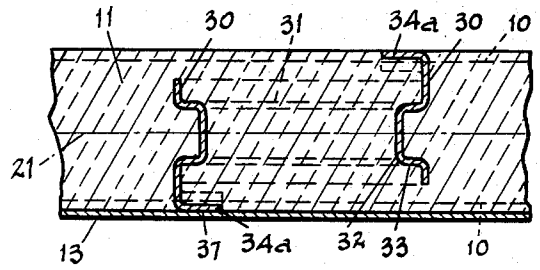


Fig. 3.

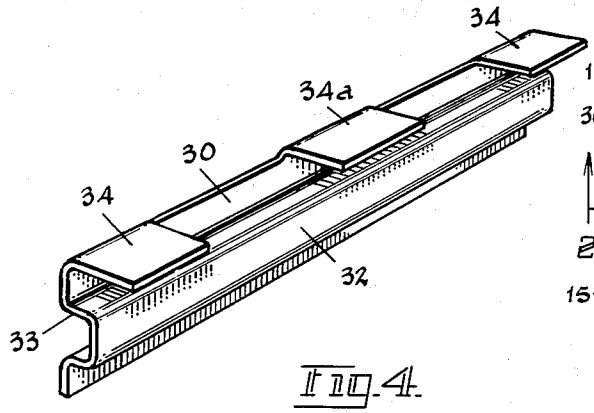


Fig. 4.

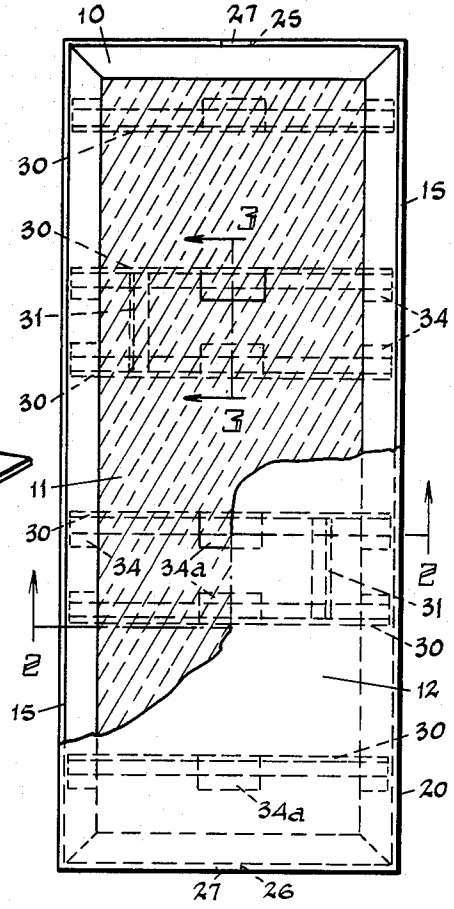


Fig. 1.

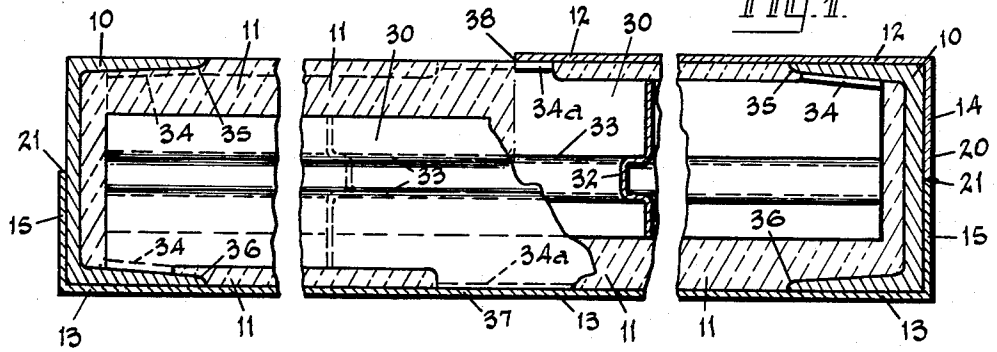


Fig. 2.

INVENTOR.
LEONARD D. SOUBIER
BY W. A. Schaich
Leonard D. Soubier

United States Patent Office 3,238,677
Patented Mar. 8, 1966

3,238,677

FIRE-RESISTANT STRUCTURAL ELEMENT

Leonard D. Soubier, deceased, late of Toledo, Ohio, by Olive M. Soubier, executrix, Toledo, Ohio, assignor, by mesne assignments, to Owens-Corning Fiberglas Corporation, a corporation of Delaware

Continuation of application Ser. No. 643,281, Mar. 1, 1957. This application Feb. 8, 1963, Ser. No. 261,551

9 Claims. (Cl. 52—98)

This is a continuation of application Serial No. 643,281, filed March 1, 1957 and now abandoned.

This invention relates to a metal firedoor, panel, etc., and a method of making same which will reduce the amount of labor involved, eliminate the usually-required mold equipment for shaping or forming the core portion and provide additional protection against high temperatures over that possible with present types of firedoors, panels, etc.

An object of this invention is to provide a firedoor, wall section, panel, a safe or similar structure having a core of insulating material such as synthetic xonotlite which is of light apparent density and which fills and contacts all of the interior portions of the structure.

A further object is to form or react the material in its structure in such manner that it may in its initial effect be a monolithic core.

A still further object is to form such a core with lines or planes of weakness which, when subjected to shock, pressure or high temperature, will be guided to part along the said planes of weakness but in such manner as to not permit transfer or transmission of heat, flame or gases therethrough.

Other objects will be apparent from the following:

In the drawings:

FIG. 1 is a face view of a door or panel with the top face covering partially removed;

FIG. 2 is a cross sectional view taken at line 2—2 on FIG. 1;

FIG. 3 is a cross section at 3—3 on FIG. 1; and

FIG. 4 is an isometric view of one form of the separator or spacer members of the frame or mold structure.

Although there may be other materials capable of use in the present invention, it is, however, preferred that synthetic xonotlite be utilized as the core material because it will actually increase its range of temperature resistance when subjected to high temperatures.

In the molding of xonotlite it is necessary to use rather high temperatures to convert the slurry to a solid. These temperatures cause the usual steel molds to have a rather large dimensional expansion and while so expanded the xonotlite forms and becomes a solid having these enlarged dimensions. Then as both the mold and the material cool down, the excessive shrinkage of the mold over that of the xonotlite engenders a condition where it is impossible to strip the xonotlite therefrom without excessive breakage or damage.

Such a shrinkage situation is very disadvantageous in the ordinary molding process, but in this present invention it becomes a desirable advantage in that every portion of the inside of the door or panel structure will be filled and a very desirable intimate contact will exist as between the core and the interior surface areas of the envelope or frame and the faces because the envelope or frame will serve as the mold into which the original slurry is poured and in which it is then indurated.

This frame or mold will be provided with horizontal and vertical cross members or spacers having certain desirable or specific shapes and which will be embedded in the integrated core in such manner as to leave a monolithic type of core with lines or planes of weakness created by these separators or spacers. These spacers may be so shaped as to give one of several different shapes to these lines of partible weakness and will be welded alternately to the top and bottom flange formations of the channel frame so as not to provide a means of heat conduction completely through the door or panel.

One method or procedure in making such a door, panel or other structure will be to pour into said mold or frame an aqueous slurry, having a water to solids ratio such as to give a density in the end product of approximately 10 p.c.f., place same in an indurator and convert the slurry to an integrated and dried core.

The only work necessary to finish the door or panel, subsequent to the integration of the core, will be to sand the exposed top surface of the core material so that it will be smooth and level with the top edge of the frame and then spot or otherwise weld, fasten or adhere the remaining face to the frame.

Such procedure will produce a firedoor or other structure of the metal clad type in which the core material is of light apparent density, capable of resistance to very high temperatures and having horizontal and/or vertical lines or planes of weakness provided therein so that when the structure is subjected to pressures or temperatures of a degree sufficient to cause bending or warpage the core will part along such lines with such parting guided or controlled by the shape of the spacer strips. This will tend to limit the possible cracking or parting of the core to these controlled areas.

In carrying out this invention there may be several forms of the invention, such as structural units, firedoors, partitions, document containers, etc., capable of high temperature heat or fire resistance wherein the envelope material is metal or other materials highly resistant to fire and/or high temperatures and wherein the core material consists essentially of a silicate compound in integrated crystalline form, such as synthetic xonotlite.

Synthetic xonotlite in integrated form is the preferred core material for the reason that when it is subjected to high temperatures it converts to wollastonite and then to pseudowollastonite, thus giving a temperature resistance range in excess of 2100° F. Further, by providing lines or planes of weakness in the core any cracking thereof, when subjected to pressures or temperatures beyond normal, will be guided along these formed lines or planes.

Conversion of the integrated xonotlite core to wollastonite, while confined in the fire resistant envelope, will lengthen the fire resisting time interval by at least the time interval required to remove the free water therefrom plus the time required to eliminate the combined water and complete the atomic rearrangement of the crystals in the change from xonotlite to wollastonite 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 considerable length before the core will reach a point of structural breakdown 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 molded synthetic xonotlite is sealed within a metal case and wherein the xonotlite has been dried to about 30%, by weight, 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, a plurality of spaced apart shaped spacers, extending between the sides of the frame or mold as well as between each other, are molded into the core so that when the core cracks it will part or separate along dentiform lines created by the spacers and form in effect articulated interdigitated sections which will give protection against leakage of gases or flame due to such warpage or cracking. Protection such as this is not possible of attainment with a normal 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 a monolithic type of core structure which when subjected to pressure or temperatures above normal will automatically become an articulated core by breaking or cracking along predetermined lines or planes of weakness. In this particular structure, a channel member **10** extends completely around the periphery of a core **11**. One of the major or face surfaces of the door unit may be formed by a sheet **12** of stainless steel or similar alloy covering one side of the door and the opposite side may be formed with a carbon steel face **13**. However, both faces may be of the same material.

The sheets **12** and **13** have their marginal portions turned inwardly in the form of flanges **14** and **15**, respectively, which overlie the channel **10**. The face plates **12** and **13** form with their respective marginal flanges **14** and **15** the edge surfaces **20** of the unit structure and may abut each other along the weld line **21**.

Vents **25** and **26** are provided respectively in the top and bottom edge surfaces of the door subsequent to the formation of the core **11** and are normally sealed with plugs **27** of low melting point material, such as some metal which will melt at or below the boiling point of water, for example, Cerromatrix metal, a low melting bismuth-tin-antimony alloy marketed by Cerro de Pasco Corporation. The purpose of sealing the vents **25** and **26** is to prevent the core **11**, after being formed and dried 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 **11** 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 in use is subjected to high temperatures.

In the preferred form as mentioned above, the core **11** is preferably initially formed of the crystalline compound xonotlite, in integrated porous form having a density of approximately 10 p.c.f. to about 25 p.c.f. or such lesser or greater density as the end use may dictate, and that said core, although monolithic in form, is in readily partible or separable sections having tongue and groove shaped spacers **30** and **31** between each other extending horizontally and, where nceessary, also vertically therethrough.

Such a core **11** when subjected to sufficiently high temperature for a sufficient length of time will lose 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 toward warpage and the possible cracking of the core material. The articulating spacers **30** and **31**, being of a type having tongues **32** and grooves **33**, tend to prevent uncontrolled 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 if such spacers are not provided.

These separators or spacers may have various shapes, one, for example, as shown in FIG. 3 where the spacers **31** are identical in shape but so positioned opposite each other as to provide lines of weakness extending through the center section of the core **11**.

In this type of fire door, where the core **11** is of the monolithic type, it is necessary to make provision in the

structure to offset the shrinkage which will occur when the core is subjected to these high temperatures. For example, if the door is subjected to a temperature sufficiently high to cause xonotlite to convert to synthetic wollastonite, there will be an overall shrinkage in the length, width and thickness of the core. By providing a heat retarding element such as the channel structure **10** with its flanges around the periphery of the core **11** or some similar means, any vacant space created by such shrinkage will automatically remain enclosed and a barrier to the transmission of fire provided.

With respect to the spacers, the tongue **32** and groove **33** portions are of such depth and width that it would be necessary for all three interdigitated legs or splines of the core **11** to be broken off in order to permit the excessive passage of heat, etc. The total shrinkage in the xonotlite core, for example, from its usual width will be approximately .7%, 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 controlling the thickness of the core to suit particular or specific conditions of heat exposure.

The basic feature herein disclosed comprises the building of a firedoor or other unit having a monolithic type core **11** 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 the change in physical and/or chemical form and/or the atomic rearrangement of the crystals forming the porous integrated core **11**.

A monolithic form of core **11** in partible sections as shown in the figure may be made and utilized as follows:

A hollow firedoor frame **10**, 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 the edge surface of the core **11**, and with the face surface fastened in position a frame or mold is fashioned. The top open face form the fill opening through which a xonotlite slurry is poured to fill said frame or mold. Vents **25** and **26** are provided after induration of the core to obviate air or vapor entrapment occurring subsequent to the molding of the core. These vents may be closed or left open as desired.

Separator strips **30** having welding flaps **34** and **34***a* and a tongue **32** and groove **33** shape through their length with flaps **34** alternately welded to the top flange **35** and bottom flange **36** of the channel **10** so that in the complete assembly each alternate separator is welded to the top flange **35** and the other strips to the bottom flange **36** to form a staggered arrangement of separator strips. This construction also permits the bottom face **12** to be tied to the alternate strips **30** as at **37** and the top face **13** to be finally tied to the balance of the strips as at **38**.

These strips **30** and **31** are made of fairly thin metal, which may be on the order of 26 ga., in order that they may have some degree of flexibility when functioning as the tongue and groove member of the core.

This frame or mold is then filled with slurry, placed in an indurator, with the pouring opening still open, subjected to a pressure and temperature and for a time interval sufficient to convert the slurry to an integrated and dried monolithic structure of a crystalline compound, the crystals of which have the formula

$$5CaO \cdot 5SiO_2 \cdot H_2O$$

This core material is dried in its mold or frame and the free water is evaporated, for example, down to approximately 30%, by weight, @ 300° F. The pouring opening in the door is then sealed with the face member **12** and the vents **25** and **26** provided. We now have a steel fire

door in which the core **11** (xonotlite) has a normal fire resistance up to approximately 1400° F. without any structural change either chemically or physically other than slight thermal expansion. 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 unaffected chemically 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 **11** is that it may begin a gradual structural breakdown 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 member **10**, which extends around the inside of the metal case and functions as a barrier to the heat transfer when the core **11** shrinks, may be made of metal or other materials resistant to high temperatures, such as treated wood.

It will be apparent from the drawings that the separator strips **30** and **31** are so designed that they do not extend completely through either the thickness or width of the core and for this reason they will not function to conduct heat therethrough. However, they do provide sufficient separation or demarcation lines, or narrow cavities, through the width and thickness of the core so that, if for any reason any tendency of the core to warp or crack should occur, these weakened areas will part rather easily and thus guide the line of separation in a controllable manner.

Such a structure thus permits an originally monolithic structure to become a sectionally articulated structure when subjected to excessive heat and/or pressure.

It is contemplated that the separators **30** and **31** may be constructed and/or shaped in several different manners or from different materials, such as wire, screening or other materials, which materials or shapes will provide the desired control and predetermined pattern of cracking or separation in the core **11**, as well as holding the face members **12** and **13** in intimate contact with the core.

From the preceding it should be quite apparent that a firedoor produced in accordance with a preferred embodiment of the present invention will have a core **11** which following its initial production will possess 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 will have a fire resistance which progressively increases at least another 1000° F. and which will have a still further potential fire resistance at a temperature of at least 2100° F. but less than 2800° F. for short intervals of time. During the above procedure of temperature change the crystals of the core structure **11** will change their chemical formula from $5CaO \cdot 5SiO_2 \cdot H_2O$ to $CaO \cdot SiO_2$.

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

I claim:

1. A fire resistant structural element comprising a solid body of crystalline structure core material in integrated form and an enveloping outer covering therefor, said covering comprising a metal peripheral frame having spaced flanges engaging opposite faces of said core material, faces of fire resistant material adhered to said flanges in opposing relationship, a plurality of tongue and groove shaped separators embedded in said core material and spaced apart through the length of said frame and extending approximately through the width and thickness thereof, said separators forming predetermined dentiform planes of weakness arranged throughout said core, welding flaps on each separator adapted for limited contact with one of said faces and its supporting flange, the flaps of each alternate separator contacting and being attached to the same face and flange, the flaps of the remaining separators being attached to the opposite face and flange and said core material surrounding substantially the entire perimeter edges of said separators and filling said flanged frame.

2. A fire resistant structural element in accordance with claim **1**, said core material being integrated synthetic xonotlite.

3. A fire resistant structural element in accordance with claim **1**, said core material containing approximately 30% by weight uncombined water.

4. A fire resistant structural element in accordance with claim **1**, said core material being integrated synthetic xonotlite and containing approximately 30% by weight uncombined water.

5. In a fire resistant structural element comprising a monolithic and generally rectangular core of insulating material composed essentially of synthetic xonotlite containing approximately 30% by weight uncombined water and having the chemical composition of

$$5CaO \cdot 5SiO_2 \cdot H_2O$$

and an outer envelope covering said core, a plurality of longitudinally elongated narrow cavities defined in and across opposite faces of said core and having a sinuous laterally disposed configuration projecting through a substantial portion of the thickness between said opposite faces, said cavities being arranged in oppositely staggered relationship and respectively defining a laterally disposed sinuous configuration, whereby said cavities afford predetermined sinuous planes of weakness between said opposite faces of said core conforming to the shape and location of said cavities.

6. A fire resistant structural element comprising a core and an enveloping outer covering therefor, said covering comprising an edge forming frame, faces of fire resistant material adhered thereto in opposing relationship, and mutually separated by the thickness of said core, said core being a monolithic body of integrated synthetic xonotlite of light apparent density ranging from about 10 to 25 pounds per cubic foot and having a reticulate array of elongated separators respectively having laterally disposed tongue and groove shaped configurations embedded therein and extending through the major portion of said thickness thereof between said faces of fire resistant material to thereby form predetermined planes of weakness within said core conforming to the shape and location of said separators, and said synthetic xonotlite containing approximately 30% by weight uncombined water.

7. A fire resistant structural element comprising a core and an enveloping outer covering therefor, said covering comprising an edge forming frame peripherally encompassing said core, faces of fire resistant material adhered thereto in opposing mutually spaced relationship, said core being a monolithic body of integrated synthetic xonotlite of light apparent density ranging from about 10 to 25 pounds per cubic foot and containing approximately 30% by weight uncombined water and with the thickness thereof sandwiched between said opposite faces, and at least one elongated shaped member molded in and longitudinally spanning a major portion of the distance between opposite peripheral portions of said core, said elongated shaped member having a laterally disposed tongue and groove shaped configuration extending through a major but only partial portion of the thickness of said core, said elongated shaped member thereby serving to mold at least one cavity in said core conforming to the location and configuration of said elongated shaped member and constituting a plane of weakness extending through the thickness of said core and running between oppositely disposed peripheral portions thereof.

8. In a fire resistant structural element comprising a generally rectangular, monolithic core of solid insulating

material and an outer envelope covering said core, a plurality of elongated narrow cavities defined in opposite faces of said core and longitudinally spanning a major portion of the distance between opposite peripheral edges of said faces, said cavities being arranged in oppositely staggered mutual relationship and respectively defining a sinuous laterally disposed configuration projecting through a major portion of the thickness between said opposite faces whereby said core is provided with predetermined resultant planes of weakness corresponding to the shape and location of said cavities within said core.

9. A fire resistant structural element in accordance with claim 8, said insulating material containing approximately 30% by weight uncombined water.

References Cited by the Examiner

UNITED STATES PATENTS

838,672	12/1906	Tyra	189—46
1,554,395	9/1925	Young.	
2,137,184	11/1938	Seil	50—157
2,238,355	4/1941	Whitenack	50—448 X
2,547,127	4/1951	Kalouseck.	
2,717,062	9/1955	Dusing et al.	189—46
2,787,345	4/1957	Soubier et al.	

FOREIGN PATENTS

123,633	12/1948	Sweden.

EARL J. WITMER, *Primary Examiner.*