

July 13, 1943.

D. ROBERTS

2,323,936

INSULATING CONSTRUCTION ELEMENTS

Filed July 15, 1937

4 Sheets-Sheet 1



Fig. 1

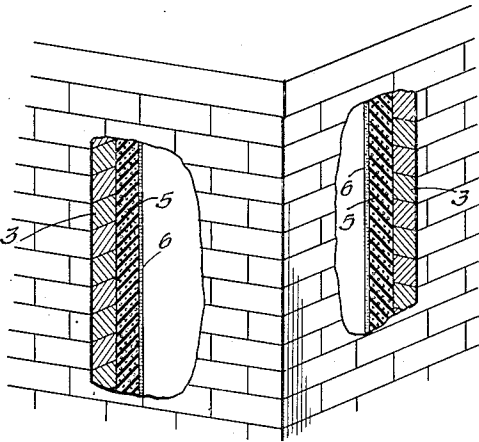


Fig. 2

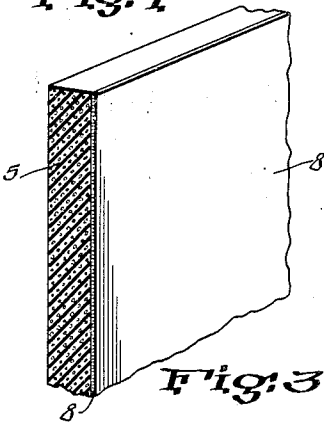


Fig. 3

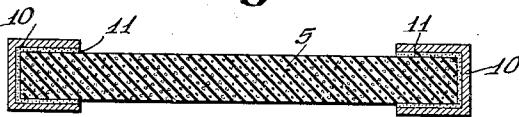


Fig. 4

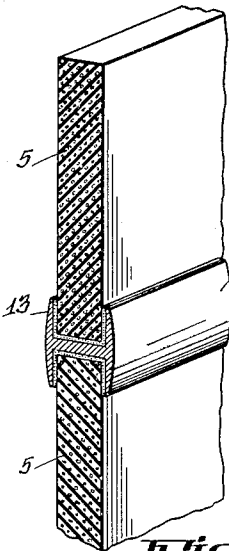


Fig. 5

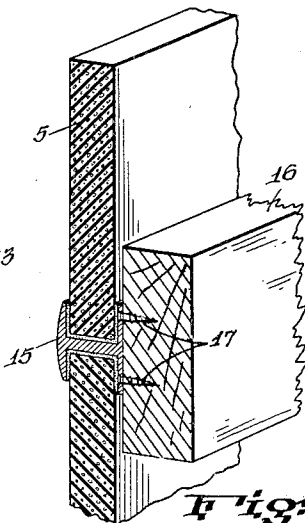


Fig. 6

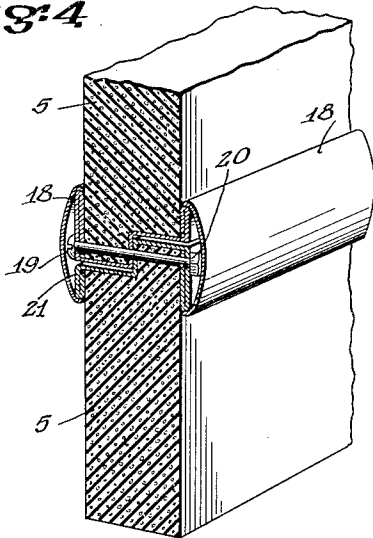


Fig. 7

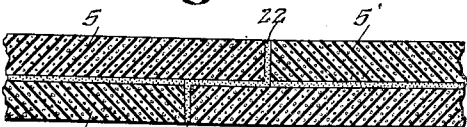


Fig. 8

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INSULATING CONSTRUCTION ELEMENTS

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4 Sheets-Sheet 2

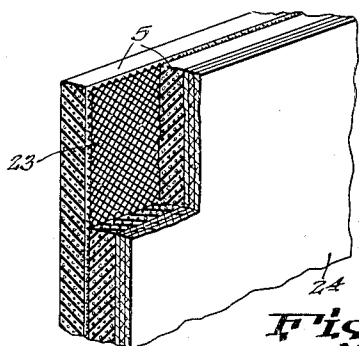


Fig. 9

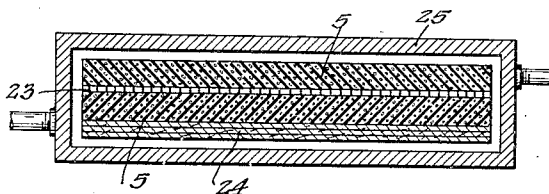


Fig. 10

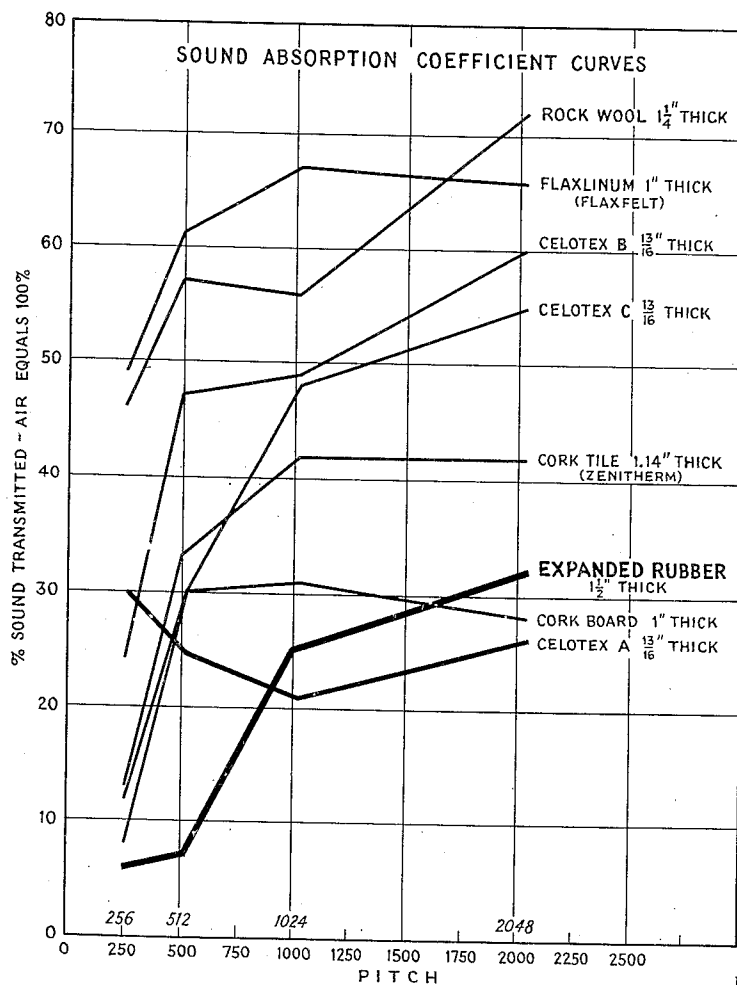


Fig. 11

LOWER C (ORGAN) - 16
PIANO, LOWER C - 126
MIDDLE C - 545
HIGH C - 770

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4 Sheets-Sheet 3

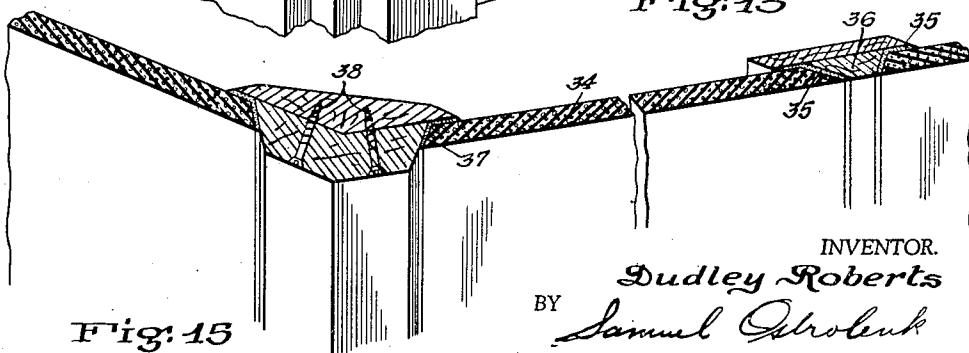
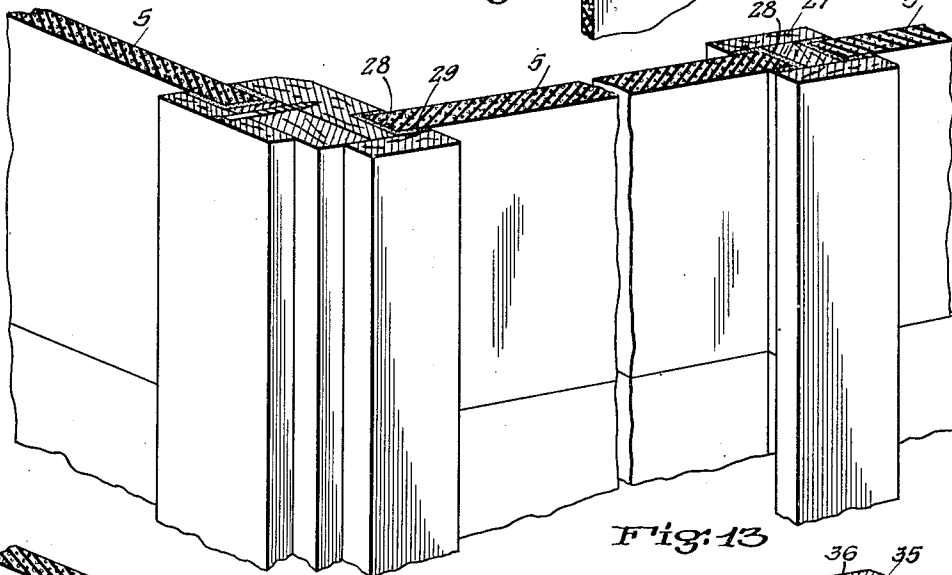
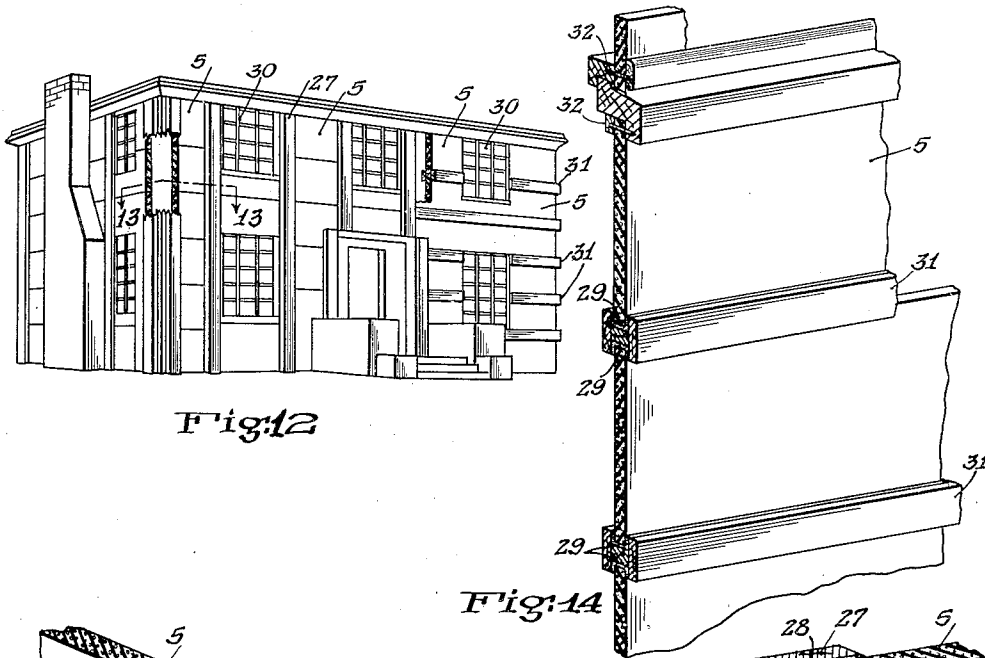


Fig. 15

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INSULATING CONSTRUCTION ELEMENTS

Filed July 15, 1937

4 Sheets-Sheet 4

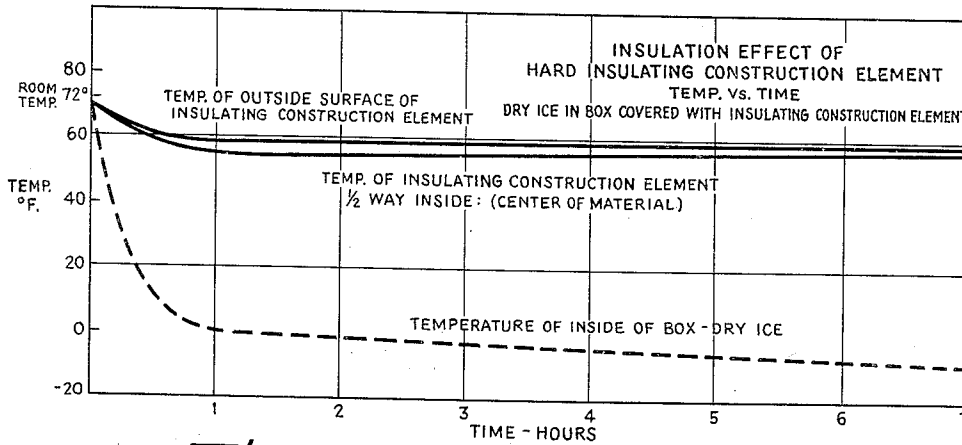


Fig. 16

INSULATING CONSTRUCTION ELEMENT CONTAINING WHITING
 A - TEMPERATURE OF SURFACE EXPOSED TO DIRECT HEAT VS TIME
 B - TEMPERATURE $\frac{1}{2}$ " FROM SURFACE OF BOARD VS TIME
 C - TEMPERATURE OF BACK SURFACE OF BOARD VS TIME

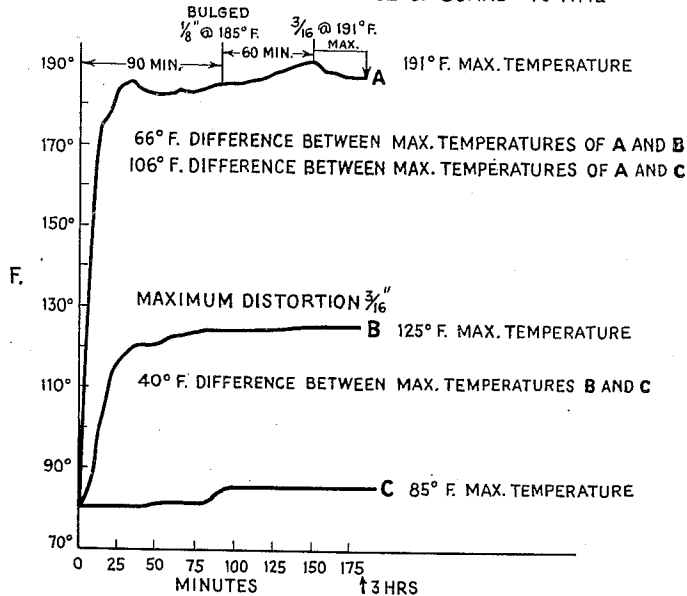


Fig. 17

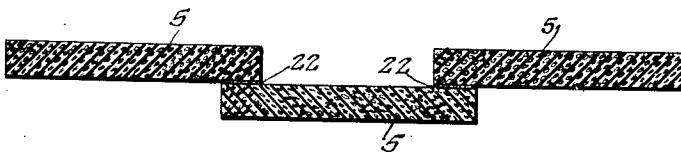


Fig. 18

BY

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UNITED STATES PATENT OFFICE

2,323,936

INSULATING CONSTRUCTION ELEMENT

Dudley Roberts, New York, N. Y., assignor to
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poration of Delaware

Application July 15, 1937, Serial No. 153,709

5 Claims. (Cl. 154—44)

My invention relates to a new insulating construction element for housing of new and unexpected properties with relation to low thermal capacity, waterproofness, great structural strength, light weight, high sound and heat insulating values, and other new and unusual properties that enable this construction element to be used by itself, without any other material such as brick, as a wall for a house.

Thus, for building low cost homes, a simple framework of grooved wood or metal members can be erected and the insulating construction elements of my invention slid into engagement therewith to provide inexpensive, waterproof and properly insulated walls of satisfactory strength.

Heretofore no single wall element has been known that possessed the necessary properties of waterproofness, structural strength, low thermal capacity and high insulating values that would enable it to be used by itself as wall material for housing.

Accordingly, in general, my invention contemplates a fabricated house construction in which my novel insulating construction element is the sole wall structure for the house, the outer surface of the insulating construction element facing the outside of the house and the inner surface facing the inside of the house.

The frame construction of the house is so arranged, as will be described in more detail hereinafter, as to permit the insulating units to be slid and secured in place frictionally and by cement.

The unique combination of properties of my material, that is, specifically, its water proofness, its low thermal capacity, its high insulating values with respect to sound and heat, its great structural strength and light weight, all of which will be explained more fully hereinafter, are peculiarly suitable to replace all of the component parts of wall construction for houses used up to this time.

The insulating construction element of my invention comprises expanded rubber or rubber-like plastic material, and in physical appearance represents a mass of rubber containing therein an infinite number of small bubbles of enclosed gas. These enclosed cells of gas are themselves sealed and sealed from each other, and are responsible for the light weight of the material and its insulating and other unusual properties. The insulating element can be made by a process as set forth in application Serial No. 706,773, filed January 15, 1934, Patent No. 2,091,335, issued August 31, 1937, of which I am a co-inventor and of which this application is a continuation

in part. Therein is described a method of expanding rubber by subjecting the rubber to an externally applied gas.

The expanded rubber element of my invention can also be made by a process using an internally developed gas. These processes will be more fully explained hereinafter.

In home construction, there has long been a search for an insulating element that will meet the rigid specifications required. In part, these consist of light weight, to obviate the necessity for steel or concrete supporting structures of great strength and therefore great expense.

In addition to light weight, the ideal material should be moisture proof so that no water or water vapor can permeate the walls; have high heat insulating properties to minimize, as far as it is possible, the necessity for developing heat within that will not be directly used in heating the air of the inside rooms themselves.

In this latter connection the thermal capacity of the insulating element which directly faces the room is of great importance. The heat capacity or thermal capacity of material is the amount of heat required to raise the temperature of 1 gram of the material 1° centigrade at 15° C. If the element requires a great amount of heat to increase its temperature, obviously when seeking to warm a cool room, a large portion of the heat developed by the heating means must be expended to bring these walls up to the proper temperature as well as to bring the air which is contained in the room to the desired temperature. This is a condition that would result when during cold weather windows are left open, as at night in the the bedroom. Conversely, in hot weather, when the walls have been heated up by the sun during the day, if their thermal capacity is high, the cooling influence of the evening cannot bring down the temperature in any appreciable time. Thus it can be seen that the thermal capacity of the material, that is its specific heat, is an important factor in insulating elements for housing.

Another problem with respect to such insulating elements resides in rendering them resistant to the attack of vermin, termites and rats.

With respect to modern housing, sound insulation is an extremely important problem. With the increase in external noises, the problem of preventing such noises from entering the house is of vital importance.

Many materials have hitherto been used as insulation compositions in the form of panels and the like. Such materials comprise "Celotex," porous light wood, a mix of hog hair and asphalt,

granulated cork with binder, wood fiber with binder, vegetable fiber in cardboard, as well as the usual construction materials, such as cement and steel. All these materials are subject to great deficiencies with respect to the desirable properties above listed.

"Celotex," porous light wood, cork and vegetable composition materials, are all subject to dry rot and damp rot since they are water-absorbent. They have little structural strength in themselves; their impact and tensile strength is low; they are of only moderately light weight; their sound and heat transmitting value is far from the ideal material. They are subject to attack by vermin, termites and rats. They are so absorbent that, to effect a coating thereupon, an unusually large amount of coating material is required because of the large seepage therein. It is difficult to effect a good laminated structure using these materials because of their relatively brittle nature.

All these materials because of their lack of many desirable properties in insulating and structural values have been found wanting and have been used only because of the lack of anything approaching an ideal structural element. The other ordinary construction units of satisfactory structural strength composed of steel or concrete have the marked disadvantage of extreme weight, entailing great expense in transportation and installation in addition to the weight load imposed upon the structure wherein they are used. Their heat insulating properties are only fair. Their thermal capacity is markedly high.

An object of my invention is to provide a new and unusual insulation and construction element.

Another object of my invention is to provide a new construction element of extremely low heat capacity.

Another object of my invention is to form a new construction element of high impact and tensile strength.

Another object of my invention is to provide a new construction element of extreme light weight.

Another object of my invention is to provide a new construction element that not only absorbs no water but is unaffected by water or water-vapor.

Another object of my invention is to provide a new construction element with unusual resistance to the transmission of sound.

Another object of this invention is to provide a new construction element that is vermin-proof and not subject to attacks by insects, such as termites, or by rats.

Another object of my invention is to provide a new construction element comprising gas expanded rubber of closed cellular structure.

Another object of my invention is to provide a new insulation element comprising an expanded mixture of rubber and a resin modifying agent.

Another object of my invention is to provide a new insulation and construction element comprising a gas expanded mixture of rubber and phenol-formaldehyde condensation product.

Another object of my invention is to provide a new insulation and construction element of gas expanded rubber with an added coating of reflecting value for reflecting and resisting heat waves to add to the material's heat-insulating properties and impact strength.

Another object of my invention is to provide a new construction element comprising a laminated element with a wood exterior and an expanded rubber interior.

Another object of my invention is to provide a new construction element comprising a steel member and gas expanded rubber attached thereto during the process of expanding the rubber.

Another object of my invention is to produce a new construction element comprising a rubber expanded to contact with a metallic re-enforcing member and a decorative facing material, such as wood, metal or other similar substance.

Another object of my invention is to produce an incubator of such low heat capacity as to provide a completely uniform temperature.

There are other objects of my invention which, together with the foregoing, will appear in the detailed description of my invention which is to follow in connection with the drawings, in which:

Figure 1 is the perspective view of a house in which a cut-away portion indicates the use of a novel insulation material of this invention.

Figure 2 is an enlarged perspective of the cut-away portion indicated in Figure 1.

Figure 3 shows a modified form of a coated construction element.

Figure 4 shows the utilization of a construction element of my invention in sliding engagement in a channel frame.

Figure 5 shows a mounting for an assembly of the expanded rubber construction elements of my invention.

Figure 6 shows modified assembly construction elements in which such assembly is joined to a frame member.

Figure 7 shows a still further modification of a means for joining construction elements to obtain a strong engagement and a water and airtight seal.

Figure 8 shows a modified assembly of the construction elements of my invention in which a strong fit and a water-proof seal is obtained.

Figure 9 shows a composite structure in which two slabs of expanded rubber are molded about and in contact with a sheet of expanded metal and a wood veneer surface.

Figure 10 shows a means for expanding the expanded rubber in contact with the expanded metal and wood veneer.

Figure 11 is a chart showing the sound absorption coefficient curves of the expanded rubber construction element of my present invention in comparison with similar materials.

Figure 12 represents a perspective of a house in which the expanded rubber construction elements of my invention constitute per se the walls.

Figure 13 represents a section in perspective taken along a line 13-13 of Figure 12. Therein is shown the practical use of the construction element of my invention as a wall for a house. The wall material is securely placed in vertical grooved frame members.

Figure 14 is a modification showing the horizontal placing of this wall material in horizontally extending grooved members.

Figure 15 is a modification showing the use of the construction element of my invention as a wall material per se in which engagement is maintained with a frame by friction and cement.

Figure 16 is a graph showing the insulation effect of the hard insulating construction elements of closed cell expanded rubber of my invention with respect to the transmission of cold.

Figure 17 is a chart showing the insulating effect with respect to heat as determined on both surfaces and the middle of the closed cell expanded rubber construction element of my invention.

Figure 18 shows a novel use and assembly of the closed cell gas expanded rubber construction element in overlapping relation.

The expanded rubber which comprises the rigid construction element of my invention is made in this way. A composition comprising the following constituents:

	Parts
Rubber, washed first grade crepe, smoked or rubber reclaim-----	100
Sulphur-----	50
Asphalt-----	25
Light calcined magnesla-----	6 1/4
Gilsonite-----	25

These constituents are thoroughly mixed on masticating rolls, the rubber being first masticated for a period of time depending on the poundage of rubber desired. To this is added the asphalt uniformly distributed over the rubber. In order to fully impregnate the asphalt in the rubber the mixture is taken to a dark room for a period of 24 hours rest, at the end of which time it is placed on a warm mill and heated to a temperature not to exceed 100° F. to plasticize the product. With the production of a plastic state, the sulphur, calcined magnesla and gilsonite in the proportions as stated above, are then added and the resultant mixture held inactive for a second rest period of 24 hours to permit thorough impregnation. This resultant dough is then taken and manufactured into various articles such as slabs, boards, etc., suitable for use in construction elements by means of a warming-up mill or forcing machine and then cut into desired sizes. The formed rubber mix in an hermetically sealed autoclave is then subjected to an inert gas for 5 hours at about a pressure of 3,000 pounds per square inch and at a temperature of about 236° F. This temperature causes a partial vulcanization of the rubber so that the injected gas is held therein. The gas impregnated rubber in the autoclave is then cooled by means of a water jacket located in the wall of the autoclave for two hours, the gas pressure released and the gas impregnated formed rubber is placed into molds either alone or in combination with metallic reinforcing means and decorative surfaces as will be more fully described hereinafter. The mold must be of the exact shape desired in the finished article. The mold is closed and subjected to heat. The heat expands the gas enclosed in the rubber, thereby increasing the volume of the rubber upwards of 600 per cent, and vulcanizing the rubber to permanently cure it. The expansion of the rubber forces it into intimate contact with the other elements adjacent in the mold and a firmly composited construction element is formed.

To effect the final vulcanization and expansion of the gassed rubber a temperature of about 328° F. over a period of about 2 hours is employed. In the process hereinabove explained, nitrogen gas is used as the gassing medium. Under slightly varied circumstances, other inert gases such as helium or carbon dioxide may also be used. Although it is obvious that the portions and the times given in this process may be varied within the spirit of the invention, certain steps set forth in the paragraph above are of vital importance in obtaining an expanded rubber with the unusual properties desired in the material. For instance, the rest period of 24 hours or thereabouts in a dark room, after the initial mastication is of great importance in restoring to the rubber the natural properties

which apparently are disturbed because of its violent working. As I have pointed out in my prior application, the molecular structure of rubber is theoretically described as normally in the form of a spiral or in extended molecular arrangement. This may be thought as giving to the rubber its elasticity and strength.

During the working of the rubber described above a disturbance of the molecular structure apparently occurs and the rubber tends to lose its natural properties. I have discovered that it is essential to provide a rest period for the rubber after the violent working operation to permit the rubber to regain its normal molecular arrangement. This rest period is given the rubber mix after the incorporation of the asphalt and mastication of the rubber and again after the sulphur, calcined magnesla and gilsonite are added on the mixing rolls and the rubber formed into a suitable shape.

The bituminous material, in the example asphalt, acts as a flux at low temperatures in the stage of partial vulcanization. By this I mean that it assists in the partial vulcanization. The ground gilsonite acts as a high temperature flux and assists in the final vulcanization.

The calcined magnesla is added as rubber toughener and plays a valuable part in my compound. Any equivalent rubber toughener, such as zinc oxide may replace the calcined magnesla.

Of extreme importance in obtaining an insulating element of the desirable properties herein set forth, is the step of partial vulcanization also set out above. The partial vulcanization gives a set to the rubber so that the gas that has been formed therein cannot escape and assures a cell tight structure of sealed non-communicating cells throughout the mass.

Referring now more particularly to the drawings, in Figure 1 I have shown, a cut-away portion 2 of a house indicating a means by which the insulation element of this invention can be utilized.

In the enlarged showing of this cut-away portion in Figure 2, it is noted that the exterior of this house is composed of bricks 3 and that on the interior of the house facing the room is a layer of the expanded rubber insulation element 5 of this invention with a decorative facing 6. This facing 6 may be either a wood veneer or other similar solid decorative facing, or a paint or coating by which decorative effects are achieved and further advantages in the properties of the expanded rubber construction element are obtained.

In Figure 3 a composite of an expanded rubber element and wood veneer is shown in perspective. The wood veneer 3 is joined to the expanded rubber insulation element 5 during the process of expanding the rubber.

In Figure 4 an expanded rubber insulation element 5 has been slid into engagement with the channel-shaped frame members 10, and in addition to the friction engagement obtained thereby a cement 11 is used to obtain further adhesion. The element is slid into engagement with its long side horizontally disposed, the channels 10 being vertically disposed. This provides a simplified assembly of construction elements.

In Figure 5 two expanded rubber insulation elements are joined by means of a metallic mounting 13 into which these insulation elements are fitted. To secure a strong fit and absolute seal, an adhesive is employed between

metallic mounting 13 and the insulation element 5.

In the modified showing in Figure 6 one side of the metallic mounting 15 is given a flat contour and provision is made for the entry of screws or fastening means 17 therein so that engagement can be made between such mounting 15 and an ordinary frame member 16. The manner of securing assembly of such mounting element with both frame and insulation elements in which an excellent seal is achieved can be seen.

In Figure 7 I have shown an extremely efficient way of securing firm engagement between two expanded rubber elements of my invention. In perfect physical engagement to secure a strong structure and a water tight fit, two expanded rubber elements 5 are molded so that their ends present a step arrangement as shown in Figure 7. Under the so shaped ends are fitted metallic fittings 21 which are formed by bending sheet metal of proper size back upon itself at its ends and shaping the middle of it in accordance with the shape of the molded elements 5. The fittings are then placed upon the ends of the rubber elements and joined by means of a fastening means 19 held in place by nut 20, the bolt 19 extending through both metallic fittings and both rubber elements. Over the folded ends of these metallic fittings and in friction engagement therewith is placed a metallic assembly means 18. This serves to protect both the joint metallic fittings and the fastening means.

Figure 8 shows a modified mounting in which insulation elements 5 are joined in overlapping relationship by means of a suitable cement to obtain a water-proof fit. In this figure the two elements 5 as well as the other two elements 5' can be molded in joined relation during the process of manufacture and the two elements thus formed joined by a cement along the line 22 only to obtain a simple water-proof seal.

In Figure 9 is shown two slabs of expanded rubber expanded in contact with a sheet of expanded metal 23 in between them, and in further contact with a veneer 24.

Figure 10 shows means for joining elements in Figure 9 during the process of manufacture of the element. In a mold 25 is laid first the wood veneer 24. Over that is laid a slab of expanded rubber 5. Thereover is placed a sheet of expanded metal 23, and over the sheet of expanded metal 23 is placed another slab of expanded rubber 25. On being subjected to heat in the mold, the gas enclosed in the rubber expands, thereby expanding the rubber into firm and intimate contact with the expanded metal and wood veneer.

Figure 11 is a chart showing the sound absorption coefficient curves in which the properties of expanded rubber are compared with insulating materials now commonly used.

In Figure 12 is shown a modern low cost house in which a simple construction is set forth using the expanded rubber construction element of my invention. In the frame members 27 are grooves 28. The frame members 27 may be of wood, metal or similar material. Since the insulating construction element of my invention is light in weight and is no great load on the frame members 27, their weight and thickness can be much less than frame members now used in house construction.

As shown in more detail in Figure 13, the frame members are first set up in their vertically aligned position. Thereupon, the insulating con-

struction elements 5 are slid in frictional engagement with the frame members 27 and secured therein by means of a cement 29. Not only can the insulating construction elements 5 be slid in the grooved members to take their proper position in the wall, but the windows 30 may also be placed in the frame members in the same way.

In Figure 14 is shown a modification in which horizontally placed frame members 31 are so positioned that the insulating construction elements 5 can be slid into fit therewith along a horizontal path. If desired, a cement 29 may also be used to firmly secure the insulating construction elements in place. A further securing means such as the screw 32 may be employed to fasten the insulating construction elements securely in place to the frame members.

In Figure 15 is shown a further modification in which a wedge shaped insulation element 34 with diverging edges 35 are placed in frictional engagement with the similarly shaped frame members 36. A suitable cement 37 may be used to secure permanent engagement. The frame members may be assembled with suitable fastening means 38.

Figure 16 shows the effect of this construction element in insulating with regard to low temperatures. In the chart herein set forth a quantity of solid carbon dioxide-dry ice is placed inside a box comprising the insulating 1½ inch construction element of my invention. As can be seen from the graph where the dotted line represents the low temperature developed inside the box by the dry ice, and the solid line immediately thereabove represents the temperature of the insulating construction element half way therein (in the center of the material), and the uppermost solid line represents the temperature of the outside surface of the insulating construction element, the material acts as an excellent insulation against cold. It can be seen that there is no substantial difference between the temperature in the center of the construction element in this experiment and the temperature on the outside surface thereof. This shows the high quality of the insulating properties.

Figure 17 represents a graph showing the influence of a high temperature when directed on a surface of a 1½ inch insulating construction element containing whitening. The legends set forth in the chart fully explain the showing thereof. The chart sets forth graphically the marked insulating properties of my material with respect to high direct heat. Thus, although the external surface of the material reaches a temperature of 191° F., the interior climbs only to 125° F. and the innermost surface is raised but slightly to a maximum of 85° F.

Figure 18 shows a novel assembly of my construction elements in which a particularly simple method of forming large surfaces from comparatively small units is shown. Therein construction elements 5 are joined with an overlap secured by a cement 22. The overlap can be a desired length depending upon the particular strength factors required of the ultimate assembly. The overlap can obviously be varied to provide a step assembly which is particularly effective as a water-proof structure as in roof manufacture. The assembly set forth is simple, requires little skill and can be utilized for all manner of structures without special training. The assembly makes it possible to use small units in place of relatively bulky large slabs which have

been found more difficult to manufacture and transport.

The various properties of this new construction element will be taken up separately.

The structural strength of the expanded rubber construction element resides in its compression, impact and tensile strength. The material has a compression strength of 72 pounds per square inch. By reason of the fact that it is composed entirely of small bubbles of gas filled rubber, its strength resides in the arch produced by each of these bubbles. An arch is known to be the ideal structure for the strength properties. It is because of this that the material has high tensile and impact strength. The extreme light weight of the element which approximates 4 to 5 pounds per cubic foot is due to the fact that the material is expanded to many times its original size and is composed primarily of enclosed gas areas bounded by rigid rubber cell walls. This extreme light weight renders it very valuable in building operations because of the lightness of the load on the framework. The cost of transportation and manipulation is far lower than construction elements of similar strength.

One of the prime advantages of the insulating construction element of the present invention resides in the great ease in shipping and in manipulation of the elements in what is termed pre-fabricated housing. A wall panel constructed in accordance with the present invention would weigh about 30 pounds. A concrete panel, such as is commonly used, of the same size would weigh 720 pounds.

The water-tightness of the material is absolute. Water-condensation is a common factor in the deterioration of the "Celotex"-type wall; that is, during the cooling down of a structure comprising "Celotex," water from the air is condensed on the surface thereof and seeps into the material, causing, in time, deterioration and rot. This expanded rubber construction element has been subjected to water for 110 hours continuously and has been found to take up only .4 per cent of water. On being exposed to the air for 48 hours, only .002 of water remains. This low percentage of water absorbed is obviously negligible. Again, the water-proof nature of this material prevents seepage or striking through of water or dampness from the outside atmospheric conditions to the interior of the structure in which it is used. It has been necessary in the past in using the "Celotex" type of insulation to have a complete water-proof barrier seal between the "Celotex" and the outside of the structure. The necessity of this barrier is eliminated when this expanded rubber construction element is employed.

The low heat capacity of this element is a new and vital factor in house construction. In an ordinary house during cold weather, windows are opened at night during sleep. When it is desired in the morning to re-heat the house, not only must the air within the room be brought up to the desired temperature but a tremendous amount of heat is needed to bring the brick walls up to the desired room temperature. This is because brick has a very high heat capacity. This will be made more clear when I refer to the fact that a heated brick will remain heated for a long period of time because of the contained heat and, inversely, it requires an appreciable amount of time to heat up a brick. The expanded rubber material which comprises this construction element is entirely different. Because of

its low heat capacity it not only can be heated up very rapidly but also discharges this heat load as rapidly on being subjected to cooling influences. A concrete illustration of the superior properties of this material is shown by the fact that it takes approximately 100 times more heat to bring the inside of a brick wall having the same insulating value as the construction element of the present invention from 0° to 70° F., than it takes in the case of the expanded rubber wall herein disclosed. This is an illustration of the condition that would occur from leaving bedroom windows open at night, and turning heat on in the morning.

The low heat capacity of the construction element of my invention makes possible additional advantages when it is employed in the construction of, for instance, rooms since only a minimum of heat is required to bring the material which comprises the walls to the desired temperature. The major portion of the heat required to heat the room is devoted to raising of the temperature of the enclosed air. Since this air is easily measurable, the heat required to raise and maintain this air to a proper temperature is easily determinable. Since this is so, the heating means can be regulated with respect to their time of operation and according to the amount of heat that has been delivered into the room.

Actual data on the specific heat of this expanded rubber element in comparison with similar materials follows:

Specific heats

(Ratio of thermal capacity to that of water at 15° C.)

Water	1.00
Expanded rubber (as herein disclosed)	.30
Cork board	.485
Celotex	.32
Granulated hard rubber	.4
Corrugated paper	.34

Attention is specifically directed to the fact that the above values represent the specific heat of the materials in bone-dry condition. Obviously in use in this art they are subjected to the influences of rain and moisture of condensation as well as ordinary seepage. As the materials absorb water, which by their nature they must, their specific heat naturally approaches that of water, namely 1. The expanded rubber element of my invention is absolutely water-proof and can absorb no water since it is composed of rubber or a mixture of rubber and modifier such as a phenol-formaldehyde resin both of which are completely water resistant. The physical structure of the material represents an infinite number of closed and sealed minute cells of the material. No physical penetration by water is therefore possible. Its specific heat therefore remains at the low .30 shown above.

With respect to the unusual property of low heat capacity with which the element of my invention is endowed, a special advantage of that property is taken by the use of this construction element in making incubators. The most important single factor in an incubator is the maintenance of a uniform temperature within. When the incubator is constructed of materials that conduct away heat, the conduction necessarily varies with respect to many influences such as external conditions. The amount of heat necessary to build up and maintain a desired temperature in the incubator also varies from time

to time. An incubator composed of the material of my invention has a definitely determinable temperature. The low heat capacity of the material means that a minimum of heat will bring the walls of the incubator to the desired temperature. Once this temperature is achieved it can be maintained in the status quo with almost no additional heat. So, for instance, in the incubation of chicken eggs the heat given off by the eggs themselves could be sufficient to maintain a proper temperature within the incubator. Thus in an incubator composed of the material of my invention it is unnecessary to maintain artificially a desired temperature by constant addition of heat. This factor is of infinite importance in the incubation of eggs since, when it is necessary to constantly add heat, there is inevitably a constant variation of temperature, which variation is extremely detrimental to the hatching of the eggs.

The simplicity of construction and its peculiar properties make the insulating construction element of my invention particularly suitable for the erection of chicken coops. A farmer, unskilled in building can quickly assemble an efficient hen-coop with the use of these elements.

A particularly efficient way of assembling the construction elements of my invention consists in assembling separate single layer units in overlapping relation by means of a simple adhesive, as for example bituminous compositions. More specifically, slabs of the expanded rubber material are overlapped for any desirable area depending upon the strength of the joint required with the cementitious material between them at this overlapping. The overlapping can be made satisfactorily with, for example, three inch engagement of each slab. Depending upon the characteristics required in the structure to be formed and the thickness of the slabs employed in relation to the desired thickness of the final product, the overlapping can be carried to any desirable degree even going so far as a complete two-ply continuous overlapping as shown in Figure 8.

Many desirable characteristics are induced by the use of this overlapping arrangement. Size of the unit slab is an important factor in the manufacturing process. It is difficult to properly mold an expanded rubber slab of great size and thickness. Irregular shapes such as tongue and groove arrangements present difficult molding problems. The rubber does not always flow sufficiently well to completely fill a small crevice in the mold to form a tongue. Thus it is difficult to make slabs with tongue and groove sides adapted to accurately engage similar adjacent slabs. Further, it is difficult to properly and uniformly cure a large and thick slab of this material. When the overlap arrangement is used, laminated or partially laminated assemblies can be formed using thinner slabs of material and producing an ultimately stronger structure.

It has been found that a relatively small area of overlap secured by a proper adhesive effects a very firm and permanent joint between the two slabs. The advantages of this type of construction can be listed as follows:

1. The strength of the slabs of expanded rubber resides largely in the external skin. Therefore, when two slabs are adhesively joined, we have two of these skins in adhesive relation. A great tensile strength results.

2. The four skins involved in a laminated joint greatly increases the sound insulation factor.

It is a well-known fact that differences in densities in a material such as a composite wall has beneficial results in reducing sound transmission.

3. The overlapping arrangement eliminates the necessity of difficult molding processes such as the tongue and groove slab or the very thick gas expanded slab.

4. The overlap construction reduces the load and strain on the edge portions of the gas expanded slab. The strength resides in the engagement of large flat surfaces.

5. The danger of cracks setting up as in a simple butted joint or even a rabbeted joint is completely eliminated.

6. The overlapping can be made as long as necessary depending upon the particular requirements of strength or other factors involved.

7. Thin slabs which are easier to gas and vulcanize than thick slabs can be utilized in this type of construction. Thin slabs also reduce the possibility of injurious expansion and contraction under adverse temperature conditions.

8. Slabs of indefinite size can be made by layering and overlapping. For example, slabs four feet long and possibly three feet wide can be joined with slabs of approximately equal width irrespective of their length. By combining such slabs in this way, boards of indefinite length can be made.

9. Warping can be largely eliminated by the use of a laminated construction as set forth.

10. The overlap construction makes possible roofing and side wall construction with simple labor and relatively low cost.

This last feature 10, referred to above, is of extreme importance in the utilization of my invention. The assembly of gas expanded closed cell rubber slabs can be effected by any ordinary worker. The overlapping construction is effected by relatively simple placement of slabs and adhesively securing such slabs. A continuous structure can be effected with relatively small units of material.

The heat insulating properties of this material have been determined. The following is a report of an experiment performed to determine the thermal conductivity of this new construction insulating material:

Specimens

Two samples, 8 inches square and of an average thickness of 1.55 inches, were cut from the new expanded rubber construction element of the present invention. The average density of the two samples, as determined at the completion of the test, was 3.92 pounds per cubic foot.

Method

The method and procedure used were those of the guarded hot plate method for determining the conductivity of material as described in Transactions of the American Society of Heating and Ventilating Engineers, volume 34, 1928.

Temperatures were measured by means of a Leeds & Northrup type K potentiometer in conjunction with the copper-constantin thermocouples associated with the aforementioned apparatus.

Heat input to the hot plate resistance grid was derived from storage batteries and computed from the electrical input as measured with an ammeter and voltmeter.

After heat flow had been stabilized, equilibrium was maintained for approximately two hours during which time frequent readings of all quantities were observed and recorded.

From the measured electrical input and the measured temperature difference across the test slabs, the coefficient of thermal conductivity was calculated from the following formula:

$$c = \frac{I \times V \times 3.415 \times d}{2 \times A (t_2 - t_1)}$$

Where—

c —Coefficient of thermal conductivity at mean temperature of test slabs, expressed in B. t. u. per hour per square foot per degree Fahr. Temperature difference per inch thickness.

I —Current to heater plate grid—amperes.

V —Voltage across heater plate grid—volts.

d —Thickness of specimen—_inches.

A —Area for calculation—.34 sq. ft.

$(t_2 - t_1)$ —Temperature difference between hot and cold plates—° Fahr.

Results

Mean temperature° Fahr. 79.7

Temperature difference° Fahr. 77.7

Current to hot plate.....amperes. .535

Voltage across hot plate.....volts. 4.18

c —B. t. u. per hr. per sq. ft. per ° Fahr. per inch at above mean temperature..... .223

The low thermal conductivity of this new expanded rubber heat insulating material is far below comparable construction elements.

Thermal conductivity of insulating materials in sheet form

Material	Density	Thermal conductivity ¹
	Lbs. per cu. ft.	
Expanded rubber.....	3.92	0.223
Insulite.....	16.2	0.34
Celotex.....	13.2	0.34
Balsam wood.....	7.3	0.33
Cyprus.....	29.0	0.67
White pine.....	32.0	0.78
Glass.....		5 to 6
Concrete.....		6 to 9

¹ Thermal conductivity according to standard definitions represents the thermal conductivity in B. t. u.'s per hour, per square foot, per degree Fahr., per inch in thickness.

The sound insulating properties of this material are in marked degree superior to comparable construction elements. Experiments to determine the sound transmission reduction efficiency have determined the following:

The test results of sound transmission reduction efficiency reported herein were made with the high speed level recorder. A description of this instruction is given in a paper entitled, "A High speed level recorder for acoustic measurements," by Messrs. E. C. Wentz, E. H. Bedell, and K. D. Swartzel, Jr., published in the January 1935 issue of the Journal of the Acoustical Society of America.

The material tested was the 1½" new expanded rubber construction element of the present invention with the hard finished surface on both sides. The test panel consisted of two 3' x 6' sections of the material, or a total area of 36 square feet. For test, this area of material was mounted in a wall opening between two adjoining sections of the laboratory. Rubber foam, compressed and cemented, served as an absolute seal between the outer edges of the material and the wall, and over the inner seam formed by the two sections of the panel.

Measurements of the loudness level were made

before and after introduction of the sample in the wall opening. The sound transmission reduction efficiency of the material as measured in decibels at the respective frequencies is given in the following tabulation.

Frequency cycles per second	Transmission loss in decibels 1½" new expanded rubber insulation element (hard finish both sides)
60.....	14.5
100.....	15
150.....	16.5
200.....	14.5
300.....	15.5
500.....	18
700.....	20
1,000.....	23
1,500.....	26
2,000.....	26.5
3,000.....	25.5
5,000.....	24

The excellent sound-proofing qualities of this material are due to the fact that the cells which comprise the material are sealed and non-communicating whereby each and every layer of cells offers a separate blockade to the transmission of sound. The sound proofing properties of the element of the present invention in comparison with other similar materials is shown by graph in Figure 11.

The vermin-proof nature of this material is primarily due to the fact that a large amount of sulphur, which is customarily used as the vulcanizing agent is present in the finished product. Such sulphur, as is well-known, is an effective deterrent to vermin, termite and rodent attack. Rubber also by its very nature is not ordinarily attacked by such vermin, termites and rodents. This vermin-proof property has a real value in modern construction, since the destructive effects of termites in particular and rats on ordinary construction elements is well-known and effects heavy replacement charges.

The addition of certain materials, such as phenol-formaldehyde condensation product before the material is expanded greatly increases its strength. The presence of this phenol-formaldehyde condensation product makes for an extremely hard expanded rubber construction element with high compressive strength, which properties are extremely valuable in construction. The addition of this small amount of phenol-formaldehyde condensation product effects a surprising change in the characteristics noted. It further increases its water-resistance and resistance to permeation of vapors or gases. The phenol-formaldehyde condensation product is added to the rubber mix, along with the other constituents, in the "B" stage. This material is added in the powdered state. The temperature of the final vulcanization of the rubber effects the conversion of the phenol-formaldehyde condensation product from the "B" stage to the infusible and insoluble "C" stage. No certain proportion of the phenol-formaldehyde condensation products need be set out here since all proportions have been found effective to produce desired properties in combination with rubber. The larger the proportion of the phenol-formaldehyde condensation product the greater the weight. Specifically a mixture containing from 10 to 50 parts of phenol-formaldehyde condensation product has been found to produce surprising improvements in strength and water resistance as above

noted. Other plastics such as hydrochlorinated or chlorinated rubber, vinyl compounds such as vinyl acetate and vinyl chloride, and other suitable artificial resins can also be used as modifying agents to obtain desirable properties.

The peculiar nature of this material makes it possible to effect valuable coatings to obtain desirable properties using a minimum of coating material. These coatings can be applied by spraying or any conventional means. The closed cell and water-proof nature of the entire material inside and out makes possible the use of an extremely small amount of coating, since none is absorbed into the material and therefore there is no need to saturate the surface to effect a continuous covering. Valuable properties are achieved by the use of reflecting coatings, such as aluminum paint or a coating of white sand, asbestos and a binder such as a lacquer. These coatings reflect light and heat waves and increase impact strength, thus markedly improving the properties of the rigid construction element.

In so far as the material of this invention is concerned the painting with aluminum paint or a combination of white sand, asbestos and a lacquer has three important advantages:

1. Prevention of refiation or distortion of the element under direct exposure to high temperatures. This means that it prevents a localized expansion of the gas enclosed in cells at those points directly under an influence of high temperature. In experiments it has been found that the construction element of this invention can stand temperatures of 180 to 200° F. without refiation, whereas a board of similar specific gravity tends to bulge where this high temperature strikes the face.

2. Flame-proofing. Such coatings render the material resistant to a direct flame which obviously is of advantage in any building use.

3. Greater surface strength. Such a coating increases the impact and the compressive strength of material.

The expanded rubber element of my invention can be produced by other processes than the external application of gas under pressure described in detail hereinbefore. For instance, to a suitable mixture of rubber, sulphur and modifying agents there is added a chemical or chemicals adapted either to react to release a gas or adapted to decompose under external influences such as heat to produce a gas in order to inflate and expand the mass. Careful control is necessary in order to preserve the sealed cell structure which is of extreme importance in the insulating element herein described. Thus a partial prevulcanization before the release of the internally developed gas will serve to hold the developed gas enclosed within cells to produce a sealed closed cell structure or, by means of a rapid accelerator, quick inversion from an unvulcanized to a vulcanized state also serves to prevent the escape of the gases and produces a closed or sealed cell structure. The gases that can be internally developed are nitrogen, carbon dioxide and similar inert gases.

The processes of molding in conjunction with re-enforcing and decorative elements is much the same for this internally blown rubber as for the externally expanded rubber described hereinbefore.

It should also be noted that the physical characteristics of the rubber with respect to tough-

ness and brittleness can be widely varied by suitable choice of modifying agents. For instance, a large amount of phenol-formaldehyde condensation product tends to produce a hard body. A large amount of sulphur, that is in the neighborhood of 50% also produces a rigid body. If, however, low percentages of sulphur are used, that is in the neighborhood of 6%, a soft body is produced.

- 10 Referring now more specifically to an insulation element comprising the expanded rubber material of the present invention in combination with re-enforcing means and decorative materials, it has been shown that the expanded rubber of this invention can be, during its process of manufacture, expanded into complete and most intimate contact with such re-enforcing means and decorative materials. A construction element of valuable properties has been made by expanding this rubber into contact with sheets of $\frac{1}{8}$ " thickness made of asbestos, cork and rubber. This latter composition facing is flame-proof and adds measurably to the compression and tensile strength of the element. It has also been found desirable to expand the material of my invention into contact with a $\frac{1}{4}$ " slab of gypsum enclosed between two layers of paper pulp composition. The adherence of the expanded rubber to this latter $\frac{1}{4}$ " slab is excellent. Joints between such laminated construction elements can be entirely filled by plaster of Paris mixture thus forming a tight wall. The use of such construction elements in house building eliminates the necessity for plastering thus saving immeasurably in the time required for ordinary plastering to dry out.

Further, a construction element can be made by expanding rubber in contact with a wood, metal or similar material. A room lined with such elements incorporates both the necessary decorative values as well as the properties of heat and sound insulation, water-proofness, structural strength, low heat capacity and vermin proofness already discussed.

- 45 As can be seen from the above description, the insulating element of my invention has broad application in many fields. I intend to restrict myself only by the following claims.

I claim:

- 50 1. An impermeable insulating element comprising a closed cell gas expanded mixture of rubber and a phenol formaldehyde condensation product.

- 55 2. An impermeable insulating element comprising a closed cell gas expanded mixture of rubber and a phenol formaldehyde condensation product having unusual light weight, high impact and tensile strength, water resistance and low thermal conductivity.

- 60 3. An insulating element comprising a closed cell gas expanded mixture of rubber and a thermosetting plastic to provide increased strength and impermeability.

- 65 4. An impermeable insulating element comprising a closed cell gas expanded mixture of rubber and from 10 to 50 per cent. of powdered phenol formaldehyde condensation product.

- 70 5. An impermeable insulating element comprising a closed cell gas expanded mixture of rubber and a powdered phenol formaldehyde condensation product, and a heat reflecting coating applied to the surface of said element.

DUDLEY ROBERTS.