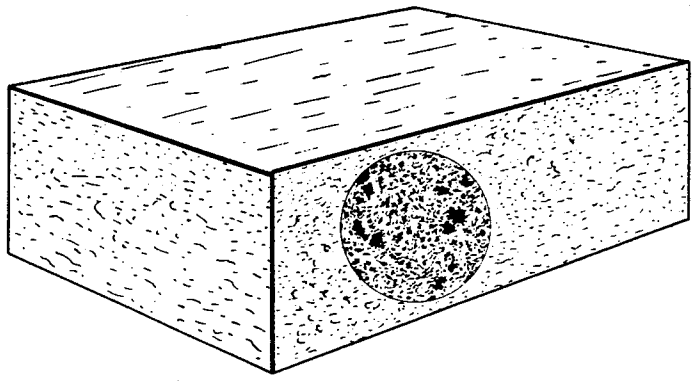
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Examiner

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HEAT INSULATING MATERIAL AND METHOD OF MAKING THE SAME

Filed April 1, 1933



INVENTOR.
Floyd B. Hobart.

BY Cowles & Mahoney
ATTORNEYS.

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25. PLASTIC BLOCK [illegible] APPARATUS

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HEAT INSULATING MATERIAL AND METHOD OF MAKING THE SAME

Floyd B. Hobart, Columbus, Ohio, assignor to The Battelle Memorial Institute, Columbus, Ohio, a corporation of Ohio

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30 Claims. (Cl. 25—156)

My invention relates to heat insulating material and method of making the same. It has to do particularly with the production of a heat insulating material which is suitable for building structures and for numerous other uses wherein it is desirable to exclude adverse temperature conditions from or retain desirable temperature conditions within any given zone, though it is not necessarily limited to such uses.

In the past, some attempts have been made to produce heat insulating materials which are effective to minimize temperature changes within given spaces. Some of these efforts have involved the use of mineral wools bound together by means of asphalt or other binders normally rendered effective by cooling or drying. Moreover, the binders used are often organic in nature and combustible and thus the product has not been fire-proof. Specific binders as asphalts or waxes have temperature limitations and are only suitable for use within narrow temperature ranges. In such cases, the strands of fibrous material have ordinarily been practically devoid of rigidity and the binders used have left much to be desired from the standpoint of strength. Thus, the product has only slight structural advantages.

Other efforts have involved the use of mineral wool and similar fibrous structures in conjunction with silicates as a binder therefor. However, products made in this way are limited as to strength and lightness and lack certain other desirable features which are possessed by products resulting from the method to be here described.

Still other efforts have involved the formation of distended mats of fibers having the property of felting together and sometimes provided with voids or air spaces, sometimes produced by the beating of foam thereinto to separate the fibers and the subsequent draining of the liquid to leave the fibers relatively spaced apart. Products made in this way are ordinarily not fire-proof or water-proof, are of limited strength, and are lacking in other desirable characteristics.

One of the objects of this invention is to provide a heat insulating material of superior insulating qualities.

Another object of this invention is to provide a heat insulating material which will be of comparatively light weight, which will be fire-proof, and which will be rigid and self-supporting.

Another object of this invention is to provide a heat insulating material which will be of such inherent strength that it may be placed in wall formation and will, in such formation, adequately resist all normal crushing strains arising from its own weight when built to any reasonable height.

Another object of this invention is to provide an insulating material of the type indicated which can be made of comparatively cheap materials and which can be produced with a minimum of difficulty.

Another object of this invention is to provide a simple method for the production of an insulating material of the type indicated.

The preferred embodiment of my invention contemplates the production of a cast or molded mass of material which contains a multiplicity of voids, which is light in weight and which is of an inherent strength adequate to support substantial heights, as for instance, an entire wall structure, formed thereof. It may be formed in blocks of small size or in unbroken walls or areas, or it may be cast in place upon steam or heating ducts or upon furnaces, ovens, boiler settings or the like, by using suitable forms or molds until the material is sufficiently fixed in place. It is of such a nature that it may be readily cut to size and shape with commonly available tools to facilitate its use under varying conditions.

More specifically, it comprises a solidified foam produced from a soluble silicate in such a way that it contains throughout its body a plurality of small voids which enhance the insulating qualities thereof. Moreover, this solidified foam is impregnated throughout with a filler, such as mineral wool or the like which reduces shrinkage and gives additional body to the material. The product is a fire-proof cellular unit embodying a multiplicity of strands of the filler, with these strands encased in a vitreous material which joins them together at their points of contact with the encased strands spaced apart sufficiently to ensure that the unit possesses high insulating characteristics. Inasmuch as the binder is the result of gelation of the soluble silicate solution and setting of the silicate thereby produced, the binding action is much more rigid than can be effected with the prior art adhesive binders previously discussed. The interlocked fibers and silicate produce a structure having a strength and rigidity markedly superior to the prior art structures described and these features, in conjunction with the entirely fire-proof nature of the material, produce a highly superior product.

The method which I preferably utilize for producing my temperature insulating material contemplates completely foaming or frothing a solu-

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tion of water soluble silicate into a mass of small bubbles from which the water is to be ultimately removed by drying to give a solid mass having a multiplicity of voids therein. Such a foam is made possible by the addition to the solution of certain agents which alter its surface tension and permit the foam to be formed by vigorous agitation of the solution in such a way as to entrain air or gases in it. It is made stable by the introduction with it of acidic salts, acid gases or acid solutions. Fillers are introduced as, for example, asbestos fiber or rock, slag or glass wools or other fibrous material.

The addition of an acid to the fiber impregnated solution of soluble silicate brings about a gelation of the solution which progresses gradually until setting occurs. At the time of setting, the strands or fibers are encased in silicate. They are bound together in a loose structure and spaced apart and supported by the foamed solution. They are rigid and strong and the interlocking action is such as to produce a strong and rigid light weight material with a multiplicity of voids of substantial size therein.

One type of product which I may produce, in accordance with my invention, is illustrated in the accompanying drawing wherein:

The figure illustrates a block of my temperature insulating material.

In one form of my method I perform the first step of the method by using the following ingredients in the proportions stated:

400 parts by weight of 42.5° Baumé commercial sodium silicate solution (comprising 60.8% water and 39.2% sodium silicate having a ratio of 1 part Na_2O to 3.22 parts SiO_2)
600 parts water
1 part saponin as foaming agent
400 parts slag wool as filler.

The liquids are mixed and the saponin added. Beating of this mixture is then employed to produce a foam and the filler is gradually added with continued beating.

When the proper thickness is attained by the gradual addition of the wool, agitation is stopped and the mixture is cast or otherwise formed into the desired shapes and allowed to dry. The molds may be removed on partial drying and the shape further dried by any suitable means, as air drying, heat or humidity drying. Shrinkage on drying is slight and allowance can readily be made for this. Dehydration may be completed at temperatures in the neighborhood of 400 to 500 degrees F. to a point of irreversibility to give a water-proof product.

My process is susceptible of considerable modification. For example, a few parts of glycerine may be added to the above formula, if desired, to strengthen or toughen the foam films, although this is not necessary.

In the second form of my method:

400 parts by weight of 42.5° Baumé commercial sodium silicate solution (comprising 60.8% water and 39.2% sodium silicate having a ratio of 1 part Na_2O to 3.22 parts SiO_2)
600 parts water
1 part saponin as foaming agent

This solution may be caused to foam by suitable agitation.

Then 200 parts of slag or rock wool are added. Agitation is resorted to to give a completely mixed mass of a creamy consistency and less viscous than that produced by the previously described composition. The agitation is preferably though not necessarily effected continuously during the introduction of the slag or rock wool.

Either during or after completion of the foaming and mixing of the ingredients, as just described, carbon dioxide gas may be passed into or over the mixture, preferably while this mixture is agitated in such a way that the gas penetrates the entire mass to react with a sufficient portion of the silicate to cause the mixture to gel. This gelation ordinarily requires an appreciable time depending upon the rate of introduction of this acid gas. Approach to the proper degree of gelation will be indicated by a stiffening or thickening of the mixture and, when the mixture thickens or stiffens to the desired degree, it may be cast or otherwise formed into the desired shapes and allowed to completely gel or set.

Various other modifications are possible in the performance of my process and in the resultant product. Thus, somewhat similar results are obtainable by substituting for the sodium silicate solution a potassium silicate solution or in fact any water soluble alkali metal silicate, though it will be understood that the question of cost is a factor to be considered.

By the term "soluble silicate", as used throughout this description and the claims, I intend to include any and all soluble silicates which are commercially available. More specifically, I have reference to those silicates wherein the silica is in larger ratio to the alkali, since the higher ratio silicates permit gelation to be brought about by the use of a smaller amount of acid or other reacting material. However, the silicates containing a higher percentage of the alkali may be made to gel upon neutralization of a sufficient amount of the alkali.

It will likewise be understood that other foaming agents may be utilized. Thus, we may substitute, for saponin, sodium oleate, or other soaps, or licorice compounds, and, in fact, any one of a number of agents which will serve to alter the surface tension of the silicate solution.

It will also be understood that the agitation upon which I rely for the creation of the foam may be effected either by beating or by the introduction of air under pressure. Foaming may even be effected by the use of chemicals such as aluminum or zinc powder which will react with a part of the available alkali to liberate hydrogen gas, though the creation of the foam by physical agitation is at present considered more desirable. For one thing, it is more easily controlled and may be discontinued at any instant to better ensure the proper dimensions of the article to be produced.

The fillers employed may be of various kinds. They may be fibrous in nature and light in weight as, for example, asbestos fiber, rock, glass or slag wools, or organic fibers as wood, cotton, flax, hair, seaweed, kapok, wool, bagasse, straw, et cetera. On the other hand, they may take the form of finely divided clay or grog or fly ash or various other ingredients used individually or in combination of any two or more, since our invention is applicable to clay ware, refractory ware or other classes of heat or sound insulating material.

While it is here stated that the carbon dioxide may be added after the complete foaming and mixing of the other ingredients, it will probably be desirable to employ a continuous process as subsequently explained, using an atmosphere in the mixing chambers of a controlled carbon di-

oxide content to ensure that the product discharged from the mixer will have the desired characteristics.

While carbon dioxide has been specified as the chemical preferably used for effecting gelation of the soluble silicate, it will be understood that numerous other chemicals may be used for this purpose. Thus boric acid is, in some respects, more desirable than carbon dioxide. Likewise, gelation may be effected by other weak acids or by a very dilute solution of a stronger acid, such as sulfuric acid.

Gelation may be brought about by the addition of acid salts as bicarbonates or bisulfates or by the salts of various metals as aluminum sulfate or calcium sulfate. Certain organic compounds which react readily with alkalis, such as phenols and other organic acids, may also precipitate silica to form gels. Thus the function in question may be effected by many chemicals though the cost and availability of the compounds is a factor.

It will likewise be apparent that, under some conditions, it may be desirable to foam the acid solution and, then introduce the filler and the silicate into the foamed acid solution. It will also be understood that the foaming of the silicate solution may be effected either during the introduction of the filler or after the filler has been introduced. These things, of course, come within the scope of my invention.

Proper control of the addition of the acidic material permits the gelation or setting of the mass to take place uniformly throughout the mass and over an appreciable and regulable period of time. Thus, the mas may be brought to any desired consistency and thereupon, cast or extruded into the desired shape and size suitable for subsequent drying and, when desired, subsequent firing.

By the use of my process, it is possible to produce my product continuously, as a result of the readiness and ease with which the reactions may be controlled. Thus, for example, a sodium silicate solution of the desired concentration and composition may be continuously introduced into a high speed mixer together with the foaming agent and the filler, so that this mixture may be foamed as it is made. This foamed mixture may then be conveyed into a second mixer wherein less violent agitation is maintained and where the acidic material may be added. On the other hand, an elongated cell type of mixer may be used as a single unit, with the silicate solution together with the foaming agent and filler being foamed as they are introduced and progress through the unit and with the acidic material being added at the proper stage in the progression of the foamed mixture through the unit.

Preferably, the process is so controlled that the final product leaves the mixer or the series of mixers in the plastic stage which has resulted from the thickening or stiffening of the silicate in the course of gelation, so that it will then be suitable for casting or for forcing continuously through dies to give an extruded column which may set in the molded shape and be cut into convenient lengths for subsequent drying to give the final product.

As a result of my process, a viscous mass is formed which, instead of being a matted structure and a structure which will disintegrate at temperatures slightly above atmospheric temperatures, will be of a cellular nature and will be fireproof and indissoluble at temperatures as high as 1000° F., more or less, depending upon the kind of material which is used as a filler. The material will be light in weight and highly effective as an insulating material. It may be cast or formed to shape as bricks or blocks or it may be cast in the place of ultimate use, either in a wall structure or upon steam or heating ducts, furnaces, ovens, boiler settings or the like, by using suitable forms or molds until the material is sufficiently viscous or fixed to retain the shape which has been given to it.

An important advantage of my invention arises from the fact that, though the product thereof is unusually light in weight, it is entirely fire-proof when made with inorganic fillers, while it is substantially so when made with organic fillers by virtue of the encasement of the organic fillers in silicate. This, coupled with the fact that it is a light weight material with a multiplicity of voids of substantal size and that it is more than self-supporting, renders it a highly desirable and novel insulating unit. The merit of the invention is further increased by the fact that the material may be made entirely water-proof, as well as fireproof.

The products produced to date by my method are apparently cellular in nature with voids which vary in size and form and which are intercommunicating to a considerable extent. Though the structure is somewhat open in its nature, its voids are of such a nature and of such a staggered arrangement that comparatively thin units have high insulating characteristics. Thus, shapes in one inch thickness have been tested by the hot-plate method and found to have a thermal conductivity of .32 B. t. u. per square foot per hour per degree Fahrenheit per inch thickness. It is apparently a network of interlaced fibers individually encased in and interspersed with vitreous material resulting from the silicate used in the mixture.

Another result of my process is that considerably larger amounts of the fillers may be wet with a silicate foam than is possible with an unfoamed silicate. Thus, relatively large amounts of fillers may be used in forming light weight heat insulation. The product obtained is quite porous and contains a multiplicity of voids with consequently enhanced insulating qualities. Moreover, it possesses adequate structural strength to be more than self-supporting in use.

The strength may be increased by controlling the rate of drying to give a skin or case of sodium silicate on the surface, if desired. Likewise, it is of such a nature that it may be readily cut to size and shape with commonly available tools to facilitate application and use.

It will be understood that the product produced by my process possesses sound insulating characteristics as well as heat insulating characteristics. Therefore, the term "heat insulating material" used in the specification and claims is intended to cover sound insulating material as well.

Having thus described my invention, what I claim is:

1. The method of making heat insulating material which comprises producing a foam from a soluble silicate solution and mixing a filler with such foam.

2. The method of making heat insulating material which comprises producing a foam from a sodium silicate solution and mixing a filler with such foam.

3. The method of making heat insulating material which comprises producing a foam from a

soluble silicate solution and mixing a fibrous filler with such foam.

4. The method of making a heat insulating material which comprises producing a foam from a saluble silicate solution, mixing a filler with such foam and introducing a substance which will effect gelation of such foam.

5. The method of making heat insulating material which comprises mixing a soluble silicate solution with a filler under such conditions that a foamy mixture is produced and effecting gelation of said solution by the introduction of an acidic constituent thereinto.

6. The method of making heat insulating material which comprises foaming a soluble silicate solution by beating and mixing said silicate solution with a filler.

7. The method of making heat insulating material which comprises foaming a soluble silicate solution by beating and mixing with a fibrous filler.

8. The method of making heat insulating material which comprises mixing a soluble silicate solution with a foaming agent, foaming such silicate solution and mixing with a filler.

9. The method of making heat insulating material which comprises mixing a soluble silicate solution with a foaming agent, foaming such silicate solution, mixing with a filler, and introducing a constituent effective to produce gelation of the solution.

10. The method of making heat insulating material which comprises mixing a soluble silicate solution with a foaming agent, foaming such soluble silicate solution, mixing with a fibrous filler and introducing a constituent effective to produce gelation of the solution.

11. The method of making heat insulating material which comprises mixing a soluble silicate solution with a foaming agent, beating to effect foaming of such silicate solution, mixing with a filler, and introducing a constituent effective to produce gelation of the silicate.

12. The method of making heat insulating material which comprises mixing sodium silicate with a foaming agent, beating to effect foaming of such silicate, mixing with a fibrous filler, and introducing an acid constituent to produce gelation of the silicate.

13. The method of making heat insulating material which comprises mixing sodium silicate with a foaming agent, beating to effect foaming of such silicate, mixing with a fibrous filler, introducing carbon dioxide gas to produce gelation of the material, casting or forming the mixture and drying the product so produced.

14. The method of making heat insulating material which comprises providing a soluble silicate solution and a solution that will react therewith to yield a gel, foaming one of said solutions, and then mixing to effect gelation.

15. The method of making heat insulating material which comprises providing a soluble silicate solution and a solution that will react therewith to yield a gel, adding a filler to one of said solutions, foaming the solution to which said filler has been added, and then mixing to effect gelation.

16. The method of making heat insulating material which comprises continuously introducing a silicate solution together with a foaming agent into a continuously operating mixer, foaming such mixture as it is received and progresses through the mixture, adding a material to effect gelation of the mixture as it passes through the mixer, and then forming to selected shape.

17. The method of making heat insulating material which comprises adding a foaming agent to a soluble silicate solution, foaming such solution, and adding to such foamed solution a material that will effect gelation and setting of the material at a rate that will permit casting or forming the material in its place of ultimate use, and casting or forming in such place of ultimate use.

18. The method of making heat insulating material which comprises producing a foam from a soluble silicate solution, adding an acidic material to such foamed solution to effect gelation and setting thereof, and heating the set product sufficiently to irreversibly dehydrate the soluble silicate.

19. The method of making a heat insulating material which comprises adding a foaming agent to a soluble silicate solution, foaming such solution, adding a filler to such foamed solution while agitating the mixture, effecting gelation of the mixture by adding an acidic material thereto, forming the mixture to selected shape and effecting drying thereof.

20. A heat insulating material comprising a dried gel formed from a soluble silicate solution.

21. A heat insulating material comprising a dried gel formed from a soluble silicate solution and a filler.

22. A heat insulating material comprising a foamed soluble silicate solution and a filler mixed with said foamed solution.

23. A heat insulating material comprising a dried gel formed from a foamed soluble silicate solution and a filler mixed therewith.

24. A heat insulating material comprising a dehydrated sodium silicate foam which is impregnated with a filler.

25. An insulating material comprising a multiplicity of fibers encased in silicate and bound together as a unit by such silicate.

26. An insulating material comprising a multiplicity of fibers encased in silicate and spaced apart but bound together at their points of intersection by such silicate.

27. An insulating material comprising a multiplicity of interlaced fibers bound together at their points of intersection by silicate.

28. An insulating material comprising a multiplicity of interlaced fibers bound together at their points of intersection by silicate and having a multiplicity of voids of substantial size therein.

29. An insulating material comprising a base of dehydrated soluble silicate.

30. An insulating material comprising a base of irreversibly dehydrated soluble silicate.

FLOYD B. HOBART.

DISCLAIMER

1,944,008.—*Floyd B. Hobart*, Columbus, Ohio. HEAT INSULATING MATERIAL AND METHOD OF MAKING THE SAME. Patent dated January 16, 1934. Disclaimer filed April 29, 1938, by the assignee, *The Battelie Development Corporation*.

Hereby enters this disclaimer to claim 29 in said specification.

[*Official Gazette May 24, 1938.*]

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