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THERMAL AND SOUND INSULATING MATERIAL AND PROCESS FOR MAKING SAME

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This invention relates to thermal and sound insulating material, composed chiefly of cellular earth, such as diatomaceous earth, and to the process for manufacturing formed articles, such as boards or slabs from same, and applying thereto a reinforcing coating. Since thermal and sound insulating materials possess similar qualities, the invention is described in terms relating to thermal insulating material.

An object of the invention is to provide a moldable thermal insulating material formed principally of diatomaceous thermal insulating earth, which is more cellular, and possesses thermal insulating properties greater than the diatomaceous earth from which it is chiefly formed, and which will not support combustion.

Another object of the invention is to provide a thermal insulating material which may be molded while plastic into forms, and which will not check, spall or crack upon drying or baking.

Another object is to provide a thermal insulating material which is provided throughout its mass with interstitial air cells distributed evenly therethrough.

Among other objects are to provide an insulating board of very light weight having tensile and transverse strength and compressive resistance, yet having sufficient flexibility to stand the rough handling of varying conditions of commercial transportation; and generally to improve upon the present type of thermal insulating material and formed and insulating construction material.

The invention has other desirable features, some of which, with the foregoing, will be set forth more in detail in the following description, wherein one form of the composition of the invention and process of making same is more fully disclosed.

With the foregoing, and other objects in view, the invention consists of the novel compounding of materials and the new structure formed thereby in the novel manner herein described, it being understood that variations in equivalent materials and variations in quantities, as well as minor changes in process of manufacture, may be resorted to within the scope of the disclosure and appended claims, without departing from the spirit of the invention.

Diatomaceous earth, which is a product well known in the art, is composed chiefly of siliceous cellular atoms, the material per se being noncombustible and a thermal and sound insulator. The silica matter is soluble in relatively strong alkali aqueous solution, such as sodium hydroxide or potassium hydroxide, or the carbonates of either. Such rigorously acting alkali solutions, if used in sufficient relative quantity, will break down the cellular structure of the diatomaceous earth, forming alkali silicate, such as sodium silicate, or potassium silicate; but relatively small quantities, or relatively mild solutions of the alkalies, serve to soften the silica of the diatomaceous cells. An insulating material may thus be formed, which, when dry, has approximately the same insulating value as the diatomaceous earth, but when formed into slabs is brittle, cracks upon drying and has excessive weight per unit volume. In making a commercial product it is desirable to have a greater number of air cells than is possessed by the diatomaceous earth per se, thus increasing the insulating value, and decreasing the weight per unit volume of the insulating material. The occlusion of additional air cells tends to detract from the tensile and compressive strength of an insulating material thus formed, and it is desirable, therefore, to introduce a cementitious, adhesive agent, which, when wet, is gelatinous, or colloidal, and of a flexible nature, so as to provide a body medium in which may be formed expansible walls for air cells, for reasons hereafter explained. For this latter material it is preferred to use gelatinized vegetable matter having gluten and starch, or proteid and starch, such, for instance, as whole grain flour, soy-bean meal (with oil extracted) or ground cassava root, commonly known as manioc. In referring to air cells herein, it is intended to include other suitable gaseous fluids, which may be introduced to the compound in the manner herein recited.

The gelatinized vegetable material may be prepared in a gelatinous colloidal state by any suitable means such as by boiling, but it is preferred that it be gelatinized chemically, such as by mixing it with an alkali solution, for which purpose any of the previously mentioned, or other suitable alkali or acid solutions, may be used, since such alkali solution softens the silicate cells of the diatomaceous earth to render them more susceptible to adhesion in the mass to be formed.

This gelatinous compound with its alkali component may be mixed with finely comminuted diatomaceous earth to form a thermal insulating product, which, when dried, has a degree of insulating value, but since all gelatinous matter shrinks to some extent upon drying and hardens upon application of heat, an insulating material thus formed is brittle and cracks upon being dried in ovens adapted for that purpose.

Since the successful commercial manufacture of wall board and other insulating products must be in large quantities, and it is necessary to have the material of such nature and consistency that it may be oven-dried without becoming brittle or cracking, this invention contemplates the addition of a finely divided fibrous material of suitable type mixed with the diatomaceous earth and the adhesive, to bond the cellular structure and give sufficient compressive and tensile strength thereto for handling in the manufacturing process when it comes from the drying ovens and in commercial transportation.

Because of the availability, cheapness, toughness, flexibility and absorbency of paper pulp fibre, it is preferred to use that material.

Since an object of the invention is to provide an insulating material having a greater number of air cells and, therefore, of greater insulating value than the diatomaceous earth, and of lesser weight per unit volume, a frothing or bubble-forming agent is provided as one of the ingredients, preferably, is a proteid which, when subjected to an alkali, such as those hereinabove mentioned, forms a gelatinous colloidal proteid glue which when added causes the mix to froth upon agitation. Casein, gluten or proportionate mixtures thereof, answer this purpose very satisfactorily, and when mixed with an alkali solution, such as sodium hydroxide, form a sodium caseinate, or sodium glutenate, as the case may be, which latter compounds form a gelatinous adhesive mass soluble in water. Since this proteid material is used for both its adhesive qualities and its frothing qualities to create additional air cells and to assist in colloidal suspension of the cells in a disperse system, it is desirable that it, after being dried, should resist solubility in water.

In order to form a water-resistant glue when dry, a fixing agent such as the hydroxide of a heavy metal, a compound yielding copper ion, or an alkaline earth such as hydrated lime, is added to this colloidal mixture, which reacts upon the soluble form to produce a compound which is insoluble in water.

Blood albumen, treated with ammonium hydroxide may be used as a satisfactory substitute for casein as a frothing, bubble-forming agent, and if so used should include a suitable insecticide such as copper sulphate.

The proportions used of the several ingredients may vary with the degree of purity of the diatomaceous earth and with the strength of the alkali which is used, and with the cellular structure and the tensile and compressive strength thereof, which it is desired that the resultant product shall possess, but satisfactory and efficient results may be obtained with a mixture consisting of substantially 22.3% of finely comminuted diatomaceous earth; .9% casein; 1.1% of wood pulp paper fibre; 1.3% gluten starch product; .4% total alkali and hydrated lime; and 74% of water, said percentages being taken by weight with relation to the total wet mix to be created.

In treating the foregoing materials, it is preferred to separately prepare the gelatinized starchy product by mixing 7 parts of a product containing starch and adding thereto 1.4 parts alkali, preferably sodium hydroxide, and 91.6 parts of water; also the proteid glue which constitutes the frothing agent, is separately formed preferably by mixing together 11.6 parts of casein, .6 parts sodium hydroxide, 1.2 parts hydrated lime and 86.6 parts of water.

It is preferred that the glue should stand after mixing to permit the gelatinization and reaction of the lime on the solubles. It is not desired to limit the method of mixing to the separate stages hereinabove described, since the proteid glue frothing agent and the starch product are both gelatinized and were it not for the relative cheapness and accessibility of the starch product, the gelatinized frothing agent may be entirely or proportionately substituted for the gelatinized starch ingredient. It is manifest that the water ingredient may be introduced as a separate element, or first mixed with other ingredients, and that the ingredients which are gelatinized may be introduced in a sufficiently liquid state to obviate the introduction of free water.

My preferred form of mixing is to soften the paper pulp in water and thoroughly shred same by any suitable means and thereafter add thereto the comminuted diatomaceous earth, and permit these two ingredients to be thoroughly mixed by mechanical agitation, after which the gelatinized starchy product is added to the mix and thoroughly mixed therewith, and lastly the protein glue frothing agent is added to the mixture. After the protein glue has been added to the mixture, the entire agglomerate is whipped, preferably by rapid mechanical agitation, and this agitation causes the agglomerate to entrap within the mass globules of air, and causes the protein glue to froth very considerably, and the latter having been previously gelatinized, it, together with the viscous gelatinized starch ingredient, supports air cells colloidally or in a disperse system.

While it is not the intention to limit the agitation process to whipping it is to be preferred over injection of air in streams or chemical formation of gaseous fluid without also whipping the mix, for the reason that whipping finely divides the air globules so that the individual cells become more uniform in size, are greatly multiplied in number and more evenly distributed throughout the mass, with greater possibility of expansion without rupture of the cell walls upon application of heat for drying.

Experience has shown that better insulating values are obtained by combining injection of auxiliary air under pressure from an independent source and simultaneously whipping the mix, and this manner of treatment is preferred since more efficient control of the volume and distribution of entrapped air can be had thereby.

The whipping process would normally raise the temperature of the mass, due to frictional drag of the beater in the mix, and this heat will tend to lower the viscosity of the mass and thus release the air entrapped therein by the air cells; also it is well known that air expands upon being subjected to heat. Therefore, during the step of whipping, it is preferred to maintain the mixture at a relatively low temperature of approximately 15 to 25 degrees centigrade, and, if desired, the auxiliary air may be brought to that temperature before injection thereof. This temperature is suitable to maintain the gelatinous consistency of the mass and the colloidal suspension of the chilled air therein. When the mass has been thus aerated until the air cells therein increase its cubical volume fifty to one hundred percent, dependent upon the cellular structure desired, the mass is then delivered upon suitable drying surfaces such as screens, molds or continuous conveyors suitably adapted to form the material into the desired shape. A sheet of suitable material,

such as paper may first be placed upon the screen. Wetting of the paper upon its surface prior to contact with the mass will prevent corrugations of the face of the insulating slab abutting thereon and incidentally assist in prevention of warping, during the dehydration process. The screens, or conveyors, are then passed through heated drying chambers for dehydration of the formed product, the preferred temperature being approximately 90 degrees centigrade for this purpose, which temperature provides a wide differential of approximately 70° centigrade relative to the whipping temperature and is sufficient to dry the material and expand the air cells without substantial shrinkage of the gelatinous products, nor drawing off any of the physical elements other than the water.

By the whipping process, and the use of material which is a frothing agent, the number of air cells within the finished product may be regulated by the amount of the frothing agent which is used and the amount of the whipping to which the material is subjected, so that an insulating material of varying weight, varying tensile strengths and varying insulating values may be produced.

Reference has been made above to reducing the temperature of the mix during its agitation so as to maintain colloidally the air cells. In addition to this purpose, the cooling of the material during whipping reserves the expansible properties of the entrapped air for expansion in the drying process. Therefore, when the formed product is subjected to heat, the air within the cells expands, thus increasing the size of the individual cell and preventing shrinkage of the material which would otherwise be caused by drying, so that the increase in the size of the air cells not only increases the insulating properties but also is a counteractive for the contraction of the gelatinous material by drying. In this expansion of the air cells the fiber ingredient not only bonds the composite mass but also reinforces the walls of the air cells which are introduced additionally to the cells of the diatomaceous earth.

The material upon drying is sufficiently rigid to be readily handled, yet sufficiently flexible that it does not crack or chip. However, it is extremely absorptive and lacks sufficient tensile and compressive strength for rough handling in practical and commercial use, and since materials of this class must be subject to transportation and rough handling in building operations, and other uses, it is necessary that it shall have sufficient strength to meet commercial needs, yet not destroy the thermal insulation values, nor the resistance to combustion. Therefore, a reinforcing coating may be applied thereto preferably after the drying of the formed slabs. As the insulating material is usually for wall covering purposes in building construction, the coating thereon should be sufficiently flexible to prevent cracking upon vibration or rough handling; should resist combustion, and also be such that a plastic wall finish may readily bond thereto without the insulating material absorbing the moisture from the plastic wall coating, and from atmospheric moisture.

If desired the reinforcing coating may be applied to only one side of the slab or to both sides depending upon the use to which the slab is to be put.

This insulating product is of very great value and utility as a base for building construction material having a finished surface, such as veneering of material such as sheet steel, laminated plyboard and the like. In such use the building material may be formed by adhering such veneer sheets to the insulating cellular body by means of the interposed cementitious coating or by suitable mechanical well known anchoring means, the veneering thereby providing a moisture-resisting coating for the cellular insulating material, in which event it may be optional whether all of the laminations of the hereindescribed coating of the cellular structure are employed.

Having thus described the invention, what is claimed as new and desired to be protected by Letters Patent is:—

1. The process of manufacturing a porous heat insulating product from diatomaceous earth, a filler comprising diatomaceous earth and organic fibrous material and a binder consisting of a gelatinized starch material, which consists in mixing the ingredients in the presence of water, whipping the mass in the presence of air; and finally dehydrating the whipped mass by heat.

2. The process of manufacturing a porous heat insulating product from diatomaceous earth, a filler comprising diatomaceous earth and organic fibrous material and a binder consisting of a gelatinized starch material, which consists in mixing the ingredients in the presence of water, whipping the mass in the presence of air while inducing an expansion of the cellularly occluded air by maintaining a relatively wide differential between the temperatures, respectively, at which the mixture is whipped and at which the mixture is dehydrated during the initial stages of dehydration; and finally dehydrating the whipped mass by heat.

3. The process of manufacturing a light highly porous heat insulating product from diatomaceous earth, a binder consisting of water soluble organic gelatinous adhesive, and finely divided organic fibrous material, which consists in mixing the ingredients in the presence of water, whipping the mass in the presence of air, and finally dehydrating the mass by heat.

4. The process of manufacturing a light highly porous heat insulating product from diatomaceous earth, a binder consisting of water soluble organic gelatinous adhesive, and finely divided organic fibrous material, which consists in mixing the ingredients in the presence of water, whipping the mass in the presence of air while inducing an expansion of the cellularly occluded air by maintaining a relatively wide differential between the temperatures, respectively, at which the mixture is whipped and at which the mixture is dehydrated during the initial stages of dehydration, and finally dehydrating the mass.

5. The process of manufacturing heat insulating material which consists in taking a gelatinized vegetable material, a proteid frothing agent, finely divided organic fiber, and diatomaceous earth whipping the mass in the presence of air until a substantial quantity of auxiliary air cells are occluded therein in a disperse system, laying the whipped mass in a layer and dehydrating it by the application of heat.

6. The process of manufacturing highly porous heat insulating material which includes the mechanical whipping of a mass composed of diatomaceous earth, finely divided organic fibrous material, a binder composed of water soluble organic gelatinous adhesive and a fixing agent therefor which forms therewith a water resistant glue when dry after being mixed in

fluent form and thereafter dehydrating the mix by heat.

7. The process of manufacturing highly porous heat insulating material which includes the mechanical whipping of a mass composed of diatomaceous earth, finely divided organic fibrous material, a binder composed of water soluble organic gelatinous adhesive and a fixing agent therefor which forms therewith a water resistant glue when dry after being mixed in fluent form, while inducing an expansion of the cellularly occulded air by maintaining a relatively wide differential between the temperatures, respectively, at which the mixture is whipped and at which the mixture is dehydrated during the initial stages of dehydration, and dehydrating the mix by heat.

8. The process of manufacturing a highly porous heat insulating product which consists in taking diatomaceous earth, vegetable fiber, a colloidal binder composed of water soluble organic gelatinous adhesive and a fixing agent for the binder which reacts on the colloidal binder and forms therewith a water resistant body when dry afted being mixed in fluent form; subjecting the mass to mechanical treatment in the presence of air to form finely divided air globules in the mass and to render the individual cells approximately uniform in size, greatly multiplied in number and evenly distributed throughout the mass; and thereafter subjecting the mass to dehydrating heat.

9. The process of manufacturing highly porous heat insulating material which includes the mechanical whipping of a mass composed of diatomaceous earth; finely divided organic fibrous material, a vegetable cementitious adhesive agent which when wet is gelatinous or colloidal and of a flexible nature, a frothing agent composed of water soluble organic gelatinous adhesive and a fixing agent therefor which forms therewith a water resistant glue when dry after being mixed in fluent form, and thereafter dehydrating the mix by heat.

10. The process of manufacturing heat insulating material which includes the mechanical whipping of a mass composed of diatomaceous earth, finely divided organic fibrous material, a vegetable cementitious adhesive agent which when wet is gelatinous or colloidal and of a flexible nature, a frothing agent composed of water soluble organic gelatinous adhesive and a fixing agent therefor which forms therewith a water resistant glue when dry after being mixed in fluent form; inducing an expansion of the cellularly occluded air by maintaining a relatively wide differential between the temperatures, respectively, at which the mixture is whipped and at which the mixture is dehydrated during the initial stages of dehydration, and finally dehydrating the mix by heat.

11. The process of manufacturing micro-porous heat insulating material which comprises taking diatomaceous earth, finely divided organic fibrous material, a gelatinized vegetable material, a frothing agent composed of an aqueous solution of an organic gelatinous adhesive and a fixing agent therefor which forms therewith a water resistant glue when dry after being mixed in fluent form, whipping the mass in the presence of air, mixing and aerating the mass while inducing an expansion of the cellularly occluded air by maintaining a relatively wide differential between the temperatures, respectively, at which the mixture is whipped and at which the mixture is dehydrated during the initial stages of dehydration, and then finally dehydrating it by the action of heat.

12. A light, highly micro-porous heat insulating material composed of finely divided solids and a multiplicity of minute voids, molded and dehydrated under atmospheric pressure from a fluent mix containing diatomaceous earth, finely divided paper pulp fibers, a binder comprising a starch adhesive in a colloidal state, and an insolubilized casein glue.

13. The process of manufacturing heat insulating material which consists in taking a gelatinized vegetable material, a proteid frothing agent consisting of casein treated with an alkali solution, finely divided organic fiber, and diatomaceous earth; whipping the mass in the presence of air until a substantial quantity of auxiliary air cells are occluded therein in a disperse system, laying the whipped mass in a layer and dehydrating it by the application of heat.

14. The process of manufacturing a light highly porous heat insulating product which consists in taking diatomaceous earth, starch gelatinized by mixing it with an alkali solution; casein subjected to the action of an alkali to form a gelatinized colloidal frothing agent, a suitable fixing agent for the frothing agent which forms therewith a water resistant glue when dry after having been mixed in fluent form and organic fibers; mixing the mass together and whipping it in the presence of air while inducing an expansion of the cellularly occluded air by maintaining a relatively wide differential between the temperatures, respectively, at which the mixture is whipped and at which the mixture is dehydrated during the initial stages of dehydration, then finally dehydrating the whipped mass by the action of heat.

15. A light highly cellular porous dehydrated insulating material formed by the process of claim 14 and comprising the products derived from diatomaceous earth, organic fiber, and a binder of a gelatinized material which while drying will form expansible walls for air cells, a proteid adhesive, a caustic alkali and hydrated lime.

16. A light highly cellular porous dehydrated insulating material formed by the process of claim 1 comprising the products derived from diatomaceous earth, organic fibrous material and a binder consisting of a gelatinized starch material.

17. A light highly cellular porous dehydrated insulating material formed by the process of claim 3 comprising the products derived from diatomaceous earth, organic fiber, and a binder consisting of a water soluble organic gelatinous adhesive.

18. A light highly cellular porous dehydrated heat insulating material formed by the process of claim 5 comprising the products derived from diatomaceous earth, organic fiber, and a binder consisting of a gelatinized vegetable material and a proteid frothing agent.

19. A light highly cellular porous dehydrated insulating material formed by the process of claim 6 comprising the products derived from diatomaceous earth, organic fibrous material, a binder composed of water soluble organic gelatinous adhesive and a fixing agent therefor which forms therewith a water resistant glue when dry after being mixed in fluent form.

20. A light highly cellular porous dehydrated insulating material formed by the process of claim 9 comprising the products derived from

diatomaceous earth, organic fibrous material, a vegetable cementitious adhesive agent which when wet is gelatinous or colloidal and of a flexible nature, a frothing agent composed of water soluble organic gelatinous adhesive and a fixing agent therefor which forms therewith a water resistant glue when dry after being mixed in fluent form.

21. A light highly cellular porous dehydrated heat insulating material formed by the process of claim 13, comprising the products derived from diatomaceous earth, organic fiber, gelatinized vegetable material, casein and an alkali.

22. The process of manufacturing a porous heat insulating product from diatomaceous earth, a filler comprising a diatomaceous earth and organic fibrous material and a binder consisting of a gelatinized starch material, which consists in mixing the ingredients in the presence of water, whipping the mass in the presence of air while maintaining a relatively low temperature and then dehydrating the whipped mass at a relatively high temperature for the purposes described.

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