June 4, 1935. B. TOWNSHEND 2,003,319

LIGHTWEIGHT CERAMIC ARTICLE AND METHOD OF MAKING THE SAME

Filed Dec. 13, 1932

Fig. 1.

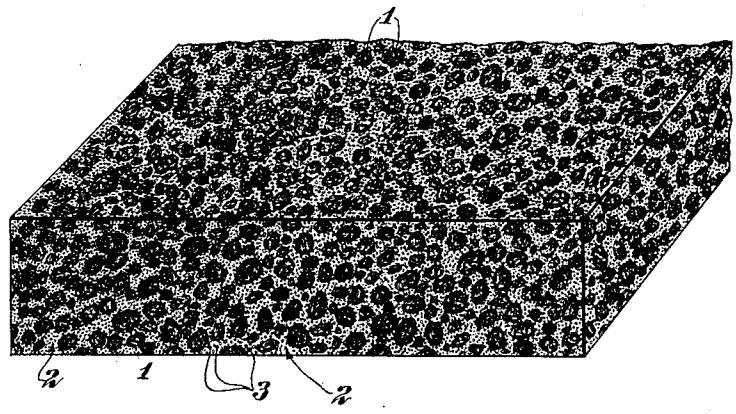


Fig. 2.

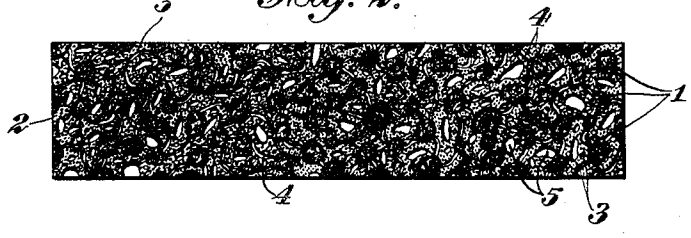
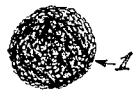


Fig. 3.



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LIGHTWEIGHT CERAMIC ARTICLE AND METHOD OF MAKING THE SAME

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20 Claims. (Cl. 25—156)

This invention relates to a lightweight ceramic article and a method of manufacturing the same. The invention relates particularly to such an article provided with voids that are partly filled with fibrous filling material, such as rock wool, or the like.

It is an object of the invention to provide a durable, washable, fireproof article of manufacture that is effective in absorbing incident sound and in thermal insulation up to temperatures of approximately 2100° F. and to provide a convenient, relatively inexpensive, and novel method of manufacture. Other objects and advantages of the invention will appear from the detailed description that follows.

The invention is illustrated by the following description and by the drawing in which

Fig. 1 is a perspective view of an embodiment of the invention.

Fig. 2 is a cross sectional view of a modified structure provided with additional capillaries or pores extending from voids within the article to an exterior surface thereof.

Fig. 3 is an exterior view of an aggregation of heat-resistant fibrous material suitable for use in compositions of the invention.

In the various figures like reference characters denote like parts.

Thus, 1 denotes a heat-resistant fibrous material, such as mineral wool including, for example, slag wool, glass wool, or, preferably, rock wool in the form of void-containing aggregations or clusters. The fibrous material should be heat-resistant to the extent of not losing its form entirely during firing of the article containing it. The binder material 2 is ceramic, is disposed between the clusters of fibers and, in the finished article, is fired to form a firm, ceramically bonded matrix between the aggregations or clusters and give rigidity to the article. The finished article retains voids present initially in the fibrous clusters and may be provided also with numerous small capillaries or pores 3, which communicate with an exterior surface of the article and with the voids in the fibrous material. In the structure shown in Fig. 2, there appear additional pores 4, resulting from the escape of a gas or the destruction of a filler material during making of the article, and also isolated cells 5 representing, for example, enclosed bubbles of gas. The pores 3 and cells 5, in the figures, are somewhat enlarged in relation to the rest of the structure.

In general, the products of the invention may be made by a process which comprises forming a mixture including nodulated rock wool or the like, a ceramic binding material, and water, shaping the mixture and removing any excess of water therefrom, as by suitable mechanical means, preferably either at very low pressure or without the use of any pressure at all, drying and then firing the shaped mixture to develop a ceramic bond and produce a rigid article provided with voids. When the product is to be used for absorbing sound, a destructible, pore-forming filler may be incorporated with the other ingredients in the original mixture and destroyed during the firing operation. The process is illustrated in more detail in the following specific examples, which are modifications of the general method.

Example I

The fibrous material used consists of rock wool. This product is made by a method that includes melting argillaceous limestone or the like, allowing it to flow from a small orifice, in a small stream, and blowing, into a receiving chamber, by means of steam in the presence of a small proportion of oil, to coat the individual fibers. The form which I use is so-called nodulated rock wool, which results from passing fibers, made as described, between thresher rollers, to give small aggregations of fibers, then collecting the said aggregations and tumbling them in a rotating device provided with screen walls, say with 7 meshes to the linear inch; fine material or shot-like particles are removed through the screen walls and the rock wool fibers retained within the tumbler are rolled into more or less round clusters or nodules. The product is a freely flowing, granular material consisting essentially of irregular spheroidal particles of average diameter that may be about one-fourth inch.

The binding material used comprises a clay that, on being fired, matures to give a firm ceramic bond, at a temperature below that of complete fusion or decomposition of the rock wool, say, at about 2000° F. Thus, Rockingham (N. J.) ball clay has been used satisfactorily.

The fibers and clay are made into a plastic mixture with water and the mixture is shaped. For example, 1 part by weight of the lightly oiled, nodulated rock wool is stirred into a mixture with 1 part of the clay and then uniformly wetted with 4 parts of water. The resulting wet mixture is shaped by being cast in molds provided with a screen bottom and removable sides. After the excess of water has drained away, say after a few minutes, the sides of the mold are removed and the shaped mixture, supported on the screen, is dried at an elevated

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temperature, as, for example, at approximately 212° F. The dried product is then fired in a kiln at a temperature below that of complete fusion or decomposition of the rock wool but sufficiently elevated to develop a ceramic bond through incipient vitrification of the clay and, preferably, also of the rock wool. There is thus produced a rigid article, with preservation of the voids within the clusters of fibers and also the shape of the fibers. Thus, there has been used to advantage firing temperatures of approximately 2000 to 2100° F.

A product so made had an overall density of approximately 29 lbs. per cu. ft. and a modulus of rupture of 95. With varying proportions of ingredients, products may be made of a density of 20 to 40 lbs. per cu. ft. and modulus of rupture of 50 to 200 lbs. per sq. in.

Example II

The procedure of Example I is followed, with the exception that the nodulated rock wool used is made water-resistant by being thoroughly coated with aluminum stearate or other water-repellent material, such as zinc stearate or a wax, before the wool is mixed with the other ingredients of the composition. The waterproofing material may be applied in dust form and then spread over the fibers by melting and tumbling, or, the waterproofing material may be applied in the form of a solution in a volatile solvent, which solvent is then evaporated.

With such water-resistant fibers, less water is necessary to form a mixture for casting. Thus, there has been used only 2.8 parts by weight of water for a mixture of 1 part of rock wool and 1 part of clay.

Example III

The procedure of Example I is modified by the incorporation, into the original mixture, of a combustible material adapted to be destroyed during firing of the product and thus to produce additional voids. The gas produced during the destruction of the filler may increase the porosity by development of gas-escape channels communicating with an exterior surface of the finished article.

There is made a mixture of 31 parts by weight of lightly oiled and nodulated rock wool, a small proportion, say 6 parts by weight, of a filler that is destructible by heat with the development of gas, suitably cork in the form of granules or sawdust, say of size such that the particles may be passed through a 4-mesh screen and be retained on a 10-mesh screen, 53 parts of Rockingham ball clay, 9 parts of a red burning clay that develops a good ceramic bond at about 2000 to 2100° F., and sufficient water to give a plastic mixture suitable for casting. The mixture is cast, drained to remove excess water, dried and fired, as described above. The firing should not be so rapid as to cause gas developed by the thermal decomposition of the filler to disrupt the shaped mixture.

A typical product made as described had an overall density of 26 lbs. per cu. ft. and a modulus of rupture of 110. It had large pores extending from the exterior surfaces to the interior of the article, and corresponding to channels through which escaped the gas from the decomposition of the filler.

Example IV

The procedure of Example III is modified in that the combustible filler material incorporated initially and later destroyed, during firing of the product, is of elongated form and, therefore, adapted to produce elongated voids.

For example, the filler may consist of fine excelsior or very fine curled wood shavings, hay, short lengths of broom straw or the like. Curled or irregularly shaped material that does not tend to pack together and that maintains its several units in spaced relationship to each other are preferred to material composed of straighter members.

The heat-destructible, elongated fibrous filler may be substituted for cork and the resulting composition treated as described under Example III.

During firing of the article, say at approximately 2000 to 2100° F., the fibers are decomposed, to leave elongated voids corresponding to positions initially occupied by the fibers and interconnecting the voids within the rock wool clusters. Also, gas of decomposition is formed and, in escaping, forms gas escape channels communicating with an exterior surface of the article.

Example V

The procedure of Example I is modified by the incorporation of a composition adapted to develop gas in the presence of water. This gas, in escaping, produces gas escape channels. Thus, the nodulated wool is soaked in a dilute solution of aluminum sulfate, dilute sulfuric acid or other suitable acidic material. The soaked wool is mixed with the clay and then, quickly, with an aqueous mixture containing a carbonate, say with an aqueous suspension of precipitated calcium carbonate or of ground dolomite. The mixture is promptly cast and drained, to produce a shaped mixture provided with voids within the clusters or nodules of fibrous material and also gas escape channels or pores 4 (Fig. 2) connecting the voids with an exterior surface. The mixture is then dried and fired with preservation of the said voids and pores.

Example VI

The procedure of Example I is followed except that there is used a density-reducing agent in addition to the rock wool. For example, the water used in forming the original mixture of fibers, clay, and water contains saponin or other foam stabilizer and air, or other suitable gas, dispersed in the form of fine bubbles.

When such a foam is used, there is made a finished product containing voids and pores and also isolated cells 5 which correspond to individual bubbles in the foam used. Many of these cells are not in communication with the other voids or pores or with an exterior surface and are very effective in thermal insulation.

Other density-reducing agents than a foam or the heat-destructible filler, of Examples III and IV, may be used.

Regardless of the particular modification of the method of manufacture that may be used, the products of the present invention have a number of interesting features.

During the mixing and shaping operations the clusters of fibers retain voids. After casting and draining away of any excess water, the fibers reenforce the mixture and thus decrease the liability of the cast product to breakage. The product made, for example, as described under Example I, is light in weight, strong, and an effective thermal insulating material. Thus, a

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product weighing 28 pounds per cu. ft. has a modulus of rupture of 110 lbs. per sq. in. and a thermal conductivity at a mean temperature of 285° F. of 0.81 B. t. u./sq. ft./inch./° F. per hr. Such a product is suitable for use at temperatures up to 2100° F. or above, say to the temperature at which the product was originally fired, with preservation of the shape or fibrous structure of the material within the voids. The fact that the voids in the finished product are partly filled with fibrous material makes these voids more effective in thermal insulation than voids of the same size would be if not so filled in part.

The products of the present invention, when first removed from the firing operation, have surfaces that are not absolutely regular. If desired, the products may be submitted to a cutting or polishing operation to remove the exterior surfaces and produce approximately the exact size and shape desired. Although the products are firm and rigid, they are adapted to be machined readily and lend themselves readily to the sizing operation.

It is not necessary to the invention to explain all of the unexpected results obtained. It is interesting, however, to note that the development of the capillaries 3, that interconnect some of the voids within the several clusters of fibrous material, may be due to the shrinkage, during firing, of clay from around fibers or elongated aggregations of fibers which extend from one cluster to another. The very high firing temperatures used causes a particularly severe shrinkage of the clay that is in contact with the rock wool fibers which themselves probably undergo incipient fusion. It is possible that the capillaries follow courses outlined originally by fibers extending from the surfaces of clusters embedded in the binding material.

The clay coating the rock wool fibers tends to preserve them under the severe conditions of firing and bonds them in the finished product.

Regardless of the correctness of any explanation advanced, the said capillaries 3 present in the product and the larger pores 4 resulting from the use of the destructible filler make the product readily permeable to incident sound. Further, the voids partly filled with fibrous materials are very effective in destroying sound admitted thereto.

The combined result is an effective sound-absorbing unit. Thus a unit, 1 inch thick, made as described under Example III, with the substitution of the 6 parts of cork there described by 12 parts of cork filler of graded size showing 80% in the range 4 to 20-mesh and 20% finer than 20-mesh, has been found to weigh 28 pounds to the cubic foot and to absorb 73% of incident sound of 512 cycles frequency and 31% of 256 cycles.

During the firing of a mixture of rock wool and clay containing iron compounds or similar color producing materials, there is produced a product of considerably lighter color than would be obtained by firing the clay alone. This result, which is particularly important when making acoustical tiles for certain architectural effects, may be due to the action of the lime content of rock wool upon the color-producing materials in the clay. In making a ceramically bonded article of selected color, comprising rock wool and clay, there may be used a clay which, when fired alone, develops a somewhat darker color than that selected.

If, on the other hand, it is desired to avoid the white color, then there may be added selected ingredients to cause the desired coloring. For example, there may be made a brown product by the use of a clay that develops a strong brown color during firing and a rock wool that is suitably colored, say, brown. The rock wool may be colored by the addition of pigmenting substances to the argillaceous limestone during the treatment preceding the blowing operation or, less advantageously, by the addition of pigment to the fibers after blowing. For example, iron compounds may be added. Thus, the rock wool fibers, before incorporation into the clay mixture, may be soaked in an aqueous solution of ferric chloride.

The proportions of materials used may be varied in a manner that will be evident to one skilled in the art and will depend, in part, upon properties desired in the finished product. The proportion of rock wool to clay may be increased, for example, if it is desired to make an exceptionally lightweight product. Or, the proportion of rock wool may be decreased, when it is desired to make a very strong, somewhat heavier product. The proportion of water used should be such as to facilitate shaping by the method selected.

The pressure used during the shaping operation should be such as to prevent collapse of the fibrous structure and preserve the voids therewithin.

The details that have been given are for the purpose of illustration and not restriction, and many variations therefrom may be made without departing from the spirit and scope of the invention.

What I claim is:

1. A lightweight article of manufacture comprising void-containing clusters of heat-resistant fibrous material and a ceramic binding material disposed between the said clusters and fired, to give rigidity to the article.

2. A lightweight article of manufacture comprising void-containing clusters of heat-resistant fibrous material, an additional density-reducing agent, and a ceramic binder material.

3. A lightweight article of manufacture comprising void-containing clusters of mineral wool and a ceramic binding material disposed between the said clusters and fired, to give rigidity to the article.

4. A porous, lightweight article of manufacture comprising void-containing nodules of rock wool and a clay-containing binding material disposed between the said nodules and ceramically bonded.

5. A porous, lightweight sound-absorbing unit comprising void-containing nodules of mineral wool and a clay-containing binding material disposed between the rock wool and ceramically bonded with preservation of the voids within the nodules, the said article being provided with pores which connect the voids with an exterior surface of the article.

6. A ceramically bonded article of manufacture provided with a plurality of voids partly filled with fibrous filling material, capillary passageways interconnecting the said voids, and pores, of larger size than the said capillary passageways, connecting the voids with an outer surface of the article, whereby the article is adapted to absorb incident sound.

7. A ceramically bonded article of manufacture provided with a plurality of voids partly filled with fibrous filling material and provided also with pores communicating with an exterior surface of the article and with the said voids.

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8. In making a ceramic product provided with voids partly filled with fibrous material, the method which comprises treating heat-resistant fibers with a water-repellent material to render the fibers water-resistant, making a plastic mixture of the treated fibers, clay and water, and shaping, drying, and firing the mixture to develop a ceramic bond, with preservation of the shape of approximately the original fibers.

9. The herein described method of making a lightweight article which comprises forming a mixture including void-containing clusters of heat-resistant fibers, clay, and water, shaping the mixture and removing any excess of water therefrom, and drying and firing the shaped mixture to develop a ceramic bond in the clay and produce a rigid article with preservation of voids within the said clusters.

10. The herein described method of making a lightweight article which comprises forming a mixture including fibers of mineral wool, clay, and water, shaping the mixture and removing any excess of water therefrom, and drying and firing the shaped mixture at a temperature below that of complete fusion of the mineral wool but sufficiently elevated to develop a ceramic bond in the clay and produce a rigid article.

11. The herein described method of making a lightweight article which comprises forming a mixture including nodulated fibers of rock wool, clay and water, shaping the mixture and removing any excess of water therefrom, and drying and firing the shaped mixture at approximately 2000° to 2100° F.

12. The herein described method of making a lightweight article which comprises forming a mixture including fibers of mineral wool, an additional density reducing agent, clay, and water, shaping the mixture and removing any excess of water therefrom, drying and firing the shaped mixture at a temperature below that of complete fusion of the mineral wool but sufficiently elevated to develop a ceramic bond in the clay.

13. The herein described method of making a porous, lightweight article which comprises forming a mixture including void-containing clusters of rock wool or the like, clay, a composition adapted to develop a gas, and then shaping, drying, and treating the said mixture to bond the clay therein and develop the said gas, whereby there are formed gas escape channels in the form of pores that extend from the positions occupied by the said clusters to an exterior surface of the article.

14. The herein described method of making a porous, lightweight article which comprises forming a mixture including void-containing clusters rock wool or the like, clay, a heat-destructible organic filler material adapted to develop a gas when subjected to an elevated temperature, and water, shaping and then drying and firing the mixture to produce a ceramic bond in the clay, to develop a gas from the said filler, and cause the gas to escape, whereby there are formed gas escape channels in the form of pores that extend from the positions occupied by the said clusters to the exterior surface of the article.

15. The herein described method of making a porous, lightweight article which comprises forming a mixture including void-containing clusters of rock wool or the like, clay, elongated units of heat-destructible filler material adapted to develop a gas when subjected to an elevated temperature, and water, shaping and then drying and firing the mixture to produce a ceramic bond in the clay, develop a gas from the said filler, and cause the gas to escape, whereby there are formed gas escape channels in the form of pores that extend from the positions occupied by the said clusters to an exterior surface of the article.

16. The herein described method of making a lightweight article which comprises forming a mixture including fibers of rock wool, clay, and water, shaping the mixture and removing any excess of water therefrom, and drying and firing the shaped mixture at a temperature below that of complete fusion of the rock wool but sufficiently elevated to develop a ceramic bond in the clay and produce a rigid article provided with voids between the said fibers, and subjecting the rigid article to a sizing operation to remove the exterior surface and produce approximately the exact shape and size desired.

17. In making a ceramic product provided with voids partly filled with fibrous material, the method which comprises forming water-resistant clusters of heat-resistant fibers, making a plastic mixture of the said clusters, clay and water, shaping, drying and firing the mixture to develop a ceramic bond with preservation of the fibrous material.

18. The herein described method of making a porous, lightweight article which comprises forming a mixture including heat-resistant fibrous material, clay, water and a composition adapted to develop a gas in the presence of water, shaping and then drying and firing the mixture, whereby there is formed a ceramically bonded article provided with pores extending from the positions occupied by the heat-resistant fibrous material to an exterior surface of the article.

19. In making a porous ceramic article of selected color, the method which comprises forming a mixture of rock wool, water, and a clay adapted, when fired alone, to develop a color somewhat darker than the said selected color, and shaping, drying and firing the said mixture.

20. In making a lightweight article, the method which comprises providing void-containing particles, applying a water-repellent material to the said particles, forming a mixture of the particles and water-repellent material with an aqueous binder composition adapted to be hardened, shaping the mixture, and then hardening the binder therein.

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