Oct. 9, 1956 R. A. NESBIT 2,765,512

FORMATION OF CERAMIC, ETC., ARTICLES

Filed July 13, 1950

Fig. 1.



Fig. 2.

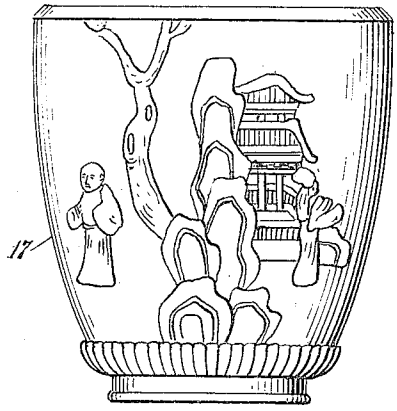


Fig. 3.

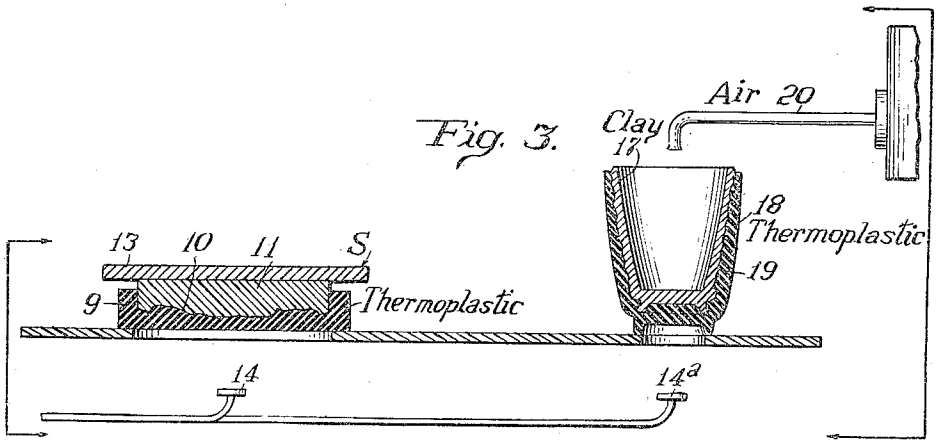
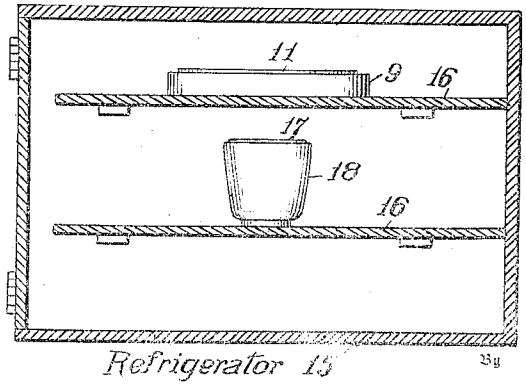


Fig. 4.



Inventor,
Robert A. Nesbit,
Attorney.

United States Patent Office

2,765,512

Patented Oct. 9, 1956

2,765,512

FORMATION OF CERAMIC, ETC., ARTICLES

Robert A. Nesbit, College Park, Md.

Application July 13, 1950, Serial No. 173,587

6 Claims. (Cl. 25—156)

This invention relates to a new and improved method of forming ceramic or equivalent articles and especially, but not with limitation thereto, ones having deep relief, undercuts and sharply defined detail in the surface pattern such as preclude practical and expeditious formation this being particularly true in the making of articles from ceramic materials of low plasticity and low strength in the green or unfired state.

In order that clay or other ceramic raw materials be used for making articles of the type described, it is necessary either that the moist or plastic clay or other ceramic raw material be rendered temporarily rigid without loss of moisture, so that the mold may be removed without distortion or damage to the shaped article and the article then permitted to dry and incidentally shrink without restraint, or that a suitable mold material, be rendered temporarily rigid so that the article may be formed within a temporarily rigid mold which is later permitted to revert to original or such a state that it does not restrain the shaped article during the drying and shrinking of the latter.

Through the procedure of this invention, the objectives mentioned are accomplished either by rendering clay, other ceramic or other raw materials of a suitable plastic consistency or moisture content and which have been formed in or around a flexible mold, temporarily rigid by freezing so that the mold may be removed from the casting without distortion or damage to the casting or shaped article, which is thereafter permitted to dry without restraint. Equivalent procedure is to render suitable fibrous or granular mold materials which are insoluble in water and which have been packed while moist around or in a flexible pattern, sufficiently rigid by freezing so that the pattern may be removed without damage to the temporarily rigid mold thus formed and so that clay or equivalent raw material may be formed in such mold by slip casting or otherwise.

Also according to this invention, clay or other ceramic raw material which has been formed into billets by pressing or otherwise, may be rendered temporarily rigid by freezing so that it may rapidly and conveniently be further formed or shaped by machine or hand tools.

Details of the application of the principles of this invention vary according to the size and shape of the articles desired and according to the working properties of the clay or other ceramic raw materials used and the following specification is to be considered without limitation, but merely as giving one or more examples of the practice and advantages of the novel principle of freezing in the ceramic, allied, or equivalent arts.

In the accompanying drawings the procedure is diagrammatically suggested and therein:

Figure 1 is a side elevation of a solid block ceramic article produced in accordance with the invention;

Figure 2 is a side elevation of a hollow or shell form of ceramic article produced in accordance with the invention;

Figure 3 is a partial vertical section and elevation of a plurality of the ceramic articles associated with their mold, heaters, etc., as employed during the instant process, and

Figure 4 is a vertical section of a conventional refrigerator which may be used, several of the ceramic articles being shown therein.

Referring specifically to the drawings, as one example, in practicing the invention, I employ a mold 9, having the pattern on its inner surface at 10 and in said mold 9 I cast an unfired ceramic article 11 by pouring or massing therein a thick casting slip of clay or other ceramic material. Among the various types of molds available, I prefer to use one of flexible material that is either stretchable or stretchable and elastic as well, and, for example, one made of a thermoplastic synthetic material marketed under the name "Plastiflex," or one made of rubber latex. Such a mold 9 may be made by pouring the molten material therefor over a pattern enclosed in a suitable form and from which pattern the flexible mold is stripped and whose hollow is the reverse of the ceramic article to be produced. The article 11 is an example only and is to be considered as representing a plaque, tile, tray or other article having a high ratio of surface area to depth.

Such articles 11 may conveniently be cast solidly by pouring thick casting slip into the mold 9. An excess of slip is used for said article 11 so that it extends slightly above the level of the opening of the mold. A slab of plaster of Paris S or other suitable absorbent material 13 is laid on the top surface of said mass of ceramic slip 11 in order to absorb surplus fluid. Said mass 11 may be subjected to moderate heat, as from a conventional burner or equivalent 14, preferably applied to the mold from below to promote flow of moisture upwardly through the mass for removal by absorption by said slab S. The latter in turn prevents an excessive rate of moisture loss from the surface of the mass 11 such as would occur if the same were heated in the open air. In this way a suitable and sufficiently uniform moisture content and consistency may be brought about rapidly. Said mass 11 is then subjected to a low temperature until frozen, as by placing the mass and mold within any conventional refrigerating enclosure 15 as on a shelf 16 thereof. While in the frozen state, the shaped or formed article may readily be removed from the mold by peeling the latter from the article because of the mold's stretch or elasticity and thus without distortion either of its general shape or form or impairment of the minutest detail of the surface pattern.

It is feasible, when desired, according to the particular article being made, to remove with hand or machine tools part of the clay or other raw material while the mass remains frozen. Optionally, a mold dressing consisting of a soap or other suitable detergent may be used to promote intimate contact of the casting slip and the surface of the mold, the slip may be deaired to reduce or eliminate bubble formation and to increase fluidity by subjecting it to reduced atmospheric pressure either before pouring or after it has been poured into the mold 9, and the slip may be heated before pouring to increase fluidity and to shorten the time required to eliminate surplus moisture. Heavy ceramic slips of as low moisture content as is consistent with fluidity are desirably employed, and slips containing non-plastic materials such as grog, flint and feldspar are desirable not only because they pass from the fluid state to a stiffened condition suitable for freezing more quickly and with minimum shrinkage, but because the articles formed from them are less subject to cracking and warping in subsequent drying and firing processes.

The range of moisture content to be present upon freez-

ing of the ceramic material is sufficiently wide to offer no practical difficulties to the ceramic craftsman. It varies between that corresponding to the consistency of formed ceramic articles which have just been removed from plaster molds after slip casting to the leather hard condition. If the slip mass is frozen before sufficient moisture has been removed, ice crystals will separate on freezing causing cracks in the article, which latter will collapse when thawed. If too much moisture is removed, the article will shrink in the mold beyond the capacity of the latter to yield with it so that cracks will appear. The range of permissible moisture content and corresponding consistency of the formed material vary with the size and shape of the article and with the composition of the raw material used. Consequently, the range may best be determined by laboratory or shop experiment for each type of article produced and material used.

Alternatively, articles of the type described may be cast by soft mud pressing, using a mud or plastic clay or equivalent of a consistency thicker than slip suitable for the size and design and degree of flexibility of the mold material. After pressing, the mass if not already within the permissible range of moisture content, is brought to a suitable consistency for freezing and is frozen all in accordance with the steps as hereinbefore described.

The freezing to which the mass is subjected according to the instant invention, accomplishes three purposes, namely, it renders the mass sufficiently rigid so that it may be separated from the mold without distortion or damage thereto, even though it has undercuts included in its design; it increases cohesion within the mass so that the cohesion is greater than the adhesion between the mass and the surface of the mold to insure clean and easy stripping or separation; and through thawing brings about a readjustment of the particles of raw materials in the mass, thus relieving strains set up in the mass during the process of stiffening in the mold.

The procedure of this invention is especially useful in forming porcelain articles of high quality since the materials used in such articles are of low plasticity which enables the use of ball clay in porcelain formulae to be reduced or entirely eliminated.

Obviously, the invention does not interfere with the usual methods of ornamentation. It may be mentioned, however, that slips of various colors may initially be applied to pattern portions or surfaces of the mold as desired, thereby producing multi-colored effects in the original casting.

Appendages or decorations may be joined to the main plastic ceramic body by molding the slip thereon and then freezing the slip to the body while both are still in the mold and the main body and the appendages or decorations may be frozen together and the mold stripped from the appendages or decorations. The appendages or decorations may even be made separately according to this invention and joined to the main body after they have been removed from the mold.

A further advantage of this method is that large objects of complex form may readily be cast, either as solid objects or with thick walls, from grog of suitable grain size or combinations of grain size. Five percent (5%) to twenty percent (20%) of sodium silicate is added to the water with which the grog is moistened. The addition of sodium silicate to the water in which the grog is suspended serves the double purpose of providing a binder which gives the formed articles sufficient dry strength and of providing a flux for fusing the grains of grog into a strong article when fired. If desired, additional fluxes in insoluble form, in the form of enamel or glaze frits, or unfritted oxides may be added to the grog. Such suspensions of grog or grog combined with fluxes are readily compacted to a consistency suitable for freezing by permitting them to settle in the mold. The settling may be expedited by vibration if desired and by absorption of part of the water by paper or other absorbent material applied to the surface of the mass at the openings through which the mass was poured into the molds. If desired, cored molds may be used, as such non-plastic materials readily become compacted by settling around the cores. If flexible cores are used they may be removed after the mass has been frozen. Rigid cores of simple form without undercuts may be removed before freezing.

Many ceramic articles of which Figure 2 is representative are of a type of design which should be formed as a shell or hollow **17** rather than as a solid block. This is especially true of vases, jars, figures, figurines, etc. Shells or hollow flexible molds **18** of the same material and character as those disclosed at **9** are used with the desired pattern produced on the inner surface **19** of the mold and therefore very intricate surface patterns will be perfectly reproduced unmarred by the usual mold marks caused by use of sectional rigid molds. Since the mold will not absorb the moisture of the plastic clay or ceramic material, the article **17** is built up by successive layers of casting slip, each layer being partially dried by subjection to heat as from the burner **14***a* and a current of air supplied by a pressure means **20** into the cavity of the shell **17** while in the mold. In the case of molds with cavities of very complex form, the plastic ceramic material may be brought to a suitable and sufficiently uniform state of moisture content by subjecting the mold and contents to moderate heat while the opening of the mold is occluded by an absorbent cover of plaster of Paris or other suitable material, so that condition of high humidity is maintained within the mold together with a high degree of motility of the water contained within the plastic clay or other ceramic raw material making up the shell within the mold. Slips of low drying shrinkage are most satisfactory, and partially deflocculated slips are more satisfactory than those which have been fully deflocculated as the latter do not adhere well to the walls of the mold in the case of the first layer poured or to layers which have previously formed in the case of subsequent pourings. From two to four layers will suffice in most cases. It instances in which the cavity of the mold is sufficiently open and symmetrical, the shell **17** may also be formed by pressing or jiggering a mass of suitable consistency into the mold. Alternatively, in instances in which the ratio of surface area to depth is high, the clay or other ceramic raw material may be cast solidly as described above for forming plaques, tile or trays, and the material not needed to form the shell may be removed while the mass is frozen with machine or hand tools.

The principles of my invention may also be practiced by slip casting in absorbent molds used in lieu of the flexible molds described, the absorbent molds being of a suitable granular or fibrous material insoluble in water, such as fine sand, talc, chalk, starch, paper pulp or suitable mixtures of the above which can be frozen into a stable unit and reverts to normal condition through thawing. The granular or fibrous material is packed while moist in or around a flexible pattern which is a duplicate in form and surface pattern of the ceramic article which is to formed. The mold material is packed so as to conform in all details to the surface of such flexible pattern. The flexible pattern if hollow may be supported during such packing by filling it with absorbent cotton, paraffine (poured and removed while molten), or another readily removed material. The packed moist mold material is drained or partially dried by contact with absorbent materials, but while still retaining part of its moisture is frozen in contact with the pattern. It is thus rendered sufficiently rigid and cohesive so that the flexible pattern may be removed without distortion of the general form or the detail of the surface of the mold material. Casting slip is then poured into the mold thus rendered temporarily rigid. Such mold material being porous, absorbs fluid from the slip, forming a shell of stiffened clay or other ceramic raw material in the same manner as a conventional plaster of Paris mold. When a shell of the desired

thickness is formed, the surplus slip is poured or drained away and the mold and contents are set aside to dry. On thawing the mold loses its rigidity as the mold materials revert to their original granular or fibrous condition. Such materials shrink in drying and the shrinkage closely parallels that of the ceramic material formed in contact with them, particularly when the latter has a high content of granular non-plastic material such as flint, feldspar and calcined powdered clay. If granular mold material is used, it becomes friable on thawing so that the greater part may be scaled, brushed or blown away and the small remainder is incapable of restraining the formed article as it shrinks during the process of drying. When completely dry, the formed article 17 is fired. Any organic mold material remaining on the article is consumed during firing and any remaining mineral mold material may readily be washed or brushed away. If the material is to be fired to high temperatures, it should be preliminarily fired at moderate temperatures not exceeding 1500° F. so that fusion of the surface of the formed article and the granular mold material does not occur and the mold may be removed without injury to the article. The advantage of this method is that it combines the advantages of one-piece mold construction, i. e. freedom from mold marks, with the advantages of the water absorption characteristic of rigid porous molds. Flexible patterns may readily be made from latex rubber or other suitable material by forming in plaster molds made by the lost wax process.

This method is not limited to the formation of ceramic articles since sand or other sufficiently refractory granular material with sufficient moisture content rendered temporarily rigid by freezing enables even a complex flexible pattern to be removed without distortion, the mold so formed to be dried after thawing and molten metals to be cast therein. The addition of a suitable binding substance such as dextrin or polyvinyl alcohol to the mold material last mentioned during drying is advantageous in maintaining stability.

The invention is advantageous, too, where articles of concrete are cast and frozen, since the frozen article may be quickly removed from the mold and the latter thus made available for reuse faster than is the case in concrete casting at the present time. In such use, of course, the concrete is frozen before start of crystallization of the cast mass.

The principles of this invention also extend to the forming of articles of special materials low in or lacking plastic ingredients, such as are frequently formed in billets by pressing, and then machined in the dry state. The addition of undesirable binders which it is necessary to add under present methods to secure the dry strength necessary for machining is obviated or reduced by freezing the billet and effecting the machining while it is temporarily rigid or frozen. This procedure also relieves strains set up in pressing.

Various changes may be resorted to within the spirit and scope of the invention.

I claim as my invention:

1. The steps in the manufacture of a ceramic article comprising casting ceramic material against a pattern of flexible material while the ceramic material contains a greater quantity of moistening agent than is necessary for the final product, then removing sufficient moisture from the cast material as to avoid formation of cracks upon freezing and instability upon thawing but leaving sufficient moisture to produce a rigid self-sustaining article upon freezing, thereupon freezing such residual-moisture-containing cast material while retaining the residual moisture, then so stripping the flexible material from the ceramic article as to preserve the integrity of the reverse of the pattern imparted to the ceramic article, and then thawing the ceramic article.

2. The steps in the manufacture of a ceramic article comprising casting ceramic material against a pattern of flexible material while the ceramic material contains more water than is necessary for the final product, then removing sufficient moisture from the cast ceramic material as to avoid formation of cracks upon freezing and instability upon thawing but leaving sufficient moisture to produce a rigid self-sustaining article upon freezing, thereupon freezing such residual-moisture-containing cast material while retaining the residual moisture, then so stripping the flexible material from the ceramic article as to preserve the integrity of the reverse of the pattern imparted to the ceramic article, thawing the ceramic article, and thereafter firing the ceramic article.

3. The steps in the manufacture of a ceramic article according to claim 1 practiced in a hollow mold of which said flexible material is a wall thereof and said pattern is on its inner surface.

4. The steps according to claim 2 wherein the ceramic material is clay built up in successive layers of casting slip.

5. The steps according to claim 2 wherein the pattern is of latex.

6. The steps according to claim 2 wherein the pattern is of thermo-plastic synthetic material.

References Cited in the file of this patent

UNITED STATES PATENTS

1,434,397	Mock	Nov. 7, 1922
2,196,258	Erdle	Apr. 9, 1940
2,291,680	Billner	Aug. 4, 1942
2,395,293	Pfleumer	Feb. 19, 1946
2,476,726	Haas	July 19, 1949

FOREIGN PATENTS

41,790	Austria	Apr. 11, 1910