UNITED STATES PATENT OFFICE.

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METHOD OF PRODUCING CERAMIC WARES.

950,954. Specification of Letters Patent. **Patented Mar. 1, 1910.**

No Drawing. Application filed August 24, 1908. Serial No. 449,981.

To all whom it may concern:

Be it known that I, EUGENE S. POWERS, a citizen of the United States, residing in Merchantville, in the county of Camden, State of New Jersey, have invented a new and useful Method of Producing Ceramic Wares, of which the following is a specification.

One of the main objects of my present invention is to devise a novel method of making ceramic ware.

Another object of my present invention is the production of ceramic wares of various shapes and grades with metal fibers embedded therein to impart tensile strength to them, thereby fitting them to be used in ways heretofore impossible. For example, slabs of such a material could often be used in place of wood, especially in buildings, thereby making a more permanent construction and reducing loss by fire.

It will be realized at once by those familiar with the art, that there are three great physical difficulties in the way of producing a ceramic ware with metal fibers embedded therein, namely: first, clay, the great matrix material of the art, contracts or shrinks while drying, therefore long fibers of a rigid material like metal, embedded in the green ware would ordinarily cause said ware to crack when drying; second, the coefficient of expansion of metal is much greater than clay or any other body material used in the art, therefore long metal fibers embedded in the ware would ordinarily cause the ware to crack when fired, due to differences in the expansion of the metal fibers and the surrounding body material; third, the metal fibers would ordinarily be destroyed by oxidation during the process of firing the ware. The first of these difficulties I overcome by using (in such amounts as to reduce the shrinkage of the green ware during drying to practically zero) in the body material of which the ware is formed any suitable substance that has no shrinkage or contraction during drying, for example, dehydrated clay, coal ashes, silica, etc. That is a body material, is used, in which the component particles are substantially in contact one with the other. The second of these difficulties I overcome by having the fibers smooth and straight enough to expand freely in the direction of their length. It is preferable to have at least one end of the fibers, except in very short pieces of ware, free, that is not covered by body material. The third of these difficulties I overcome by regulating the amount of air supplied for combustion. The fires are run until the ware is practically indurated, so there will be a slight excess of carbon monoxid gas in the products of combustion thereby forming a reducing atmosphere and then I finish off by running the fires so there will be an excess of air in the products of combustion, thereby oxidizing the outside of the ware, but I do not continue this oxidation long enough to penetrate to the fibers.

To assure that the fibers will not rust when the ware is exposed to the weather, they are given a fusible inorganic coating, which melts at a lower temperature than the body material, causing a film of the surrounding body material to completely vitrify when the ware is fired. This coating of flux also serves to free the fibers from the surrounding body material and permit them to expand more readily and consequently lessens the danger of their expansion cracking the ware. Coating the fibers with flux also causes the body material, after the ware has cooled off, to hold the fibers more firmly. After the wares are fired to induration they should be cooled down slowly so as to reduce and equalize the stresses on the fibers and the surrounding body material, that is, the ware should preferably be annealed.

Steel, the strongest and cheapest commercial metal, has a melting point several hundred degrees above the maximum temperature required in ceramics, and therefore is the metal that will be most used in my process, but is not the only metal that can be used. The maximum cross section of any fiber that can be used is that section whose perimetral expansion, under the maximum temperature required to indurate the wares, will not be enough to crack the surrounding body material. One method of procedure in making a cheap ceramic ware with metal fibers embedded therein, is as follows: Take dry coal ashes and grind them to a desired fineness and then take dry earth or clay containing hydroferric oxid or other suitable flux and reduce it to a uniform consistency by grinding or other means, use one part by weight of this dry ground earth or clay to five parts, by weight, of the dry ground ashes, mixing together thoroughly and then stirring in thoroughly sufficient water to

cause the mixture to ball when squeezed in the hand. The mixture is then ready to be molded into the ware.

The molds, if used to shape the material, can be of iron, steel or other suitable material of the required dimensions with removable bottoms. These molds can be filled by sieves operated mechanically, the wires being placed into the molds at the proper time as they are filling up. After a mold is filled the body material in it is compressed to the required thickness by running the mold under a suitable press. The green ware or tile is removed from the mold and carried away on the removable bottom of its mold. The wires or metal fibers may be coated with sodium or potassium, silicate or other suitable flux which preferably melts at a lower temperature than the body material. These green tiles will not have tenacity enough to permit them being stacked up like ordinary ware, but, unlike ordinary ware, can be dried and fired very rapidly, in fact so rapidly, that drying and firing become one operation. And these can be conducted continuously and very economically in some suitable form of channel furnace through which the ware is passed on trucks on which they were placed directly from the presses.

It is apparent that the above method of procedure can be varied indefinitely, both as regards the materials used and the manner of manipulating them, without departing from my invention. For example, any body material and any flux known to the ceramic art can be used in place of the ashes and the yellow earth or clay. Furthermore, it is apparent that the flux need not be added to the body material dry and is only added when the body material is too refractory. In fact it should be readily understood that the only difference in preparing body material for use in making metal fibered ware and non-metal fibered ware is that it must be prepared so that it will have practically no shrinkage when changing from a wet to a dry state. Again it should be apparent that the metal fibers and body material need not be brought together in the manner stated above. The only essential is that the fibers be placed in the body material in such a manner and under such conditions that they can expand without rupturing the surrounding body material and that the body material have a uniform density, the same as is required of the body material in non-metal-fibered ware. The method of placing the fibers in the body material is immaterial.

The fibers can be given by any means, a thin coating of any flux as long as it will melt at a lower temperature than the body material. The essential thing about the fibers is that they are smooth and straight enough to expand in their length without rupturing the surrounding body material. Furthermore the manner of firing is also unessential as long as the fibers are not destroyed. Some specimens I have made have been dried and fired in one operation in an ordinary stove using anthracite pea coal, the specimens being covered up with the coals. The unprotected specimens were thus buried in highly heated carbon which until the carbon is well consumed produced below the surface of the coals more carbon monoxid gas, even under forced draft, than it does carbon dioxid gas. The specimens were thus indurated without being oxidized. Other specimens were fired in a gas kiln but they may be fired in any desired kiln.

In making metal fibered or non-metal fibered ceramic products the physical and chemical properties of the kiln atmosphere is altered to produce desired changes in the appearance, or finish and quality of the product, the only requisite is that the firing be conducted so as not to destroy the fibers.

From the above it is seen that there is no reason why glazed ceramic wares, also ceramic wares of various colors can not be made with metal fibers in them by my process.

It is to be understood that where in the claims I speak of metal fibers, that by the term "fiber" I intend to include metal pieces of any desired size or shape which may be used in carrying out my novel method. It is also to be understood that where in the claims I speak of ceramic objects the term "ceramic" is to be taken as applying broadly to the potter's art which comprises all those products made of such body materials as clays, earths, disintegrated, silicious minerals, ashes, etc., of which the products are first formed and then their component particles united and the products indurated by the action of heat on a suitable flux or fluxes naturally or artifically present in the body material.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is: —

1. The method of making metal reinforced ceramic objects, which consists in molding such objects of material which is practically non-shrinkable in drying, coating substantially straight metallic fibers with fusible silicate, embedding them in the objects being molded, and firing the objects thus prepared in a reducing atmosphere.

2. The method of making metal reinforced ceramic objects, which consists in taking a body material of such a nature that it will not shrink appreciably when drying, forming the same into objects, embedding therein metal fibers in such a manner and under such conditions that they can expand during firing without rupturing the surrounding body material, and then indurat-

ing the objects thus formed by firing the same in a kiln in such a manner and under such conditions that the metal fibers will not be destroyed.

3. The method of making metal reinforced ceramic objects, which consists in taking a body material of such a nature that it will not shrink appreciably when changing from a moist to a dry state and at the same time of forming the same into objects embedding therein metal fibers in such a manner that each fiber is separated from the other fibers by the surrounding body material and in such a manner and under such conditions that each fiber can expand during firing without rupturing the surrounding body material, and then indurating the body material by firing in such a manner and under such conditions that the metal fibers will not be destroyed.

4. The method of making metal reinforced ceramic objects, which consists in preparing a body material of such a nature and in such a manner as to avoid shrinkage from drying, and during the process of forming the same into objects embedding in the body material metal fibers in such a manner that each fiber is separated from the other fibers by surrounding body material and in such a manner and under such conditions that each fiber can expand during firing without rupturing the surrounding body material, and then firing the body material in such a manner and under such conditions as to prevent destruction of the metal fibers.

5. The method of making metal reinforced ceramic objects, which consists in molding such objects of material which is practically non-shrinkable in drying, giving substantially straight metallic fibers a fluxible inorganic coating, embedding them in the objects being molded, and firing the objects thus prepared in a reducing atmosphere to indurate them.

6. The method of making metal reinforced ceramic objects, which consists in molding such objects of body material in which the component particles are substantially in contact one with the other so that there can be practically no contraction from drying, coating substantially straight metal fibers with a flux, embedding the fibers thus coated in the objects being molded, and firing the products thus prepared in a reducing atmosphere to indurate them.

7. The method of making metal reinforced ceramic objects, which consists in molding such objects of a body material in which the component particles are substantially in contact one with the other so there can be practically no contraction from drying, coating substantially straight metallic fibers with a fusible silicious mineral, embedding the fibers thus coated in the products being molded, and firing the objects thus prepared in a reducing atmosphere to indurate them.

8. The method of making metal reinforced ceramic objects, which consists in molding such objects of a body material which has its component particles substantially in contact one with the other so there can be practically no contraction from drying, coating substantially straight metallic fibers with sodium silicate, embedding the fibers thus coated in the objects being molded, and firing the objects thus prepared in a reducing atmosphere.

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Witnesses:
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