Dec. 1, 1959 W. A. DANIEL 2,914,834

METHOD OF MAKING CERAMIC CYLINDERS

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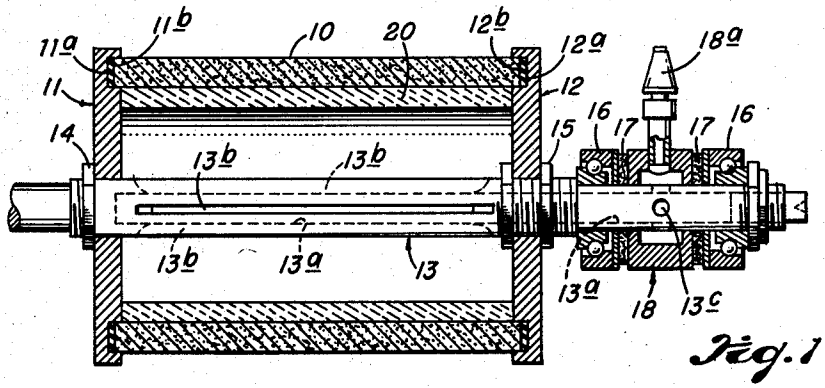


Fig. 1

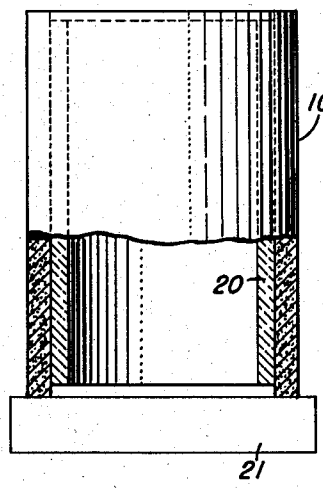


Fig. 2

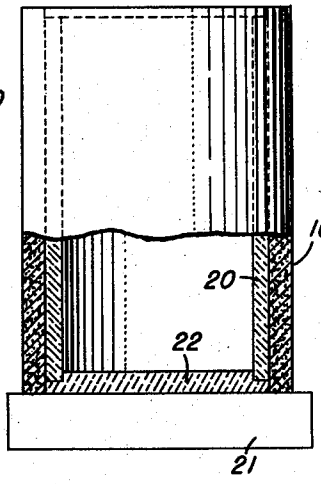


Fig. 3

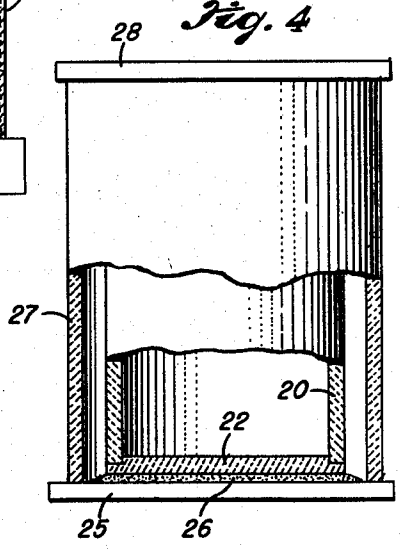


Fig. 4

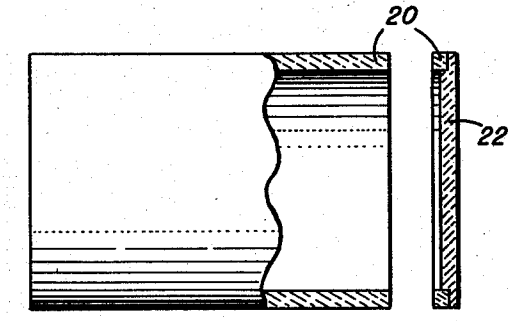


Fig. 5

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METHOD OF MAKING CERAMIC CYLINDERS

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5 Claims. (Cl. 25—157)

This invention relates to the manufacture of tubular ceramic objects and has particular application to thin-walled hollow cylinders of ceramic material that shrink appreciably during firing.

A general object of the invention is to reduce distortion of tubular ceramic objects during firing.

It is well known that many ceramic materials become quite soft during firing and distort in response to relatively slight forces. To reduce the distorting force of gravity on hollow cylinders, they are fired in vertical position while resting on a flat surface. However, if the cylinder shrinks, inward movement of the base is resisted by friction between it and the supporting surface so that the lower end is often belled or oval, and a substantial portion must be cut off and discarded. This belling has been reduced by supporting the cylinder upon a "shrinkage" ring of the same ceramic and of substantial radial thickness during firing, but shrinkage rings are expensive and are not always successful.

In accordance with the present invention, an end wall of the same ceramic material is formed on the base end of the cylinder. This end wall tends to shrink during firing at the same rate as the cylinder, and has sufficient strength, by virtue of its large radial dimensions, to overcome the frictional resistance of the supporting surface. This substantially eliminates any distortion of the cylinder from a true cylindrical shape during firing, after which the lower end is cut off close to the end wall.

The most satisfactory presently known way of forming large-diameter, thin-walled, hollow ceramic cylinders is by centrifugal slip-casting, and a feature of the invention is a method of forming a suitable end wall on a centrifugally cast cylinder.

Other objects and features of the invention will be apparent from the following detailed description taken in connection with the drawing, in which:

Fig. 1 is a longitudinal sectional view illustrating the centrifugal slip-casting of a hollow ceramic cylinder.

Fig. 2 is a schematic diagram showing a mold containing a centrifugally cast cylinder positioned on a porous slab, ready for the casting of an end wall thereon.

Fig. 3 is a diagram like Fig. 2, with the end wall poured.

Fig. 4 is a schematic diagram showing a cylinder with an end wall positioned in a muffle for firing.

Fig. 5 shows a finished cylinder with the end wall removed.

Fig. 1 shows a portion of a centrifugal casting machine that may be used to produce open-ended, hollow ceramic cylinders. It comprises a porous cylindrical mold **10**, which may be of plaster of Paris, and is supported between two end walls **11** and **12**. The end walls have annular grooves **11***a* and **12***a*, respectively, for receiving the ends of the mold **10**. Gaskets **11***b* and **12***b* may be positioned in the annular grooves **11***a* and **12***a*, respectively, to effect a fluid seal. The end walls **11** and **12** are supported on an arbor **13** having nuts **14** and **15** bearing against the outer surfaces of the end walls **11** and **12**, respectively, for securing them tightly against the cylindrical mold **10**. The arbor **13** has a central passage **13***a* extending from the end wall **11** past the end wall **12**, and has radially extending slots **13***b* extending therefrom between the end walls **11** and **12** for the discharge of slip into the mold. Slip is supplied to the passage **13***a* through a hollow bushing **18** encircling the shaft beyond the mold end wall **12** and communicating with the passage **13***a* through radial holes **13***c* therein. The bushing **18** remains stationary while the arbor **13** rotates, and is sealed with respect to the arbor by washers **17** of resilient material which are compressed between the opposite ends of the bushing **18** and a pair of ball thrust bearings, **16**, **16**.

In operation, the bushing **18** is connected to a source of slip through a suitable line connected to a nipple **18***a* on the bushing **18**, and, while the arbor **13** is rotated by any suitable mechanism, a desired quantity of slip is forced through the nipple **18***a*, the hollow bushing **18**, the passage **13***a* in the arbor, and out through the slots **13***b* into the rotating mold. The slip is quickly forced by the centrifugal force into a layer **20** which is hereinafter referred to as the casting or the cylindrical casting. The spinning of the mold is continued until the casting **20** has been sufficiently dried by transfer of water from the slip into the porous mold **10** to make the casting self-supporting. The mold end wall **11** is then removed, after first removing the nut **14**, and the cylindrical mold **10** with the casting **20** adhering thereto is removed from the casting apparatus and is set in vertical position on a porous slab, of material such as plaster of Paris, as indicated at **21** in Fig. 2.

It will be observed that by virtue of the annular grooves **11***a* and **12***a* in the mold end walls **11** and **12** of Fig. 1, the cylindrical mold **10** extends beyond the end of the casting **20**.

An end wall **22** is then formed on the lower end of the casting **20**, while the latter is in semi-wet condition, by pouring a quantity of slip into the cylinder while positioned as shown in Fig. 2. The slip flattens out by its own weight, as shown in Fig. 3, and dries by absorption of moisture therefrom into the porous slab **21** to form an end wall **22**. The assembly of the casting **20** and the end wall casting **22** is permitted to dry in the cylindrical mold **10** and on the porous slab **21** until they detach themselves from the mold and slab, after which the mold **10** may be lifted off of the casting **20**, and the assembly of the casting **20** and the end wall **22** may be then lifted off the slab **21**.

The assembly of the casting **20** and **22**, after further drying if necessary, is then placed, as shown in Fig. 4, on a refractory slab **25** which is covered with a layer of leveled refractory sand **26**. The casting is enclosed with a refractory tube or muffle **27** and a top plate **28** of refractory material. The entire assembly is then placed in a suitable kiln and fired.

As previously indicated, some ceramic materials become quite soft during the firing operation, and also contract substantially. This contraction normally results in uniform radial contraction of the casting **20**, provided such contraction is not impeded by any resistant forces. When a casting **20** without an end wall **22** is supported directly on a refractory slab, the radial contraction at the lower end of the casting is restrained, and belling or distortion from true concentric shape often results. However, the end wall casting **22** prevents such distortion, because it has sufficient body to overcome its frictional resistance to movement along the refractory slab **25**, and carries the lower end of the casting **20** with it.

It is important that the end wall **22** extends below the end of the casting **20**, and not merely be joined to the inner surface of the casting **20**, because the bond between the base **22** and the casting **20** may then be

insufficient to prevent the cap from shrinking radially inwardly away from the cylinder **20**. When the end wall **22** is formed as shown, extending completely below the lower end of the cylinder **20**, it has no tendency to pull radially inwardly away from the cylinder **20** during the firing operation.

After the firing has been completed and the assembly has cooled, the end wall **22** and a small portion of the casting **20** may be sawed off, as shown in Fig. 5, to leave the desired open-ended cylindrical ceramic shape. The small portion of the casting **20** that is removed with the end wall **22** is negligible compared with the portion that must often be discarded when the cylinders **20** are fired without the end wall **22** to reduce belling and other distortion.

Although for the purpose of explaining the invention a particular embodiment thereof has been shown and described, obvious modifications will occur to a person skilled in the art, and I do not desire to be limited to the exact details shown and described.

I claim:

1. The method of reducing distortion in a hollow ceramic cylinder during firing thereof comprising: forming at one end of the cylinder while it is in semi-wet condition a ceramic end wall extending across the end and in bonding contact with the end surface of the cylinder; drying the assembly of cylinder and end wall; firing said assembly with said end wall resting on a horizontal supporting surface and the cylinder supported in vertical position entirely on said end wall; and removing said end wall.

2. The method of claim 1 in which said end wall is formed on the end of the cylinder by pour casting.

3. The method of claim 1 in which said end wall extends into said cylinder in contact with a zone of the inner surface thereof next adjacent the end thereof.

4. The method of producing a hollow ceramic cylinder comprising: centrifugal slip-casting a ceramic cylinder in a hollow absorbent cylindrical mold having a removable end closure extending into the mold whereby one end of the cylinder is spaced from the adjacent end of the mold; removing said end closure; supporting said mold with the cylinder therein in vertical position on a flat absorbent surface with said adjacent end of the mold resting on said surface; casting a ceramic end wall on said cylinder by pouring slip into said cylinder to a depth sufficient to fill said mold at least to said one end of said cylinder; drying the assembly of cylinder and end wall; firing said assembly with said end wall resting on a horizontal supporting surface and the cylinder supported in vertical position entirely on said end wall; and removing said end wall.

5. The method of claim 4 in which said slip is poured to a level above said one end of said cylinder, whereby the end wall joins the cylinder both over the surface of said one end and over a zone of the inner surface adjacent said end.

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