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[54] **CONSTRUCTION PROCESS AND APPARATUS FOR FORMING CERAMIC WALLS**

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[63] Continuation of Ser. No. 796,692, Feb. 5, 1969, abandoned.

[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **65/19,** 65/136, 65/144, 65/335

[51] **Int. Cl.** **C03b 5/04**

[58] **Field of Search**.....65/18, 19, 122, 136, 144, 335

[56] **References Cited**

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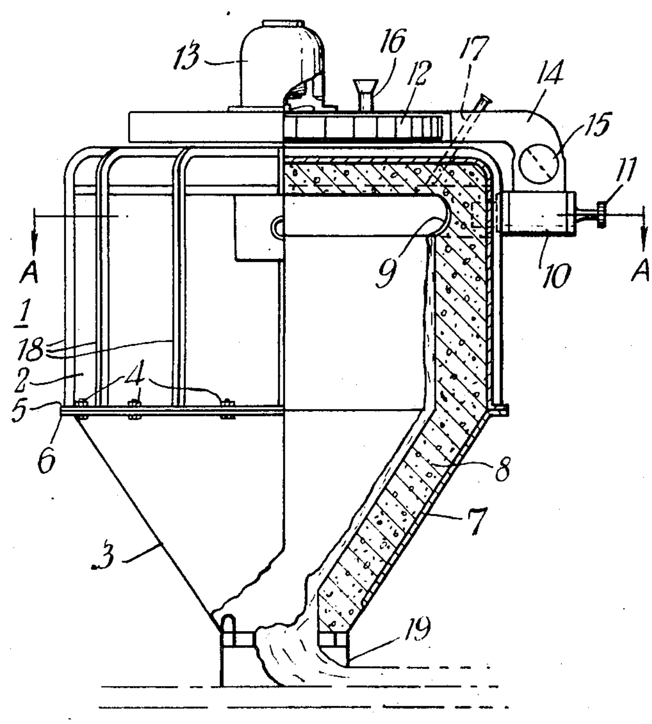
[57] **ABSTRACT**

A method of heating raw material in which a stream of particles of raw material are fed through the hot zone of a heat source in a housing. The heat transforms the particles into a completely or partially molten state and the particles are then discharged from the housing. They may be deposited in moulds or in superposed successive layers.

8 Claims, 3 Drawing Figures



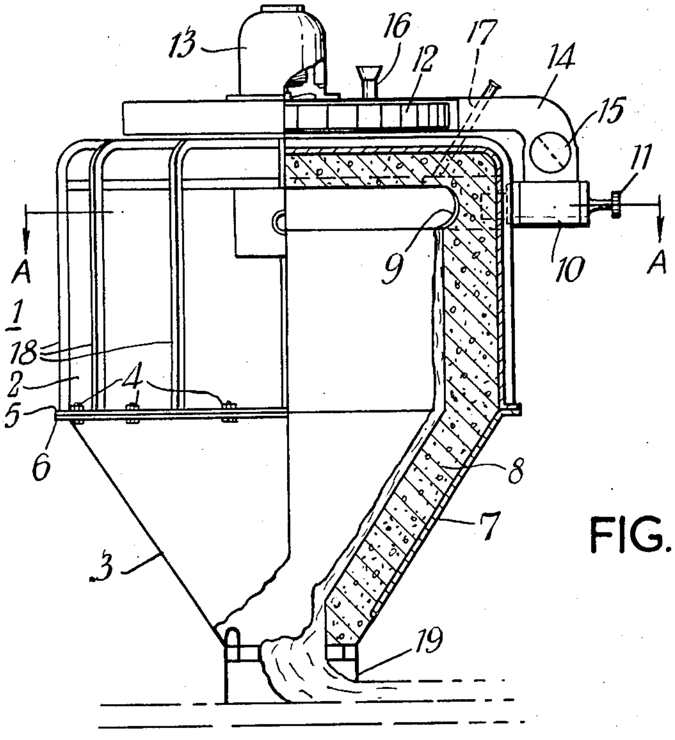


FIG. 1

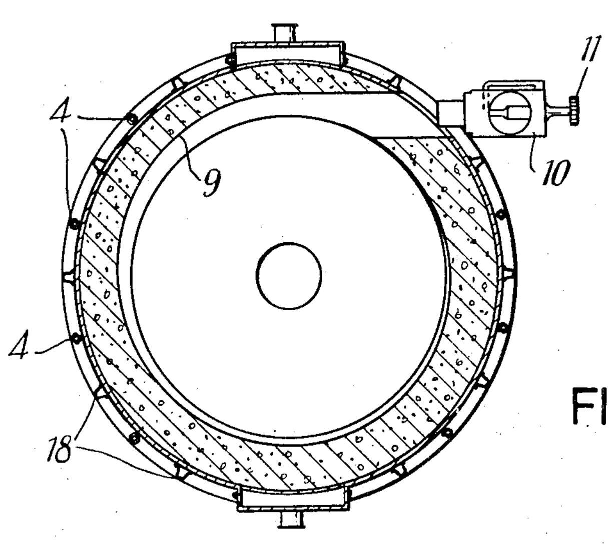


FIG. 2

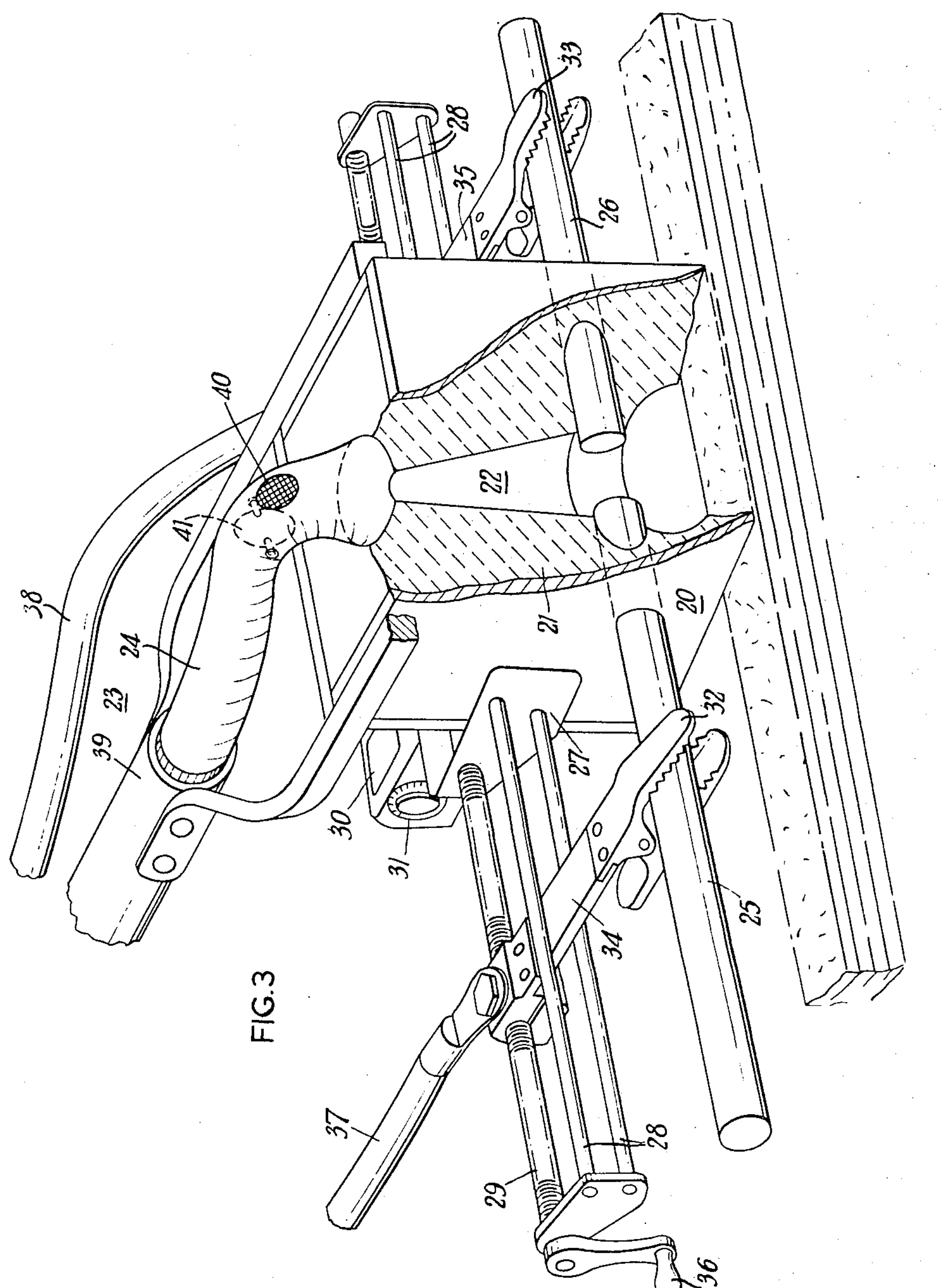


FIG.3

CONSTRUCTION PROCESS AND APPARATUS FOR FORMING CERAMIC WALLS

This is a continuation of application, Ser. No. 796,692 filed Feb. 5, 1969, now abandoned.

The present invention relates to a construction process and apparatus therefor.

According to one aspect of the present invention there is provided a construction process including the steps of passing a continuous stream of particles of raw material for making a ceramic into a chamber and through the hot zone of a heat source in said chamber, whereby the particles are transformed into a partially or completely molten state in said chamber, depositing the molten material from the chamber in superposed successive layers, each layers, apart from the first, adhering to the next adjacent layer by virtue of its molten state, and allowing said layers to cool.

According to another aspect of the present invention there is provided construction apparatus including a housing defining a chamber, a heat source operative to produce a hot zone in the chamber, a raw material supply duct disposed to direct particles of raw material into the hot zone in order to transform particles of raw material into a partially or completely molten state, and an outlet in the housing through which the molten particles may be discharged, the housing being so constructed that the particles are maintained in a molten state until they reach the end of their travel through the chamber, and means for moving the housing so as to deposit molten material therefrom in superposed successive layers.

In order than the invention may be more clearly understood two embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 shows an elevational view in partial section of one embodiment in which the hot zone is produced by an oil fired burner,

FIG. 2 shows a section in plan view taken along the line A—A of FIG. 1,

FIG. 3 shows an embodiment in which the hot zone is produced by an electric arc.

Referring to FIGS. 1 and 2 the apparatus comprises a housing 1 having an upper cylindrical metal portion 2 joined to a lower inverted conical metal portion 3, by means of a number of bolts 4 extending through flanges 5, 6 formed on adjoining edges of the metal portions 3, 4 respectively. A layer of fiber glass insulation 7 is disposed around the interior wall surface of the housing 1 and a refractory cement lining 8 is disposed on this layer of insulation 7. A volute recess 9 is formed in the refractory cement lining 8 and an oil burner 10 is positioned at the entrance of the recess 9 so that the flame from the burner is directed into the recess 9. The oil burner 10 incorporates a fuel control 11.

A centrifugal fan 12 driven by a fan motor 13, is disposed on top of the housing 1. The fan 12 feeds air under pressure through a duct 14, incorporating an airflow control 15, to the burner 10.

A raw material supply duct 16 leads into the housing for the fan 12. Thus, the air stream produced by the fan 12 carries particles of raw material fed into it through the duct 14 to the burner 10 and thence to the chamber defined by the housing 1. The raw material may alternatively be fed directly to the chamber defined by the housing 1 through a duct 17 (shown in broken-line in FIG. 1) the particles of raw material in this case entering the chamber directly into the path of the flame issuing from the burner 10.

The upper portion 2 of the housing 1 is provided with strengthening ribs 18 and the base of the lower portion 3 forms an outlet 19 which is constructed as a guide for molten material produced in the chamber.

In operation of the apparatus, particles of raw material are fed into the chamber either through the supply duct 16 or through the supply duct 17. In the case of supply through the supply duct 16 the particles of raw material are carried into the chamber with the flaming gases issuing from the burner 10. In the case of supply through the supply duct 17 the particles of raw material are introduced into the path of these flaming gases. In both cases the particles of raw material are carried round the volute recess 9 and a rotary motion is imparted to the particles. The resultant centrifugal force acting on the particles tends to hold the particles on the wall of the recess 9. As the particles melt due to the heat supplied by the burner 10 the external surface of the particles becomes tacky and the particles stick to the wall of the recess. The fluidity of the particles increases until the particles merge with each other and flow down the refractory lining 8 under the action of gravity.

A continuous stream of molten material is discharged from the chamber through the outlet 19 at the base of the lower portion 2. The exhaust gases from the burner 10 are also discharged through the outlet 19.

As the molten material is discharged the apparatus is moved along the building surface so that a layer of the material is deposited on the surface. This layer immediately hardens and adheres to the surface. Thus a number of superposed layers may be built up by a number of passes of the apparatus over the building surface.

Referring to FIG. 3 the apparatus of this embodiment comprises a rectangular housing 20 with an asbestos lining 21. An aperture of generally conical shape is bored through the lining 21 between two opposite faces to form a chamber 22 and a sand supply duct 23 comprising a flexible sand-feeding hose 24 is connected to the aperture at the end of smaller diameter. Two further apertures are bored in two further opposite faces of the lining 21 these apertures being co-axial and their common axis being disposed perpendicular to the axis of the conical aperture. Two rod-shaped carbon electrodes 25 and 26 are inserted through these apertures so as to extend into the chamber 22 and define therebetween a gap. The diameter of the carbon rods 25, 26 is approximately half the average diameter of the chamber 22.

A frame comprising a U-shaped portion 27 and four guide rails 28, two being connected to one leg and two being connected to the other leg of the U-shaped portion, is connected to the housing 20 such that the U-shaped portion partially surrounds the housing 20 and the guide rails 28 extend parallel to the carbon rods 25 and 26. A screw threaded shaft 29 is rotatably connected to the frame and extends the length of the frame parallel to the guide rails. The portion of the shaft 29 at one side of the housing 20 is right hand threaded and the portion of the shaft 29 at the other side of the housing 20 is left hand threaded. A feed motor 30 is mounted on the frame and is connected to the shaft 29 through a low speed reduction gear. A rheostat 31 is provided for motor speed control.

Two clamping jaws 32 and 33 are respectively clamped to the two carbon rods 25 and 26. The jaws 32 and 33 are respectively connected to two insulated arms 34 and 35 in which two apertures are respectively provided at their ends remote from the jaws. The apertures are screw threaded in a complementary manner to the threaded portions of the threaded shaft 29, one of the apertures being right hand threaded and being mounted on the right hand threaded portion of the shaft 29 and the other portion being left hand threaded and being mounted on the left hand threaded portion of the shaft 29.

The insulated arms are respectively disposed between the two pairs of guide rails 28 such that when the threaded shaft 29 is rotated the arms and therefore the carbon rods 25 and 26 move along the shaft 29 and do not rotate with it. A handle 36 is connected to one end of the shaft 29 whereby the shaft 29 may be manually rotated in order to adjust the gap between the carbon rods 25 and 26 for striking an arc.

Two electrical leads 37 and 38 are respectively connected to the two insulated arms 34 and 35 and to the secondary winding of a transformer. The leads 37 and 38 are clamped to a tube 39 which is connected to the end of the sand-feeding hose 24 remote from the housing 20. An air exhaust grid 40 is provided in the sand feeding hose 24 and a baffle plate 41 is disposed inside the hose 24 in front of this grid 40 to deflect the sand to prevent sand being carried out through the grid 40 with the air stream carrying the sand to the arc chamber 22. The tube 39, which is itself rigid, is rigidly connected to the lining 21 in the housing 20.

In operation the carbon rods 25 and 26 are moved towards each other by means of the handle 36 until the gap is sufficiently small for the arc to be struck. When the arc has been struck the gap is widened to its optimum value for the current fed to the arc. The speed of the feed motor 30 is set by the rheostat 31 in dependence upon the current fed to the arc. A stream of sand particles is fed on a current of air through the tube 39 and sand feeding hose 24. The air escapes through the air exhaust grid 40 and the sand particles are deflected down through the arc chamber 22 which is vertically arranged. The sand particles fall through the arc under the force of gravity and are completely or partially transformed into a molten state. The molten particles are then deposited on the building surface below and owing to their molten state adhere to that surface. As the molten sand particles are being deposited the arc chamber 22 moves along the building surface and a layer of sand particles is thus formed. The process is repeated and the building component is built up in successive layers.

The apparatus of both embodiments is mounted for mobility in three dimensions. For the construction of a circular building the apparatus may, for example, be mounted on a pillar through an arm. The pillar is screw threaded thus enabling the apparatus to be raised or lowered and the arm carries a counter weight so that the apparatus may be moved out from the pillar to the desired radius. Thus as the apparatus performs a circular motion of a desired radius it is raised by a predetermined amount during each revolution as the wall to be formed is built up. For example, at each pass of the apparatus a layer of fused material from ⅛ to ¼ of an inch is deposited on the wall and thus the apparatus would be raised by this amount during one revolution. If it were desired to form a dome or a spire the radius of revolution of the apparatus could be progressively decreased. No forms or supports would be necessary as the material will harden within seconds.

The amount of sand fed to the arc or to the oil burner and the current consumed by the arc or the oil consumed by the oil burner is controlled in dependence upon rate of construction and the quality of the finished material required. If the sand particles are completely transformed into a molten state the elements of the sand will, when resolidifying, assume a new molecular structure and a glass-like substance will be produced. If, however, only the outer surface of the particles is melted the particles will adhere to each other and a substance akin to sandstone will be produced. The quantity of sand which can be fed to the arc or to the oil burner will of course be greater in the case where the particles are only partially melted than in the case where the particles are completely melted for a given current fed to the arc or quantity of oil to the oil burner. For example, 15 gms of silica sand per second can be melted in an arc consuming a current of 250 amperes at 100 volts. If the sand is only partially melted however, three to four times this quantity can be dealt with by the same arc in the same time. The apparatus may be made enlarged in order that a larger volume of silica sand can be dealt with. The velocity at which the apparatus moves over the building surface will depend upon the current fed to the arc or upon the rate at which oil is fed to the burner.

It is important that the molten material is not allowed to harden before it reaches the building surface as no bond would be made and for this reason it is necessary to make the gap between the arc and the surface or between the oil burner and the surface as small as possible. It is also necessary to keep the temperature of the surface as high as possible to enable the bond to be made. It is important therefore that the time-lag between passes of the apparatus is short, or it may be necessary to insulate the surface between passes.

In both embodiments the heat from the source should be contained in a small area and heat losses should be kept to a minimum. Air movement through the arc chamber should be kept at a minimum to limit the rate of oxydation of the carbon rods and also to prevent convection losses.

In passing sand through the arc it is important that the flame is not extinguished by too much sand being passed at any one time. In the event of this happening the arc must be struck again and the rods moved to their optimum position for that current.

The raw material used may be silica sand, as described above, or particles of glass or a mixture of the raw materials of glass, for example, lime, soda ash and silica sand, or any similar fusable material.

The raw material used may also be blast furnace slag in appropriate proportion with other suitable ingredients. As will be appreciated, the raw material used will partially determine the finished ceramic product.

Another factor which will effect the ceramic product is the temperature at which the process is carried out which in turn depends upon the fuel feed rate. Also the thickness of the deposited layers will effect the structural qualities of the construction.

The running temperature of the apparatus envisaged is in the range 1,100° to 1,400° C. the lower limit being determined by the raw material melting point and the rate of feed of raw material and the upper limit by the apparatus itself. Clearly, therefore, these limits may be varied, if desired, in dependence upon the apparatus and raw material used.

Coal dust or coal mine waste may be fed into the apparatus in order to increase the temperature for a given fuel feed. It is possible that once the process is running at the correct temperature the primary fuel feed, such as oil or electric current, may be discontinued and combustion sustained by the coal dust itself thus saving on fuel costs. A variety of colored ceramic products may be obtained by an appropriate choice of the raw material.

This method of construction will enable the builder to work without the use of moulding or form making systems now used in cement concrete practice. The product will set hard in seconds after each pass of the apparatus so affording a saving in time in that no delay is necessary as in the setting of concrete.

The simplest apparatus described may be modified so that arches of bridges may be built, large diameter pipes spun, rectangular or other shaped buildings constructed or roads laid.

Finally, although the invention has been described with reference to an electric arc or an oil burner as the source of heat other sources of heat may be employed provided they are of sufficient intensity to melt the particles as they pass through them. In this respect, for example, an oxygen acetylene flame may be employed instead of an electric arc.

I claim:

1. A method of building a structural member in the open, directly on a ground surface, the method comprising the steps of providing ceramic producing particles of raw material and a housing defining a chamber having a heat source thereon, a material inlet and a material outlet, passing said ceramic producing particles in a continuous stream through said material inlet into said chamber, supplying air to a heat source and then directing the heated air tangentially to the inner wall of the chamber in regulated flow to hold the particles along the wall of the chamber so that said ceramic producing materials are transformed into a partially or completely molten state in which they adhere to one another and form a continuous molten glass of ceramic material in said chamber, moving the housing over the ground surface along a narrow path whereby said continuous molten mass of ceramic material flows continuously in layer form from said chamber through said material outlet and is deposited onto the ground surface along said path in superposed successive layers, each layer, apart from the first which adheres to the ground surface, adhering to the next adjacent layer by virtue of its molten state, and allowing said layers to cool.

2. A method of building a structural wall in the open, directly on a ground surface, the method comprising the steps of providing ceramic producing particles of raw material and a housing defining a chamber having a heat source therein, a material inlet and a material outlet, passing said ceramic producing particles in a continuous stream through said material inlet into said chamber and through the hot zone of said heat source in said chamber, so that the said ceramic producing particles are transformed into a partially or completely molten state in which they adhere to one another and form a continuous molten mass of ceramic material in said chamber, moving the housing over the ground surface along a narrow path whereby said continuous molten mass of ceramic material flows continuously in layer form from said chamber through said material outlet and is deposited onto the ground surface, then moving the housing successively along said path to build up a wall of superposed successive layers, each layer, apart from the first which adheres to the ground surface, adhering to the next adjacent layer by virtue of its molten state, and allowing said layers to cool.

3. A process as claimed in claim 1, comprising introducing said particles into the air fed to the heat source whereby said particles are brought into the chamber in the heated air.

4. A process as claimed in claim 1, comprising feeding said particles directly into said heated air in the chamber.

5. A construction apparatus comprising a housing defining a chamber, a heat source comprising a burner operative to produce a hot zone in the chamber and including a fan operative to feed air under pressure to the burner, the housing comprising an upper cylindrical portion having an interior volute recess with a tangential inlet mounted to direct a stream of flaming gases emitted by the burner during operation of the burner to travel along a circular path, a raw material supply duct disposed to direct particles of raw material into the hot zone whereat said particles are held in said circular path and are transformed into a partially or completely molten state, said housing having a lower outlet through which the molten material may be discharged, the housing being so constructed that the particles are maintained in a molten state until they reach the end of their travel through the chamber, and means for moving the housing so as to deposit the molten material discharged therefrom in superposed successive layers.

6. Apparatus as claimed in claim 5, in which the raw material supply duct extends to the fan so that the particles of raw material are carried along in the air stream to the burner and enter the chamber in the stream of flaming gases emitted by the burner.

7. Apparatus as claimed in claim 5, in which the raw material supply duct leads directly into the chamber.

8. A construction apparatus comprising a housing defining a chamber, a heat source comprising a pair of electrodes, between which electrodes an electric arc may be struck when fed with electric current to produce a hot zone in the chamber, a raw material supply duct leading to the chamber to direct particles of raw material into the hot zone to transform the particles of raw material into a partially or completely molten state, a gridded aperture in said duct through which air may be exhausted and a plate disposed inside the duct in front of the gridded aperture to deflect particles of raw material carried along by an air stream in the

duct into the chamber, said housing having an outlet through which the molten material may be discharged, the housing being so constructed that the particles are maintained in a molten state until they reach the end of their travel through the chamber, and means for moving the housing so as to deposit molten material discharged therefrom in superposed successive layers.

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