Nov. 22, 1938. H. E. CRAVEN, JR., ET AL 2,137,931

METHOD OF AND APPARATUS FOR GRANULATING PORCELAIN ENAMEL AND THE LIKE

Filed June 9, 1936 2 Sheets-Sheet 1

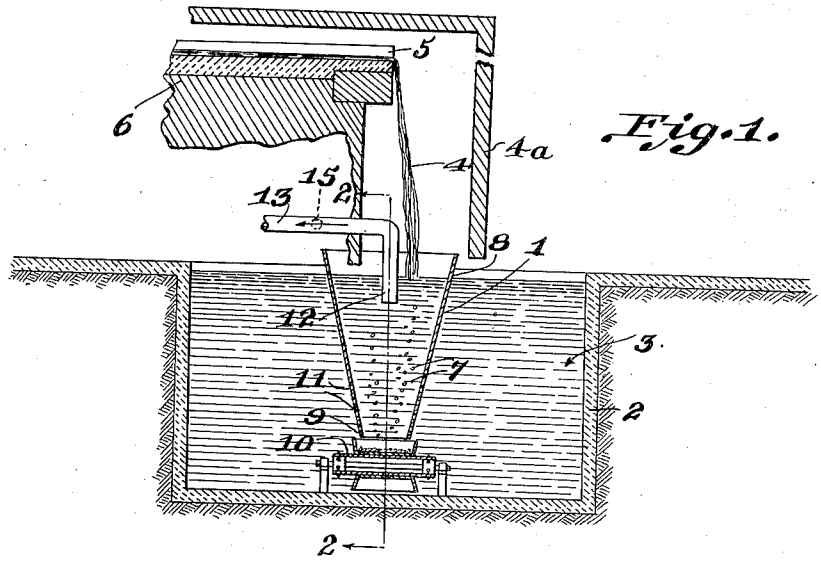


Fig. 1.

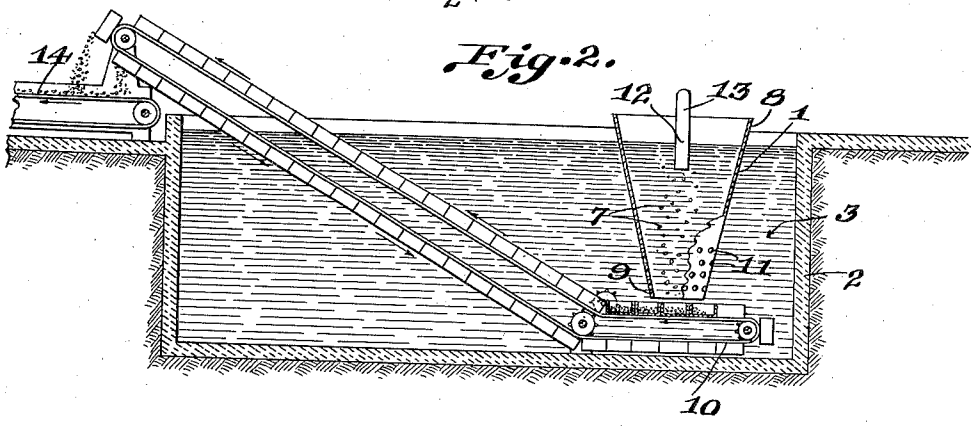


Fig. 2.

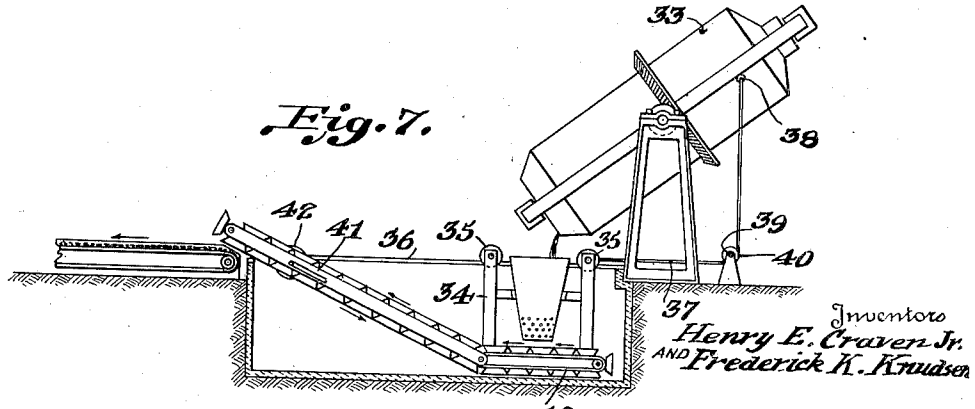


Fig. 7.

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Filed June 9, 1936 2 Sheets-Sheet 2

Fig. 3.

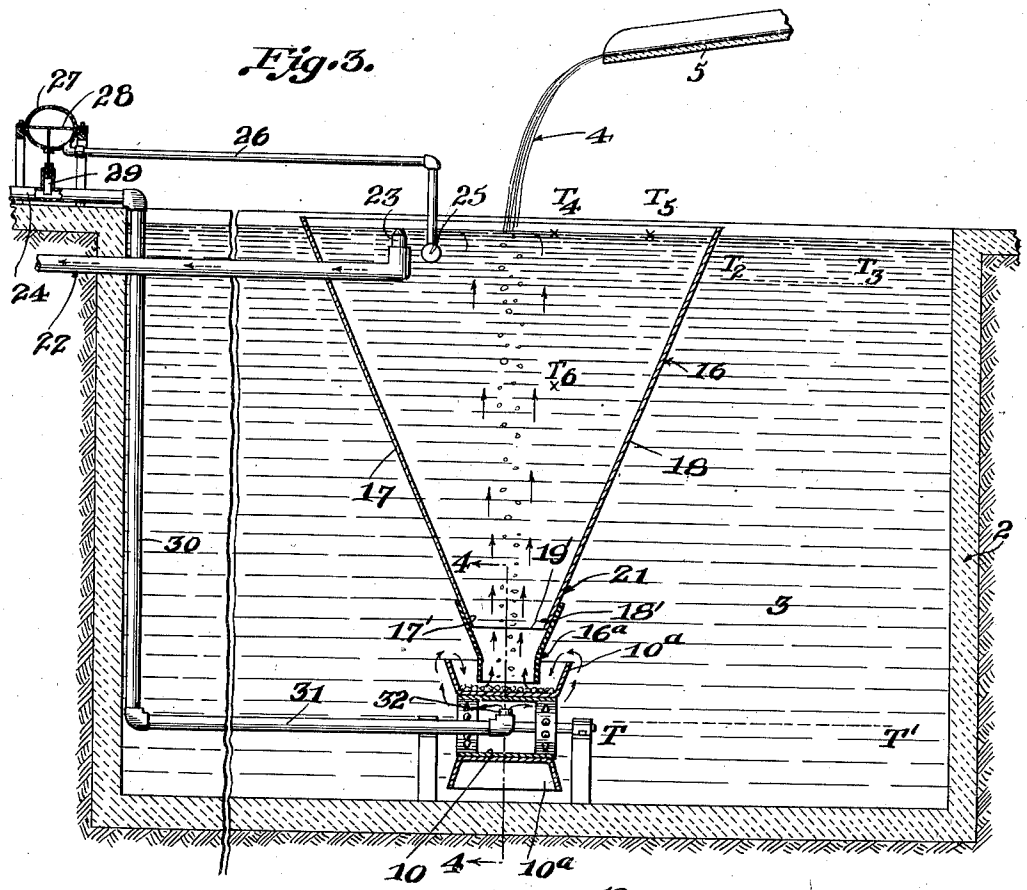


Fig. 5.

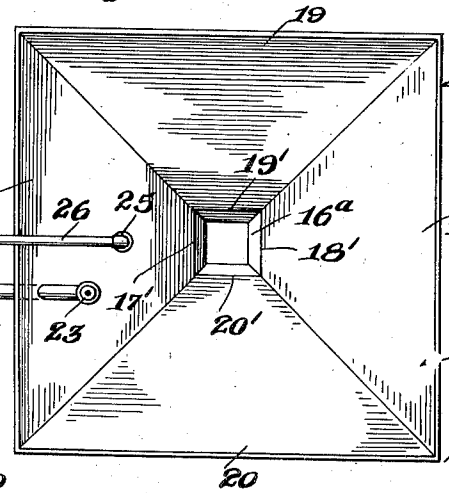


Fig. 6.

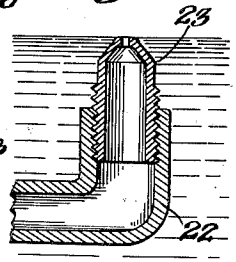
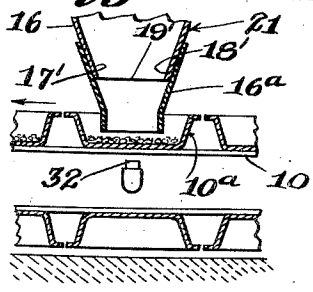


Fig. 4.



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METHOD OF AND APPARATUS FOR GRANULATING PORCELAIN ENAMEL AND THE LIKE

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Application June 9, 1936, Serial No. 84,382

6 Claims. (Cl. 83—91)

The present invention relates to the quenching of molten materials to shatter them, and more particularly to the quenching of vitreous-forming material, such as porcelain enamel.

The object of quenching molten enamel is to produce particles sufficiently shattered for easy grinding. Heretofore, usually, the molten enamel has been quenched by allowing it to run from the smelting furnace into a perforated metal basket or car suspended in a pit or trough of water. The molten enamel or glass, upon being brought in contact with the water, is chilled, thereby causing the solidified enamel glass or frit to break into discrete particles, ranging in size from about one-quarter of an inch to fine powders. If the glass is not properly quenched, large hard lumps of unshattered glass form in the tank. The larger particles are undesirable and are removed from the frit, after drying, by screening.

In the quenching step, the initial portion of the charge falls the entire distance through relatively cold water to the bottom of the car. As the car fills, the distance of fall of the solidified enamel or frit accordingly diminishes, and the severity of the quenching action is automatically reduced. Simultaneously, the water in the quenching car becomes more and more heated until steam is generated around the molten glass, preventing by its outward rush, the proper immersion of the glass in the quenching water and resulting in the formation of large hard lumps, as above described. As a result, the frit from the top of the car is not exposed to a quenching action of identical severity with that in the bottom of the car, and there is thereby produced a product of non-uniform physical and/or chemical properties. In an effort to overcome this difficulty, a stream of water has been introduced into the top of the car with the stream of molten enamel. Since the incoming water is introduced into the car, together with the molten material, the water is in a highly heated state by the time it reaches the car and flows out through the perforations in the top sides thereof. In this manner, it has very little cooling eeffct upon the water already in the car. During the final stages of the pour, large lumps of glass form and it is necessary to break these by hand in the car. This is an expensive and inefficient method and is conducive to contamination of the materials by metal from the stirring rods.

A further defect in the present method lies in the quenching pits. In order that the quenching cars may be manipulated therein, it is necessary that these pits be large, holding one thousand (1000) or more gallons of water. The excess water introduced during quenching is removed through overflow pipes at the end of the pits. Since this overflow comprises chiefly the heated water flowing from the top of the quenching car, it is obvious that there is very little change in the actual pit water, since it does not come in contact with the molten glass and is not heated. As a result, soluble salts dissolved from the enamel glasses and drained into the pits from the cars as they are removed, tend to build up, and these, in time, will affect the enamels being quenched.

The prior art method is further defective in that the stream of molten material falls through the air for a considerable distance between the furnace discharge lip and the quenching tank. During the fall, the surface of said stream of material is cooled and of greatly increased viscosity. Consequently, upon the immersion of the stream of molten material into the quenching medium, this skin of highly viscous material is resistant to the shattering action of the quenching medium and retards the penetration of the medium to the central portion of the stream. If the quenching car be well filled and the distance of fall of the molten material through the quenching medium in consequence short, the center portion of the stream will not be properly quenched, but will solidify in hard lumps and particles of widely differing consistency from the material in the lower part of the car. In accordance with the present invention, a method and apparatus is provided for continuously removing the frit so that, in general, substantially all the particles of the frit will have the same distance of fall and will be subjected to the same heat treatment.

From the above it is clear that the hard particles result from the failure of the quenching medium to penetrate the fallen molten material and entirely break it up before it cools. Generally stated, variation in the conditions of quenching will produce large lumps and particles of hard consistency. The large lumps cause excessive loss on the dryer screen or passing the latter will be too hard for satisfactory grinding. The presence of such particles greatly increase the time of grinding and decrease the efficiency. Further, the presence of hard particles in the enamel is particularly undesirable, since it causes the production of enamels of variable composition and gives rise to hard particles and lumps on the surface of the enameled ware.

The present invention provides a suitably shaped vessel, preferably in the form of a truncated cone or pyramid mounted in the quenching pit, under the furnace overflow lip or tapping

spout in an inverted position with the larger diameter end positioned just above the surface of the quenching medium and the bottom or lesser diameter end positioned just above a conveyor of any suitable type located on the pit floor so that the molten material in falling through the vessel is guided onto the conveyor and continuously removed. The vessel is further provided at the top with an outlet or overflow conduit which continuously removes the heated quenching medium from the top of the vessel and induces a continuous flow of the medium in a direction countercurrent to the direction of the falling molten and quenched material, removing dissolved substances, and the induced inflow at the bottom of the vessel assists in preventing the washing of the frit out of the vessel and conveyor into the pit proper, giving a uniformly quenched material, free from large and/or hard lumps and adsorbed or entrapped soluble salts.

In accordance with the present invention, it is preferred to provide positive means for preventing fine frit material from being washed from the buckets of the frit removal device, which may be in the form of a conveyor. This may be accomplished by attaching a flexible sleeve or the like to the bottom of the quenching vessel, said sleeve being adapted to extend into suicessive conveyor buckets as the buckets pass beneath the quenching vessel. This arrangement will insure that the material will be deposited in the buckets well below the rim of the conveyor.

In order that the present invention may be clearly understood, it will be described in connection with the accompanying drawings, in which:

Figure 1 is a vertical transverse section of the quenching apparatus.

Figure 2 is a longitudinal vertical cross-section on the line 2—2 of Figure 1.

Figure 3 is a vertical transverse section of a modified form of quenching apparatus in which thermostatic means are provided to function in connection with the cold water inlet to control the amount of cold water fed to the quenching vessel.

Figure 4 is a cross sectional view taken on the line 4—4 of Figure 3.

Figure 5 is a plan view of that form of the invention shown in Figure 3.

Figure 6 is a detail view of the overflow nipple.

Figure 7 is a side view partially in section showing the quenching vessel synchronized with the discharge of a rotary smelter so that as the smelter is tilted, the quenching vessel continues to move under the tapping lip of the smelter.

In the form of the invention shown in Figures 1 and 2, there is provided a truncated cone 1 suitably supported in any desirable manner in the pit 2 having flowing therethrough in a direction counter-current to the falling quenched material, a quenching medium 3, which is usually water. The cone 1 is positioned in the pit 2 between the discharge lip or tapping spout 5 of the smelter 6, so as to trap the molten enamel fall issuing from the discharge lip, the enamel forming frit particles 7 as it strikes the water. The upper portion 8 of the cone extends slightly above the surface of the water. The cone is of sufficient height to give a suitable quenching action to the falling frit particles 7 under the conditions of counter-current flow, as hereinafter set forth.

The base portion 9 of the cone 1 is sufficiently constricted to trap the frit enamel, and guide it onto a conveyor 10, shown as the bucket type, but which may be of any type, the conveyor functioning to remove the frit from the cone base. The conveyor 10 is spaced from the base 9 of the cone just sufficiently to allow the flowing water to pass therebetween and into the cone. The conveyor 10, preferably, although not necessarily, discharges onto a conveyor 14. The cone adjacent its base 9 may be provided, if desired, with water-intake holes or perforations 11.

Extending into the cone 1 adjacent its upper portion 8 is an exit conduit 13 having its lower end 12 dipping below the water line.

A thermostatic valve 15 may be inserted in the exit pipe 13. This valve functions to control the temperature of the outgoing water. When the temperature of the outgoing water is too high, the valve opens and allows more water to leave the cone 1.

In carrying out the invention in the apparatus shown in Figures 1 and 2, the smelter 6 is tapped and the molten enamel passes over the discharge lip 5 and falls in a stream 4 into the water 3 flowing through the cone 1. The molten enamel 4 upon coming in contact with the water, becomes chilled and shatters in the form of frit of small particle size 7. The water in the upper portion of the cone 1 becomes heated due to its contact with the molten enamel, and this heated water is pumped or siphoned off through the exit conduit 13, thereby inducing an upward counter-current flow of cold water from the bottom of the pit 2. The incoming cold water passes between the bottom 9 of the cone 1 and the conveyor 10, and in one form of the invention, through the holes or perforations 11 in the lower part of the cone 1, the flow of water being so regulated as to give a maximum quenching action without sucking the fine particles of frit into the exit conduit 13. Due to the combined action of the upward counter-current flow of the cold water through the cone 1 and the uniform fall of the frit 7 through the cone, the enamel frit passing from the bottom 9 of the cone onto the conveyor 10 is uniformly quenched to a small particle size of uniform hardness, thus eliminating the variable particle size and the hard particles which result from the ordinary method of water quenching.

The continuous removal of the frit particles by the conveyor prevents accumulation of the frit in the cone or pit and the removal of the water through the exit pipe 13 prevents the accumulation of soluble salts in the quenching water, and maintains a more nearly uniform temperature in the quenching medium.

In the form of the invention shown in Figures 3 to 6 inclusive, there is substituted for the cone 1 a truncated pyramid 16 having inclined side walls 17, 18, 19 and 20 provided with bottom edges 17', 18', 19' and 20' forming a base portion 21. The upper portion of the vessel 16 extends slightly above the surface of the water. Extending into the vessel 16 is an overflow outlet conduit 22 provided with an adjustable nipple 23. The level of the water in the vessel 16 may be adjusted by means of this nipple.

A flexible extension member or sleeve 16a is attached to the bottom 21 of the pyramid 16, said extension member being adapted to extend into and almost to the bottom of successive buckets 10a of the conveyor 10 as the latter moves lengthwise of the pit. This prevents the washing of frit 7 from the buckets 10a by currents in the quenching medium 3, which may well occur if the bottom end 21 of the vessel 16 and the buckets 10a are separated by an appreciable amount of space. As the buckets pass under the quenching vessel 16,

the flexible extension 16a readily shifts its position to allow the free passage of the buckets. This arrangement insures (1) the frit will be deposited in the buckets well below the rim of the conveyor, (2) that the flow of frit between buckets will be reduced to a minimum, and (3) it will be exceedingly difficult to wash material out of the conveyor as the latter passes through the water in the pit.

Thermostatic means are provided to control the amount of colder quenching water entering the lower portion of the quenching bath, said means being controlled by the temperature of the water in the upper portion of the quenching bath.

Suitably located without the pit is a water inlet conduit 24. A thermostatic regulator bulb 25 having a gas therein extends into the top portion of the quenching medium present in the vessel 16, the bulb 25 being connected by a pipe 26 to the regulator 27 on inlet pipe 24, the latter being provided with a diaphragm 28 operating a water valve 29. The inlet water passes through inlet pipes 30 and 31, the latter being positioned, preferably, adjacent to the floor of the pit. The exit end of the pipe 31 is provided with a nipple 32. It is preferred that the exit nipple be positioned directly under the conveyor 10.

It is preferred that the molten material 4 falling from the tapping spout 5 strike the quenching water 3 in the quenching vessel 16 in the center of the vessel.

As the temperature of the water of the quenching medium adjacent the overflow 23 increases, the gas pressure in the bulb 25 rises and this increased gas pressure is communicated through conduit 26 to diaphragm 28, springing the latter out and opening the valve 29 to increase the flow of cold water into the pit 2.

Since the only outlet for the overflow water is overflow conduit 22, the opening 23 of which is located within the quenching vessel, as cold water is introduced into the pit, the hydrostatic balance is disturbed and cold water flows into the buckets 10a around the extension member 16a and forces the heated water at the top of the quenching vessel out through the outlet nipple 23.

The presence of the flexible extension member 16a acts to constrict the opening into the quenching vessel 16 and generates an upward current, which also aids in preventing the passage of frit from the buckets into the pit. The thermostatic valve 27 is so regulated that there will always be some flow of fresh quenching medium into the pit.

The use of a thermostatic arrangement, such as set forth, or a similar arrangement, which may be non-thermostatic, permits the maintenance of the quenching bath at its zone of contact with the molten material at a substantially constant temperature.

The cone shown in Figures 1 and 2 may also be equipped with an extension member similar to the extension member 16a.

It will be at once evident to those skilled in the art of quenching molten materials that the proper functioning of the invention will be in no way limited to the type or design of inlet or outlet for the quenching medium used, their sole purpose being to maintain a continuous flow countercurrent to the falling quenched material of sufficient strength and volume to maintain the desired temperature in the quenching vessel. Thus, for example, the flow may be controlled by a thermostatic or other valve in the outlet conduit, as in Figures 1 and 2, where the flow is induced by means of a pump or syphon, or, as in Figures 3 to 5, where the outlet conduit may consist of an overflow pipe and the inflow is controlled. It will be apparent that the means of flow control may be either manual or thermostatic, the latter, of course, being preferable. Further, it is apparent that the position of the inlet pipe in the pit has no direct bearing on the proper functioning of the invention, although it is evident that the positioning of the inlet conduit fairly close to the bottom of the vessel, thus providing a colder quenching medium for the vessel, may be more economical than a more distant location.

The present invention may be utilized in connection with a rotary smelter. For example, using a one thousand (1000) pound rotary smelter 33, the quenching vessel 1 or 16 may be mounted on a car synchronized with the discharge gear of the smelter and moved through the pit towards the smelter as the smelter approaches its extreme position. For example, the vessel 1 or 16 and the conveyor 10 is mounted on a car frame 34 mounted on wheels 35 adapted to run on a track 36 on the pit edge. A cable 37 is secured to the smelter 33 in the frame 34 at any suitable points, as at 38 and 39, respectively. The cable 37 passes over a pulley 40.

As the smelter 33 is tilted upwardly, the cable 37 pulls the car frame 34 and vessel 1 or 16 under the smelter lip 5. The discharge end of the conveyor 10 is mounted on a slotted bar 41 to allow the conveyor to move as an entirety as the car frame 34 moves. A hand wheel 42 is attached to the pit wall and runs into the slot. The primary requirement of the apparatus is that the point 38 move in the vertical plane the same distance the car 34 moves laterally through the water.

A one thousand (1000) pound charge is poured from the smelter into the vessel 1 or 16 at the rate of approximately one hundred (100) to two hundred (200) pounds per minute, the conveyor speed and the upward flow of water through the vessel 1 or 16 being regulated to give proper quenching to the stream of molten enamel. The conveyor is only actuated and the water stream circulated while the furnace is being discharged.

When the apparatus is used with a reverbatory or so-called "box-type" smelting furnace, no movement of the cone during tapping will be necessary. In a furnace of the continuous smelter type, the vessel 1 or 16 is placed under the discharge lip and the conveyor is operated and the water circulated continuously during the period the smelter is in operation.

When using the cone I in connection with a continuous smelter, the cone receiving the discharge from the smelter at the rate of approximately twenty (20) to fifty (50) pounds per minute, the cone should, preferably, be thirty-six (36) inches high with a twenty-four (24) inch maximum diameter, and an eight (8) inch minimum diameter. The distance from the lip 5 of the smelter to the top of the cone should be, preferably, about two (2) feet, and the fall through the water should be preferably about three (3) feet. The temperature of the enamel flowing from the lip will vary between approximately 1800° and 2200° F.

The quenching bath will be maintained at a maximum temperature most feasible for the production of satisfactory frit.

Some of the factors which influence the maximum temperature at which it is desired to maintain the quenching bath are the viscosity of the enamel, the temperature of the molten enamel, the amount of enamel flowing through the

quenching medium per unit of time, and the heat transfer rate of the enamel. Broadly stated, the temperature must be sufficient to produce a satisfactory product of uniform size and devoid of large and hard particles. It has been found that in each frit, there is a fairly definite temperature below which a satisfactory product having the characteristics specified will be obtained and above which a non-uniform improperly quenched product will result.

For example, a white enamel smelted at a temperature ranging from 1900° to 2000° F. may be properly quenched in a medium with a maximum temperature of from 150° to 160° F., while a ground coat enamel smelted at temperatures 200° to 300° F. higher than the white enamel should be quenched in a medium whose maximum temperature lies in the neighborhood of 120° F. It will be understood that the above examples are merely for purposes of illustration and in no way limit the invention, since the quenching temperature of each product must be determined experimentally for that product, depending upon the characteristics thereof.

Under the conditions specified, when quenching a ground coat enamel the quenching bath at its zone of contact with the molten material is maintained at a temperature of approximately 150° F. It has been ascertained that to maintain a temperature of 150° F. at the surface of the quenching bath, it is necessary to pass approximately twenty (20) gallons of water per minute through the system. Here again, this figure is illustrative and is not by way of limitation.

The following shows the temperature of the feed water, and that of the water in the pit, and the quenching cone at different levels.

Referring to Figure 3, the temperature of the pit water along and adjacent the line T—T' is about 50° F. The temperature of the water at the top of the pit along the line T_2T_3 is about 100° F.

The quenching cone temperatures are as follows:

Position	Depth	Temperature
		°F.
Overflow		120
Adjacent cone wall at point T_5	Surface	115
Adjacent molten frit column at point T_4	Surface	120
Adjacent descending frit column at point T_6.	2'	100

In the above example, it is to be noted that there is a difference of 40° between the water surface in the cone, or truncated pyramid, and the water entering the bottom of the device. The rise in temperature through the quenching cone will be gradual.

It may be pointed out that the control of the surface temperature, or the temperature closely adjacent the surface of the quenching medium present in the quenching vessel automatically gives proper quenching.

It is desired to point out that the herein described method of and apparatus for quenching enamel may be used with any of the existing types of enamel smelting furnaces. Further, the method and apparatus may be used for the quenching not only of glasses and porcelain enamel body frits, but also for clinker from rotary cement kilns, pottery glazes, and wherever it is desirable to shatter or divide material into a product having as a result of quenching, uniform physical and chemical characteristics.

In accordance with the present invention, there is provided a method of continuously quenching molten materials including porcelain enamel and the solidified frit resulting from the contact of the molten material with the quenching bath.

As the molten material falls through the bath, the quenching medium is caused to flow countercurrently to the falling material, and is removed through an outlet conduit located in the top portion of the quenching device while the quenched molten material is continuously removed from the bottom of the device, thus providing a material uniformly quenched and free from hard lumps and particles and adsorbed or entrapped soluble salts.

While it is desired to thermostatically maintain the temperature of the bath, other methods may be employed to control the volume of cold water fed to the quenching bath, this volume being of such a quantity as to maintain the optimum quenching temperature in the upper part of the quenching bath. The invention, therefore, in its broadest form, is not limited to a method or apparatus using thermostatic means, although this is preferred.

Thermostatic means, or equivalent means, may be associated with either the intake means for delivering cold water to the bath or exit means for the hot quenching medium.

While a truncated pyramid or cone is the preferred shape for the quenching vessel, vessels of other shapes may be used, the vessel being of such a shape or having associated with it a separate element which, in connection with the vessel, is adapted to trap the solidified product. The quenching vessel may be made in various sizes and may receive more than one stream of molten material, such as molten porcelain enamel for use in a rotary type smelter. However, in the preferred form of the invention, the quenching vessel receives a single stream of molten material, or several streams which are positioned closely adjacent one another.

If desired, during the time the enamel is flowing from the lip 5 into the quenching vessel 1 or 16, the enamel may be bathed in combustion gases and the temperature of the enamel maintained. This is shown diagrammatically in Figure 1, wherein the stream 4 is enclosed in refractory shield 4a. The gases of combustion pass from the smelter 6 and protect the molten enamel 4 from the chilling influence of the outside air. This enables the enamel to reach the quenching vessel at a higher temperature than is now common practice. Further, the discharge and quenching may take place inside of a completely enclosed furnace rather than outside, as is now the practice in all other types of smelters.

It may be pointed out that ordinarily when the enamel is allowed to leave the furnace at about 1900° F. a temperature drop of 200° or more occurs immediately upon the flow of the enamel into the cold air. This increases the viscosity of the enamel and makes proper quenching difficult, since the heavy stream becomes cold and sluggish. Therefore, the shock in entering the quenching medium or water is not so great and the shattering effect of the quenching action is not as pronounced or uniform as it might be. If the stream of molten material is bathed in combustion gases flowing from the furnace, the flowing enamel is maintained at a temperature of around 1900° to 2000° F. until the very moment the molten enamel is quenched. If the discharge

and quenching arrangement is not enclosed in a furnace, there may be some excess of outside air which may somewhat decrease the temperature of the combustion gases. However, even in this case, the temperature of the flowing enamel stream 4 will be greatly increased. This control of the temperature of the flowing enamel will assist in giving a more superior product.

What is claimed is:—

1. The method of treating molten porcelain enamel comprising feeding the molten enamel to a quenching bath, flowing the quenching bath counter-currently in contact with the enamel, correlating the contact temperature of the quenching medium with the viscosity, temperature and heat-conductivity of the enamel to be quenched, and constantly maintaining said quenching medium at its initial zone of contact with the molten enamel substantially at said correlated temperature during quenching to shatter the enamel and produce a frit of substantially uniform particle size and composition.

2. The method of treating molten porcelain enamel comprising flowing the molten enamel through an inert heating medium adapted to prevent the air from unduly cooling the molten enamel prior to its entry to a quenching bath, feeding the enamel to a quenching bath, flowing the quenching bath counter-currently in contact with the enamel, correlating the contact temperature of the quenching medium with the viscosity, temperature and heat-conductivity of the enamel to be quenched, and constantly maintaining said quenching medium at its initial zone of contact with the molten enamel substantially at said correlated temperature during quenching to shatter the enamel and produce a frit of substantially uniform particle size and composition.

3. The method of treating molten porcelain enamel comprising feeding the molten enamel to a quenching bath, flowing the quenching bath counter-currently in contact with the enamel, correlating the contact temperature of the quenching medium with the viscosity, temperature and heat-conductivity of the enamel to be quenched, constantly maintaining said quenching medium at its initial zone of contact with the molten enamel substantially at said correlated temperature during quenching to shatter the enamel and produce a frit of substantially uniform particle size and composition, maintaining said quenched enamel in contact with the quenching bath through a uniform distance of fall, and thereafter continuously removing said quenched enamel from the bath.

4. In a quenching apparatus adapted to treat molten material, a substantially imperforate quenching vessel having a material inlet at the top and a material outlet at the bottom, said vessel being located in a pit and in communication with the pit at its bottom opening and positioned to receive the molten material and trap the latter as it falls in a solidified state through the quenching medium flowing through said vessel, means for removing heated quenching medium from the top of the vessel, means for feeding colder quenching medium to the pit adjacent the lower portion of the vessel, means in the pit adjacent to the bottom outlet of the quenching vessel for continuously removing solidified material from the quenching vessel, and valve means for controlling the inflow of the quenching medium to maintain the flow of quenching medium into the quenching vessel through the bottom opening under a pressure permitting the material to settle from the bottom of the quenching vessel and onto the removal means while preventing the washing of the material from the vessel and the removal means into the pit.

5. In a quenching apparatus adapted to treat molten material, a quenching vessel in a pit having an outlet for quenched material open to the pit and positioned to receive the molten material and trap the latter as it falls in a shattered state through the quenching medium, means for removing heated quenching medium from one portion of said vessel, means for feeding colder quenching medium counter-currently to another portion thereof, means associated with one of said means to control the volume of cold quenching medium entering said vessel, means in the pit adjacent the outlet of the quenching vessel for continuously removing the solidified material from the quenching vessel, and means to direct the flow of material to said removal means and to prevent the washing of solidified material from the removal means into the pit by the motion of the removal means, said means including a flexible member substantially surrounding the outlet of the quenching vessel and extending into the removal means.

6. In a quenching apparatus adapted to treat molten material, a quenching vessel in a pit having an outlet for quenched material open to the pit and positioned to receive the molten material and trap the latter as it falls in a shattered state through the quenching medium, means for removing heated quenching medium from one portion of said vessel, means for feeding colder quenching medium counter-currently to another portion thereof, means associated with one of said means to control the volume of cold quenching medium entering said vessel, a series of buckets for continuously removing the solidified material from the quenching vessel, means for moving the buckets in communicative connection with the outlet for quenched material, means to prevent washing of said material from the buckets into the pit by the motion of the buckets, said means comprising a flexible member substantially surrounding the outlet of the quenching vessel and extening into each successive bucket as the latter pass beneath the outlet of the quenching vessel.

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