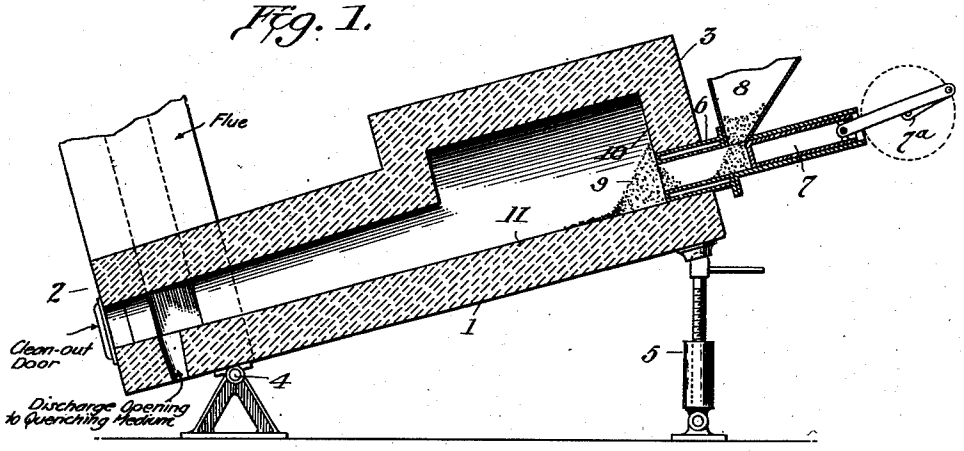
Nov. 22, 1938. R. H. TURK 2,137,930

PROCESS OF SMELTING ENAMEL

Original Filed May 14, 1931 3 Sheets-Sheet 1

Fig. 1.



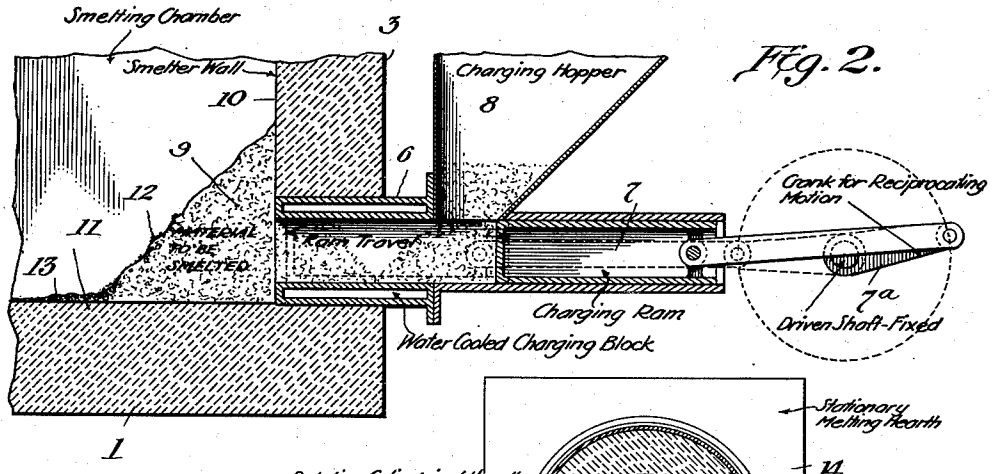


Fig. 2.

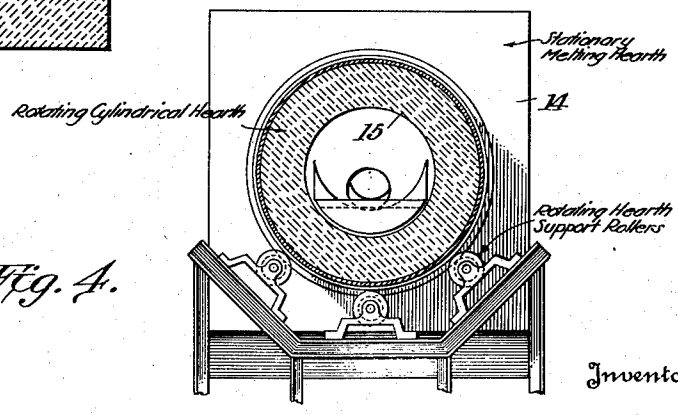


Fig. 4.

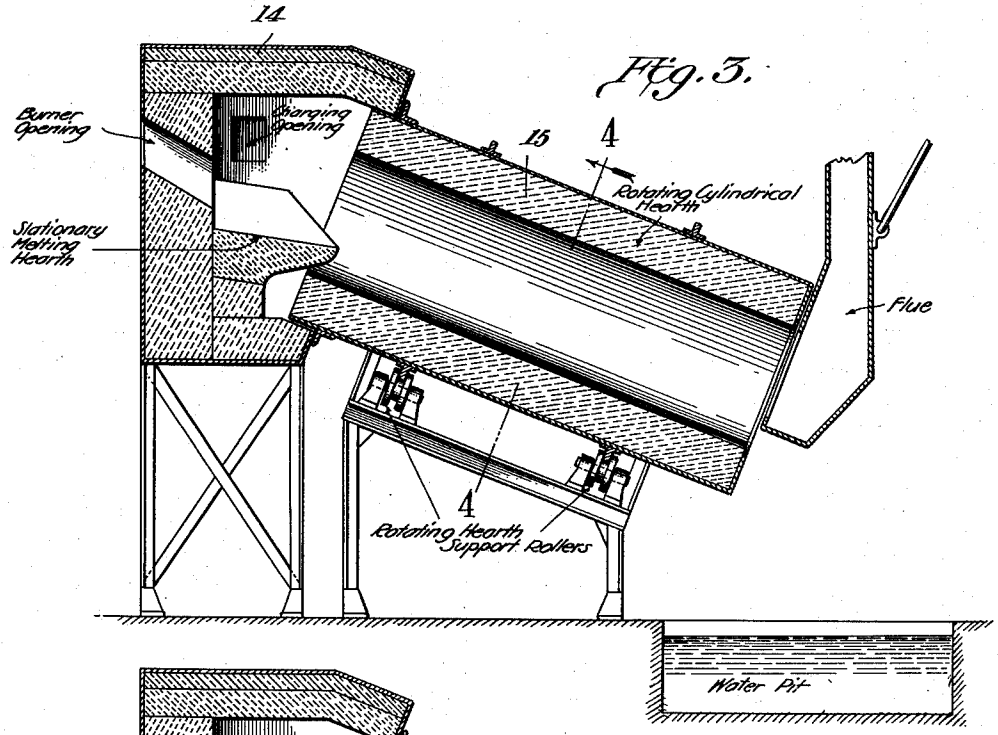
Inventor,
Richard H. Turk
By Isaac P. Tashof,
Attorney

Nov. 22, 1938. R. H. TURK 2,137,930

PROCESS OF SMELTING ENAMEL

Original Filed May 14, 1931 3 Sheets-Sheet 2

Fig. 3.



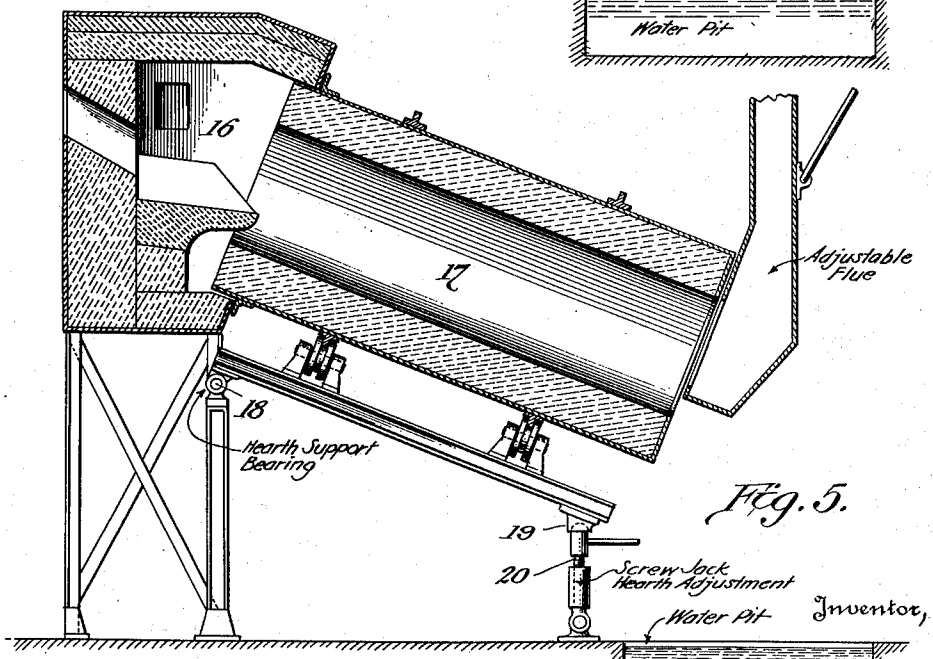


Fig. 5.

Inventor,
Richard H. Turk
By Joan P. Sarhoff,
Attorney

Nov. 22, 1938. R. H. TURK 2,137,930

PROCESS OF SMELTING ENAMEL

Original Filed May 14, 1931 3 Sheets-Sheet 3

Fig. 8.

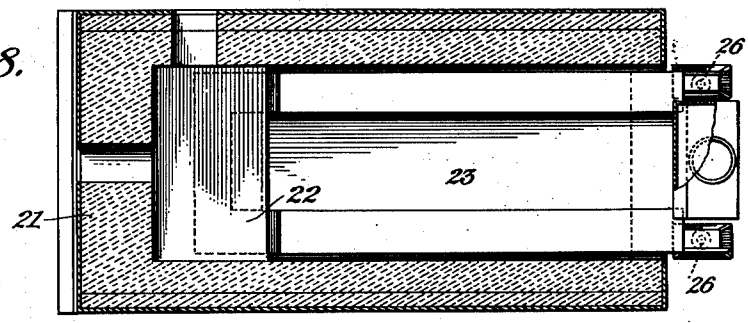
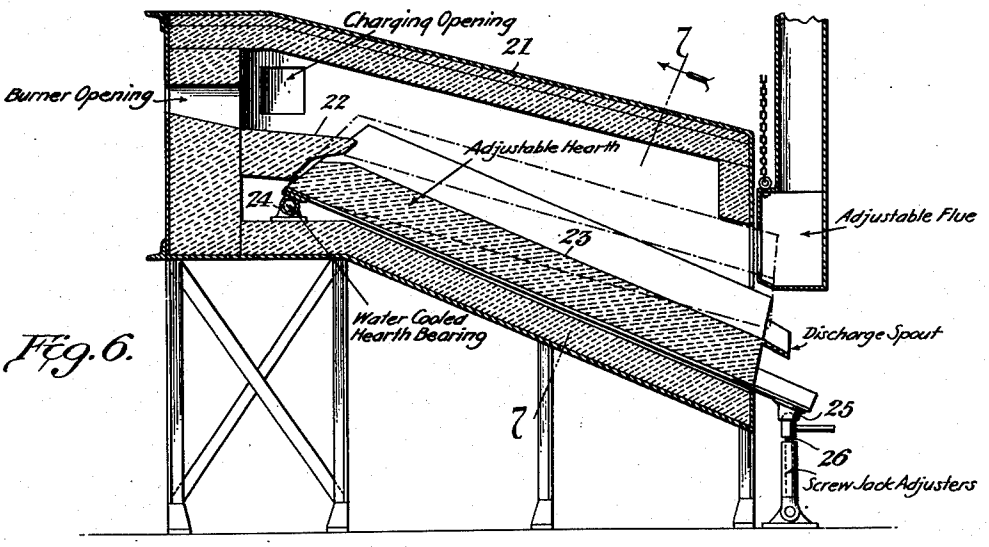


Fig. 6.



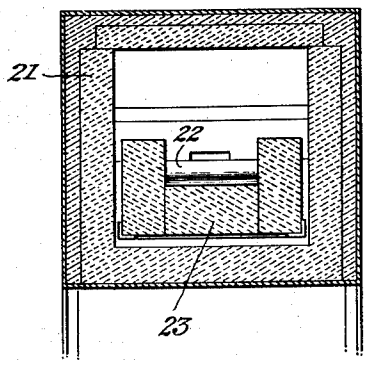


Fig. 7.

Inventor,
Richard H Turk
By Isaac P. Tashof,
Attorney

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UNITED STATES PATENT OFFICE

2,137,930

PROCESS OF SMELTING ENAMEL

Richard H. Turk, Baltimore, Md., assignor to The Porcelain Enamel and Manufacturing Company of Baltimore, Baltimore, Md., a corporation of Maryland

Application May 14, 1931, Serial No. 537,475
Renewed July 28, 1936

4 Claims. (Cl. 49—77)

The present invention relates to the production of vitreous materials including enamels, glazes and other vitreous compounds.

The present practice in the smelting of enamels and the like consists in smelting them in a rotary or reverbatory smelter. The rotary type of smelter consists of a refractory lined steel cylinder having conical ends. A burner is placed before an opening in one end and the gases of combustion and other gases formed by the decomposition of the raw materials escape through an opening in the opposite end of the furnace. In operating with the rotary type of furnace, the enamel batch after compounding and thorough mixing is charged therein after the furnace has reached a temperature of about 2000° F. It usually requires about three hours to smelt such a charge, but the time and temperature may vary considerably, according to the character of the raw material used and the properties which it is desired that the final enamel product shall have. After the smelting process is finished, which is indicated by the termination of all bubbling, the molten mass is poured from the furnace by tilting the same. The molten material is allowed to fall into a large container of cold water where it is chilled to fine particles. Instead of using a rotary type of furnace, a reverbatory type of furnace may be used.

While smelters of the character set forth may be designed to take care of most any size batch, they are all limited to intermittent operation, which has its economic limitations. For example, as the size of the smelter increases, the length of time required for discharging the smelted enamel greatly increases. As much as 25% of the total time involved in a complete cycle may be required for discharging a large intermittent type of smelter. To remove the objections inherent in the intermittent or batch smelting process, it is desirable that the enamel be continuously smelted. However, until the present invention, the continuous smelting of enamels was not practical as serious obstacles were met with.

The simplest design of a continuous smelter is one wherein a long hearth is employed and into one end of which there is intermittently or continuously charged a small batch of raw enamel. The enamel melts and flows on the hearth as it is smelted to the opposite end of the hearth where it is discharged into cooling water. The only control which can be exercised over a continuous smelter of this type is through temperature regulation. However, proper smelting of enamels involves not only temperature control, but also control of the period of time of smelting. For each enamel there is an ideal smelting temperature and time. While this temperature may be lowered and the enamel proportionately given a longer smelting period, very often desirable qualities in the finished enamel are sacrificed. The same or similar undesirable qualities are present in the finished enamel when the temperature is increased and the period of time of smelting shortened.

It has heretofore been proposed to continuously smelt enamels utilizing an inclined stationary smelting hearth, the inclination thereof being fixed in view of the particular composition of the enamel charge and the temperature at which it is smelted. The time of smelting may also be fixed by the temperature employed. If for any reason it becomes necessary to change the composition of the enamel, the only manner in which the furnace may be utilized is to change the temperature of smelting, as if the temperature previously used for an enamel batch of a different composition is employed, the enamel remains on the inclined hearth for either too long or too short a period necessary to produce a completely smelted enamel maintaining its desirable properties. However, with an increase or decrease of temperature, the enamel becomes over-smelted or under-smelted. Further, when the same furnace is used continuously for smelting an enamel of a predetermined composition, the slope of the inclined hearth changes due to the erosion of the furnace lining by the charge. With such a variation of hearth inclination, variation of the smelting temperature becomes necessary with the resultant production of an enamel characterized as being over-smelted or under-smelted. It is, therefore, clear that in the prior practice of continuously smelting enamels for a given furnace, it has been impossible to regulate the rate of flow of the enamel on the smelting hearth to correlate the time and temperature of smelting to produce at the smelting temperature employed an enamel which is neither under-smelted nor over-smelted.

Therefore, in accordance with the present invention enamels of a predetermined composition are smelted at a predetermined temperature, the rate of flow of the enamel on the smelting hearth being regulated to correlate the time and temperature of smelting to produce at the smelting temperature employed an enamel which is neither over-smelted nor under-smelted. Stated differently, the time that the enamel is on the smelter hearth is regulated regardless of the temperature and, where constant temperature is employed, the

time the enamel is on the smelter hearth is readily controlled.

Further, it has been ascertained that in the continuous smelting of enamels, the continuous charging of the raw material into the smelter without any special precautions as to such charging interferes with the production of uniform homogeneous enamels, the raw material charge being constantly charged on a stream of molten enamel resulting in small particles of the raw enamel being carried more rapidly through the smelter than they would have been had they not been so introduced into the molten enamel. Therefore, in accordance with the present invention, there is fed to the molten enamel a preheated raw enamel charge, the feeding thereof being preferably continuous, but not necessarily so. More specifically, there is formed a charge or reservoir of raw material adjacent a molten mass of enamel. This mass of raw enamel is subjected to the heat produced during the smelting process to preheat the raw material. A portion of the charge at and adjacent its free surface is fed to the molten enamel and homogeneously combines therewith. Additionally, raw enamel is fed to the charge or reservoir of raw enamel to maintain a constant supply of raw preheated enamel. Preferably, the free face of the raw enamel is allowed to assume its natural angle of repose. However, the invention is of course not limited thereto as the angle of repose may be artificially varied by suitable mechanical expedients. In accordance with the present invention, the rate of which the raw preheated enamel is fed to the reservoir of raw material is controlled to maintain a constant supply of raw material to the charge and to allow the particles of enamel charge to be sufficiently heated to become quickly and homogeneously incorporated in the flowing molten enamel bath.

The objects of the present invention will be sufficiently clear from the above discussion of the improvements in the art of smelting porcelain enamels which are effected in accordance with the present invention, and from the following specification.

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 cross section somewhat diagrammatic of a reverbatory smelter constructed to permit the angle of inclination to the horizontal of the smelter hearth to be varied;

Fig. 2 is an enlarged cross sectional view showing the manner in which the raw enamel is preliminarily charged into the furnace and becomes preheated prior to its actual introduction into the molten enamel;

Fig. 3 is a vertical section somewhat diagrammatic showing the combination of a stationary melting hearth and a rotating cylindrical hearth having a fixed inclination permitting the time of smelting of an enamel to be regulated independently of temperature variation, this being accompanied by varying the speed of rotation of the smelting hearth;

Fig. 4 is a transverse section on line 4—4 of Fig. 3;

Fig. 5 is a vertical section somewhat diagrammatic showing the combination of a stationary melting hearth and a rotating cylindrical hearth which may be adjusted to various inclinations to control the rate of flow of the enamel through the furnace;

Fig. 6 is a cross sectional view somewhat diagrammatic of a reverbatory furnace having a fixed stationary melting hearth and an inclined adjustable smelting hearth;

Fig. 7 is a transverse cross section on line 7—7 of Fig. 6;

Fig. 8 is a plan view of the furnace shown in Fig. 6.

The form of furnace shown in Figures 1 and 2 comprises a reverbatory furnace 1 having a discharge end 2 and a charging end 3. The furnace is pivotally mounted adjacent the discharge end 2 on a pivot 4, and adjustably mounted adjacent the charging end by means of a jack 5 or other lifting medium. It is of course obvious that instead of employing a single pivoting member and lifting jack a plurality of such members may be used.

Mounted in the charging end 3 of the furnace 1 is a water-cooled charging block 6 operatively receiving a charging ram 7 operated by means of a crank 7a or other mechanical equivalent. The charge of raw enamel is fed to the charging block 6 by means of a charging hopper 8. Referring to Figure 2, it is to be noted that an enamel charge 9 is maintained at an appropriate angle to the horizontal, this angle being preferably the angle of repose of the particular enamel being smelted. The charge or reservoir of raw enamel rests against a portion of the side wall 10 and on the smelter melting hearth 11. The volume of the enamel charge 9 is maintained approximately constant by continuously feeding raw material from the hopper 8 at the same rate at which particles of the charge on and adjacent the surface 12 of the charge are preheated and sintered or melted and fed on to the melted charge 13. This procedure avoiding charging raw enamel particles on to a moving stream of molten enamel was adopted in view of experiments which showed that when the raw material was charged on to the molten enamel, small particles thereof were carried through the smelter more rapidly than they would have been if they had not fallen on the molten enamel, thereby resulting in the production of a non-homogeneous or imperfectly finished enamel. In the procedure set forth, a charge or reservoir of raw enamel is given an opportunity to become preheated and its outer surface is either in a highly heated state and sintered or melted or about to become so. Therefore, these particles, if not already melted, melt almost instantaneously when the enamel particles strike the molten enamel 13. The enamel charge 9 is afforded sufficient time for this to occur by regulating the speed at which the raw enamel is fed from the charging block by the ram 7.

The procedure set forth not only results in a uniform heating of the enamel being smelted and produces a better final product, but also gives a more efficient heat economy, as there is no draft through the charging block allowing highly heated gases to escape.

It is of course obvious that the raw material may be charged into the smelter by any device adapted to continuously or progressively feed small quantites of the enamel charge. Such a device may be a plunger, screw conveyor, ram, or the like.

Figures 3 and 4 show another form of apparatus suitable for smelting enamels in which the rate of flow of the enamel on the smelting hearth is regulated to correlate the time and temperature of smelting. In this form there is provided a stationary melting furnace 14 in combination

with a rotary furnace 16 set at a predetermined constant angle to the horizontal. The furnace 16 may be rotated at a variable speed acting in a sense to increase the distance over which the molten enamel may travel and thereby vary the time of smelting or, stated differently, the rate of flow of the enamel on the rotary hearth may be controlled. For any given enamel, of course the speed of rotation for smelting at a given temperature would be constant. However, if another enamel of different composition and having the same or a different smelting temperature is smelted at a predetermined temperature in the furnace, the speed of rotation of the rotary furnace may be increased or decreased as necessary to obtain a completely smelted enamel, that is, one that is neither over-smelted nor under-smelted.

In the form of apparatus shown in Fig. 5, there is provided a stationary furnace 16 and an adjustable rotating furnace 17, the latter being pivotally supported at 18 and adjustably supported at 19 by means of a screw jack 20, or its mechanical equivalent.

In this form of apparatus the rotating furnace 17 may be given any suitable inclination, depending upon the type of enamel being smelted, the inclination being controlled so that the time of smelting is correlated with the temperature to produce an enamel that is neither over-smelted nor under-smelted. Stated differently, the inclination of the rotary furnace is adjusted to regulate at a predetermined temperature the rate of flow of the enamel through the rotary furnace.

In the form of apparatus shown in Figure 5, the speed of rotation of the rotary cylinder may be regulated concurrently with the inclination thereof, these factors being adjusted and correlated to permit a specific type of enamel to be smelted at a specific predetermined temperature in a continuous manner so as to eliminate under-smelting or over-smelting, the rate of flow of the enamel through the rotary furnace being determined by the speed of rotation and angle of inclination.

In the form of apparatus shown in Figures 6 to 8 inclusive, a reverbatory furnace 21 is provided having a melting hearth 22 and an adjustable smelting hearth 23, the latter being pivoted at 24 and adjustably supported at 25 by means of a jack 26.

It is of course obvious that the furnaces set forth in Figures 3 to 8 inclusive may be provided with means for continuously or progressively feeding a preheated charge, as described in connection with Figures 1 and 2.

In order to illustrate the present invention whereby the rate of flow of the enamel through the smelter is controlled at a predetermined temperature to produce completely smelted satisfactory enamel, the following is set forth: a small continuous smelter such as set forth in Figures 1 and 2 was utilized for the smelting of the enamel. The smelter was provided with an adjustably inclined hearth pivoted at one end and mounted on jacks at the opposite end so that the inclined hearth could be raised or lowered to change the angle of inclination of the hearth to the horizontal. The smelter was gradually heated to a temperature of 1950° F. and constantly maintained at this temperature. Small quantities of a raw batch of sheet iron enamel were charged into the smelter intermittently at about the rate at which the enamel smelted. It was ascertained that when the hearth was set at an angle of 15° with the horizontal, employing the predetermined temperature set forth, the enamel was not thoroughly smelted as it discharged from the smelting hearth. In an attempt to produce a satisfactory enamel which was completely smelted, the temperature of smelting was raised. At this raised temperature, the enamel was smelted to a greater degree than before and flowed more rapidly through the smelter, but at the same time it began to lose some of its opacity. It is well known that opaque enamels, particularly those which obtain their opacity from fluorides, must be smelted below certain temperatures, otherwise the fluorides are driven off and their opacity is lost.

It was definitely ascertained that at the angle at which the smelter was inclined the proper smelting of this enamel could not be carried on regardless of temperature variation. It has previously been determined from prior practice with the intermittent type of smelter than 1950° F. was the proper temperature for smelting the raw batch of sheet iron white enamel used. Maintaining this temperature, the angle of inclination of the furnace hearth was adjusted to 10° to the horizontal and with this inclination the enamel was smelted at 1950° to produce a final properly smelted enamel. This clearly brings out the basic point of the present invention that when using an inclined hearth the same must be adjustable so as to regulate the rate of flow of the enamel along the hearth at the predetermined temperature employed. In other words, the present invention in its most specific aspect covers the continuous smelting of enamel on an inclined hearth wherein the angle of inclination of the hearth to the horizontal is varied to regulate the time of smelting and this independent of temperature variation. It is, therefore, clear that the temperature is held constant and the time of smelting regulated to correlate the latter with the former to produce at the smelting temperature employed an enamel which is neither under-smelted nor over-smelted. The continuous process of smelting enamel is also carried out in such a manner as to charge into the smelter raw material, the latter always presenting a free surface to the smelter gases which function to gradually bring the particles on and adjacent the free surface to the smelting temperature.

As is to be expected, the angle of inclination of the melting hearth to the horizontal will depend upon a number of factors, including the character of the enamel and the smelting temperature which it is necessary to use in order to produce a thoroughly smelted enamel. In smelting some enamels employing a melting hearth and an inclined mixing, fining, or smelting hearth, it is sufficient to adjust the latter at an angle of 15° to the horizontal; in other cases it is conceivable that the smelting hearth may be at an angle of 2° or 75° to the horizontal. It may be pointed out that the basic feature of applicant's invention in one of its forms is to regulate the flow of the enamel on the inclined hearth so that at a predetermined temperature it does not reach the discharge end of the hearth until a completely and properly smelted enamel is produced. As set forth, very satisfactory results have been obtained by inclining the angle of the hearth between 5° and 55° with the horizontal. However, the present invention in its broadest aspect is not limited to the employment of any specific angle of inclination.

The process of charging a furnace herein set

forth, while of particular value in the continuous smelting of enamel whereby the rate of flow of the enamel is regulated, is not limited thereto. The charging method may be used in a semicontinuous process, although it is of particular value in a continuous process as herein set forth.

The process of smelting vitrous enamels, especially porcelain enamels in a rotary furnace and controlling the speed of rotation thereof to regulate the rate of flow of enamel over the smelter hearth so that the smelted enamel will be neither under-smelted nor over-smelted, is claimed in applicant's co-pending application Serial Number 197,917, filed March 24, 1938.

Having described my invention, what I claim is:

1. In the art of smelting at different times enamels of varying composition and having varying smelting temperatures and periods of smelting in the same smelter having an inclined adjustable hearth, the process of selecting a particular enamel having a definite smelting temperature and period of smelting, feeding said enamel on to the inclined hearth, adjusting the inclination of the hearth to regulate the flow of the enamel over the hearth so that the particular enamel selected will have its normal period of smelting at its correct smelting temperature and will be neither over smelted nor under smelted, removing the enamel from the smelter, then feeding a different enamel having a different period of smelting on to the inclined hearth, again adjusting the inclination of the hearth to regulate the flow of the enamel over the hearth so that said enamel will have its normal period of smelting at its correct smelting temperature and will be neither over smelted nor under smelted, and removing the enamel from the smelter, said process allowing different enamels having different characteristics as above set forth to be smelted at different times in the same furnace.

2. The process of continuously melting and smelting a porcelain enamel charge at a predetermined temperature comprising forming adjacent the higher end of an inclined smelting hearth a reservoir of preheated raw enamel material having one face only exposed to and in contact with combustion gases, said face being at an angle of repose, which is essentially the natural angle of repose of said raw material, whereby the exposed face of said material-reservoir is sintered and/or melted and the so-conditioned enamel material flows onto the hearth to form a flowing mass of molten material, continuously replenishing said reservoir of raw material by feeding fresh raw material thereto sufficient only to maintain in the reservoir a constant uniform supply of preheated raw enamel material and to maintain the exposed face at said angle, and controlling the rate of flow of enamel on the hearth and the temperature of smelting to control the degree of smelting, so that the smelted enamel will be neither under-smelted nor over-smelted.

3. The process of continuously melting and smelting a porcelain enamel charge in a smelter having an inclined hearth provided with an inlet end and an exit end comprising introducing heating gases adjacent the inlet end of the smelter, and exhausting the gases of combustion at the opposite exit end of the smelter, forming adjacent the higher end of said hearth a reservoir of preheated raw enamel material having one face only exposed to and in contact with the combustion gases, said face being at an angle of repose, which is essentially the natural angle of repose of said raw material, whereby said exposed face is sintered and/or melted, and the so-conditioned enamel material flows onto the hearth to form a flowing mass of molten material, continuously replenishing said reservoir of raw material by feeding fresh raw material thereto sufficient only to maintain in the reservoir a constant uniform supply of preheated raw enamel material and to maintain the exposed face at said angle, and controlling the rate of flow of enamel on the hearth and the temperature of smelting to control the degree of smelting, so that the smelted enamel will be neither under-smelted nor over-smelted.

4. The process of continuously melting and smelting a porcelain enamel charge containing an opacifying agent in a smelter having an inclined hearth provided with an inlet end and an exit end, comprising introducing heating gases adjacent the inlet end of the smelter, and exhausting the gases of combustion at the opposite exit end of the smelter, forming adjacent the higher end of said hearth a reservoir of preheated raw enamel material having one face only exposed to and in contact with the combustion gases, said face being at an angle of repose which is essentially the natural angle of repose of said raw material, whereby said exposed face is sintered and/or melted and, the so-conditioned enamel material flows onto the hearth to form a flowing mass of molten material, continuously replenishing said reservoir of raw material by feeding fresh raw material thereto sufficient only to maintain in the reservoir a constant uniform supply of preheated raw material and to maintain the exposed face at said angle, and controlling the rate of flow of enamel on the hearth and the temperature of smelting to control the degree of smelting, so that the smelted enamel will be neither under-smelted nor over-smelted, said temperature of smelting being maintained at a point inhibiting any substantial loss of enamel opacity.

RICHARD H. TURK.