

- [54] **ENDLESS FURNACE**
[75] Inventor: **Henry A. Gornall**, Lyndhurst, Ohio
[73] Assignee: **Ferro Corporation**, Cleveland, Ohio
[22] Filed: **Oct. 26, 1972**
[21] Appl. No.: **301,119**

Related U.S. Application Data

- [60] Continuation-in-part of Ser. No. 167,002, July 28, 1971, abandoned, which is a division of Ser. No. 853,336, Aug. 27, 1969, Pat. No. 3,649,327.

- [52] **U.S. Cl.**..... **432/138, 432/52, 432/239**
[51] **Int. Cl.**..... **F27b 9/00**
[58] **Field of Search**..... **432/52, 53, 45, 56, 57, 432/11, 124, 128, 131, 230, 18, 122, 261, 138, 160, 55, 241, 239**

References Cited

UNITED STATES PATENTS

- 3,588,060 6/1971 Hermans..... 432/53

3,395,904	8/1968	Maeda	432/138
1,919,650	7/1933	Hagan	432/53
2,973,568	3/1961	Greger	432/138
2,127,742	8/1938	Ladd	432/52
3,079,135	2/1963	Buckholdt	432/138
2,622,861	12/1952	Talley	432/138
3,026,595	3/1962	Ludowici	432/138

Primary Examiner—John J. Camby

Assistant Examiner—Henry C. Yuen

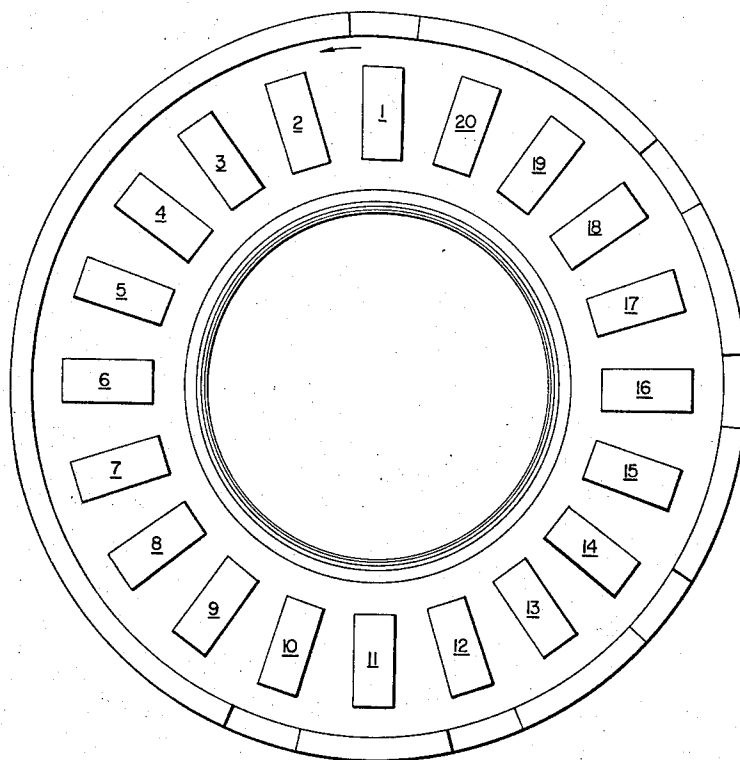
Attorney, Agent, or Firm—Milton L. Simmons

[57]

ABSTRACT

An endless porcelain enameling tunnel furnace having an inner and outer periphery, a plurality of ports positioned along said outer periphery in spaced relationship to each other to permit entry and removal of a work piece to be placed in said furnace, an internal radiant heat means, and internal means for continuously advancing work pieces to be enameled.

13 Claims, 2 Drawing Figures



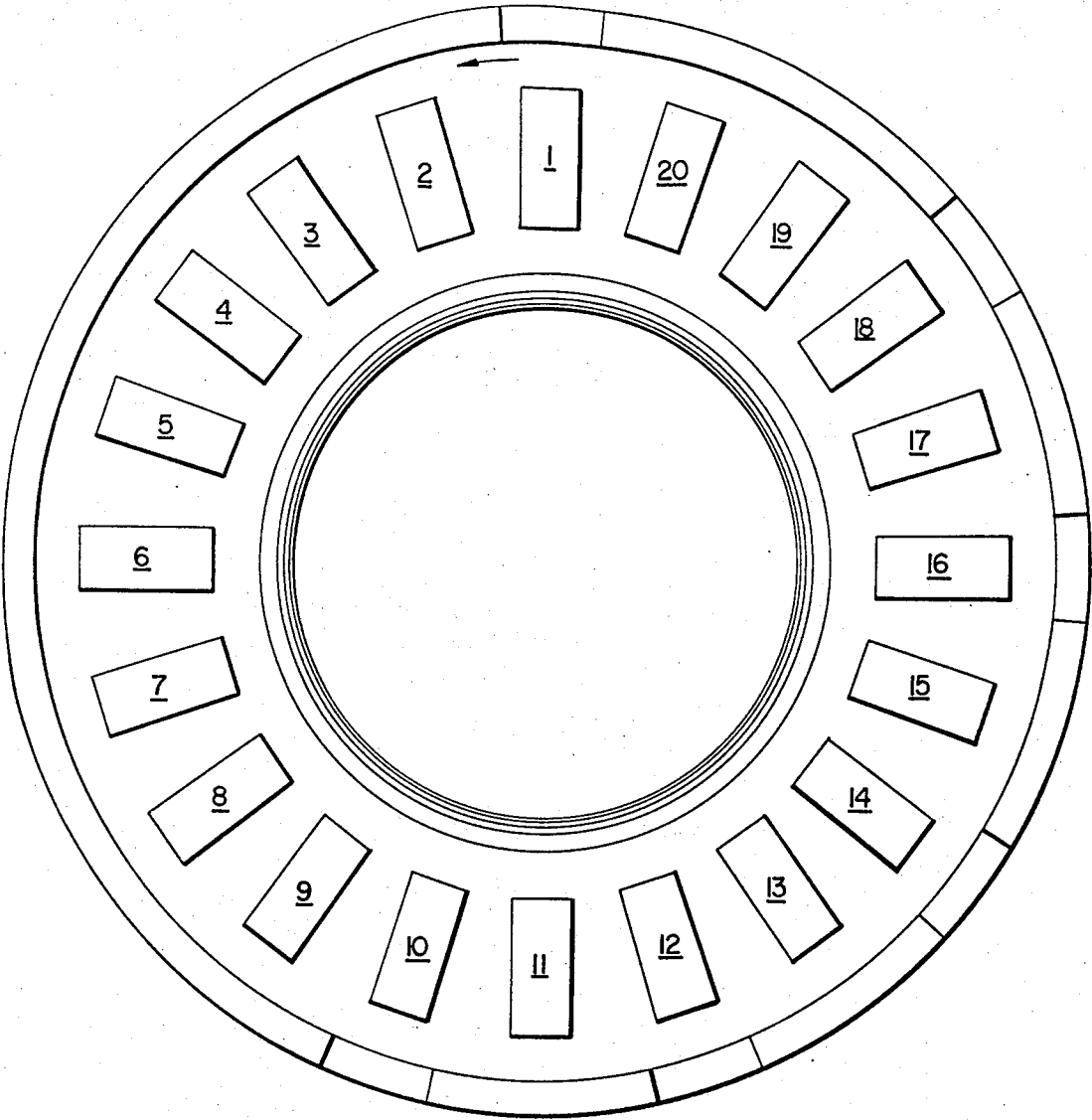


FIG. 1

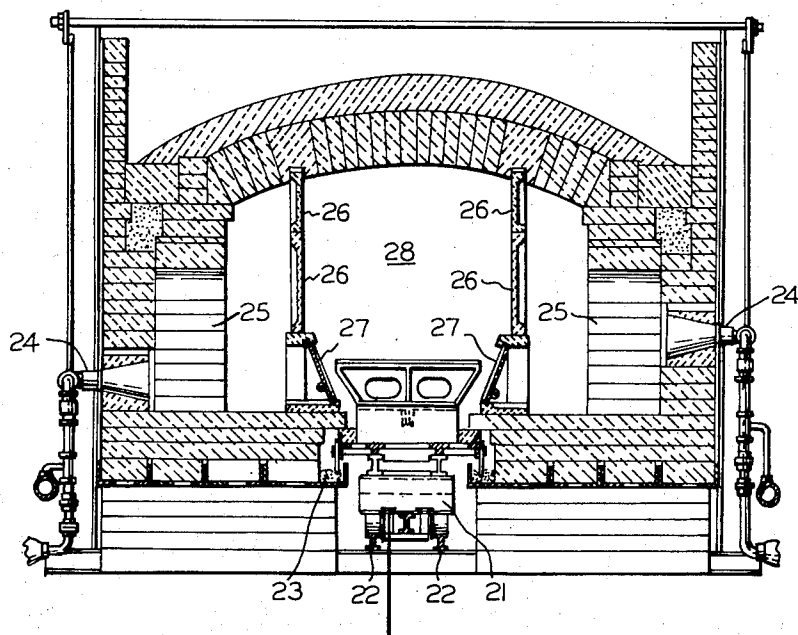


FIG. 2

DRIVE FOR
ADVANCING
WARE

ENDLESS FURNACE

This is a continuation-in-part application of U.S. application Ser. No. 167,002 filed July 28, 1971, now abandoned, which in turn is a divisional application of U.S. application Ser. No. 853,336, filed Aug. 27, 1969, now issued into U.S. Pat. No. 3,649,327.

This invention relates to a furnace ideally suited for the continuous dry process enameling of metal objects, particularly cast iron bathroom fixtures, and to a process for continuously coating and firing said metal objects to be enameled in a single, unitary, endless furnace. More particularly the furnace is endless or circular end having an inner and outer periphery, a plurality of ports or doors of a size sufficient to permit entry and removal of a metal work piece to be placed in said furnace, said ports positioned along said outer periphery in spaced relationship to each other, an internal radiant heat means, and internal means for advancing work pieces to be preheated and enameled.

In the attached drawings:

FIG. 1 is a schematic plan view of the circular, endless enameling tunnel furnace of this invention, and

FIG. 2 is a vertical cross section through said furnace.

Preferably the process contemplates electromechanical means for inserting and withdrawing metal work pieces from said furnace, and electromechanical means for dusting or applying the dry enamel powder to be fired. Other than the novel, endless aspect with spaced ports, the furnace of this invention is of conventional basic structure as employed for ceramic firing and is fitted with insulated fire brick or the like and contains one or more muffles or radiant tubes and the like for providing radiant heat.

Enamel coating of metal objects by the dry or powder process comprises heating a metal object to a temperature of about 1,700°–1,800° F., uniformly distributing over the surface of the object an enamel powder which is to be coated thereon, and fusing the powdered metal object by heating it in a suitable furnace to a temperature of about 1,700°–1,800° F.

It is necessary to periodically remove the object from the furnace in order to apply the dry enamel powder, depending upon the number of coatings desired.

This has been handled by an operator called an enameler using electro mechanical means. Because of the physical requirements for the enameler, i.e., the ability to withstand high temperature, be able to insert and remove from the furnace objects of considerable weight by the use of a simple fork-like tool and have the ability to apply a uniform distribution of enamel powder over the metal object, it has been difficult to obtain enamellers and thus maintain good production and uniform application. For these reasons electromechanical means are preferably employed both to insert and remove objects from the furnace and also dust or apply the powder enamel. Means for enameling by the dry process is described in Dutch Pat. No. 6,712,672, esp. FIG. 13 which patent is herein incorporated by reference. Means for dusting are also described and illustrated in said patent. Although for large and bulky objects such as bathtubs it is normally preferred to employ electromechanical means to handle such objects, for many applications requiring less skill and particularly concerning small objects such as lavatories and sinks, the use of an enameler is quite satisfactory.

While the aforesaid patent represents an advance in the art as to means for inserting, withdrawing, and dusting heavy bathtub objects, the straight line furnace described therein has certain deficiencies which are obviated by this invention. The primary defect is that in a straight line furnace it is necessary to remove the means for transporting the object to be enameled when the object is removed which results in a substantial amount of heat loss. Consequently, the transporting device must be reheated when it is returned to the furnace to transport a new object. The overlooking of the heat loss to trays, conveyor chains and rollers "has caused important furnaces to fail to meet the capacity and fuel consumption guarantees, with disastrous results to the furnace builders who were responsible." Industrial Furnaces Vol. 1, 5th Ed., Trinks and Mawhinney, published by John Wiley & Sons, N.Y. In addition the heat loss is greater with a straight line furnace at the entrance and exit points since heat tends to radiate in a straight line. In the furnace of the invention, however, the heat tends to radiate around the axis of the furnace and not out the entrance or exit points. Further the endless furnace of the invention permits the furnace to be placed in a more compact area. Moreover when the same port is used both for loading and unloading, the same equipment or operator can be used to handle the object. When desired, however, objects can be placed in and removed from the furnace at a variety of locations depending upon the time and temperature requirements of the article to be fired and/or the equipment space and personnel requirements.

The invention is illustrated by the accompanying drawing FIG. 1, which is a schematic representation of a top view of the furnace and FIG. 2, which is a cross section of said furnace. A plurality of supports (trays) for carrying the pieces to be enameled are illustrated by the numbers 1 through 20. A number of conventional means for moving the supports may be utilized. One can utilize railway type cars placed on rails or similar type means as depicted in FIG. 2. As illustrated there are entrance and exit ports opposite trays 1, 10, 12, 14, 16 and 18. There can be more or less ports however, depending on the size of the furnace, the temperature and residence times employed, etc. The trays as illustrated are moving in a counterclockwise direction but they can be moved in the opposite direction as well. Work pieces are introduced at point 1, removed at points 10 and 14 for dusting, reinserted at points 12 and 16 and finally removed at point 18 for cooling. The trays are not moved in the furnace at a constant rate but rather are allowed to remain opposite an exit or entry point for a time sufficient to remove and insert a work piece. Accordingly, depending upon the size of the furnace, the residence time, temperature employed and the size of the work piece can be removed for dusting and reinserting into the furnace before any work pieces in the furnace are advanced. Likewise for very large furnaces, the cycle can be completed in a quarter or half of the furnace and thus two or more entrance and terminal exit ports will be employed. In a preferred embodiment, heat loss is minimized at the ports by employing an air curtain when the doors are opened.

The following example will illustrate the invention in more detail.

EXAMPLE I

As illustrated in FIG. 1, bathtubs to be enameled are

introduced at point 1 and are withdrawn for cooling at point 18. The temperature of the furnace is automatically maintained between about 1,700° and about 1,800° F. and the residence time for a tub is maintained between about 20 minutes and about 60 minutes excluding the time between removal at points 10 and 14 for dusting and reinsertion at points 12 and 16. The tubs are advanced such that a tub is stationary at each of the entrance and exit ports for a time between about ½ minute and about 1½ minutes to provide a preheating time of between about 18 and 24 minutes. The pieces are inserted and withdrawn by means of a fork-like device. Two dusting operations are employed to obtain a thick coating of enamel and a piece to be returned to the furnace after dusting is returned within about one minute after its removal.

In another embodiment of this invention the pieces to be coated are merely preheated in the circular furnace and removed for dusting and placed in another endless furnace or box furnace of the conventional type. By this method it is not necessary to strictly control the furnace conditions such that a piece is not baked for too long a period or reinserted in the furnace before being properly dusted. The difficulties are minimized, however, when the furnace is conducted according to Example 1 inasmuch as there are two dusting operations. In some cases one dusting operation will be sufficient.

As stated above, any number of conventional means may be utilized for advancing ware through the furnace, and as illustrated in FIG. 2, a rail-type vehicle 21 traveling on rails 22 provides a means for advancing the ware through the furnace, its running gear protected from the hot furnace atmosphere by sand seals 23.

Conventional oil or gas burners 24, served by fuel and air lines as shown, and appropriately staggered around the inner and outer periphery of the furnace, fire inwardly through the arched burner blocks 25.

By any of well known flue and duct systems, the hot gases of combustion are exhausted from the furnace.

Muffle tile 26 and 27, continuously placed around the interior of the furnace, form an effective barrier against any products of combustion entering the enameling chamber 28.

The relatively thin muffle tile are effectively brought to a bright red heat by the burners 24, said muffle tile thereby effectively providing the means of radiant heat for firing the enameled sanitary ware as it passes through the enameling chamber.

By conventional sensing and control means the burners may be continuously adjusted to provide the desired temperature at various points along the interior of the furnace.

As it will be observed from FIG. 2, in cross section the furnace of this invention may be of relatively conventional structure, constructed of refractory brick held together by buckstays at the required intervals along its circumference.

As used throughout the specifications and claims, "tunnel furnace" and "enameling furnace" are synonymous as they apply to the furnace of this invention, and furnaces of this general cross section are described at length by Andrews in his treatise "Porcelain Enamels," 2nd Edition (the Garrard Press, publishers, Champaign, Illinois).

See particularly Chapter 11 of Andrews, "Firing and Furnaces," and the section entitled "Tunnel Furnace," at page 440 et seq.

Consistent with porcelain enameling furnace terminology then, "tunnel furnace" contemplates an enameling furnace having a linear, tunnel-like firing passage, along the length of which are zones of varying temperature.

The location of burners, as depicted in FIG. 2, and by Andrews throughout Chapter 11, form no part of this invention, and whether they are used to fire a periodic or tunnel furnace, their number and position is essentially a matter of choice, dictated by such considerations as peak firing temperature, and the mass of tooling plus ware throughput per unit of time.

Also, as is well known in the porcelain enameling art, "radiant heat means," refers to either (a) a muffle which serves to keep products of combustion out of contact with the work to be enameled, which muffle, at the same time, is elevated by the heat of combustion to a radiant temperature sufficient to maintain the various zone temperatures, or (b) banks of electrical resistance elements which may be utilized to provide radiant heat directly to the ware to be enameled. Either means fires the ware principally by radiation and convection and promotes a substantially turbulence-free ambient firing atmosphere free of any products of combustion which would react with the enamel surface during fusion, resulting in unsightly surface blemishes and defects in the finished porcelain surface.

Too, as will be readily apparent from the Andrews text, and related disclosures in the field of porcelain enameling, "tunnel furnace" carries the connotation that the tunnel itself, substantially enclosed by muffle tile, is stationary, as are entry and discharge ports, with respect to the ware to be fired which moves progressively through said tunnel.

I claim:

1. A curvilinear porcelain enameling furnace having a pair of substantially concentric, curvilinear endless sidewalls bridged by a roof therebetween over their respective lengths, said walls and roof forming an endless, substantially enclosed curvilinear tunnel, three consecutive ports positioned along the outer sidewall in spaced relationship to each other to permit entry or removal of a work piece into or from said furnace, internal radiant heat means, means associated with said internal radiant heat means for maintaining said enclosed tunnel substantially free of products of combustion, and internal means for progressively and chronologically advancing work pieces in one direction through said tunnel.

2. The furnace of claim 1 wherein the ports comprise a first charging port to permit charging of a work piece, a second port to permit removal of a work piece to be dusted with powdered enamel and for recharging the powdered enameled work piece, and a third port for removing the resultant fired enamel work piece.

3. A curvilinear porcelain enameling furnace having a pair of substantially concentric, curvilinear endless sidewalls bridged by a roof therebetween over their respective lengths, said walls and roof forming an endless, substantially enclosed curvilinear tunnel, six consecutive ports positioned along the outer sidewall in spaced relationship to each other to permit entry or removal of a work piece into or from said furnace, internal radiant heat means, means associated with said internal ra-

5

6

diant heat means for maintaining said enclosed tunnel substantially free of products of combustion, and internal means for progressively and chronologically advancing work pieces in one direction through said tunnel.

4. The furnace of claim 3 wherein the ports comprise a first charging port to permit charging of a work piece, a second port to permit removal of a work piece to be dusted with powdered enamel, a third port for recharging the powdered enameled work piece, a fourth port to permit removal of a work piece to be dusted with more powdered enamel, a fifth port for recharging the powdered enamel work piece, and a sixth port for removal of the resultant fired enameled work piece.

5. A curvilinear porcelain enameling furnace having a pair of substantially concentric, curvilinear endless sidewalls bridged by a roof therebetween over their respective lengths, said walls and roof forming an endless, substantially enclosed curvilinear tunnel, four consecutive ports positioned along the outer sidewall in spaced relationship to each other to permit entry or removal of a work piece into or from said furnace, internal radiant heat means, means associated with said internal radiant heat means for maintaining said enclosed tunnel substantially free of products of combustion, and internal means for progressively and chronologically advancing work pieces in one direction through said tunnel.

6. The furnace of claim 5 wherein the ports comprise a first charging port to permit charging of a work piece, a second port to permit removal of a work piece to be dusted with powdered enamel, a third port for recharging the powdered enameled work piece, and a fourth port for removing the resultant fired enameled work piece.

7. A curvilinear porcelain enameling furnace having a pair of substantially concentric, curvilinear endless sidewalls bridged by a roof therebetween over their respective lengths, said walls and roof forming an endless, substantially enclosed curvilinear tunnel, five consecu-

tive ports positioned along the outer sidewall in spaced relationship to each other to permit entry or removal of a work piece into or from said furnace, internal radiant heat means, means associated with said internal radiant heat means for maintaining said enclosed tunnel substantially free of products of combustion, and internal means for progressively and chronologically advancing work pieces in one direction through said tunnel.

8. The furnace of claim 7 wherein the ports comprise a first charging port to permit charging of a work piece, a second port to permit removal of a work piece to be dusted with powdered enamel, a third port for recharging the powdered enameled work piece, a fourth port to permit removal of a work piece to be dusted with additional powdered enamel and for recharging the powdered enameled work piece, and a fifth port for removal of the resultant fired enameled work piece.

9. The furnace of claim 2 wherein said internal radiant heat means is for maintaining the interior of said furnace, in the vicinity of said second port, at peak dry process enameling temperatures.

10. The furnace of claim 6 wherein said internal radiant heat means is for maintaining the interior of said furnace, in the vicinity of said third port, at peak dry process enameling temperatures.

11. The furnace of claim 6 wherein said internal radiant heat means is for maintaining the interior of said furnace in the vicinity of said second and third ports at peak dry process enameling temperatures.

12. The furnace of claim 8 wherein said internal radiant heat means is for maintaining the interior of said furnace, in the vicinity of said second, third and fourth ports, at peak dry process enameling temperatures.

13. The furnace of claim 4 wherein said internal radiant heat means is for maintaining the interior of said furnace in the vicinity of said second, third, fourth and fifth ports at peak dry process enameling temperatures.

* * * * *

45

50

55

60

65