United States Patent

Whitehouse

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[54] **FURNACES**

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[52] **U.S. Cl.** ....**263/8 R,** 263/28

[51] **Int. Cl.**...**F27b 9/24**

[58] **Field of Search**............................263/8, 28; 25/142 HA

[56] **References Cited**

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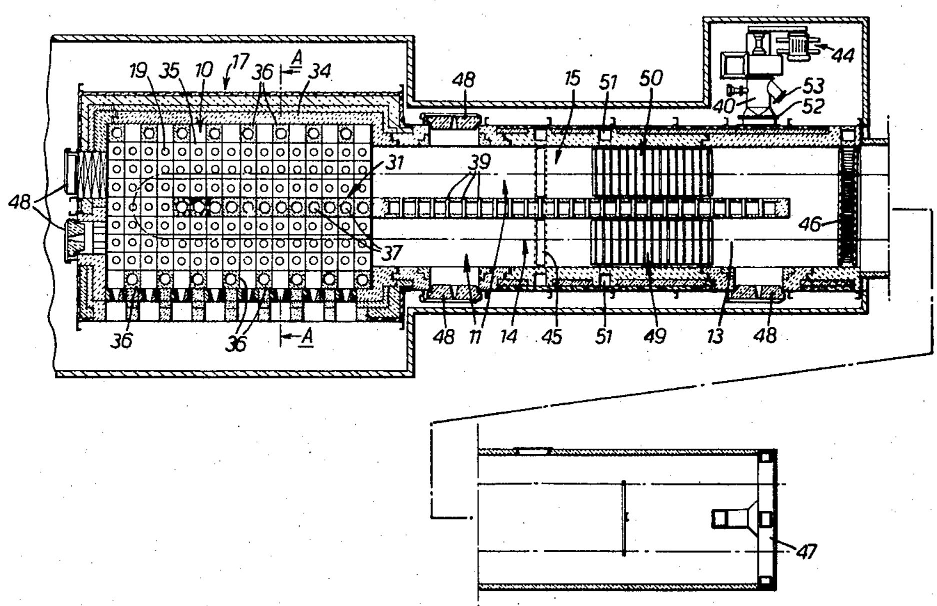
[57] **ABSTRACT**

A direct fired tunnel-type continuous heat treating furnace, particularly adapted to fire porcelain enamel articles, wherein the conventional muffle has been eliminated in favor of a system of perforate refractory shapes, so disposed to channel, and directly and evenly distribute, heat from the burners of said furnace throughout its hot zone.

4 Claims, 6 Drawing Figures



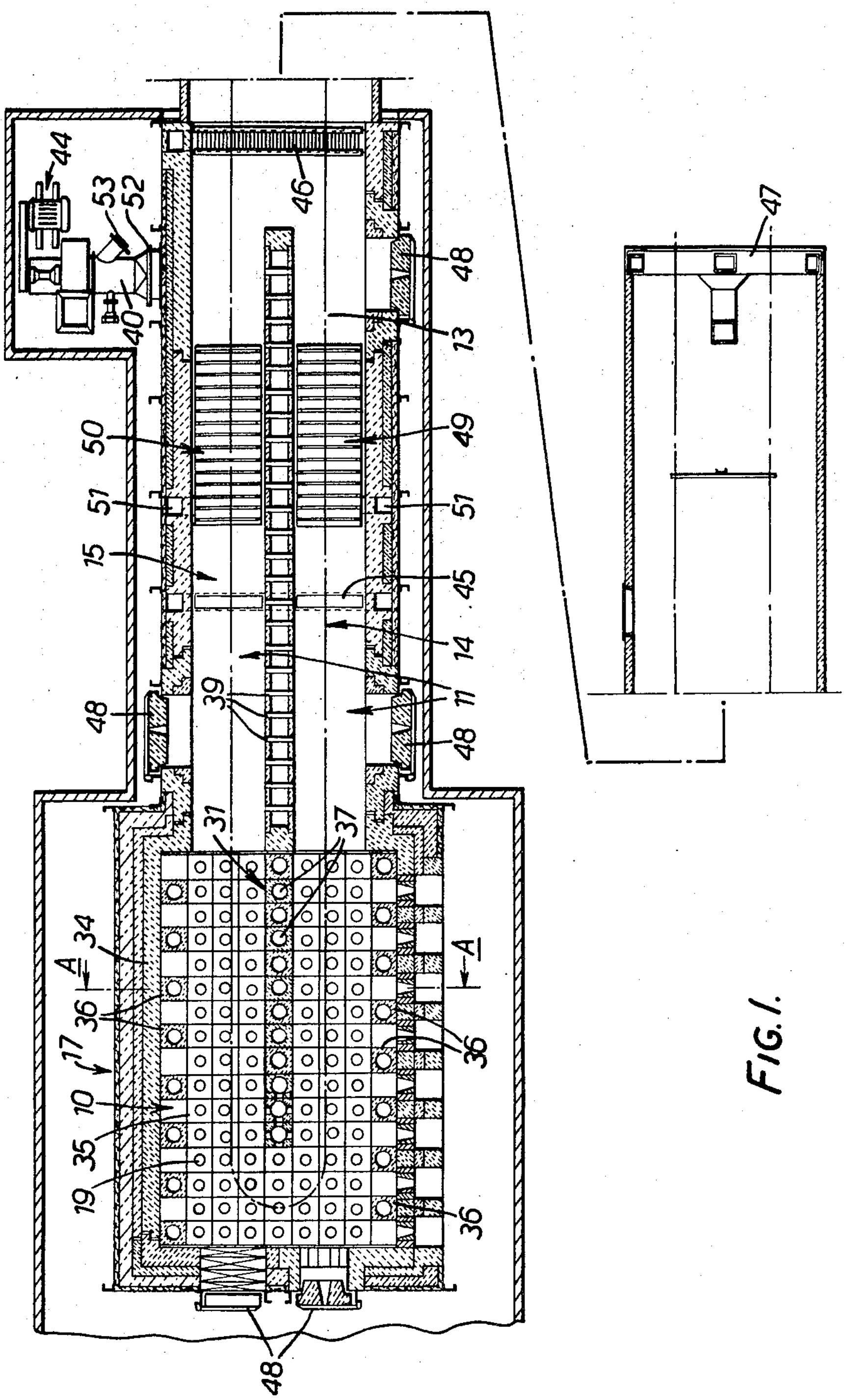


FIG. 1.

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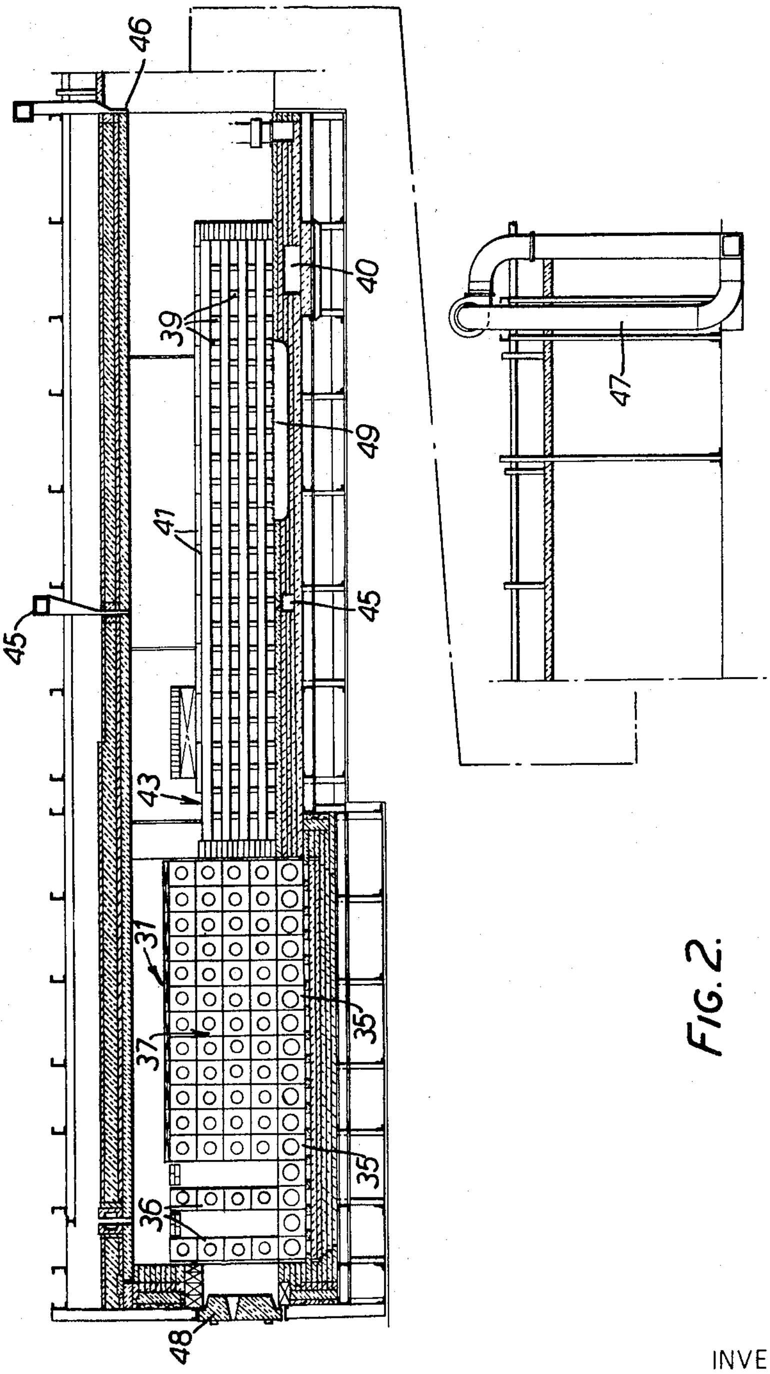

FIG. 2.

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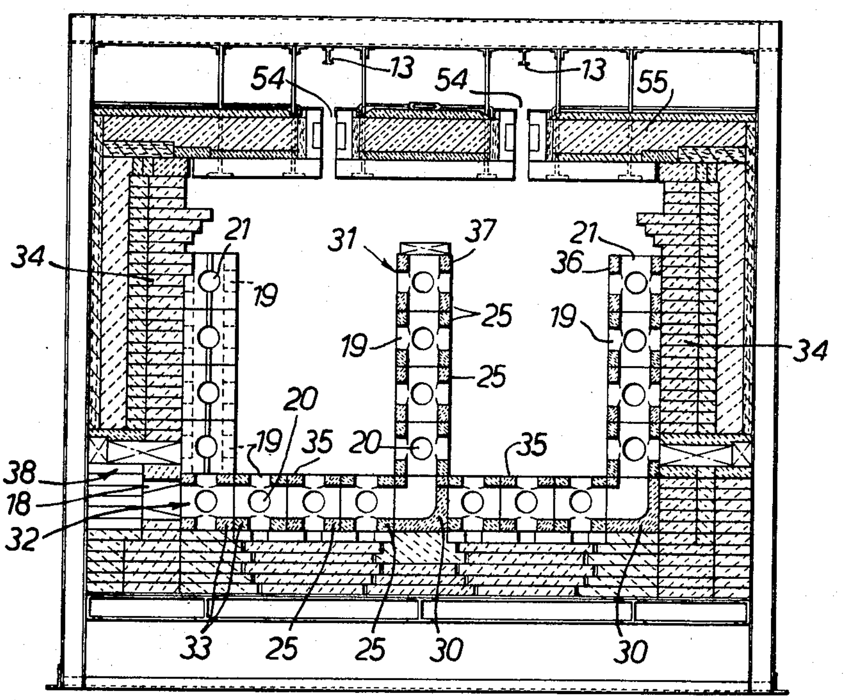

FIG. 3.

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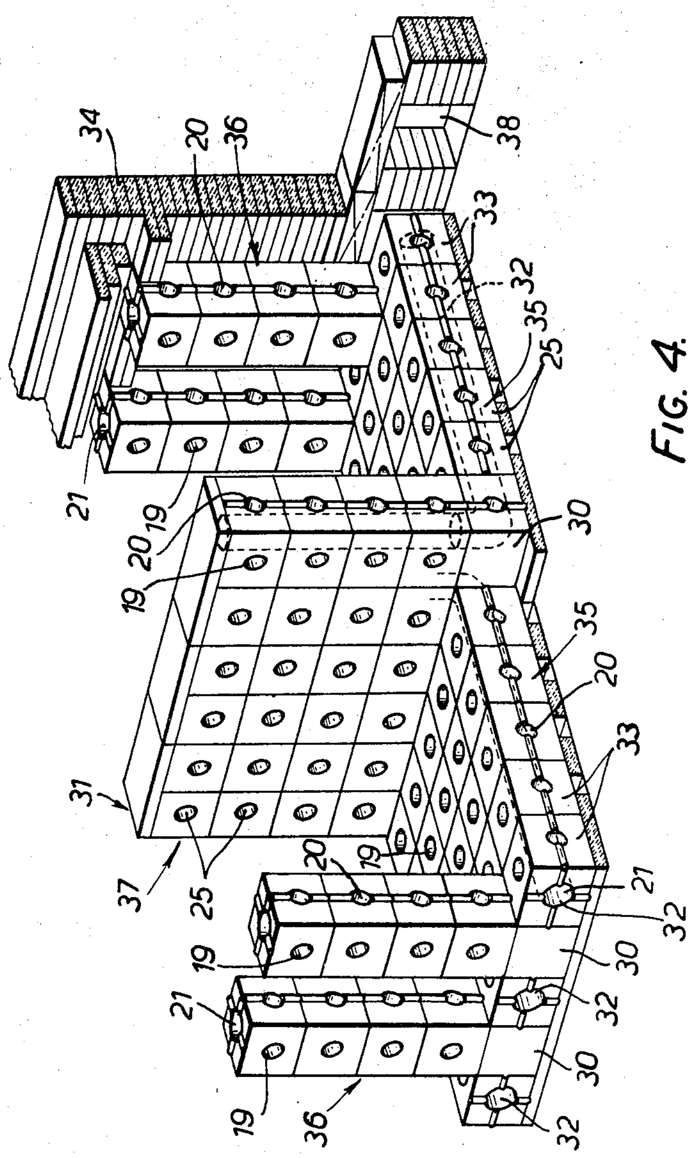

FIG. 4.

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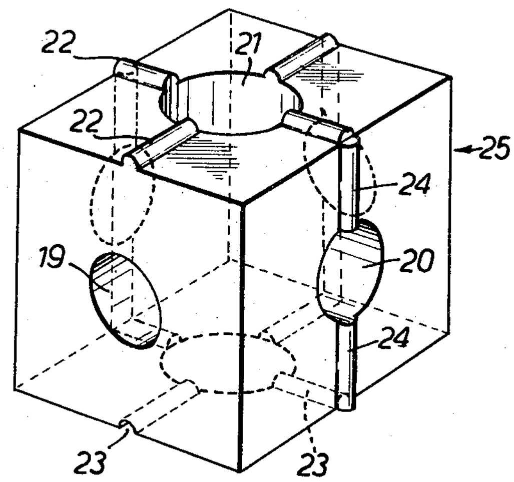

FIG. 5.

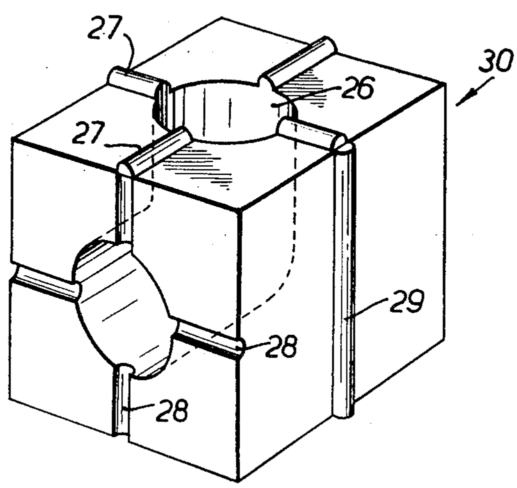

FIG. 6.

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FURNACES

The invention relates to furnaces, particularly, but not exclusively for enameling. When enameling articles it is essential that during the heating operation the article being enameled is heated evenly, or cracks and blemishes will be formed in the enamel. Therefore the temperature around the whole surface of the article should be uniform within about 2° C. In the past, furnaces used for enameling have either been electrically heated or indirectly heated by combustible fuels so that the flue gases do not come into contact with articles in the furnace.

The present invention provides a directly fired furnace in which the flue gases are caused to circulate within the furnace chamber to provide a heating atmosphere of substantially uniform temperature about the articles to be heated.

Of course, the nature of the flue gases must be compatible with the article to be heated. For example, for firing enamel ware, low sulphur fuels are employed such as the natural gases.

More specifically, the invention provides a direct fired tunnel furnace comprising a semi-flue duct system for circulating within the tunnel hot gases from burners, the said duct system comprising, for each burner, a main under floor flue duct extending from a burner nozzle at one side of the tunnel to a main rising duct in a wall at the opposite side of the tunnel, both said main ducts being provided with flue ports for the discharge of hot gases into the tunnel.

Preferably, the side walls, floor and ceiling of the furnace chamber are of heat insulating materials such as insulating fire bricks or insulation bricks, rather than refractory bricks.

In the case of a straight through tunnel furnance, successive burners along the length of the tunnel are preferably arranged on alternate sides of the tunnel. The tunnel may alternately be a U shaped tunnel, in which case all the burners along the limbs of the U tunnel project into the tunnel through the outer side wall, and between each burner duct there is preferably an auxiliary duct made of an insulating material comprising an underfloor cross duct and a side wall duct extending up the outer side wall, with interconnecting passageways between the auxiliary duct and the adjacent main ducts.

The flue system is preferably constructed of loosely assembled but mechanically interlocking insulation fire bricks having passageways therethrough and projecting ribs and recesses on faces thereof for interengagement with corresponding ribs and recesses on adjacent bricks.

One form of directly fired tunnel furnace according to the invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIG. 1 is a variously sectioned plan view of a directly fired U shaped tunnel furnace according to the invention;

FIG. 2 is a variously sectioned elevation of the furnace of FIG. 1;

FIG. 3 is a section on the line A—A of FIG. 1;

FIG. 4 is a perspective view of the semi-flue system construction of the U limbs of the U furnace of FIG. 1;

FIG. 5 is a perspective view of one type of brick used in the construction of the flue system;

FIG. 6 is a perspective view of another type of brick used in the construction of the flue system.

The tunnel furnace shown in the drawings is a U shaped furnace for fusing cast and sheet iron porcelain enamel. A tunnel of that shape is usually desirable since the hot outgoing articles can give up their heat to cold incoming articles, thereby helping to conserve heat.

The furnace consists of a fusing chamber **10** and preheating and cooling chambers **11**. Articles to be heated are supported from a conveyor **13** which is outside the furnace there being a slot **54** along the whole length of the tunnel through which a supporting member attached to the chain projects. Articles enter along the limb **14** of the U tunnel where they are preheated before entering the fusing chamber **10**, and come out along the limb **15** where they give up some of their heat to the cold incoming articles. The fusing chamber flue system is constructed from bricks which are stacked directly one upon or adjacent another. Two types of bricks are used and they are illustrated in FIGS. **5** and **6** respectively. Most of the flue system is constructed from the type of brick illustrated in FIG. **5**. These bricks each consist of a rectilinear block of about 12 × 13⅛ inches having holes extending through the bricks along the three principal axes thereof. A hole **20** of about 5 inches diameter extends between the square faces, and a similar hole of 5 inches diameter between a pair of the other faces. The other pair of faces has a longer hole of about 7½ inches diameter extending between them. One face through which the hole **21** passes has two sets of projecting semi-circular ribs **22**, and the opposite face has corresponding grooves **23**. One face through which the hole **20** passes has one set of projecting semi-circular ribs **24**, and the opposite face has a corresponding groove. These ribs and grooves need not be semi-circular as illustrated but may alternatively be tapered for example.

The other type of brick **30** illustrated in FIG. **6** is the same size as the brick **25** already described, but has a 7½ inch diameter hole **26** connecting the top face to an adjacent front face, both faces being of 12 × 13⅛ inches. There are two projecting sets of semi-circular ribs **27** on the top face and corresponding grooves **28** on the adjacent front face. One of the side faces has a projecting semi-circular rib **29** and the opposite side face has a corresponding recess. The back and bottom faces are flat.

The construction of the interior of the furnace is best seen in FIG. **4**, which shows a perspective view of a part of the U limbs of the furnace. The flue system is constructed mainly from the bricks **25**, which are positioned to form an L shaped structure with a brick **30** at the corner of L and the large holes **21** forming a flue passage way extending along the length of the L. These L shaped structures are built side by side with the upright limbs of the L's on alternate sides and with two such assemblies backing onto one another so that a central dividing wall **31** is formed. This wall **31** forms the dividing wall between the two limbs of the U furnace.

The flue system thus as a series of underfloor ducts **35**, side wall ducts **36** and main rising ducts **37**. Furnace side walls **34** (only one of which is shown in FIG. **4**) extend up the outer sides of the flue system construction blocking off the holes **19** on the outer sides of the side wall ducts **35**. These walls **34** are made of insulation bricks. The furnace side walls **34** have burner ports **38** in line with the open ends of the underfloor ducts **35** through which burners **18** project that is in line with alternate underfloor ducts **35** which form main underfloor ducts along each outer side of the furnace. The other underfloor ducts which are connected to the side wall ducts form auxiliary ducts which are connected to the main underfloor ducts by intercommunicating passageways which are formed by the holes **20** in the bricks **25** of the under floor ducts **35**. Flat bricks are placed along the top of the center wall **31** to block off the ends of the main rising ducts **37**. The burner ports **38** are made of a refractory material and the two bricks **33** adjacent each burner port are made of a semi-refractory material in order to withstand the heat of the burner. Since there is nothing on top of the bricks adjacent the burners there is very little tendency for these bricks to squat and spall from the wall load container. The rest of the bricks **25** and **30** are made of an insulating fire brick material and the side walls **34** and roof **55** are made of insulation brick. Refractory materials have a coefficient of thermal conductivity of around 7–9, insulating fire bricks of around 1.5–2.5 and insulation bricks as low as 1–1.5. The direct firing and low conductivity of the bricks enables the furnace to warm up and cool down very quickly. In this particular case the furnace can warm up to an operating temperature of 840° C within an hour, since the furnace structure itself conducts away relatively little heat, so that most of the heat goes into warming the fusing chamber air space.

At the inner end of the furnace, there is no center wall and the under floor ducts **35** extend the full width of the furnace. Burners project into each of these underfloor ducts at their open ends as can be seen in FIG. **1**, there being no auxiliary underfloor ducts.

At the outer preheating and cooling chambers **11** of the U furnace the center wall **31** is constructed as a hollow wall having tie members **39** holding the two sides together. At the outer end the cavity within the hollow wall is connected to an exhaust flue **40** through the floor of the furnace. The top of the wall is covered with flat bricks **41** sealing off the cavity. However a gap **43** is left to provide an inlet for exhaust gases into the cavity. In FIG. **2** the gap **43** is shown at the inner end of the hollow wall, however it may be positioned wherever desired.

In operation, the burners force hot burnt gases into their associated main under floor ducts **35**, while an exhaust fan and motor **44** exhausts gas out of the furnace through the exhaust duct **40**. Considering first the innermost part of the furnace where there is no dividing wall, the hot gases flow along the under floor ducts **35** and up the side wall ducts which are the main rising ducts in this part of the furnace, the gases gradually escaping into the furnace chamber through the holes **19** in the underfloor ducts **35**, and the holes **19** and **20** in the side wall main rising ducts **36**. The main stream of hot gases from a given burner, having entered the furnace chamber through the holes **19** and **20** in the side wall duct **36** with a certain amount of momentum, ascend up the side wall of the furnace chamber and across the roof of the furnace chamber towards the center. As it reaches the center the gas begins to cool and lose its momentum and thus descends towards the bottom of the fusing chamber to complete a generally circular path. At the bottom of the chamber the gases are warmed by the hot gases from the burners coming up through the holes **19** from the main under floor ducts. At the same time the exhaust fan is drawing the gases towards the outer end of the furnace, so that the gases tend to be drawn outwards towards the adjacent underfloor duct which is fired from the opposite side. The gases being heated again, rise and this time are drawn up into a generally circular path as before, but this time in the opposite direction of circulation. Thus the hot gases are continuously mixed and circulated in way which avoids any significant degree of temperature stratification in the furnace chamber and provides an even temperature distribution over a large cross sectional area of the fusing chamber.

In a straight through tunnel furnace the construction of the flue system would be similar to the innermost end of the U furnace described herein. However with a U furnace it is not possible to have burners at the center wall **31**.

Along the U limbs, the burners force hot gases into their respective main under floor ducts **35** as before. The main gas flow passes under the floor and up the respective center wall ducts **37** which are the main rising ducts, with the hot gases emerging into both limbs of the fusing chamber through the holes **19** in the main rising ducts **37**. Some of the hot gases, however, pass through the holes **20** in their respective main under floor ducts into the adjacent auxiliary underfloor ducts, which are not connected directly to a burner **18**. A trickle of hot gas thus comes out of all the holes **19** in the floor of the furnace chamber, with a trickle also ascending up the side wall ducts **36** and out into the furnace chamber through the holes **19** and **20**. The main hot gas flow ascends up both sides of the center wall **31** and then outwards across the roof of the furnace to either side of the furnance. By then the gas is beginning to cool and lose its momentum and so descends but as it descends around the side wall ducts it is heated by the trickle of hot gases emerging therefrom, and further heated when it reaches the bottom of the fusing chamber by the hot gases emerging from the holes **19** in the floor of the chamber. The gas then rises and is caught up with the fresh main flow of hot gases emerging from the center wall main rising ducts and thus a circulatory gas flows is created. The exhaust fan causes the gases to move towards the exhaust outlet so that the gases in each limb of the U furnace follow a generally helical path towards the exhaust outlet.

There are three air seals, an inner air seal **45** an interior air seal **46** and an exterior air seal **47**, in the preheating and cooling chambers **11** which keep the heat in the furnace and prevent cold air being drawn in from the outside. The inner air seal **45** and interior air seal **46** both act from the top of the furnace to the bottom. This direction of action is desirable, not only because the center wall **31** in the case of the inner air seal **45** makes a sideways seal impractible, but also because the air blast acts to hold the article on its hook. A sideways acting seal might blow the article off its hook, and within the furnace this would be extremely awkward. The exterior air seal **47** is a center to side seal. Since the length of the seal from center to side is shorter than that from top to bottom, the center to side seal is more effective than a top to bottom seal. At the exterior an article blown off its hook can easily be picked up and put back onto a hook.

In the preheating and cooling chambers **11**, there is no flue system to ensure adequate circulation of the gases therein and prevent temperature stratification, so that the hot gases tend to rise towards the roof. Adjacent the air seals this stratification is reduced, as the air seal gas flow from top to bottom, imparts some of its motion to the gases within the furnace. There is however a space between the inner air seal **45** and the interior air seal **46** where the air seals are too far away to impart a sufficient coutra crown gas flow. At this place grids **49** and **50** are provided in the floor of each limb of the chambers **11** respectively. The spaces beneath these grids are connected by a conduit **51** with a pump (not shown) and gas is pumped from the ingoing limb **14** into the outgoing limb **15**, to provide the necessary gas motion to reduce the temperature stratification.

The furnace is provided with normally closed doors **48**, which allow access into the furnace for repairs etc. When the furnace is shut off.

Aspiratory or inspirator type burners may be used. With aspirator type burners the power turn down ratio is in the region of 4:1, and with the inspirator type, in the region of 10:1. In the case of inspirator type burners the excess air supplied to the burners can be varied from zero to 200 per cent. However, whatever type of burner is used, the fuel used must be a very lower sulphur content fuel such as natural gases if the furnace is being used for enamelling, as the sulphur products of combustion are likely to cause surface scumming.

The exhaust system is adjustable so that it may be balanced to meet the range of the fuel input. For this purpose there is a damper **52** in the exhaust flue **40** and an adjustable air inlet **53** into the exhaust flue **40**.

The furnace temperature is controlled by a standard control system using sensing thermo-couples.

The above described type of furnace is especially suitable for direct fired furnace designed to have a heat input of between 2,000 and 100,000 B.T.U. per cubic foot per hour, at the burner location.

Additional and alternative air circulation air seals can be applied in the preheat and cooling chamber **11** where the gases are circulated prior to exhaust to atmosphere.

Under certain conditions, additional air inlets may be provided at the top of the furnace chamber to dilute and impart coutra crown flow of gases. In the above described furnace, the insulating bricks give the furnace a very short light up period, and the expansion and contraction of the bricks does not cause the walls to crack as the bricks are loosely stacked. The loose stacking of the flue system bricks has the further advantage that repairs to the flue system structure are very simple since the damaged bricks may be replaced without destroying other bricks when removing the damaged bricks.

The operating efficiency of the furnace is high, since the furnace can be shut down ready for repair or maintenance and brought to operating temperature again, each in about 1 hour, by virtue of the low thermal capacity of the furnace structure. The thermal efficiency is also high again due to the low thermal capacity and also the vigorous circulation of heating fluid.

The flue system gives rise to a gas circulation within the furnace chamber that gives a very even temperature distribution over a large cross sectional area of the furnace tunnel, which makes the furnace suitable for enamelling large articles such as gas cooker casings. The furnace temperature may also be controlled very accurately and rapidly.

One major advantage of the above described furnace construction over conventional muffle furnaces currently used for enamelling is that the fragile, expensive muffle tiles or plates are entirely dispensed with.

The perforated blocks provide a novel form of furnace construction which is relatively simple and cheap to erect and repair. The blocks, being self supporting, form both the lining walls and the flue ducts and ports in those walls and in operation act both as a means of distributing the hot gases and heat radiating masses.

Furnaces constructed from these blocks have side walls and floors which constitute substantially evenly heated radiating surfaces. These blocks could, of course, find useful application in other furnaces than the tunnel type with which the foregoing description is primarily concerned, and can be employed with advantage for example, in various forms of box and tower furnace.

The invention accordingly includes within its scope the novel apertured blocks adapted for assembly to form a furnace floor or side wall in which the aperture in the blocks form ducts for flue gas and flue ports connecting the ducts to the interior of the furnace chamber. The invention further includes a furnace which has one or more side walls and/or a floor so constructed.

I claim:

1. A direct fired tunnel furnace having a furnace chamber bounded by a bottom wall and a pair of opposed side walls; a

plurality of main duct systems each comprising a two ended underfloor duct in said bottom wall, a main rising duct in one of said side walls disposed at an angle to said floor duct, connected directly to, and communicating directly with, one end of said underfloor duct, a plurality of flue ports in said underfloor and main rising ducts connecting said ducts to said furnace chamber, a plurality of burners each associated with a respective one of said duct systems and arranged to discharge hot flue gases into said underfloor duct at one end thereof opposite the end connected to, and communicating directly with, said main rising duct.

2. The tunnel furnace of claim 1 wherein said side walls are each composed of a plurality of blocks loosely assembled one on another and each having main apertures therethrough, main apertures of adjacent blocks being in register with each other to form said main rising ducts, said blocks further having side apertures therethrough intersecting said main apertures to form said flue ports.

3. The tunnel furnace of claim 1 wherein said furnace chamber is of U configuration in plan having a common partition wall in which said rising ducts are formed adjacent rising ducts being connected to respective underfloor ducts on opposite sides of said partition wall.

4. The tunnel furnace of claim 1 wherein said furnace is of the straight through type, and successive burners along said tunnel are arranged on alternate sides of said tunnel.

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