Dec. 1, 1936. W. A. DARRAH 2,062,642

FURNACE FOR ENAMELING, HEAT TREATING, ETC.,
AND PROCESS OF APPLYING HEAT THEREFOR

Filed May 12, 1933 2 Sheets-Sheet 1

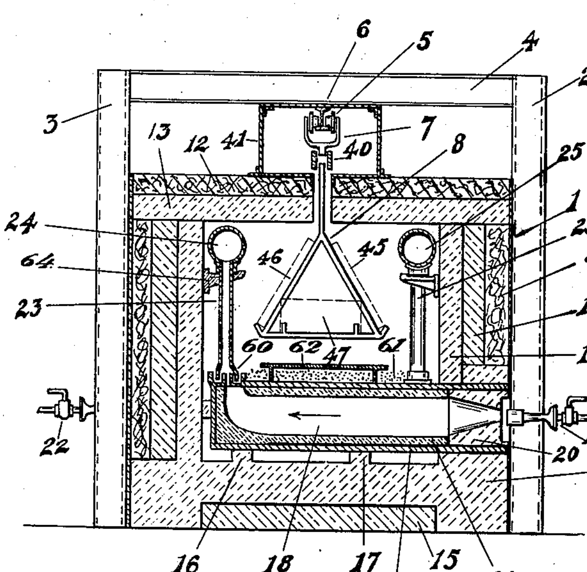

Figure 1.

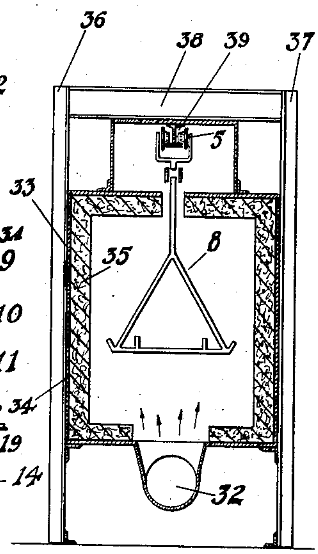

Figure 2.

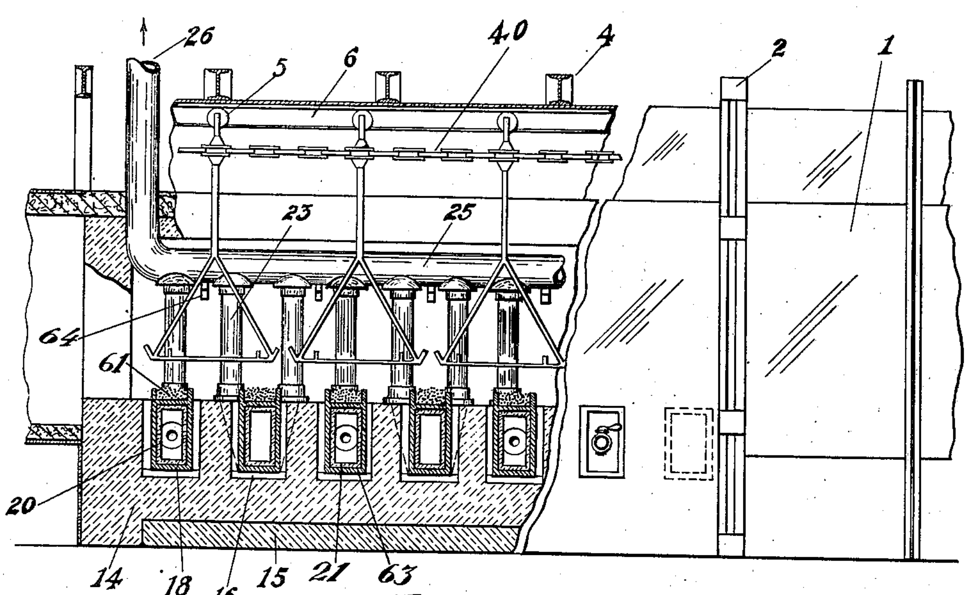

Figure 3.

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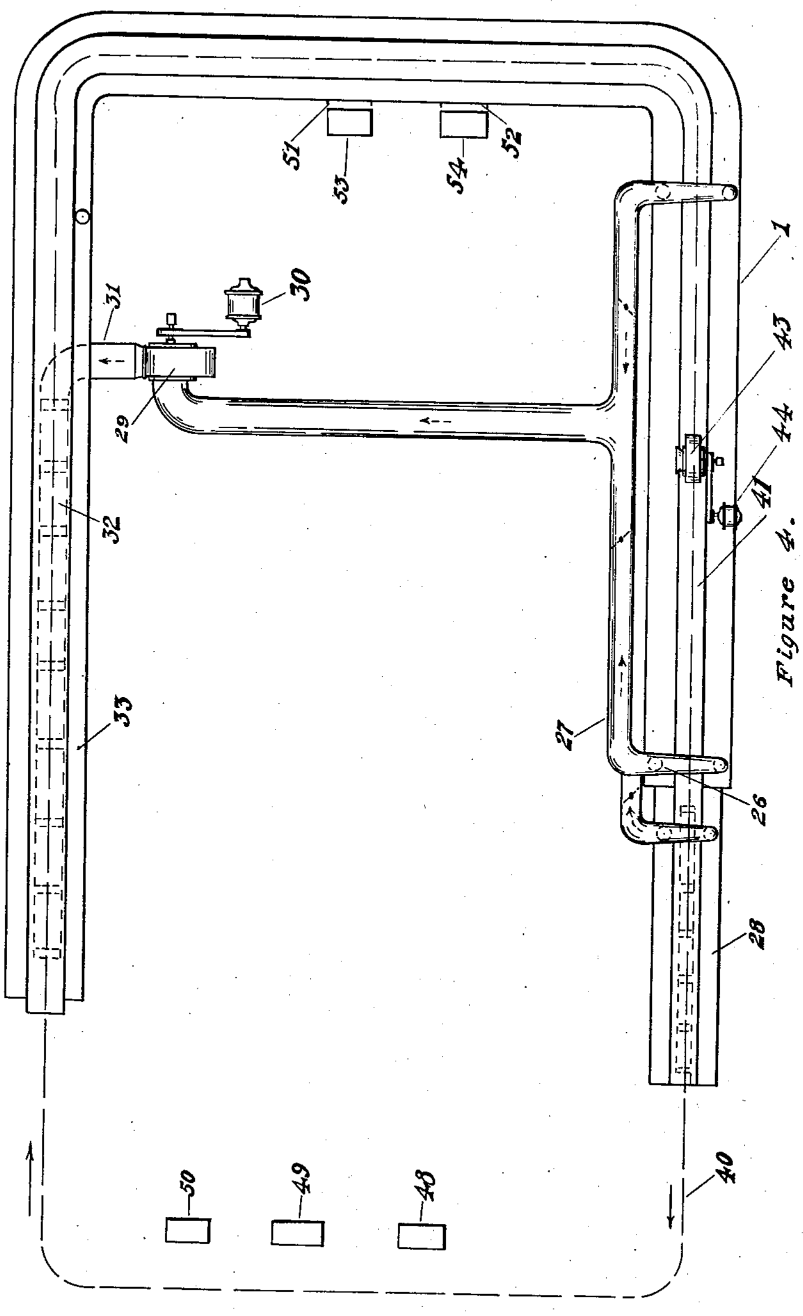

Figure 4.

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FURNACE FOR ENAMELING, HEAT TREATING, ETC., AND PROCESS OF APPLYING HEAT THEREFOR

William A. Darrah, Chicago, Ill.

Application May 12, 1933, Serial No. 670,701

13 Claims. (Cl. 263—8)

This invention relates to methods, apparatus and processes for applying heat in such operations as heat treating, enameling, brazing and similar operations.

Some of the objects of this invention are to provide economical, durable, efficient equipment for transmitting heat at medium or high temperatures in the general class of operations as outlined above.

Other objects of this invention are to obtain uniform heat distribution with a minimum temperature difference throughout the equipment. Another object of this invention is to provide equipment which will permit the maintaining of any desired heat cycle within the equipment. Another object of this invention is to provide a device many portions of which may be readily renewed from the outside of the furnace without closing down the entire equipment.

Other objects of this invention will be apparent from the specifications, claims and drawings attached hereto.

Referring to the drawings:

Figure 1 shows a vertical cross sectional elevation through one of the combustion chambers of my equipment.

Figure 2 shows a vertical cross sectional elevation through the dryer portion of my equipment.

Figure 3 shows a vertical longitudinal elevation partly in section, while

Figure 4 shows a general arrangement in plan indicating the method of assembling the component units in my device.

In the drawings 1 indicates a shell or housing supported by buck stays 2 and 3 which are connected together in their upper portion by I-beam 4. A series of trolleys 5, roll on I-beam track 6 and carry by means of yoke 7 supporting members 8 which may preferably be formed from heat resisting alloy or similar material. Within housing 1 is placed an insulating layer 9 followed by heat resisting insulating layer 10 next to which is placed a layer of refractory 11. In the case of the roof or top of the furnace, 12 indicates an insulating layer and 13 a layer of refractory, while the hearth or floor of the furnace is formed from refractory 14 with an insulating layer 15 beneath the hot zone. Refractory hearth 14 carries a series of piers or supports 16 and 17 upon which is placed a series of combustion chambers 18 which should preferably be formed from materials possessing qualities of high heat conductivity and at the same time being able to resist the destructive action of high temperatures. Such heat resisting alloys as combinations of iron and chromium, nickel and chromium and equivalent materials as well as silicon carbide or aluminum oxide refractories are suitable for this work, preference being given for permanence at high temperatures and good heat conductivity.

A burner 19 is provided with each combustion chamber and delivers products of combustion through combustion block 20 into the interior of combustion chamber 18. In order to further protect the material from which combustion chamber 18 is constructed, I may place a further lining 21 of refractory material which is designed to partially relieve the material of the combustion chamber 18 from the excessive heat which is occasionally produced closely adjacent to the combustion block.

It will be understood that one of the important features of my invention is a multiple of combustion chambers similar to 18 which are shown in a typical figure in Figure 3. For purposes of convenience and to aid in obtaining a uniform heat distribution, I may arrange the series of combustion chambers so that the burners are on alternate sides of the furnace in which case burner 22 of Figure 1 represents the burner supplying the combustion chamber adjacent to 18 with fuel mixture. It is preferable for the burner to be arranged to supply the entire amount of air and combustible such as gas or oil these being supplied under a slight positive pressure and in the correct ratio for complete combustion.

The combustion gases liberated within chamber 18 travel toward the rear end of the combustion chamber and then upward through a series of radiators 23 which may well be formed of heat resisting alloys, although in this case also various commercial refractories having a high heat conductivity may be employed if desired.

For purposes of convenience in obtaining a relatively large radiating surface, I prefer to employ a number of radiating tubes 23 each combustion chamber supplying a group of several radiating tubes.

The radiating tubes 23 are preferably constructed as a unit which may be placed in a socket or receptacle within combustion chamber 18. This arrangement permits ready removal of radiating members 23 or the independent removal of combustion chamber 18.

Radiators 23 preferably connect into header conductor 24 while a similar conductor 25 is placed on the opposite side of the furnace. Conductor pipes 24 and 25 carry the products of combustion from each of the combustion chambers along the furnace to the discharge point 26 where they connect to air duct 27 and are mixed with air from the cooler 28. This mixture of products of combustion and air is then taken into the intake of fan 29 which is driven by motor 30. The mixture is delivered by means of discharge duct 31 to the longitudinal bottom duct 32 which is placed beneath dryer 33.

Dryer 33 consists of a shell or housing 34 insulated by a layer of material 35 and supported by a series of buck stays of which 36 and 37 are typical examples. Buck stays 36 and 37 are tied together at their upper portion by I-beam 38 which carries track I-beam 39 and trolleys 5 and work support 8 as in the case of the furnace.

The cross sectional appearance of cooler 28 may well be substantially identical with the construction of dryer 33 and Figure 2, therefore, may represent equally well a vertical elevation in cross section of either the cooler or the dryer.

In the case of the furnace, the cooler and the dryer, the trolleys 5, the connecting chain 40 and the upper portion of work support member 8 are all enclosed in a metal housing or duct 41 which is preferably closed on all sides except for the narrow slot in the bottom through which the work may pass and the ends which of course are provided with an opening sufficiently large to just permit the travel of the moving member. This arrangement serves to reduce the interchange of air or circulating gases between the furnace chamber and the room and if desired I may supply a fan or blower 43 operated by motor 44 to maintain a slight pressure within housing 41 and, at the same time, to deliver a stream of air to the duct 32 beyond the cooler 28.

It will be obvious that many variations may be made in the arrangement of parts as shown on the drawings without departing from the spirit of my invention, thus for example conductor pipes 24 and 25 may if desired be placed within the walls of the furnace or above the top of the furnace, although I prefer in many cases to locate it as shown in the drawings in order to take advantage of the radiating surface which it offers.

In operating equipment which I have invented for carrying out my process, the material to be heated is located upon carrier or conveyor 8 and for purposes of illustration the material being heated is indicated by the dotted areas 45, 46 and 47 of Figure 1.

It should be clearly understood that many forms of carriers may be employed and the work may be arranged in many different manners the illustration here being purely diagrammatic.

I will describe the operation of my equipment in the specific cases in which it is applied to the baking or burning of enamel work as for example sheet metal parts for stoves, kitchen ware and related uses. It should be understood that I am not restricting my equipment or process to this application, but am merely suggesting a specific process for purposes of clearness and simplicity.

Referring to the general arrangement of equipment shown diagrammatically in Figure 4, it will be assumed that the steel sheets which are to be enameled are delivered to the operators whose position is indicated by the rectangles 48, 49 and 50 respectively. At this point the sheet metal may be dipped in a water suspension of enamel and then placed upon one of the work supporting members 8 which of course travel by the operators continuously being suspended from chain 40. The work support 8 with the material being treated then passes into dryer 33 the general travel being in the direction shown by the arrows adjacent to chain 40. Within the dryer the wet sheets are subjected to the action of a rapid stream of air moving upward from duct 32 over both sides of the work. As previously explained the stream of heated air is derived from the waste products of combustion from furnace 1 and the heated air from cooler 28.

The speed of chain 40 is controlled so that the time that the work remains in dryer 33 is sufficient to properly dry and to some extent preheat the work supports and the work. The material then passes directly into oven 1 unless it is desired to inspect the work or remove a portion of the enamel in which case doors or openings 51 and 52 are provided adjacent the operator's positions 53 and 54 respectively.

Within the furnace the work travels over a series of combustion chambers 18 and between the two rows of vertical heating members 23, 23—A and the conduits 24 and 25. The temperature of the work is thus raised quite rapidly, the heat being transferred partly by radiation and partly by convection as will be described later. The work having received the proper heat treatment for the proper time as the chain carrying the work travels continuously through furnace 1, the work eventually leaves the furnace and enters cooler 28 where it is subjected to the action of a stream of cool air which removes heat from the work and the work carrier delivering this heat to the dryer. After leaving the cooler 28 the work is unloaded and the cycle may be repeated.

In applying my invention I may of course utilize any desired temperature and time. I have found, however, that for drying, temperatures ranging from 300 to 600° F. give satisfactory results providing the time ranges from three minutes to fifteen minutes depending upon the nature of the material being dried. In the enameling operation it is customary to utilize temperatures ranging from 1500 to 1700 most operations being carried on, however, in the neighborhood of 1600° F. The time for burning the enamel coat will vary with the work, ranging from two minutes in the case of light sheets to four or five minutes in the case of more difficult work. The time element is, of course, varied by altering the speed of the chain 40 in the usual commercial manner through any standard variable speed device.

Referring again to the details of the operation of the furnace, it will be noted that by varying the amount of fuel burned in each of the individual combustion chambers any desired cycle of heat application on the incoming work may be obtained. Thus in present commercial furnaces of other types serious difficuties are encountered due to the fact that the ends of the furnace incline to be colder than the central portion and the heating is not on the desired cycle. To overcome this condition I merely open wider the burners supplying heat to the combustion chambers adjacent the ends of the furnace or reduce the amount of heat by reducing the amount of fuel burned in the combustion chambers adjacent to the central portion of the furnace.

In some furnaces it is desired to have a gradual increase in temperature and then hold the temperature constant for the balance of the cycle. Obviously this condition or any other may be readily obtained by graduating the amount of fuel burned in each combustion chamber.

I obtain results in this manner which cannot be secured by any commercial furnaces now available in which the fuel is normally consumed in longitudinal ducts extending substantially the entire length of the furnace as distinguished from transverse combustion chambers in the case of my invention.

Another difficulty to which the long longitudinal ducts are inherently susceptible is the cumulative effect of expansion which may be due either to thermal gases or to a growth or expansion of the material itself. It will be apparent that in the case of a furnace 40 or 50 feet long a single long duct is subject to a cumulative expansion which becomes so serious that great difficulty is encountered in maintaining the structure of the combustion chamber tight or free from leaks or cracks. On the other hand in the case of my invention the combustion chambers are inherently short being ordinarily only three or four feet in length and thus expansion is a negligible factor. In connection with enameling and certain heat treating, baking and brazing operations, it is highly desirable to maintain an atmosphere within the furnace which is free from even small traces of products of combustion. This condition is obtained in my device by eliminating, as far as possible joints particularly in long or extensive surfaces. For example combustion chamber **18** may well be formed substantially as an integral unit, the only joint being at the point at which connection is made to the radiating members **13** and even this joint may be welded or otherwise closed if desired. Such a construction is not possible in the case of long combustion chambers which are ordinarily employed in furnaces now in commercial use.

By extending the combustion chambers substantially through the outer wall of the furnace it is also possible to entirely remove a combustion chamber from the outside of the furnace in case the combustion chamber fails for any one of a number of reasons. This construction, therefore, makes it possible to repair or replace a combustion chamber entirely from the outside of the furnace. Another advantage of my device arises from the fact that if a combustion chamber should fail due to the cumulative effects of heat and time, it can be cut out by merely closing the valve on the gas burner and the equipment can operate with merely a slightly reduced capacity or by increasing the amount of fuel burned in the other combustion chambers, the equipment may operate without any appreciable change in thermal capacity.

This condition is entirely impossible in present day furnaces where the combustion chambers extend over substantially the entire length of the hearth.

It will be noted that the combustion chambers are supported at a minimum of points and are arranged in such a manner as to be free from contact with all parts of the furnace as far as possible. In other words, a space is provided between each combustion chamber and the furnace wall on all sides and at the end. This construction permits free expansion of the combustion chamber independent of the furnace structure and further provides for a ready transfer of heat from the combustion chamber. The transfer of heat may take place as radiation from the combustion chamber to the brick work of the furnace including the refractory piers between the combustion chambers. By secondary radiation from the walls, refractory piers, etc., the interior of the furnace and the work being heated receives a large amount of heat, as well as of course, by direct radiation from the walls of the combustion chamber. Another factor resulting from this arrangement is the rapid movement of air or gases within the furnace housing as a result of convection currents caused by the hot combustion chamber located near the lower portion of the furnace. The atmosphere within the furnace becomes heated particularly in the space between the combustion chambers and the walls and the piers as well as beneath the combustion chamber. The air heated at this point rises rapidly and is replaced by cooler air. This circulation not only serves to maintain the temperature within the furnace quite uniform but also assists materially in transferring the heat from the furnace interior to the materials being heated. The circulation also insures that a uniform atmospheric condition will be maintained within the furnace at all times. In the case of an enameling operation it is highly desirable to maintain an oxidizing atmosphere in contact with the work and in a furnace in which the interior atmosphere is relatively stagnant, the proper oxidizing conditions are not always obtained. The device which I have invented, however, overcomes this difficulty and insures a complete distribution of oxygen at all times.

In carrying out my invention I do not wish to be restricted to the specific details here disclosed as many modifications are obviously possible without departing from the spirit of my invention. Various types of conveyors or conveyor equipment may be employed or the material may be moved through the furnace by hand. Many materials may be used for various parts and the relative arrangements may be modified. A wide range of fuels mays be employed by making the obvious modifications required for each of the fuels.

One of the desirable features of my invention arises from the fact that the combustion system and particularly the ducts, radiating members, etc., may be maintained under a slight negative pressure owing to the action of the circulating system in drawing products of combustion from the combustion chamber and delivering them to the dryer. One of the advantages of this arrangement arises from the fact that in case of leakage in the walls or joints of the combustion system and the related ducts, there will be no leakage of products of combustion outward into the furnace, but on the contrary a slight leakage from the interior of the furnace into the combustion system and ducts. This insures that undesirable materials from the combustion system will not enter the furnace. On the other hand, the slight internal leakage provides a gradual change of the furnace atmosphere which is desirable rather than otherwise.

One feature of my invention involves the means of supporting the muffle and connecting it to the exhaust stack. Muffle **21** terminates at the end opposite the burner in a sand seal which makes connection with the vertical radiating members **23**, **23A**, etc. Members **23** and other type are suspended from transverse flues **24** and **25**. These radiating members preferably hang freely so that as they change in length with temperature variations they merely project a greater or lesser distance into the sand seal indicated by 60. It will be apparent that the temperature range from a cold furnace to a furnace at operating temperature will be very great and it would be quite hopeless with present facilities to expect all parts of the hot metal system to expand at the same rate.

If expansion did not take place at the same rate the equipment would be seriously warped or tear itself apart. The device of the sand seal as shown overcomes this difficulty. Vertical radiating members 23, 23A, etc., also serve to deliver a portion of heat to the chamber in which the work is placed. The bulk of the heat, however, is supplied by the horizontally extending combustion chamber members which are located beneath the work. With this arrangement the material being enameled is heated promptly from its underside owing to the fact that a much greater portion of the heat is liberated beneath the articles being enameled. Under these conditions, I have found that it is feasible to maintain the temperature of the metal upon which the enamel is being placed, as for example a steel sheet, at a higher temperature than the enamel itself. This condition makes for rapid enameling and permits a much more satisfactory bond between the enamel and the steel. This arrangement also gives a better enameled surface since the enamel itself is not raised to sufficiently high temperatures to cause change in its physical or chemical structure.

I have found that when enamel is heated either for too long a time or to an excessive temperature, marked and undesirable changes take place in both the physical and chemical nature of the enamel. These changes may show themselves by a reduction in the opaqueness, a loss of brilliancy in the colors, the formation of bubbles or a change in the appearance of the colors.

A sufficiently prolonged heating at too high a temperature tends to reduce the opaqueness of the enamels in many cases apparently by dissolving the small articles which case this property.

The arrangement shown also causes a rapid and rather positive circulation of the atmosphere within the furnace chamber but outside of the muffle. This circulation of the atmosphere is helpful in enameling, as I have found a quiet atmosphere or one relatively free from agitation, gives the poorest results and the least satisfactory surface to the enamel. The rapid circulation of the atmosphere within the furnace also serves to create a more uniform heat distribution within the furnace.

In the case of equipment of this nature, it is inevitable that pieces of enamel, metal or other materials will fall from the work being treated and in some cases come to rest on the horizontal surfaces of the heating system. In some cases this material causes undesirable deterioration of the alloy which forms the outer covering of the heat radiating muffles. In order to avoid this I have found it expedient in many cases to place a removable protecting layer above the top horizontal surfaces of the heat radiating muffles. A wide range of materials may be used for this purpose, but it is desirable to use something which will not retard the liberation of heat as otherwise these surfaces would reach excessive temperatures. One method which I have defined for this purpose, is to cover the upper horizontal surface with a heat conducting granular material such as grains of silicon carbide or related product. This is indicated by 61 in the drawings. I may also utilize a baffle shown as 62. This may be preferably of a low grade heat resisting alloy which may be removed or replaced as desired. In the case of the baffle it should be well separated from the surface of the muffle in order to permit free circulation of air or gases between the baffle and the surface of the muffle in order to avoid restricting the heat flow.

It should be understood that I may use either or both of the means described.

I have found that the most satisfactory conditions are obtained when the refractory lining 21 is surrounded by a tight metal shell formed from some heat resisting alloy, as for example, an alloy of iron, chromium and nickel. Alloys of this nature are less subject to cracking than the refractory materials which are placed inside and it is of course desirable to insure that there is no leakage whatever from within the combustion chamber to the space outside the combustion chamber, as any unburned fuel, traces of sulphur, carbon monoxide, etc. will adversely affect the nature of the enamel. I, therefore, provide an outer shell 63, surrounding refractory container 21 and preventing any possibility of leakage therefrom. Refractory lining 21 may preferably be free to move or expand independently of the alloy shell 63.

It will be understood that many changes may be made in the specific embodiment of my invention as set forth in the drawings. Also many materials may be substituted for those which are described for purpose of illustration.

While the drawings show a means for supporting the work being enameled in the form of a conveyor or moving support it should be understood that many features of this invention are not specifically restricted to the moving conveyor and I may as desired, use either a stationary work support or a movable work support. It will also be obvious that I may use a support which moves intermittently thus combining the features of both types.

Having now fully described my invention what I claim as new and wish to secure by Letters Patent in the United States, is as follows:

1. A heating device consisting of a heating chamber, a movable support for work in said heating chamber, an insulated housing, a horizontally extending combustion chamber located in the lower portion of said housing, a rigid heat resisting shell surrounding said combustion chamber, a refractory lining within said shell, a discharge duct leading products of combustion from said combustion chamber and a yieldable removable sealed joint between said shell and said duct for removing products of combustion from said combustion chamber without leakage into said housing, said joint being arranged to yield in both a horizontal and vertical plane to compensate for movements of either said shell or said duct while maintaining said joint tight.

2. An enameling furnace consisting of an insulated housing, a preheating chamber, a heating chamber, a heat radiating combustion chamber located in the lower portion thereof, but spaced away from the bottom of said housing and free to expand independently thereof, a movable work support designed to hold material being enameled at a level above said radiating combustion chamber and ducts for carrying out of said furnace the products of combustion from said combustion chamber, said ducts being connected to said preheating chamber and so arranged as to deliver said products of combustion

directly into contact with the material therein.

3. An enameling furnace consisting of an insulated housing, a heat radiating combustion chamber located in the lower portion thereof, but spaced away from the bottom of said housing and free to expand independently thereof, a movable work support designed to hold material being enameled at a level above said radiating combustion chamber, flue means for carrying out of said furnace the products of combustion from said combustion chamber, a preheating chamber adjacent said insulated housing, a duct in the lower portion of said preheating chamber, openings in the upper portion of said duct, and means for delivering the products of combustion from said combustion chamber to said duct in said preheating chamber.

4. In a heating furnace, a housing, a slot in said housing, a conveyor extending through said slot, a radiating combustion chamber consisting of a metallic housing enclosing a refractory lining, supports for holding said radiating combustion chamber away from contact with the bottom and sides of said heating device and a duct for removing products of combustion from said radiating combustion chamber, and a flexible joint between said duct and said combustion chamber, said joint consisting of adjacent rigid surfaces with the space therebetween filled with comminuted material.

5. In a furnace a preheating chamber, a heating chamber, a combustion chamber within said heating chamber, a heat conducting durable lining within said combustion chamber, means for supplying fuel to the interior of said combustion chamber, an exhaust duct from said combustion chamber to said preheat chamber, a yieldable joint connecting said combustion chamber and said exhaust duct, and gas moving means for delivering the products of combustion from said combustion chamber to said preheat chamber through said duct.

6. A combustion chamber for heating a furnace by radiation consisting of a metallic outer shell of heat resisting material, an inner lining of refractory heat conducting material and a yieldable joint to an exhaust duct from said combustion chamber, said joint being formed of vertical spaced-apart surfaces, with a space between said surfaces filled with comminuted material.

7. A heating device consisting of a housing, a unitary horizontally extending combustion chamber within said housing, fuel supply means for delivering combustible material to the interior of said combustion chamber, means for supporting said combustion chamber out of contact with the walls and bottom of said housing, and a vertically extending radiating member connected to said combustion chamber by means of a yieldable joint so as to conduct products of combustion from the interior of said combustion chamber and radiate heat therefrom to the interior of said housing, while excluding said products of combustion from entrance to said housing, said joint being formed by two interlocking spaced-apart surfaces with the space between filled with comminuted material.

8. A heating device consisting of a housing, a conveying means outside said housing and extending into the interior thereof, a preheating chamber adjacent said housing, a unitary horizontally extending combustion chamber within said housing, fuel supply means for delivering combustible material to the interior of said combustion chamber, means for supporting said combustion chamber out of contact with the walls and bottom of said housing, and a vertically extending radiating member connected to said combustion chamber by means of a yieldable sand sealed joint so as to conduct products of combustion from the interior of said combustion chamber and radiate heat therefrom to the interior of said housing, while excluding said products of combustion from entrance to said housing, and a gas moving device and a duct system to deliver said products of combustion into the interior of said preheating chamber.

9. A conveyor type furnace including a housing, a conveyor operating within said housing, a muffled combustion chamber within said housing, a preheating chamber adjacent said housing and served by said conveyor, a cooling chamber adjacent said housing and served by said conveyor and duct means for drawing hot gases from said cooling chamber and said combustion chamber and delivering them into said preheating chamber, to preheat material entering said furnace.

10. A heating furnace consisting of a housing with a conveyor passing therethrough, a muffled combustion chamber beneath said conveyor and within said housing, a preheating chamber adjacent said housing, a duct in the lower portion of said preheating chamber and means for delivering the products of combustion from said combustion chamber into said duct beneath said preheating chamber, said hot products of combustion being then distributed by said duct throughout the length of said preheating chamber and into direct contact with material being heated in said preheating chamber.

11. In a heating furnace, a housing, a combustion chamber within said housing, a work-supporting means above said housing, a burner device for supplying products of combustion into said combustion chamber and a protecting medium formed of comminuted material above said combustion chamber to protect the same from material falling from the work on said work-supporting device.

12. A conveyor furnace unit consisting of a heating chamber, a preheating chamber, and a cooling chamber, a conveyor mechanism arranged to transport material through the entire unit, a series of independently expansible muffled combustion chambers arranged to supply heat to said heating chamber by radiation while excluding products of combustion, a duct in said preheating chamber connected by gas tight yieldable joints to said muffled combustion chambers arranged to receive products of combustion from said combustion chambers, said cooling chamber, heating chamber and preheating chamber being sealed together to prevent entrance of outside air.

13. A conveyor furnace unit comprising a preheating chamber, a heating chamber and a cooling chamber constructed as an integral unit to prevent leakage, a conveyor mechanism for moving material through said chambers, an individually expansible muffled combustion chamber within said heating chamber arranged to supply heat by radiation and exclude products of combustion, a duct in said preheating chamber connecting to the exhaust from said products of combustion and arranged to preheat incoming work, and a gas tight yieldable joint connecting said duct and said combustion chamber.

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