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2,386,429

PRODUCTION OF METALS IN MULTIPLE RETORT DISTILLING FURNACE

Filed Aug. 7, 1943

2 Sheets-Sheet 1

Fig. 1.

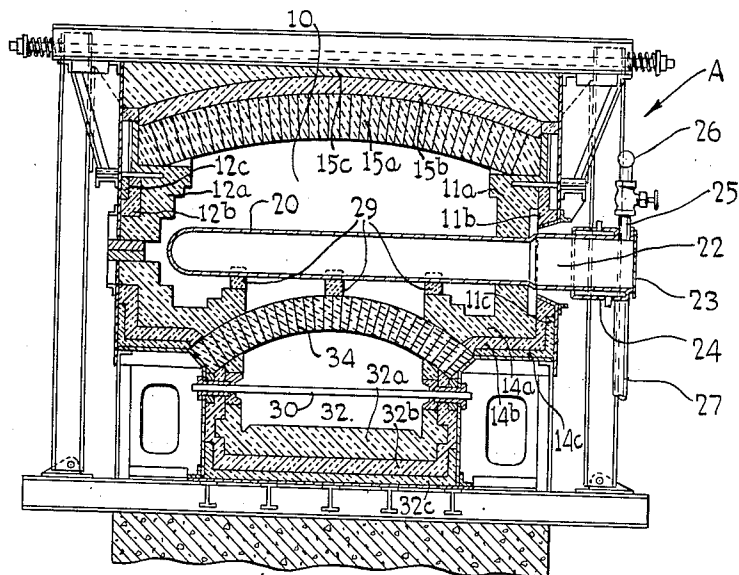
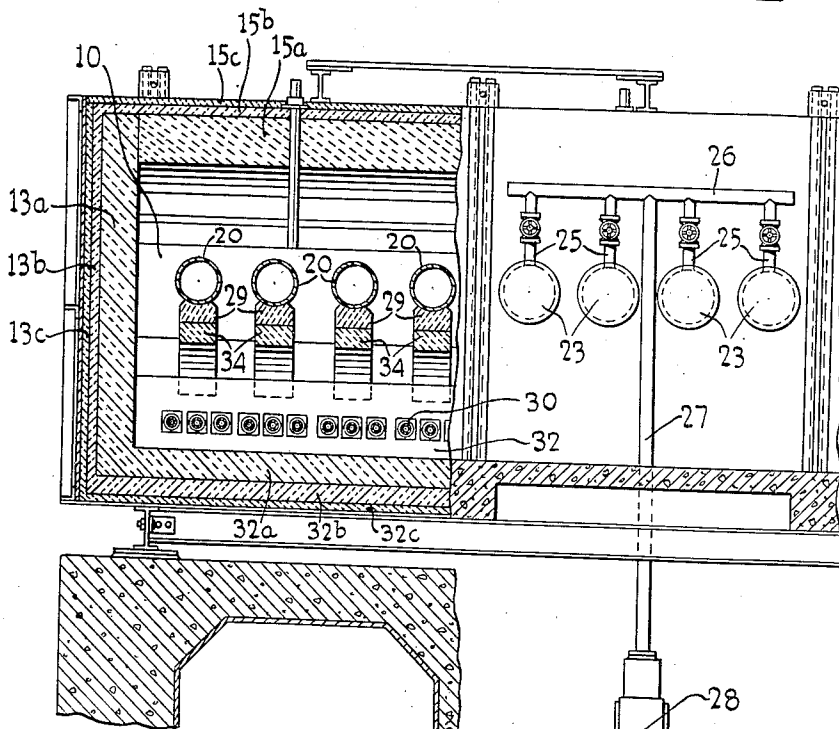
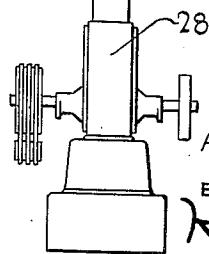


Fig. 2.



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2 Sheets-Sheet 2

Fig. 3.

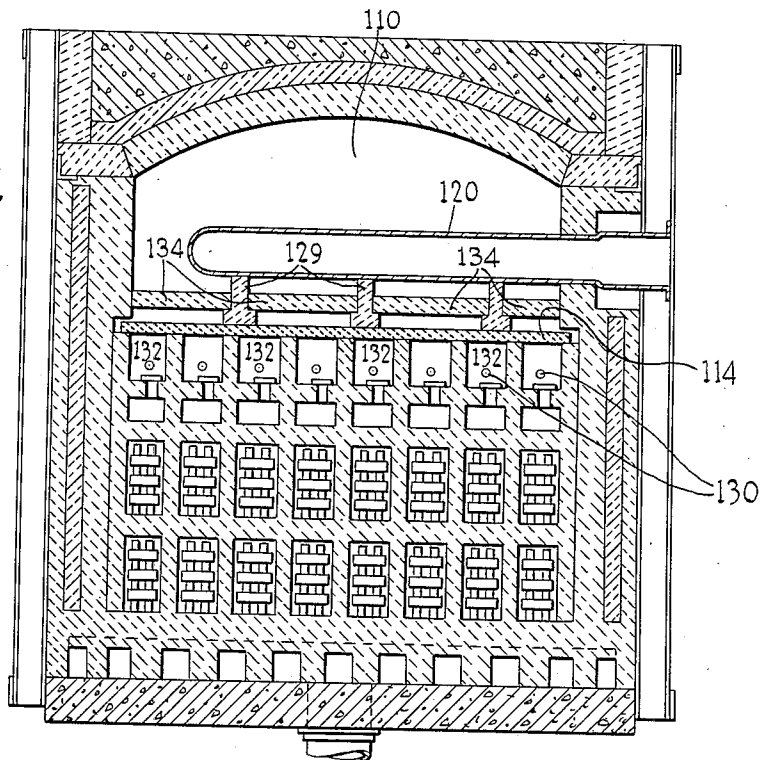
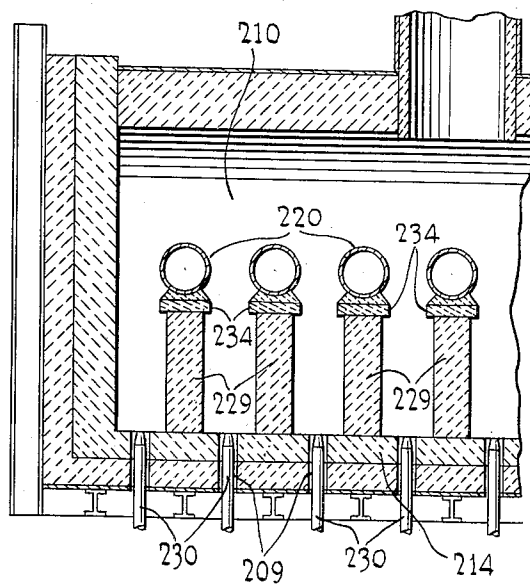


Fig. 4.



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PRODUCTION OF METALS IN MULTIPLE
RETORT DISTILLING FURNACES

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10 Claims. (Cl. 13—20)

This invention relates to the distillation of metals in multiple retorts and to multiple retort metallurgical furnaces. The invention is particularly useful for the production of magnesium according to the so-called "ferro-silicon" process.

In that process magnesium-bearing material, such as calcined dolomite, is reacted with ferro-silicon by heating charges of the reactants to high temperatures in multiple metal retorts located within a common furnace. The retorts must be kept closed to the atmosphere and under nearly absolute vacuum during the reaction period, during which gaseous reaction products including magnesium vapor pass from each retort into a connected condenser where magnesium is condensed in metallic form. After complete reaction each retort-condenser assembly is opened to recover magnesium and discharge the reacted materials, whereupon another charge is inserted, the retort is reclosed and another reaction period ensues.

During each reaction period the retorts must be subjected to such high temperatures and such great pressure differences between their inside and their ambient atmospheres that retorts made of ordinary metals or refractories would immediately collapse under the stresses involved. To avoid this and yet secure good heat conductance to the charges therein the retorts are made of special heat-resistant alloys, such as iron-nickel alloys, but even so there remains a grave problem to overcome, of keeping the retorts from warping, bending and cracking so rapidly as to prohibit satisfactory or economical operations. Whenever a crack or fissure develops in a retort it leaks pressure and must be replaced. This would occur so frequently in the use of known multiple retort metallurgical furnaces that the process could not be practiced, if at all, without periodically discontinuing the retorts from service and turning and resetting them on their mountings so as to distribute bending, warping, and cracking effects as uniformly as possible around each retort wall.

The main object of this invention is to provide new methods for use in the production of metals in multiple retort distilling furnaces, and new furnaces to carry out these methods, which prolong the life of retorts and constitute the means of avoiding prohibitive costs, wastes and interruptions to operation, otherwise caused by the rapid bending, warping and cracking of retorts, in processes carried out at high temperatures under strong vacuum conditions. Another object is to render unnecessary the periodic releasing

and resetting of retorts on their mountings in multiple retort furnaces. Another object of this invention is to secure efficient and substantially uniform heating and reaction conditions in the operation of multiple retort metal distilling furnaces. A specific object of the invention is to provide multiple retort distilling furnaces suitable for the efficient production of magnesium according to the ferro-silicon process. Other objects and advantages of my invention will appear from the following description.

I have observed that the factors tending to cause rapid retort failure in operations of the type above described are not only the high temperatures and vacuums established during each reaction period but also the periodic changes in heat dissipation rates and pressure conditions which occur in the course of production operations. When the retorts are opened to discharge their contents and insert new charges heat is dissipated from the retort walls at a rate much faster than the rate prevailing during the reaction period, and the retorts consequently tend to be cooled abruptly and to contract in dimensions. On the other hand, during the ensuing reaction period the rate of heat dissipation drops, which tends to increase the retort temperature correspondingly, and at the same time a strong vacuum is maintained which causes the ambient furnace atmosphere to exert a great pressure on the expanding retort walls. In the use of known multiple retort metallurgical furnaces these factors would subject the retorts repeatedly to intense heat strains and dimensional changes, producing destructive bending, warping and cracking effects. Further factors to be contended with are that the retorts in such furnaces generally are heated by direct heat exchange with the flame or the primary heat radiation of the furnace heat supply and in the presence of strong drafts of furnace gases, and these entail objectionable temperature differences along the length and elsewhere over the heat-absorbing surfaces of the retorts.

According to my invention a very great store or reservoir of heat is provided for the furnace chamber in which the retorts are located, the retorts are heated predominantly by radiation from this heat reservoir, and heat is supplied into the chamber during the course of operations at an average rate sufficient to offset average heat losses and thus to maintain the store of heat nearly constant and at the desired reaction temperatures at all times. The amount of heat stored and kept available to the retort walls is so great that normal wide fluctuations in the rate of heat

dissipation through the retort walls, or in the rate of heat flow into the furnace, are able to cause only relatively minute changes in the retort temperature, and in this way the retorts are relieved of drastic heat strains and dimensional changes such as otherwise would produce destructive bending, warping and cracking effects. The action of the heat reservoir, to eliminate wide temperature changes otherwise caused by varying rates of heat dissipation or heat supply, is analogous to the governing action of a flywheel upon the speed of a rotating machine where the load on the machine or its driving power fluctuates over a wide range.

To this end, the furnaces herein disclosed are made with a large chamber, into which the retorts extend in parallel spaced relation to each other, and the chamber is defined predominantly by thick heat-absorbing, heat-radiant refractory structures having a heat capacity which exceeds by many times the average hourly heat-absorbing capacity of the retorts. In quantitative terms, the total heat-radiant surface area provided by these structures generally is at least twice the total area of heat-absorbing surface provided by all of the retorts within the furnace chamber, and this ratio preferably is at least three to one in furnaces adapted for the ferro-silicon process. The refractory walls of such furnaces preferably are made at least 9 inches thick, and the furnace is made to hold a volume of heat equivalent to at least 45 B. t. u. for each B. t. u. of heat absorbed through the retort walls in an hour of operation for magnesium production.

While the heat supply for the furnace may be furnished in various ways, within the foregoing aspects of my invention, a further feature of my preferred embodiments resides in furnishing the heat which maintains the desired reaction conditions to the furnace itself, rather than directly to the retorts, and in heating the retorts predominantly by secondary radiation from the furnace structures, rather than by direct exchange with the primary radiation from the heat source. The retorts preferably are shielded from this primary radiation, such as by means of heat-radiant refractory structures located between each retort and the source of the heat supply. Furthermore, the furnace chamber preferably is kept closed against the inflow or egress of gases so that the atmosphere therein normally is quiescent and undergoes circulation only as the result of convection currents. In these ways, it is possible to keep each retort at sufficiently uniform temperatures over its entire surface area under all conditions of operation, obviating irregular temperatures and heat strains caused by localized impingement of primary heat radiation or furnace flames upon retort walls, and the preferred embodiments also obviate the variations of retort temperature otherwise induced by sweeping gases within the furnace chamber. A further result achieved by maintaining a dead or quiescent atmosphere in the furnace is that the composition of the gases contacting the retort walls is subject to ready control, so that it is possible to exclude substances, such as sulphur compounds, which at high temperatures are particularly damaging to the welds and to the special alloys, such as iron-nickel alloys, used in making the retorts of furnaces for magnesium production.

The accompanying drawings, forming a part hereof, illustrate several forms of multiple metal

retort distilling furnaces embodying the features of the present invention.

In the drawings,

Figure 1 is a vertical cross-section through a furnace which constitutes a preferred embodiment of the invention;

Figure 2 is a front elevation, partly in longitudinal cross-section, of the furnace shown in Figure 1;

Figure 3 is a vertical cross-section through another preferred embodiment, designed for the use of a gaseous fuel; and

Figure 4 is a vertical longitudinal section through a portion of a third form of construction, which embodies some but not all of the features of the invention.

The embodiment illustrated in Figures 1 and 2 is an electrically-heated multiple retort furnace adapted for the production of magnesium according to the ferro-silicon process. The furnace has a horizontally elongated chamber 10, which constitutes a heat reservoir; a plurality of metal retorts 20 extending transversely into the space within the chamber, in parallel and spaced relation to each other; and a plurality of electrical heating elements 30, such as those known in the art as "globars," disposed in a well 32 at the base of the chamber and distributed lengthwise thereof in symmetrical relationship to the several retorts.

Each retort 20 leads through the front wall of the furnace structure into an integral condenser section 22 outside the furnace chamber. The condenser has a removable front cover 23, a cooling jacket 24, and a vent pipe 25 that is connected through manifold 26 and exhaust line 27 with a vacuum pump 28. When the covers 23 of the several retorts connected with a certain pump 28 are closed, and the pump is operated, a vacuum condition suitable for magnesium distillation is established in each of the several retort-condenser units.

The furnace chamber 10 is defined by heat-radiant refractory walls of great heat-absorbing capacity. Each wall preferably is made with a plurality of courses of refractory brickwork, totaling at least 9 inches thick. As shown, the front, back, end and bottom walls have inner courses 11a, 12a, 13a and 14a, respectively, made of heat-absorbing refractory such as firebrick; the roof or top wall and the wall of well 32 have inner courses 15a and 32a, respectively, made of similar material; and beyond its inner course each wall has at least one course or layer of heat-insulating refractory material, such as indicated at 11b, 12b, 13b, 14b, 15b and 32b, respectively. The roof is made with a third or outer layer 15c of heat-insulating material, while the other walls as shown have outer layers 11c, 12c, 13c, 14c and 32c of refractory material such as firebrick.

The volume and heat capacity of the furnace chamber 10 are much greater than in the case of any multiple retort metallurgical furnaces known to the prior art. For example, the average clearance between the top of each retort 20 and the inner roof course 15a preferably is at least twice the retort diameter. The retorts are spaced apart a distance exceeding half their diameter, so that the chamber has unusual length as well as height. This spacing of the retorts is provided not only to maintain a great heat capacity in the chamber but also so that the entire heat-absorbing area of each retort may receive radiant heat substantially uniformly from the adjacent furnace structures without having the heat flow to

any area of one retort obstructed objectionably by an adjacent retort. The relationship of chamber volume and heat capacity to the heat-absorbing capacity of the retorts within the chamber may be expressed in terms of the ratio of the total heat-radiant surface area of the chamber to the total heat-absorbing surface area of the retorts. This ratio is at least two to one in all embodiments of the invention, and in Figures 1 and 2 it is at least three to one.

As seen in Figures 1 and 2, the retorts 20 are mounted on insulating tiles 29 which in turn are supported from firebrick arches 34 disposed across the bottom of chamber 10 between the respective retorts and the underlying heating elements 30 in well 32. The arch structures thus shield the bottoms of the retorts against the primary heat radiation from the heating elements, which radiation, however, they absorb and radiate secondarily so that the entire heat-absorbing area of each retort is exposed to a substantially uniform heat flow composed predominantly of secondary heat radiation from the refractory structures defining the chamber 10. The furnace chamber, moreover, is entirely closed against the inflow or egress of gases, so that a dead atmosphere, free from sulphur or other gases harmful to the retorts, is maintained in the furnace. The furnace atmosphere circulates only in response to convection currents, and this circulation contributes to the desired uniformity of heating conditions.

In furnaces constructed for magnesium production, as herein disclosed, the heating means are adapted to supply heat into the furnace chamber at an average rate sufficient to hold it at an ambient reaction temperature of about 1150° to 1200° C. The furnace chamber is made to hold a quantity of heat equivalent to at least 45 B. t. u. for each B. t. u. of heat absorbed by the retorts in an hour under reaction conditions. At a reaction temperature of about 1150° C., for example, the retorts will absorb heat at an average rate in the order of about 1500 B. t. u. per hour per square foot of retort surface.

In operation, the furnace chamber is kept at reaction temperatures 24 hours a day, and the retorts are maintained on their settings throughout their life. In the course of operations for magnesium production, a charge is fed into each retort through the front or condenser end while cover 23 is open, the cover is then clamped in place, and pump 28 then operates to establish the desired vacuum inside the retort. Upon the completion of reaction, the vacuum is broken, cover 23 is removed, magnesium metal is then removed from the condenser, and the reacted residue in the retort is discharged, whereupon the retort is ready to receive another charge. The retorts receive heat substantially uniformly from the furnace structures throughout these operations, and the great store of heat kept available in the furnace walls, at the desired temperature, so greatly overweighs the effects of widely fluctuating rates of heat dissipation or heat supply that the temperature of the retorts is kept sufficiently uniform to avoid the destructive effects of dimensional changes and heat strains.

The form of construction illustrated in Figure 3 is a gas-fired muffle furnace embodying the features described hereinabove. It is a modification of the well-known "Curran-Knowles" furnace, and so needs not be described in complete detail. As appears from the drawings, the prin-

cipal differences between the form of Figure 3 and the form of Figures 1 and 2 are that the furnace chamber 110 of the former is separated from the well containing the heating means by means of a heat-conductive refractory muffle wall 114, above which the retorts 120 are supported on refractory piers 129, and between each retort and the muffle are lateral pier extensions 134 which shield the bottom of the adjacent retort against direct heat exchange with the primary radiation from the muffle wall, in a manner similar to the action of arches 34 in Figures 1 and 2. Combustion chambers 132 extend lengthwise in the well below 114 and are fired by gas from burners 130 disposed at the end walls of the furnace. The chambers below 132 accommodate the air supply for combustion and serve other purposes well understood in the art.

The third form of construction, illustrated in Figure 4, is a flame-fired furnace which embodies some but not all of the desirable features hereof and hence is less desirable than the other preferred forms already described. The furnace chamber 210 has a refractory bottom wall 214 formed with openings 209 to accommodate the heating means 230, which are burners for gaseous or liquid fuel. The retorts 220 are disposed centrally in chamber 210, being supported on massive piers 229 of heat-absorbent, heat-radiant refractory material. These piers have lateral caps or flanges 234 which assist in shielding the retort bottoms from direct heat exchange with the burner flames. The furnace is not wholly effective to keep all areas of each retort heated substantially uniformly, because of the presence of flames and sweeping combustion gases in chamber 210. As in the preferred embodiments, however, the furnace chamber is large and has a heat capacity at operating temperatures exceeding by many times the hourly heat-absorbing capacity of the retorts therewithin; the heat-radiant surface area of the refractory structures defining the chamber is at least twice the total heat-absorbing surface area of the retorts; and the retorts are largely shielded from direct heat exchange with the flames which provide the furnace heat supply, so that the heat flow to the retorts is composed predominantly of secondary radiation from the chamber heat reservoir.

It is to be understood that the details and forms described hereinabove and illustrated in the drawings are presented to illustrate the practice of this invention but are not considered as restrictions or limitations thereupon, except as they may be set forth in the appended claims and essential to distinguish the features claimed from the teachings of the prior art.

I claim:

1. A multiple retort distilling furnace comprising a furnace chamber defined predominantly by heat-absorbing, heat-radiant refractory structures, a plurality of metal retorts extending into said chamber so as to be heated predominantly by radiation from said structures, means for heating said structures so as to maintain their temperature substantially constant, the total heat-radiant surface area of said structures being at least twice the total heat-absorbing surface area of said retorts, and means for shielding the retorts against direct heat exchange with said heating means.

2. A multiple retort distilling furnace for the production of magnesium according to the "ferro-silicon" process, comprising a horizontally elongated furnace having a chamber defined by

walls consisting predominantly of heat-absorbing, heat-radiant refractory structures, a plurality of metal retorts extending transversely into said chamber in parallel spaced relation to each other and disposed in a horizontal row lengthwise thereof so as to be heated predominantly by radiation from said structures, and means for heating said chamber without substantial heat conduction from the heating means directly to the retorts, said structures having a total area of heat-radiant surface within the chamber exceeding by at least twice the total area of said retort surface, and said chamber having a heat capacity at production temperatures at least forty-five times greater than the average hourly heat dissipation through the walls of said retorts in the course of magnesium production.

3. A multiple retort distilling furnace for the production of magnesium according to the "ferro-silicon" process comprising an elongated chamber constituting a heat reservoir, and closed against the inflow and egress of gases so as to have a dead atmosphere therein subject to disturbance only by convection currents, said chamber defined predominantly by walls of heat-absorbing, heat-radiant refractory structures having great heat storing capacity, a multiplicity of metal retorts extending transversely into said chamber in parallel spaced relation to each other so as to be heated predominantly by radiation from the walls of said structures, and means for heating said structures without substantial heat conduction from the heating means directly to the retorts, said structures having a total area of heat-radiant surface exceeding by at least twice the total heat-absorbing surface area of said retorts, and said reservoir having a heat capacity at an ambient temperature of about 1150° C. equivalent to at least about 45 B. t. u. for each B. t. u. of heat absorbed per hour by said retorts in the course of magnesium production.

4. A multiple retort metallurgical furnace comprising a horizontally elongated furnace chamber, means for heating said chamber, a plurality of metal retorts mounted in a horizontal row in parallel spaced relation to each other within said chamber, said chamber being defined predominantly by refractory structures, including the walls thereof, of great heat-absorbing capacity, means for heating said chamber and walls, said walls being at least about nine inches thick and having heat-radiant surfaces, the area of which totals at least twice the total area of the heat-absorbing surfaces of said retorts, and means for disseminating the heat from said heating means predominantly to said structures so that heat radiates therefrom substantially uniformly to the heat-absorbing surfaces of all the retorts.

5. A multiple retort metallurgical furnace comprising a horizontally elongated furnace chamber, means disposed along the bottom of said chamber for heating the same, a plurality of metal retorts mounted in a horizontal row in parallel spaced relation to each other within said chamber and intermediate the bottom and the top thereof, and refractory shielding means disposed between each retort and said heating means so as to shield the retorts against direct and irregular heat exchange with said heating means, said chamber being defined predominantly by refrac-

tory structures of great heat-absorbing capacity having heat-radiant surfaces the area of which totals at least twice the total area of the heat-absorbing surfaces of said retorts.

6. A multiple retort metallurgical furnace comprising a horizontally elongated furnace chamber, means for heating said chamber, a plurality of metal retorts mounted in a horizontal row in spaced relation to each other within said chamber so as to be heated predominantly by radiation from walls of said chamber, said chamber being defined by refractory structures of great heat-absorbing capacity and by a heat-radiant muffle wall extending lengthwise of the furnace between said heating means and said retorts, said structures having a total heat-radiant surface area exceeding by at least twice the total heat-absorbing area of said retorts.

7. A multiple retort metallurgical furnace comprising a horizontally elongated furnace chamber, means for heating said chamber, a plurality of metal retorts mounted in a horizontal row in spaced relation to each other within said chamber so as to be heated predominantly from walls of said chamber, said chamber being defined by refractory structures of great heat-absorbing capacity and by a heat-radiant muffle wall extending lengthwise of the furnace between said heating means and said retorts, said structures having a total heat-radiant surface area exceeding by at least twice the total heat-absorbing area of said retorts, and said structures including a plurality of refractory shields each disposed intermediate the bottom of one of the retorts and said muffle wall so as to shield the retorts from the primary heat radiation from said wall.

8. A multiple retort metallurgical furnace comprising a horizontally elongated furnace chamber, means for heating said chamber, a multiplicity of metal retorts mounted in a horizontal row in spaced relation to each other within said chamber and intermediate the bottom and the top thereof so as to be heated predominantly by radiation from walls of said chamber, said chamber being closed against the inflow and egress of gases so as to have a dead atmosphere therein subject to disturbance only by convection currents, a heat-radiant muffle wall defining the bottom of said chamber and extending lengthwise thereof over said heating means, the other walls of said chamber being defined by thick refractory material of high heat-absorbing capacity having heat-radiant surfaces the area of which totals at least twice the total area of the heat-absorbing surfaces of said retorts.

9. A furnace as described in claim 8, and thick refractory members supporting the respective retorts within said chamber as aforesaid, said members having horizontal extensions between the respective retorts and the muffle wall to shield the retorts against the primary heat radiation from said wall.

10. A furnace as described in claim 5, wherein said heating means comprise a multiplicity of electrodes disposed in a well below said chamber in symmetric relation to said retorts and said shielding means comprise arches each extending across the bottom of said chamber below one of said retorts.

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