June 14, 1932. E. H. BUNCE ET AL 1,863,185

METALLURGICAL FURNACE

Filed March 24, 1930

Fig. 1,

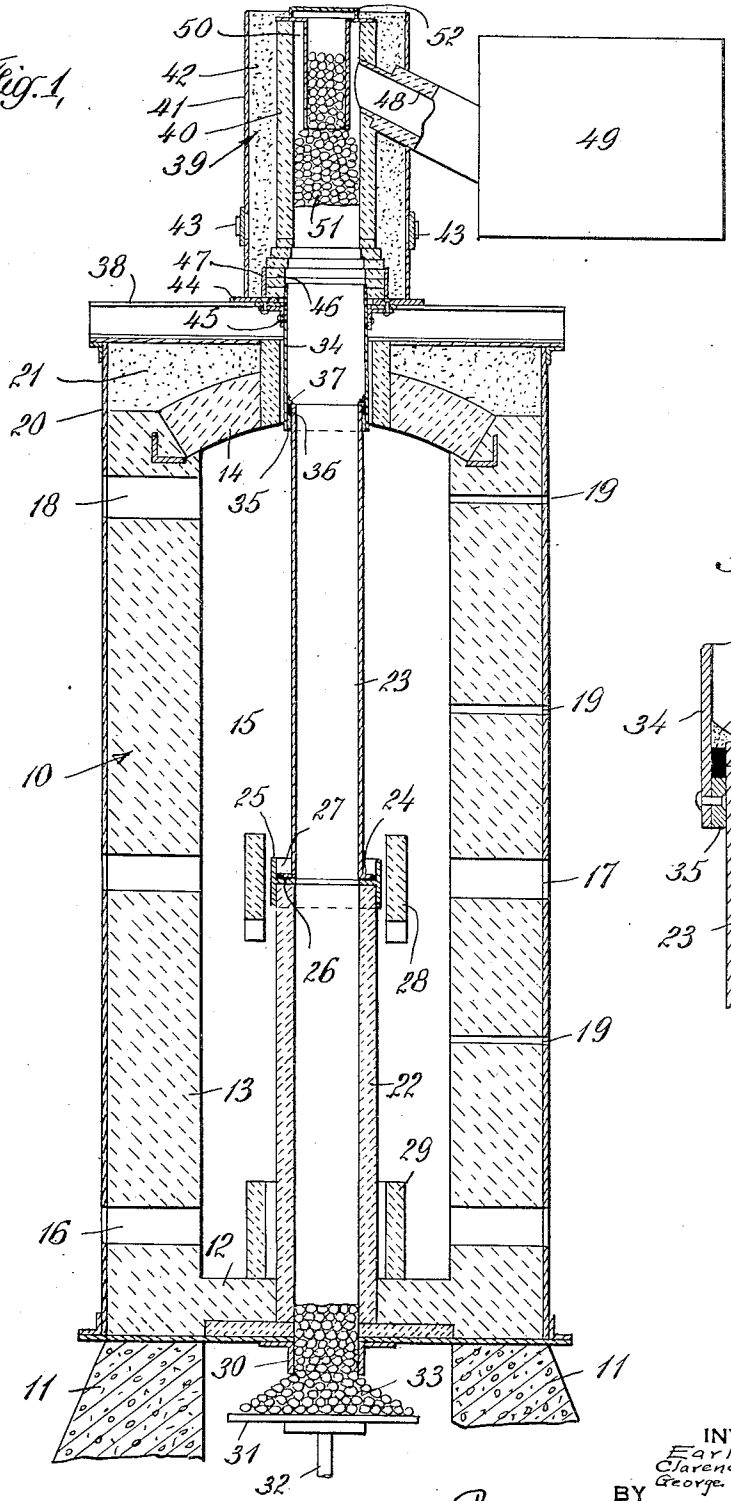
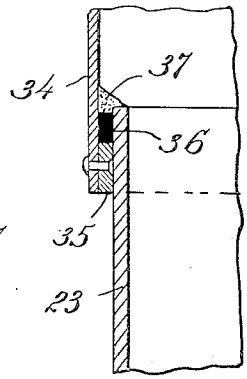


Fig. 2,



INVENTOR
Earl H. Bunce
Clarence J. Lentz
George T. Mahler
BY
Prince, Davis, Marvin & Edmonds
ATTORNEY

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UNITED STATES PATENT OFFICE

EARL H. BUNCE, CLARENCE J. LENTZ, AND GEORGE T. MAHLER, OF PALMERTON, PENNSYLVANIA, ASSIGNORS TO THE NEW JERSEY ZINC COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY

METALLURGICAL FURNACE

Application filed March 24, 1930. Serial No. 438,463.

This invention relates to metallurgical furnaces and has for its object certain improvements in metallurgical furnaces. The invention relates more particularly to externally heated reduction furnaces, such as are employed in the reduction of zinciferous materials.

It has heretofore been proposed to build-up externally heated chambers or retorts for the reduction of zinciferous material with a multiplicity of pieces of temperature-resistant material of good heat-conducting qualities. The pieces of temperature-resistant material usually consist of refractory material, such as densely pressed silicon carbide bricks, which are carefully assembled to form a substantially zinc-vapor-tight chamber. Such a built-up retort is disclosed in United States Patent No. 1,680,726, of which one of us is a copatentee. The patent more particularly discloses a vertically disposed and externally heated retort built-up of a multiplicity of suitable refractory brick fitted together with plain butt joints. Charge materials in the form of agglomerates are progressively passed downwardly through the retort as the zinc reduction step proceeds to completion. While such built-up retorts are a marked improvement over the monolithic and built-up retorts heretofore employed, in time they tend to rupture. This rupturing of the retorts takes place more particularly in their upper sections. Considerable time, labor and expense are involved in repairing or re-building such ruptured retorts.

When employing a retort such as that disclosed in the above mentioned patent in the reduction of zinciferous material, it is customary to maintain a temperature of approximately 1250° C. throughout the height of the heating chamber. Since the charge materials are progressively passed through the retort, as the reduction step proceeds to completion, the agglomerates are relatively cool in the upper end of the retort and they become hotter and hotter as they proceed through the retort. An externally applied temperature of approximately 1250° C., in the case of some zinc ores at least, seems necessary in order to drive sufficient heat into the core of the charge to remove or eliminate the last traces of available zinc. This means that toward the end of the reduction process the charge materials will thus have risen to a temperature of close to 1250° C.

In the case of the charge materials confined in the upper section of the retort, it is to be noted that the cool charge takes on heat rapidly, thus tending quickly to abstract a very large amount of heat away from the inner face of the retort walls. As the heating operation continues, the agglomerates next to the inner retort walls gradually reach their temperature of reduction. The agglomerates close to the inner retort walls are soon sufficiently heated to reach their temperature of reduction. The resulting zinc reduction step is itself an endothermic reaction, i. e., the reaction takes up heat.

Due to the difference in the temperature on the outside of the retort walls (approximately 1250° C.) and the inside of the retort walls at its upper section (approximately 1000° C.), numerous stresses and strains are set up in the retort walls, which are proportional to the temperature differential, between the inside and the outside of the walls. These stresses and strains in time tend to rupture the retort walls.

A different situation, however, exists in the lower section of the retort. By the time the agglomerated charge materials have reached the lower section of the retort, the reduction step itself will have proceed to, or almost to, completion. Since these agglomerates have been subjected to continuous heating during their passage from the upper end to the lower end of the retort, they are no longer relatively cool and have taken on a temperature substantially equal to that maintained at the outside of the retort walls. Furthermore, since the reduction reaction has gone to substantial completion, further amounts of heat are not taken up to effect the reduction reaction.

In other words, the charge materials confined in the lower section of the retort may be regarded as a substantially inactive or dead load that finally attains a temperature substantially equal to that provided on the in-

side of the retort walls. The spent charge materials adjacent to the inside of the retort walls thus serve to take up the temperature shock that the inner walls of the retort are normally subjected to when fresh charge materials are being heated. This means that there is less temperature differential between the inside and the outside of the walls of the lower end of the retort. It therefore follows that stresses and strains are not readily set up in the walls of the lower retort section, and therefore they are not as susceptible to rupture as are the walls of the upper retort section.

In copending application, Serial No. 168,914, filed February 17, 1927, there is disclosed an apparatus for smelting zinc comprising a vertically disposed metal retort adapted for external heating. The charge materials, preferably in an agglomerated form, may be progressively passed downwardly through the retort as the reduction operation proceeds to completion. Metal retorts offer a number of desirable advantages; especially over retorts built-up of refractory bricks. In the first place, a metal retort may have a wall of less thickness than that of a refractory brick retort, therefore a considerable amount of heat may more readily be passed through the walls of such a metal retort and into the charge materials confined therein, and thus the temperature differential between the outside and the inside of the metal retort walls is very low. As a consequence, less heat is required in the surrounding heating chamber to hold a given temperature within a metal retort. This means that a metal retort may be heated with less fuel consumption than in the case of a refractory retort. Since less heat is necessary, the furnace setting is normally given a longer life. Moreover, since large quantities of heat may be promptly transferred through the relatively thin walls of a metal retort into the charge materials confined therein, the progression of the charge materials therethrough may be speeded over that possible with a refractory retort having thick walls, but otherwise of the same dimensions. Since a metal retort may be built in a single section, it is readily substituted as a unit for one that has failed. In the case of a refractory brick retort, on the other hand, considerable time is required to tear down an old retort and build up a new one.

Metals and alloys are well adapted to withstand the heat shocks produced by the insertion of fresh batches of charge into the top of a verticle zinc retort of the type discussed here. The fresh charge at the top of the retort since the reaction between zinc oxide and carbon in the charge is endothermic, acts as a cooling agent and tends to keep the top of a metal retort from reaching a temperature at which it would soften to a dangerous degree. However, as the zinc is progressively eliminated from the downwardly moving charge, the bottom of the retort is less cooled and may thus become exposed to a dangerous degree of heat. In the case of refractory retorts, the reverse is true: a refractory retort built of appropriate materials will stand the high bottom temperature to which it is subjected on account of the progressive elimination of zinc from the charge better than the heat shocks produced at the top by the insertion of fresh charge.

A study of reducing operations conducted within a vertically disposed and externally heated retort shows that the ideal retort would be one constructed of materials which will at its top section deliver to the inside wall of the retort a large quantity of heat somewhat above the temperature of reduction (950° C.) with the least possible heat differential across the thickness of the retort wall, and which will, as the charge moves downwardly, deliver at the inside wall of the retort the desired quantity of heat at a gradually increasing temperature; until at the lower section of the retort the inside wall temperature approximates 1250° C. These conditions require that the heating chamber of the furnace be constructed or equipped with devices capable of controlling the combustion of fuel so that the heating chamber temperature rises from that required to deliver an inside wall temperature somewhat above 950° C. at the top section to an inside retort wall temperature of about 1250° C. at the lower section of the retort.

As a result of our investigations, we have determined that a metallurgical furnace may be constructed which substantially fulfills the ideal operating conditions just enumerated. A combination retort has been developed which for the most part satisfies these specifications. In the case of a vertically disposed and externally heated retort, we have found that a metal upper section of suitable construction may advantageously be employed which will withstand temperatures of at least 1000° C. in a reducing atmosphere on the inside of the retort, and in a reducing or oxidizing atmosphere on the outside of the retort for a relatively long period of time without failure. The lower section of the retort is constructed of suitable heat refractory material, such as brick, which will withstand a temperature of 1250° C. in the same atmosphere for a relatively long period of time without failure. We have also found that a joint may be provided between the refractory section and the metal section of the retort that is substantially zinc-vapor-tight.

Our invention therefore contemplates a metallurgical furnace comprising an externally heated reduction retort built-up in part of refractory material and in part of metal.

In the present preferred practice of the in-

vention, the metallurgical furnace is provided with a vertically disposed and externally heated reduction retort, the lower section of which is built up of a multiplicity of pieces of suitable heat refractory brick of good heat-conducting qualities, while the upper section is constructed of suitable metal, preferably an alloy, adapted to withstand the prevailing temperatures and atmospheres. A joint is provided between the refractory brick section and the metal section that is substantially zinc-vapor-tight. The retort is centrally disposed within an appropriate heating chamber. Suitable fuel may be introduced into and burned within the heating chamber to provide the desired temperatures and quantities of heat.

When operating the metallurgical furnace of the invention in the reduction of zinciferous materials, the heating chamber of the furnace is maintained at a temperature gradient of approximately 1250° C. at its lower end and about 1000° C.–1050° C. at its upper end. Thus, the temperature at the bottom of the refractory brick retort may be maintained around 1250° C. The temperature at the joint between the refractory and metal sections of the retort is maintained at approximately 1100° C., and the temperature around the upper section of the metal retort is maintained at about 1000–1050° C.

The gradual increase in the heating chamber temperature from the top to the bottom of the retort may be brought about by the burning of the fuel at the bottom of the heating chamber and cooling the products of combustion as they rise toward the top of the heating chamber. Thus, the hot combustion gases may be cooled by introducing a cooling agent, such as steam or air, into the central and/or upper sections of the heating chamber.

Or, in utilizing a down-drop, the combustion fuel may be introduced at or near the top of the main heating chamber, and air may be introduced at various points throughout the height of the chamber to regulate the combustion of the fuel to give the desired temperature gradient; or, a separate heating chamber may be provided for each retort section.

The novel features of the present invention, it is believed, will be better understood by reference to the accompanying drawing, taken in conjunction with the following description, in which:

Fig. 1 is an elevational section of an apparatus adapted for the practice of the invention; and

Fig. 2 is an enlarged sectional detail of a telescoping joint shown in Fig. 1.

The apparatus shown comprises a main furnace structure 10 resting on concrete foundations 11. The furnace structure comprises a bottom 12, side walls 13 and an arched roof 14 constructed of suitable refractory material, such as heat-resistant brick. These furnace linings define a heating chamber 15.

A suitable number of ports 16 and 17, extending completely through the side walls of the furnace structure are appropriately spaced throughout the height of the furnace structure. These ports are adapted to receive air and fuel, such as pulverized coal, oil, gas, etc., which may be burned within the heating chamber. Electrical energy may also be employed appropriately to heat the furnace and to effect the desired reduction operation. One or more ports are preferably provided at or near the lower section and at or near the middle of the heating chamber. An outlet 18 is provided at or near the upper end of the heating chamber for the withdrawal of heating gases. This outlet preferably connects with a stack or chimney (not shown). A number of relatively small openings 19 are provided through the side walls of the furnace structure at spaced intervals throughout the height of the heating chamber for the taking of pyrometric readings. An outer metallic casing 20 completely surrounds the main furnace structure. The space between the top of the metallic casing and the arched roof is filled with suitable heat-insulating material 21, such as diatomaceous earth.

A vertically disposed retort extends centrally of and completely through the heating chamber. The retort shown comprises two connecting sections, a lower section 22 constructed of suitable refractory material, such as refractory brick, and an upper section 23 constructed of suitable metal, such as an alloy, that is adapted to withstand prevailing temperature and atmospheric conditions. It is important that the two sections of the retort be joined hermetically. That is to say, the joint between the two sections should be substantially zinc-vapor-tight. Moreover, the joint should be sufficiently tight to prevent retort gases from escaping into the heating chamber, or heating gases in the heating chamber from seeping into the retort.

In the construction shown in the drawing, the lower end of the upper (metal) section is flared out to form a lip, shoulder or flange 24. This flanged section forms a base for the support of the metal section of the retort. A suitable connector casting 25 is placed between the upper end of the lower retort (refractory) section and the lower end of the upper section. This connector casting base is circular in plan, with an opening in the center to conform to the configuration of the adjoining retort sections, and T-shaped in cross-section. The lower half of the casting embraces the top of the refractory retort section and rests thereon. An intervening layer of silicon carbide fines is preferably provided on the upper face 26 of the refractory retort section, so that the casting may be non-leakably

pressed thereon by the overhead weight of the metal retort section. It is preferred that the outside flanges of the casting fit snugly against the outside surface of the upper end of the refractory retort section, in order to provide as far as possible a non-leaking joint. The upper half of the connector casting serves to receive the flanged portion of the lower end of the upper metal retort section. The space 27 between the outer wall of the end of the metal retort and the inner upper portion of the connector casting ring is filled with silicon carbide fines, sand or similar material to act as a seal.

Baffle walls 28 are advantageously built into the side walls of the furnace structure. These baffles extend laterally across the heating chamber and are so positioned with respect to the ports located about midway up the heating chamber that heating gases or fuel introduced therethrough may be deviated from and kept substantially out of immediate contact with the retort. The ports in question are shown in the side walls of the furnace substantially on the same level as the joint between the upper and lower sections of the retort. The baffles are advantageously placed close to the joint in order to protect the same from direct contact with heating gases at their hottest zone introduced through the immediate ports. In fact, steam and/or air may be introduced through these ports to cool the heating gases thus protecting the metal retort section against over-heating.

Similar protecting baffles 29 are constructed in the bottom of the furnace in order to protect the lower retort section from immediate contact with combustion gases resulting from the burning of fuel introduced through the lower ports. The baffles may of course likewise be fastened into the side walls, or a combination of the two types of construction may be employed.

While the retort, or its sections, may have any desired configuration, in the present preferred practice of the invention the retort is circular in outline, having an internal diameter of 15¾ inches. The passageways of both sections of the retort are in substantial alignment with one another. In order that the retort may expand and contract independent of the furnace structure, it is preferred that the retort be supported by the furnace structure at not more than one point. In the present instance, the lower section of the refractory retort is supported by the bottom of the furnace structure.

Densely pressed silicon carbide bricks are employed to build-up the refractory retort section. Its side walls are 4½ inches thick. The metal retort section consists of an alloy of nickel-chromium-iron, having a wall thickness of 1 inch. In the apparatus shown, the refractory retort section has an overall height of 9 feet 11 inches, and the metal retort section has an overall height of 10 feet 1 inch.

The lower end of the refractory retort section terminates with a sleeve member 30 which acts as an extension thereof. This sleeve is attached to the underside of the bottom of the furnace structure, and its passageway is in substantial alignment with the passageway of the retort. A revolving platform 31, moving about a vertical axis 32, is located immediately below the lower end of the retort and sleeve. It is adapted to receive spent residues or agglomerates 33 and to discharge them as the platform is revolved.

The upper end of the metal retort section movably connects with a metal prolongation 34, which may be constructed of wrought iron, into which the metal retort section advantageously telescopes (see Fig. 2). This metal prolongation preferably extends a convenient distance above the furnace structure. The telescoping joint provided between the upper end of the metal retort section and the metal prolongation comprises an annular band 35 of flat iron, 2½ inches wide by ½ inch thick, riveted along the inside of the lower end of the metal prolongation. The inside diameter of the annular band is sufficiently large to permit of the entry of the metal retort section, so that any expansion or contraction of the metal retort section may easily take place within the fixed metal prolongation. One or more layers of asbestos wick packing 36 are snugly fitted into the space provided between the upper periphery of the metal retort section and the inner periphery of the metal prolongation immediately above the annular band. Silicon carbide fines 37 or the like may be placed above the wicking in order completely to seal the telescoping joint. A slip joint of this type is adapted to permit expansion and contraction of the metal retort section.

The top of the furnace structure is provided with a number of spaced I-beams 38 upon which rests an eliminator structure 39 adapted to support and contain an eliminator 40. This eliminator structure comprises an outer metallic casing 41 that completely surrounds the eliminator, leaving a space adapted to receive heat-insulating material 42, such as coal dust. One or more doors 43 are provided at or near the lower end of the metal casing for the removal of dust coal in order to regulate the temperature of the eliminator during reduction operations. The outer metallic casing may be of any size adapted to give an intervening layer of heat-insulating material of desired thickness. The metal casing is preferably open at the top, or has an opening at or near the top, for the introduction of heat-insulating material.

A base plate 44 rests on the I-beams, which is adapted to support the eliminator struc-

ture. A number of spaced lugs 45 are permanently attached to the metal prolongation of the retort. They are advantageously made of angle iron and are riveted to the metal prolongation, as well as to the base plate 44.

The upper end of the metal prolongation joins with the eliminator by means of a telescoping joint 46, constructed of suitable refractory material, such as heat-resistant brick. These brick are preferably of the same general type as that employed in the building-up of the eliminator, i. e., silicon carbide brick. The desired telescoping effect may be obtained by arranging the joint brick in the form of inverted steps, as shown in the drawing.

It will be seen that the telescoping joint may be so constructed as to provide an eliminator of any desired cross-sectional configuration. The brick going into the joint are advantageously kept in alignment by means of a circumferential steel band 47.

An off-take pipe 48 is provided at or near the upper end of the eliminator for the withdrawal of zinc vapor and retort gases. It communicates with a zinc vapor treatment device 49. If zinc metal is to be produced, this device consists of a condenser. If, on the other hand, zinc oxide is to be manufactured, the device is one adapted to effect the oxidation of the incoming zinc vapor. In the case of the manufacture of zinc dust, the device consists of a canister designed for the condensation of the zinc vapor into minute zinc particles.

The upper end of the eliminator is provided with a charge feeding device 50 that extends downwardly in the eliminator to a distance slightly below the gas and vapor off-take pipe, so that charge materials 51 may be kept therefrom; thus leaving a free passageway to and through the off-take pipe. A removable cap 52 fits over the mouth of the charging device.

The above described apparatus may be operated as follows in the reduction of zinciferous material, and more particularly with respect to zinciferous material containing objectionable amounts of lead and the like:

The cap 52 is removed and an appropriately agglomerated charge of mixed zinciferous material and carbonaceous reducing agent is fed into the charging device 50. A sufficient amount of the agglomerates are thus introduced until the communicating passageways of the retort sections, the eliminator and the charging device itself are substantially filled. The cap 52 is then returned.

Air and fuel, such as oil, are introduced through the ports 16 and 17. As the combustion gases circulate around both the lower and upper retort sections, spent gases ultimately find their way through the opening 18 and into the stack or chimney (not shown). The highly heated combustion gases formed by the fuel introduced through the lower ports 16 strike the baffle walls 29, thus protecting the retort section 22 from immediate contact therewith. In a similar manner, the baffle walls 28 protect the joint between the lower and upper retort sections from immediate contact with the combustion gases resulting from fuel introduced through the ports 19.

Pyrometric temperature readings are periodically or continuously taken through the openings 19. Temperature conditions within the heating chamber 15 are suitably regulated in accordance with the temperature gradients to be maintained. In order to have a temperature gradient increasing from the upper end of the heating chamber to the lower end of the heating chamber, the hottest gases are preferably introduced through the lower ports. As the heating gases rise upwardly through the heating chamber, while swirling around the retort, they are gradually cooled. If additional cooling effects are desired, steam and/or air may be suitably introduced at various points throughout the height of the heating chamber. Thus, steam may advantageously be introduced through the ports 19. The relatively cooler steam contacts with the rising heated gases and tends effectively to lower their temperature. A cooling medium may also advantageously be introduced through openings 19, or similar openings provided in the side walls of the furnace structure for that purpose. As pointed out above, it is preferred to maintain a temperature of approximately 1250° C. in the lower part of the heating chamber, and a temperature of approximately 1000°–1050° C. in the upper end of the heat-chamber.

The heat externally applied to both the lower and upper sections of the retort is ultimately driven through the retort walls and into the charge confined therein. Since the upper metal retort section has a relatively thin wall, heat is readily transferred through its walls into the charge. As pointed out above, under ideal operating conditions it is preferred to have large quantities of heat transferred to the charge materials in the upper section of the retort. This desirable result is obtained with the metal retort section, while yielding a relatively small temperature differential between its outer and inner wall surface. On the other hand, it is also preferred to deliver the desired amount of heat into the charge materials in the lower end of the retort at increasing temperatures. This advantageous result is obtained when employing a lower retort section constructed of refractory brick, the walls of which are sufficiently thick to withstand the elevated temperature.

When the charge materials confined within the retort are heated to their temperature

of reduction, zinc vapor is liberated and retort gases are evolved. Due to the natural buoyancy of the hot vapor and gases, they tend to rise upwardly. This upward movement of the vapor and gases is preferably assisted by providing and maintaining a stack draft throughout the system. For this purpose, it is advantageous to have a retort of substantial height. Moreover, in the preferred practice of the invention, regulated amounts of gases, such as air, are admitted into the lower end of the retort.

As reduction proceeds to completion, the spent residues or agglomerates 33 are removed from the lower end of the retort by setting the revolving platform 31 in motion. The movement of the platform tends to withdraw spent residues. As fast as spent residues are removed, the inner column of agglomerates within the retort section tends to lower itself, thus effecting a progressive movement of the agglomerates downwardly through the retort. The cap 52 is again removed and further amounts of fresh charge materials are introduced into the charging device, to compensate for the spent residues that have been withdrawn from the lower end of the retort. If the process is to be operated substantially continuously, the cap may be removed and connection made with a source of material adapted to feed fresh agglomerates into the system as fast as spent residues are removed therefrom.

The liberated zinc vapor and evolved retort gases rise upwardly through the passageways of the retort sections, as agglomerates move downwardly. The mixture of zinc vapor and retort gases ultimately finds its way into the eliminator 40, where it contacts with the hot body of agglomerates confined therein, and which agglomerates are about to be subjected to the reduction operation.

If the zinc vapor is contaminated with objectionable amounts of lead, dust, or the like, and it is desired to eliminate the same, the temperature of the agglomerates confined within the eliminator must be carefully controlled. In other words, under appropriate temperature conditions, the hot agglomerates confined within the eliminator are adapted to filter out the lead and dust without undue condensation of zinc vapor, while permitting the purified vapor to pass on. If the temperature of the agglomerates is too hot, provision should be made for removing the excess heat. This may be accomplished by lowering the amount of heat-insulating material 42 in the metal casing 41. Coal dust may readily be removed from the door or doors 43. On the other hand, if the agglomerates are not sufficiently hot to avoid the condensation of appreciable amounts of zinc vapor, additional heat-insulating material should be provided around the eliminator to inhibit dissipation of heat. This result may be accomplished by introducing more heat-insulating material into the metallic casing.

The mixture of zinc vapor and retort gases ultimately finds its way through the off-take pipe 28 and into the zinc vapor treatment device 49. As pointed out above, if the zinc vapor is to be treated for the manufacture of zinc metal, this device consists of a suitable condenser. On the other hand, if zinc oxide is to be produced, the device is adapted to effect the oxidation of the zinc vapor. Furthermore, if zinc dust is to be made, the device consists of a canister adapted to condense the incoming zinc vapor into minute particles of zinc.

A consideration of the structural features of the above described apparatus will readily indicate that the metallurgical furnace of the invention is peculiarly adapted for the reduction of zinciferous materials. The relative advantages and disadvantages of refractory retorts and of metal retorts are so balanced against one another in the combined retort of the invention that the old disadvantages are minimized while practically all of the advantages of both types of construction are retained.

We claim:

1. An apparatus for the reduction of zinciferous material comprising a vertically disposed and externally heated reduction retort, the lower section being built-up of a multiplicity of refractory brick, the upper section being formed of suitable metal, the two sections being joined by an intervening casting adapted to make a substantially zinc-vapor-tight joint.

2. An apparatus according to claim 1, in which the upper end of the metal retort section movably connects with a fixed metal prolongation.

3. An apparatus according to claim 1, in which the upper end of the metal retort section telescopes into a fixed metal prolongation whereby expansion and contraction of the metal retort may freely take place within the metal prolongation.

4. An apparatus according to claim 1, in which the intervening casting is T-shaped in cross-section so that the lower half of the casting embraces the top of the refractory retort section and rests thereon, and so that the upper half of the casting supports a flanged portion of the lower end of the metal retort section.

5. An apparatus according to claim 1, in which the joints between the retort sections and the intervening casting are sealed with an appropriate agent.

In testimony whereof we affix our signatures.

EARL H. BUNCE.
CLARENCE J. LENTZ.
GEORGE T. MAHLER.