My invention relates to apparatus for melting and treating metal.

The invention has among its objects the provision of an improved furnace for melting, or melting and treating, metal, particularly aluminum, the treatment comprising passing a gas through the molten metal in an improved manner. Other objects of the invention will be understood from the following description when read in the light of the accompanying drawings of several embodiments of the invention, the scope of the invention being more particularly pointed out in the appended claims.

In the drawings:

Fig. 1 is a section of the furnace on the line 1—1 of Fig. 4;

Fig. 2 and 3 are sections, on an enlarged scale, of details of the metal discharge conduit shown in Fig. 1;

Fig. 4 is a section on the line 4—4 of Fig. 7, with parts in elevation;

Fig. 5 is a section of the skin door shown in Fig. 4, corresponding to a section on the line 5—5 of Fig. 6 on an enlarged scale;

Fig. 6 is a section on the line 6—6 of Fig. 4, with parts in elevation;

Fig. 7 is a section on the line 7—7 of Fig. 4, with parts in elevation;

Fig. 8 is a section on the line 8—8 of Fig. 1, on an enlarged scale;

Fig. 9 shows a detail, on an enlarged scale, corresponding to a section on the line 9—9 of Fig. 7;

Fig. 10 is a fragmentary view illustrating a modified form of charging means for the furnace;

Fig. 11 is a section on the line 11—11 of Fig. 10; and

Fig. 12 is a section on the line 12—12 of Fig. 11, with parts omitted.

Referring to the furnace illustrated by Figs. 1 to 9 of the drawings, the same comprises a body portion A and a removable cover portion B.

The body portion A of the furnace illustrated comprises a sheet metal casing 1 preferably formed of steel plates welded together to enclose the four sides and bottom of said body portion to render it air tight. The furnace chamber C in the body portion of the furnace has a lining of refractory blocks preferably of hard carbon. A row of elongated laterally abutting blocks 3, extending from one side of the furnace chamber to the other, constitutes the bottom wall of this lining. As shown, each of the furnace chamber end walls constituted by the lining is formed of a pair of superimposed elongated blocks 5 the lower of which rests upon the adjacent end block 2 of the bottom wall of the lining. Each of the furnace chamber side walls constituted by the lining is formed of a pair of superimposed elongated blocks 7 the lower of which rests upon the end portions of the row of blocks 3. As shown (see Fig. 4), the end portions of the blocks 5 are recessed at 9 for receiving the end portions of the blocks 7. As illustrated in Figs. 1, 4 and 7, the abutting portions of the blocks 3, 5 and 7 and 1 are keyed together by the elongated carbon rods 11 of square cross-section received in and fitting complementary keyways in their abutting surfaces. The roof of the furnace chamber C, as shown, is formed of slabs 13, preferably of graphite, which extend transversely across the furnace chamber and are supported on the shoulders 15 formed at the upper portions of the uppermost blocks 5 and 7.

As shown, the blocks 3 rest upon slabs 11, of graphite, supported by a layer 19 of insulating brick which rests upon the bottom wall of the casing 1. The slabs 17, being of graphite, provide an anti-friction surface for permitting relative sliding between the furnace lining and the firebrick insulating layer 18.

Laterally the furnace lining is surrounded by a layer of firebrick tile 23 backed by a layer of insulating brick 21, the space between this latter layer and the lateral walls of the casing 1 being filled with a layer 25 of resiliently yieldable heat refractory packing material to permit overall contraction and expansion of the metallic casing and furnace walls enclosed by it independently of each other. As shown, resting upon the edge of the lateral walls of the furnace chamber enclosed by the metallic casing 1 is a coping 27 of firebrick retained in place by the angle-irons 29 welded to the lateral walls of the casing interally thereof and extending continuously thereabout.

Interiorly of the furnace chamber is a row of parallel graphite electric heating resistors 31 extending transversely of said chamber. These resistors are connected for series flow of current by graphite plates 33 which rest upon graphite or carbon plates 35 suspended from the roof slabs 13 by graphite or carbon rods 37. On the upper ends of the rods 37 are screwed graphite or carbon nuts 39 resting upon heat refractory electric insulating blocks 41, the latter resting upon blocks 43 of porous carbon constituting a refractory layer of relatively poor heat conductivity resting upon the upper surfaces of the slabs 13.

The space between the cover and the furnace roof slabs 13 is filled with a layer 45 of heat refractory insulating material, preferably broken charcoal, inverted cup-like covers 47 of carbon resting upon the slabs 13 being positioned over the...
upper ends of the suspension rods 37, nuts 39 and blocks 41 and 43 for keeping the charcoal out of contact with them. As shown, the end resistors are secured by couplings 48 to extensions 49 of graphite projecting through aligned openings 51 and 53 (Fig. 4) in one of the lateral walls of the furnace. A resiliently yielding packing sleeve 55 of heat refractory material in the opening 53 and surrounding the extension 48 serves to render the joint between the latter and the furnace walls air tight, while a bushing of refractory electric insulating material 57 serves to insulate from the metallic casing the extension and copper terminal lug 59 carried by the extension. The resistors and the manner of supporting them form the subject matter of applicant's co-pending application Serial Number 573,537, filed January 18, 1945, now Patent No. 2,472,613, granted June 7, 1949 and it is believed need not be herein further described.

As shown, the cover portion B of the furnace, comprises end and side channel-irons 61 welded together to form a continuous rim for the cover. These channel-irons at the sides of the furnace receive elongated blocks 63 the inner sides 65 of which are outwardly and downwardly inclined as shown in Fig. 1. The blocks 63 are supported by these inclined sides 65, and the abutting edges of blocks 63 of carbon extending transversely across the furnace, the abutting edges of the slots being keyed together, as indicated at 69 in Fig. 1, in the same way that the blocks of the furnace lining are keyed together. Resting upon the slots 67 and supported thereby and by the inclined sides 65 of the blocks 63 is a layer 71 of refractory firebrick.

Extending continuously about the lateral walls of the metallic casing 1 at the exterior thereof adjacent its upper edge is a laterally projecting metallic flange 73 carrying the upwardly projecting continuous flanges 75. Carried by the channel-irons 61 of the cover adjacent its upper edge is an exterior continuous laterally projecting flange 77 carrying the continuous downwardly projecting flanges 79, one of these flanges being adapted to project into the space between the two flanges 75 and the other into the space between the lateral wall of the metallic casing and the adjacent flange 75. The spaces into which the flanges 79 project are adapted to be filled with oil or sand, or a mixture of the two, and thus form a labyrinth seal for rendering air tight the joint between the cover and body portion of the furnace.

For charging the furnace chamber with molten metal the casing 1 is provided with an extension 81 in which is contained a body of firebrick or other refractory material built up to form a funnel 83 into which the molten metal may be poured from a ladle. The discharge opening 85 of the funnel leads to an interior chamber 87 formed in the body of the firebrick. One side of this chamber is formed by a tile-like slab 89 which rests upon the bottom 81 of the chamber, the bottom edge of the tile being notched, as indicated at 93, to form a passage for discharge of metal from the chamber. The passage formed by the notch 93 communicates with a vertical passage 95 extending well above the top edge 97 of the notch 93. The passage end of the passage 95 communicates with a conduit 99 extending through the furnace wall to the furnace chamber. When metal is poured into the chamber 87 through the funnel 83 it will discharge from said chamber into the furnace chamber by way of the notch 93, vertical passage 95 and conduit 99. When the pouring operation is discontinued the body of metal having an upper level L will remain in the chamber 87 and passage 95. This level, being above the upper edge 97 of the notch 93, will cause the metal to seal the furnace chamber against entrance of air and discharge of treated gas. For keeping liquid metal in the furnace chamber during operations the body of metal remaining in the chamber 87, notch 93 and passage 95 said chamber at its upper portion is shown as provided with an electric resistance heating element 101, preferably in the form of a rod of graphite. This heating element extends across the chamber and at opposite edges projects through openings in the lateral walls of the chamber as shown in Fig. 8, the ends of the element carrying the copper terminal lugs 103 so that heating current may be passed through it. As shown, the heating element is insulated from the metallic casing, and the joint between it and the furnace walls is packed and rendered air tight, in the same ways as are the resistor extensions 48. Heat radiated through the conduit 99 from the furnace chamber C will augment the heating effect of the heating element 101.

Molten aluminum may be charged into the furnace chamber C to fill the same to a level LL. In the furnace chamber the aluminum is purified by subjecting it to heat by bubbling chlorine gas through it. Chlorine is substantially inert with respect to molten aluminum, when as nitrogen, usually considered as an inert gas, would form aluminum nitrides under such conditions and contaminate the aluminum. Gases such as hydrogen and carbon monoxide, which are inert with respect to many molten metals, would dissolve in molten aluminum and give it poor casting qualities.

For bubbling the gas through the molten aluminum the furnace chamber, as shown, is provided adjacent its bottom with a row of transversely extending parallel tubes 105 having closed ends 107. These tubes, according to the present invention, are formed of porous material, preferably carbon. The gas is admitted to the tubes under sufficient pressure to overcome the head of molten metal at the exterior of the tubes to cause the gas to discharge through the pores of the tubes and bubble through the metal a diffused volume of gas. The chlorine bubbling through the metal flushes out or otherwise removes carbon monoxide and hydrogen dissolved in the aluminum, which, if allowed to remain therein, would make the aluminum cast poorly. When chlorine is employed as the gas it also converts to chlorides any zinc or magnesium commonly contained in aluminum, which chlorides go off as a fume. Further, the gas stirs up the molten metal and, being highly diffused, scour from it and carries to the surface of the melt aluminum oxide particles which are commonly contained in the aluminum, particularly aluminum scrap, which particles upon such removal float upon the surface of the melt.

During the operation of bubbling chlorine through the metal the latter is heated by passing electric current through the resistors which causes heat to be radiated downwardly on the surface of the metal to raise its temperature. It has been found that the effects of the chlorine gas are augmented if the temperature of the aluminum is raised as high as possible. However, this temperature should not exceed about 2200° F., as otherwise aluminum carbides will be
9,510,988 formed from the carbon surfaces in contact with the aluminum, which will contaminate the latter, and in fact such action will act to clog and destroy the porosity of the carbon tubes and in time cause said tubes to fall.

It will be understood, however, that the invention is not limited to treating aluminum, or to the use of chlorine, as bubbling an inert gas through molten metal, for example nitrogen through molten copper, will act to remove hydroxides and oxides from the metal and to flush out undissolved particles in the same way as the chlorine acts to remove aluminum oxide particles from molten aluminum.

The porosity of the carbon of which the above mentioned tubes are made may be such as to pass 4 to 33 cubic feet of air, at 15% humidity, per minute per square foot of carbon surface at a pressure of 2 inches of water. The carbon which will pass 4 cubic feet of air under the conditions just mentioned has an average pore size of about 69 microns, and this scale of carbon which will pass 33 cubic feet of air under the above conditions has a pore size of about 190 microns, both being about 48% porous.

Preferably the carbon employed is that which would pass about 33 cubic feet per minute under the above conditions, so as to make it possible to pass a large amount of the chlorine gas through the metal with a pressure of about 2 inches of water in excess of the head of metal on the tubes. For all practical purposes the permeability of the tubes with respect to chlorine is substantially their permeability with respect to air.

As shown, the tubes 105 are supported by blocks 109, preferably of carbon, resting upon the carbon floor of the furnace chamber. As best illustrated by Figs. 7 and 9, the tubes are connected by non-porous carbon T's 111 and elbows 113 to a manifold 115 of non-porous carbon. At the center portion of this manifold is shown a T 117 of non-porous carbon connected by a non-porous carbon nipple 119 to the lower portion of the bore 121 of a vertically extending non-porous carbon block 123. The upper end of this bore is shown as closed by a plug 125 screw-threaded into it, and another screw-threaded into the block is a conduit 127 of carbon channels extending through the furnace walls to their exterior and is supplied with chlorine gas under pressure from a source of supply, a suitable valve (not shown) in the conduit being provided for establishing and maintaining a flow of chlorine gas to the bore 121. Preferably the conduit 127 communicates with the bore 121 at a point above the level of metal contained in the furnace chamber, so as to insure against the possibility of molten metal that may enter the bore 121 by leakage in the joints submerged in the metal or by reason of seepage of metal through the pores of the tubes 105 working into the conduit 127, which, if it did, might freeze therein and block said conduit. Any metal that enters the tubes 105, manifold 115 and bore 121 will be kept molten by heat conducted through the tube and manifold walls and block 123, and as entered into the bore 121 it will blow out such metal through the pores of the tubes 105 and other points of possible leakage.

As illustrated, the blocks 7 adjacent the conduit 121 are recessed to form an elongated vertical groove generally on the interior faces of the blocks the opposite side walls of the groove being formed with longitudinally extending keyways 131 coextensive with the length of the groove. The block 123 is of the same cross-sectional shape as the groove 129 so as to lie flush with the inner surfaces of the blocks 7, being integrally formed with longitudinally extending keyways 133 which fit the keyways 131 so as to retain the block 123 in said groove. Preferably the block 123 is of no longer length than necessary to have the conduit 127 positioned at a sufficient height above the level of the metal in the furnace chamber. After this block is lowered into the groove 129 an unbored block 135 of exteriorly the same cross-sectional shape is lowered into the groove so as to rest upon the top of the block 123, the block 135 being retained against vertical movement in the groove by the firebrick coping layer 21 which is subsequently installed. As shown in Fig. 7, the lower end surface of the groove 129 is inclined downwardly toward the furnace chamber, as indicated at 137, and the lower end surface of the block 123 is correspondingly shaped. This causes the block 123 to tend, under the force of gravity, to slide down said inclined surface 137 toward the furnace chamber, whereby to cause the keys 133 to bear against the sides of the keyways 131 adjacent the furnace chamber so as to take up any loose fit between the parts and thus in effect secure a rigid construction.

For discharging the treated metal from the furnace chamber, the blocks 5 at one end of the furnace are, as shown in Figs. 1 and 4, also formed with an elongated vertical groove 129 identical with that above described, said groove also having the inclined lower end 137 and keyways 131. In the groove in the blocks 9 is received an elongated block 139 having elongated keys 133 for fitting the keyways 131. Also in the groove 129 receiving the block 139 is placed a block 143 which rests upon said block 139, the construction in the respects mentioned being like that heretofore described. The block 139 is formed with a vertically extending bore 145 which at its lower end opens into the furnace chamber adjacent the bottom of the latter, the upper end of the bore being closed by a plug 147 screw-threaded therein. Tapped into the block 139, and opening into the bore 145 thereof above the level LL of the metal in the conduit 145 is a conduit 144. This conduit is connected, by a T 151, to an upwardly extending conduit 153 and a downwardly extending conduit 155. The conduit 153 is connected to a vacuum pump (not shown), while the conduit 155 is connected to a casting machine or the like (not shown). By exhausting the conduit 153 by means of the vacuum pump sucked through the bore 145 and conduit 144, and will flow downwardly through the conduit 155 and discharge therefrom. Only sufficient vapors need be exhausted from the conduit 153 to cause the arrangement of conduits to form a siphon. In this way the metal will be discharged from the furnace chamber without the possibility of entering air into said chamber. The molten metal in the bore 145 will act to seal said bore during the periods between metal discharging operations.

The conduits 149 and 155 and the adjacent portion of the conduit 153 and fittings associated therewith are preferably formed of carbon. For preventing metal from freezing in these conduits and fittings the conduits are preferably surrounded by heating elements comprising coils of resistance wire 157 (Figs. 2 and 9) embedded in the sleeves 159 of insulating material surround-
Instead of entering the aluminum into the furnace chamber C in molten form, the same may be charged thereto in solid form, say in the form of compressed bales of scrap (Figs. 10 and 11). As illustrated in Figs. 10 and 11, there is an extension at 209 at the end of the furnace. Leading through this extension to the interior of the furnace are one or more conduits 211, of rectangular cross-section, preferably of graphite. The conduits are surrounded by a mass 215 of insulating brick forming a continuation of the adjacent portion of the heating layer 22. As shown, each conduit 211 is provided with a pair of spaced control gates 215 and 217 adapted to be raised or lowered by the manually controlled air cylinders 218. Leading to the space between these two gates is a valve-controlled pipe 221 for admitting city illuminating gas, or other relatively inert gas, to the space between the two gates. The gate 217, as shown, at its lower edge is formed with a notch 223, so that when gas is supplied through the pipe 221 to the space between the two gates with the gates closed the gas will exhaust that space of air. When the space between the gates is so exhausted the gate 217 may be raised to permit the bale S to be slid into the conduit from the table T to enter the space between the two gates, after which the gate 217 may be closed and the gate 215 opened to permit the bale to be pushed into the furnace by means of a rod entered through the notch 223 in the gate 217. By properly regulating the amount of gas supplied through the pipe 221 the escape of chlorine gas from the furnace and the entrance of air thereto will be prevented.

When employing the form of furnace shown by Figs. 10, 11 and 12, the furnace may be initially charged with sufficient molten aluminum to cover the tubes 105, so that bales of scrap entered into the furnace may float on such metal while being melted and thus properly distribute the charge. This initial charging of molten aluminum into the furnace may be done by entering into the furnace chamber through the conduit 211 from the exterior of the furnace the end portion of the spout of a funnel, from the lower portion of the body of which the funnel the spout projects laterally, said body being supported by the tube 114, whereinupon molten aluminum may be poured into the body of the funnel to cause said metal to discharge through the funnel spout into the furnace chamber.

It will be understood that within the scope of the appended claims wide deviations may be made from the form of the invention described without departing from the spirit of the invention.

I claim:

1. A furnace having means forming a furnace chamber adapted to maintain a pool of metal therein, blocks forming a lining for said chamber, means forming a passage from the exterior of said chamber at one level to the interior of said chamber at a lower level comprising a vertically extending block having a vertically extending passage therein, a lateral wall of said lining being formed to provide a vertically extending groove opening laterally into the interior, wherein said groove said vertically extending block is received, said groove being formed with a vertically extending shoulder facing the vertically extending bottom of said groove, said vertically extending block having an oppositely facing vertically extending shoulder at its lower end contacting said groove shoulder of said groove for retaining said block in said groove, said block and groove at their
lower ends having cooperating contacting inclined surfaces for causing the weight of said block to hold said shoulders in contact.

2. A furnace having means forming a furnace chamber adapted to maintain a pool of metal therein, blocks forming a lining for said chamber, means forming a passage from the exterior of said chamber at one level to the interior of said chamber at a lower level comprising a vertically extending block having a vertically extending passage therein, a lateral wall of said lining being formed to provide a vertically extending groove opening laterally into said chamber, in which groove said vertically extending block is received with a lateral wall of said vertically extending block flush with the exposed surface of said wall, said groove being formed with a vertically extending shoulder facing the vertically extending bottom of said groove, said vertically extending block having an oppositely facing vertically extending shoulder slidably contacting with the shoulder of said groove for retaining said block in said groove, said block and groove at their lower ends having cooperating contacting inclined surfaces for causing the weight of said block to hold said shoulders in contact.

3. A furnace for treating metal having, in combination, walls forming a substantially closed furnace chamber adapted to maintain therein a pool of molten metal having an upper free surface, means for heating such pool of metal, means inert with respect to chlorine at the temperature of the melt for diffusing chlorine gas and bubbling it through the metal of such pool for stirring and scavenging it, which last mentioned means presents a gas receiving cavity having a wall exteriorly exposed to the interior of said chamber in position to contact with the metal of said pool below its upper free surface, said wall of said cavity being of chlorine gas pervious porous carbon capable of conducting through its pores chlorine gas supplied to said cavity under pressure for discharge from said pores in diffused state at the exposed metal contacting surface of said wall, the furnace being formed with passage means leading through its walls from the exterior of the furnace for supplying such gas under pressure to said cavity, vent means for the furnace chamber at its upper portion above the upper free surface of the pool of molten metal adapted to be maintained therein, which vent means is adapted to maintain above said upper free surface an atmosphere of the chlorine gas bubbled through such pool, a skim door for said chamber, and gas discharge means at said door for projecting gas across the door opening for preventing entrance of air to and escape of chlorine gas from said chamber when such door is open.

FRANK F. POLAND.

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