Jan. 22, 1946. W. BONSACK 2,393,306

MELTING FURNACE

Filed May 22, 1943 3 Sheets-Sheet 1

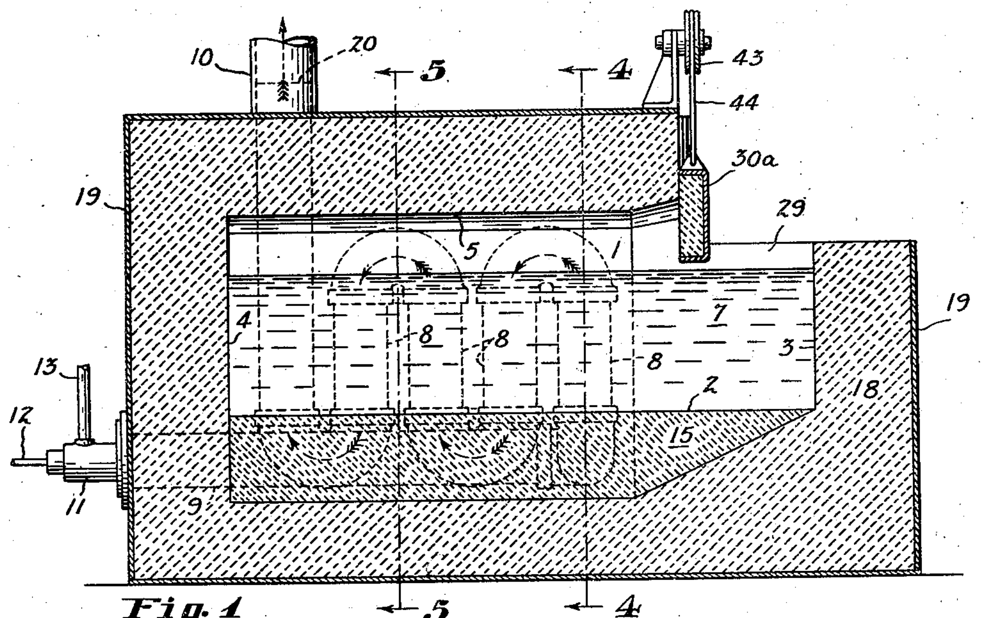

Fig. 1

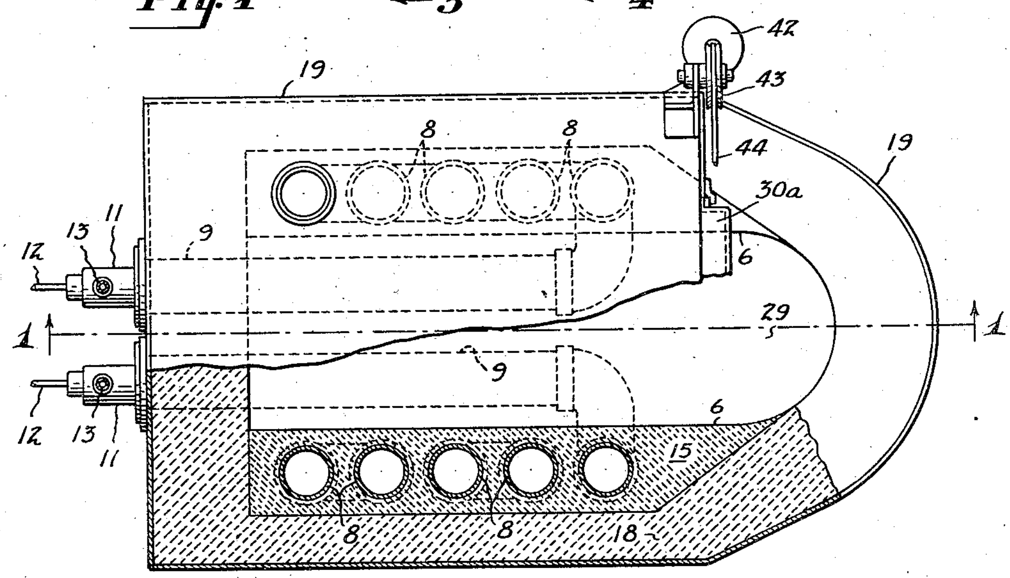

Fig. 2

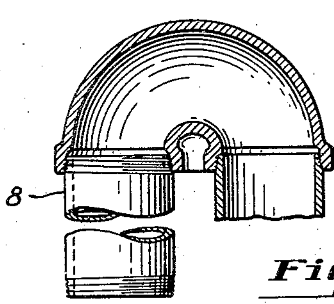

Fig. 3

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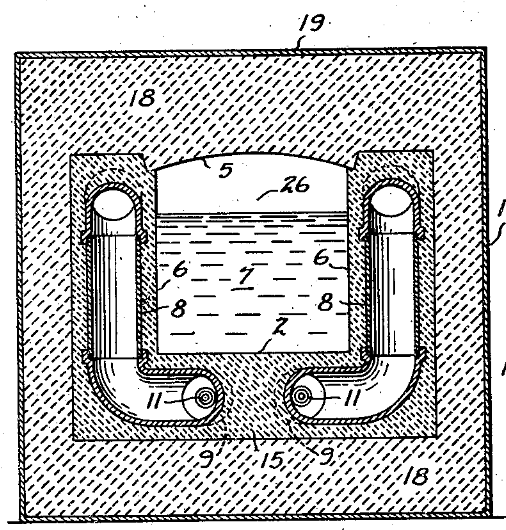

Fig. 4

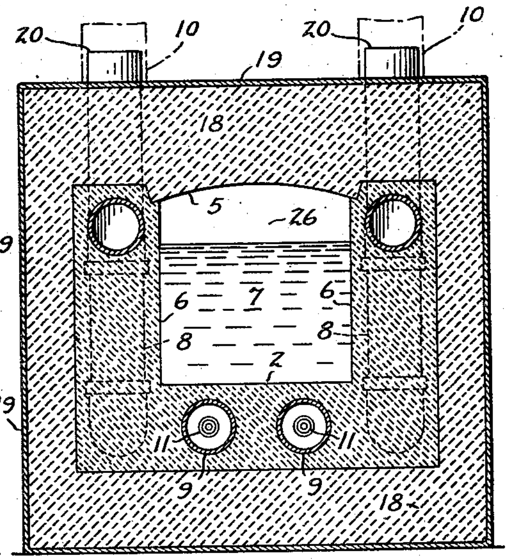

Fig. 5

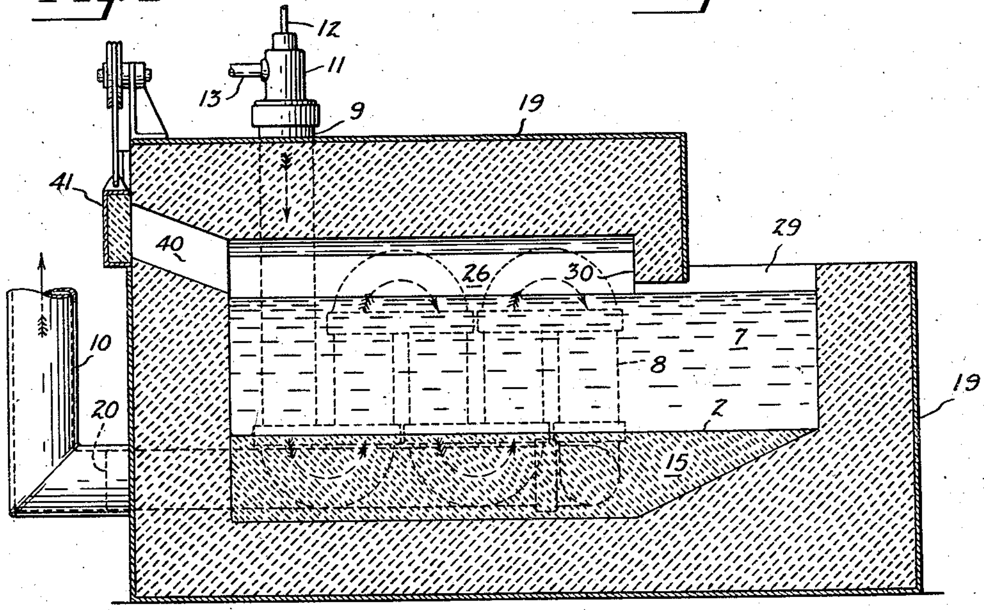

Fig. 6

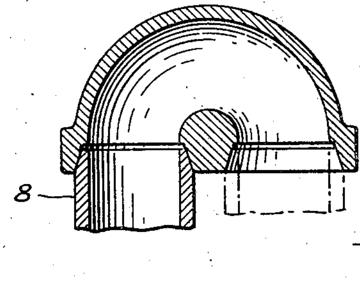

Fig. 7

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MELTING FURNACE

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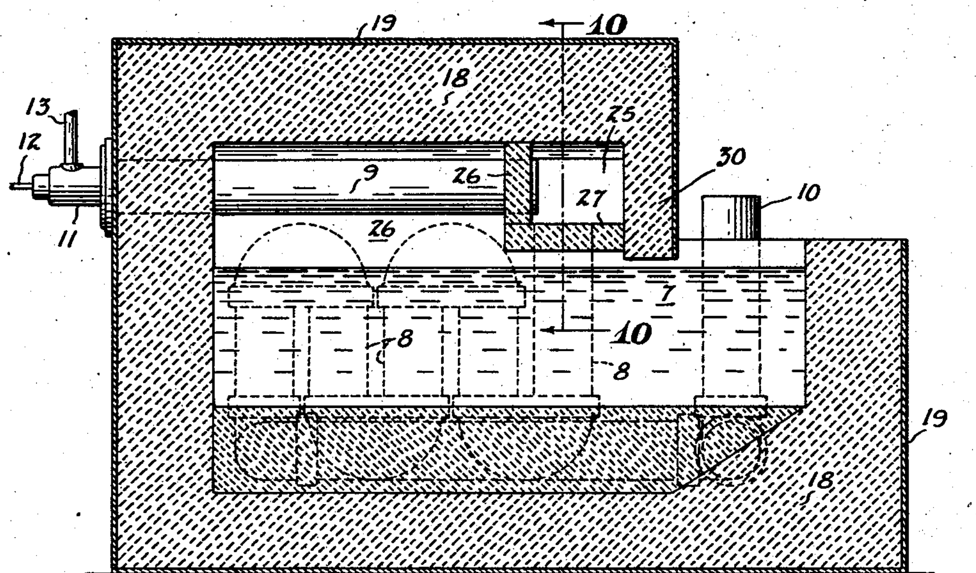

Fig. 8

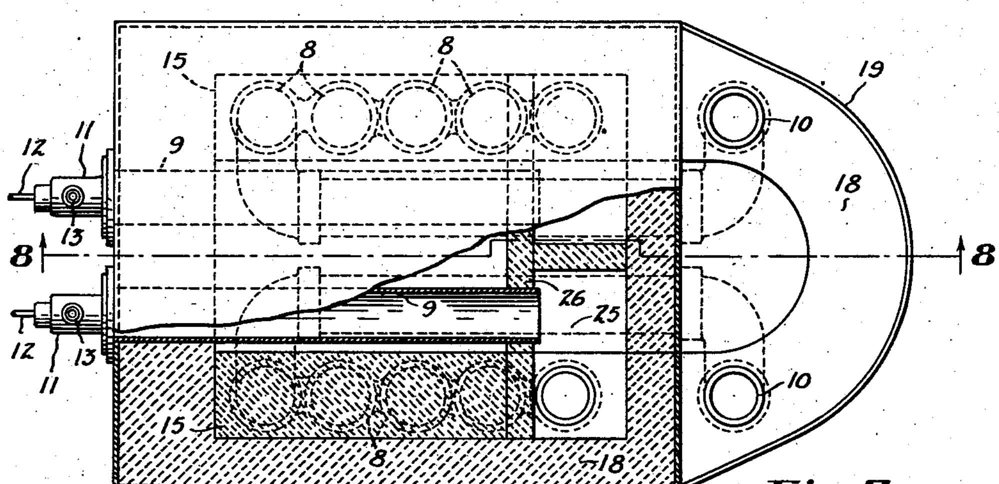

Fig. 9

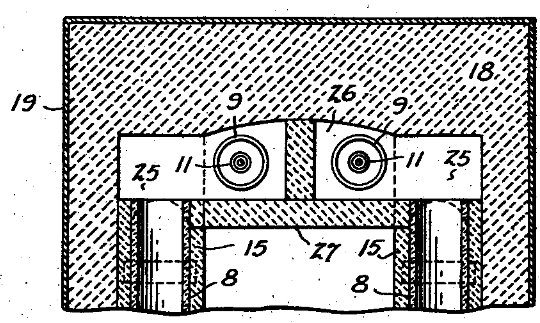

Fig. 10

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UNITED STATES PATENT OFFICE

2,393,306

MELTING FURNACE

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Application May 22, 1943, Serial No. 488,035

5 Claims. (Cl. 266—33)

This application is a continuation-in-part of my prior application, Serial No. 401,770, filed July 10, 1941, Patent No. 2,331,887, October 17, 1943. The invention relates to improvements in melting and holding furnaces for the melting of light alloys, such as aluminum alloys.

Aluminum alloys are generally melted in furnaces of the open-hearth type where the flame comes in direct contact with the surface of the metal. It has been recognized that such contact with the surface of the metal is undesirable for the reason that contamination of the alloy with gaseous materials occurs and substantial loss of the alloying ingredients takes place. Furnaces wherein the alloy is heated solely or substantially entirely by radiation and conduction to the upper surface of the metal are also disadvantageous for the reason that they are relatively inefficient and there is a substantial temperature gradient between the upper and lower surfaces of the metal; this is especially the case with alloys having high reflectivity. The temperature gradient is often as much as 150° F. per foot of molten metal thickness. When there is a gradient in temperature between the upper and lower surfaces of the metal, the alloys produced are also of varying characteristics because the alloying ingredients are more soluble at higher than at lower temperatures.

It has been proposed to overcome some of these difficulties by retaining the heating fluid or hot gases in a closed chamber above the surface of the metal so that heating is solely by radiation from the walls of the chamber. This prevents the hot gases from coming in contact with the surface of the metal, but the differences in the temperatures of the upper and lower surfaces of the metal is not improved. Also, such furnaces using only radiant heat are not considered practical because it takes so long to heat the metal.

In the melting of metals such as lead or tin, or lead alloys, etc., which metals do not appreciably dissolve certain metallic material, e. g. iron, copper and the like, it has also been proposed to provide furnaces wherein the heating takes place through the side walls of a metallic vessel holding the molten metal. Such a furnace or melting pot is illustrated in the Lundt Patent 2,137,693. Furnaces of this type, however, are entirely unsuited for the melting of light metal alloys for the reason that aluminum alloys dissolve metallic constituents with which they come in contact, thereby causing contamination of the alloy and destruction of the metallic furnace walls.

Furnaces have also been proposed for annealing and heat treating metal castings and the like by circulating heating fluid or hot gases through tortuous passageways between a refractory lining and the insulated body portion of the furnace. Such furnaces are entirely unsuitable for the manufacture and melting of light alloys for the reason that unburned hot gases, or even non-combustible gases, will pass right through the porous refractory materials of the linings and contaminate the light alloys being melted to such an extent that they do not produce desirable castings. But such furnaces do have the advantage in that the metal being melted has a more uniform temperature than that which is heated solely by contact between the heating fluid and the upper surface of the metal.

It is an object of the present invention to provide a melting furnace of high efficiency, suitable for melting light alloys, wherein the products of combustion do not contaminate the material being melted, so that a degasifying treatment is unnecessary, and wherein melts of substantially uniform temperature throughout are produced.

It is another object of the present invention to provide a furnace of high efficiency wherein the products of combustion are prevented from contacting the metal and wherein loss of the metal being melted is minimized.

It is another object of the present invention to provide a melting and holding furnace which permits ready access to the molten metal for casting purposes and which utilizes a larger proportion of the heat energy from the fuel than do furnaces heretofore proposed.

It is still another object of the present invention to provide a furnace which prevents the products of combustion from contaminating the alloy being melted and which also has good life and has no metallic portions in contact with the metal.

Other objects will be apparent from the following description of the invention, as illustrated by the drawings in which:

Figure 1 is a vertical sectional view of a furnace embodying the present invention;

Fig. 2 is a plan view, with parts broken away, of the furnace shown in Fig. 1;

Fig. 3 is an elevational view, partly in section, of a portion of a tortuous, tubular conduit in a furnace embodying the present invention;

Fig. 4 is a sectional view on the line 4—4 of Fig. 1;

Fig. 5 is a sectional view on the line 5—5 of Fig. 1;

Fig. 6 is a vertical, longitudinal sectional view of a modified form of furnace embodying the present invention;

Fig. 7 is an elevational view of a portion of a tortuous conduit used in the furnace of Fig. 6;

Fig. 8 is a longitudinal, vertical sectional view of another modified form of furnace embodying the present invention;

Fig. 9 is a plan view, with parts broken away, of the furnace of Fig. 8; and

Fig. 10 is a vertical sectional view through a portion of the furnace shown in Fig. 8, taken on the line 10—10 of Fig. 8.

The furnaces of the present invention have a suitable refractory material, such as silicon carbide, graphite, etc., in contact with the molten metal so that conduction of heat to the molten metal takes place substantially entirely through the refractory material.

Melting furnaces of the present invention have as conductive heating means tortuous tubular heating ducts or passageways in the side walls and preferably also in the bottom of the furnace to conductively heat the metal. Between the tortuous conductive heating tubes and the metal, however, a refractory material such as silicon carbide, graphite, etc., is utilized to prevent the molten metal from making direct contact with the tortuous tubes. This refractory makes contact with the body of the metal and conducts the heat from the tortuous tubular passageways into the body of metal. The refractory lining thus serves as a heat conductor but prevents contact between the solubilizing aluminum or magnesium alloys and the material of the tubes.

The tubes are preferably composed of a refractory metal such as the high temperature-resistant alloys of steel containing nickel and/or chromium, or alloys of nickel. The tubes prevent migration of gaseous material through the refractory. Even though the tubular material has a substantially higher coefficient of expansion, it is surprisingly found that it is possible to utilize a refractory material between the tubes and the metal without causing cracking of the refractory when the tubes are heated. The heat conducted from the tubular passageways may constitute the major portion of the heat utilized in the melting of the metal, but in a preferred modification of the present invention, radiant heating means above the surface of the metal is also utilized.

Referring more particularly to the drawings, in which like parts are indicated by like numerals of reference throughout the several views, the furnaces of the present invention have a melting chamber 1 formed by a bottom wall 2, and walls 3 and 4, a top wall 5 and side walls 6. The bottom wall 2 and portions of the side walls 3 and 4 form a hearth portion 7 to support the molten light alloy.

Conductive heating means, such as gas-impervious tubes 8, are disposed in one or more walls of the melting chamber 1. The tubes 8 may be of a refractory metal, such as steel alloys containing a large amount of nickel, nickel alloys or the like, and they form a gas-impervious tortuous passageway for the passage of hot gases between the burner tube 9, which may be horizontally located beneath the upper surface of the bottom wall 2, and a stack connection 10 which may be open to the atmosphere if desired. The burner tube 9 in the furnace of Figs. 1 and 2 is in the bottom wall of the furnace and one end thereof is suitably connected to a burner 11 having a suitable gas or oil conduit 12 and an air connection 13 to respectively supply fuel and air from suitable sources (not shown).

The tubes 8 and 9 and the molten metal in the hearth portion 7 of the melting chamber 1 are separated by a conductive-type refractory material 15. The material 15 is preferably silicon carbide, graphite, mixtures of silicon carbide and graphite, etc. The conductive material 15 is preferably arranged over the entire bottom and side walls of the furnace, or at least over sufficient area in the bottom and walls of the furnace to overlie the tubular burner tubes 9 and the connecting tubes 8, which form the tortuous tubular heating passages. By forming the more conductive material in the sides or bottom with one or more tapered end portions so that the cross sectional thickness of the material is gradually reduced from the vicinity of the tubes to the edges, greater efficiency in the use of the material is had. The combustion tubes 9 and the connecting tubes 8 are preferably substantially entirely embedded within the conductive refractory material 15.

In order to prevent breakage due to different degrees of expansion between metallic refractory tubes and conductive refractory 15, a small air space may be provided between the tubes 8 and the refractory 15 in the assembly of the furnace. This may be accomplished by coating the tubes 8 and 9 with a combustible material, such for example as a thick starch paste, so as to slightly increase their diameter, and thereafter embedding the coated tubes in the plastic mass of the refractory material 15. Upon use of the furnace, the starch is burned to provide the required room for expansion.

Insulation such as a relatively non-conductive refractory material 18 is provided between the walls of the combustion chamber and the refractory material 15 therein and the outer surfaces of the furnace, which may be of sheet metal 19.

In the modification shown in Figs. 4 to 7, inclusive, the burner tube 9 which connects with the burner 11 and the tortuous passageway formed by the tubes 8 is substantially vertical and is at least partly disposed within the conductive refractory material in the side walls of the hearth portion of the furnace. The stack connection 10 is connected to a horizontal exhaust portion 20 of the tubes 8. Thus, in the modification of Figs. 4 to 7, the hot gases are directed downwardly through the burner tubes 9 in each of the furnace walls, through the respective tortuous passageways formed by the tubes 8 in the side walls of the furnace, and thence through the horizontal exhaust tube 20 in the furnace bottom and the stack connection 10 to the stack or heat exchanger.

By making the connections through the entire passageway between the burner tube 9 and the stack connection 10 substantially impervious to gas, the tendency for formation of gaseous metal is substantially eliminated. Also, by disposing the refractory material 15 between the bath of molten metal on the hearth portion 7 and the tubes 8 and 9, the destructive effects of the molten metal on the tubes 8 and 9 are also eliminated. Since heat is applied through at least the side walls of the furnace, convection currents are set up which I have found maintain the entire bath of metal at substantially uniform temperature. In addition, the efficiency of the furnaces is much higher than the efficiency of the open-hearth furnaces generally in use.

In the modifications of Figs. 8 to 10, one end of each of the burner tubes 9 is connected to a heat-supplying means, burner 11, and the other end is connected through a suitable header or connector 25 to the tortuous passageway formed by the tubes 8 in the side walls. Each of the burner tubes 9 serves as a radiant heating means in the radiant heating chamber 26 above the surface of the metal-retaining portion 7. The radiant heating means may comprise any number of burner tubes 9, substantially gas-impermeably connected to the headers 25, which may be formed by sides 26 and 27 in conjunction with a portion of the walls of the furnace, as illustrated. Usually one or two burner tubes 9 are sufficient for most melting furnaces.

It is generally preferable to have portions of the side walls and the bottom of the furnace extend beyond the upper wall to provide a dipping chamber 29 in communication with the melting chamber. The dipping chamber may be used to charge the alloying ingredients into the furnace as well as to facilitate removal of the molten alloy. The dipping chamber 29 may be substantially entirely separated from the radiant heating portion 26 above the surface of the metal in the melting chamber by a curtain wall 30, which extends from the top of the furnace to almost the surface of the metal in the melting chamber.

Suitable openings, such as the clean-out opening 40 (see Fig. 6) which is controlled by the counterbalanced closure 41, may be provided above the surface of the metal to serve as means for permitting access to the metal on the hearth for cleaning or skimming the upper surface thereof, etc. If desired the curtain wall or a portion 30a (Fig. 1) thereof may be movable and serve as the means for permitting access to the surface of the metal in the hearth portion 7 of the melting chamber. The portion 30a may be suitably carried by guides and may be connected to the counterweight 42 by a connector 44 adapted to travel over the pulley 43.

While the heating tubes 8 and the burner tubes 9 are preferably of refractory metal, as above-designated, it is possible to utilize especially formed silicon carbide tubes which have low impermeability to gases. The tubes 8 may be round or square, or of any desired cross sectional shape.

Although several embodiments of the invention have been herein shown and described, it will be understood that numerous modifications of the construction shown may be resorted to without departing from the spirit of this invention as defined in the appended claims.

What I claim is:

1. A melting furnace for melting light alloys comprising end walls, side walls, bottom and top portions, which together form a melting chamber having a hearth portion substantially entirely of refractory material to receive and support the metal, conductive heating means in said bottom and side walls of the furnace, said conductive heating means comprising a plurality of refractory metal tubes connected together to form a tortuous, substantially gas-impervious passageway, heat conductive refractory surrounding said metal tubes and between them and the surfaces of said bottom and side walls adapted to contact the metal in the melting chamber, said conductive refractory closely overlying said metal tubes, burners having one end thereof connected to said bottom tubes and to said connecting tortuous passageways for supplying heating fluid therethrough, the end of said tortuous passageway which is not connected to said bottom tubes and burners being connected to a stack.

2. A melting furnace for melting light alloys comprising end walls, side walls, bottom and top portions, which together form a melting chamber having a hearth portion substantially entirely of refractory material to receive and support the metal, conductive heating means in said bottom and side walls of the furnace, said conductive heating means comprising a plurality of refractory metal tubes connected together to form a tortuous, substantially gas-impervious passageway, silicon carbide surrounding said metal tubes and between them and the surfaces of said bottom and side walls adapted to contact the metal in the melting chamber, the silicon carbide closely overlying said metal tubes, a burner for supplying heat to said furnace and a connecting tube connecting said burner to said bottom tubes and said tortuous passageway, the end of said passageway remote from the burner being connected to a stack.

3. A melting furnace for melting light alloys comprising end walls, side walls, bottom and top portions, which together form a melting chamber having a hearth portion substantially entirely of refractory material to receive and support the metal, conductive heating means in said bottom and side walls of the furnace, said conductive heating means comprising a plurality of refractory metal tubes connected together to form a tortuous, substantially gas-impervious passageway, heat conductive refractory surrounding said metal tubes and between them and the surfaces of said bottom and side walls and adapted to contact the metal in the melting chamber, said heat conductive refractory closely overlying said metal tubes, a burner for supplying heat to said furnace and a connecting tube connecting said burner to said bottom tubes and tortuous passageway for supplying heating fluid thereto, said connecting tube being substantially vertically disposed in said heat conductive refractory in a side wall portion of the furnace, all portions of said walls in contact with the metal in the melting chamber being of a refractory material, whereby the solubilizing effect of said metal on said tubes of the conductive heating means is eliminated, the end of said passageway remote from the burner being connected to a stack.

4. A melting furnace for melting light alloys comprising end walls, side walls, bottom and top portions, which together form a melting chamber having a hearth portion substantially entirely of refractory material to receive and support the metal, conductive heating means in said bottom and side walls of the furnace, said conductive heating means comprising a plurality of refractory metal tubes connected together to form a tortuous, substantially gas-impervious passageway, heat conductive refractory surrounding said metal tubes and between them and the surfaces of said bottom and side walls and adapted to contact the metal in the melting chamber, said heat conductive refractory closely overlying said metal tubes, a burner for supplying heat to said furnace and a connecting tube connecting said burner to said bottom tubes and tortuous passageway for supplying heating fluid thereto, said connecting tube being substantially horizontally disposed in said heat conductive refractory in the bottom portion of the furnace, all portions of said walls in contact with the metal in the melting cham-

ber being of a refractory material, whereby the solubilizing effect of said metal on said tubes of the conductive heating means is eliminated, the end of said passageway remote from the burner being connected to a stack.

5. A melting furnace for melting light alloys comprising end walls, side walls, bottom and top portions, which together form a melting chamber having a hearth portion substantially entirely of refractory material to receive and support the metal, conductive heating means in said bottom and side walls of the furnace, said conductive heating means comprising a plurality of refractory metal tubes connected together to form a tortuous, substantially gas-impervious passageway, heat conductive refractory surrounding said metal tubes and between them and the surfaces of said bottom and side walls and adapted to contact the metal in the melting chamber, said heat conductive refractory closely overlying said metal tubes, a burner for supplying heat to said furnace and a connecting tube connecting said burner to said bottom tubes and tortuous passageway for supplying heating fluid thereto, said connecting tube being disposed above the upper surface of the metal in the melting chamber of said furnace, all portions of said walls in contact with the metal in the melting chamber being of a refractory material, whereby the solubilizing effect of said metal on said tubes of the conductive heating means is eliminated, the end of said passageway remote from the burner being connected to a stack.

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