May 10, 1927. 1,628,375

M. UNGER

APPARATUS FOR REFINING METALS

Filed Dec. 31, 1925

Fig. 1.

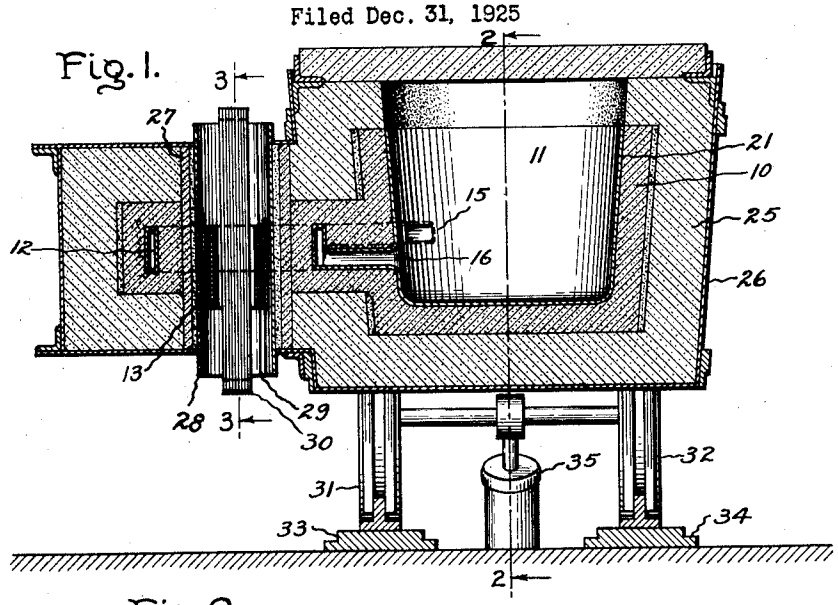


Fig. 2.

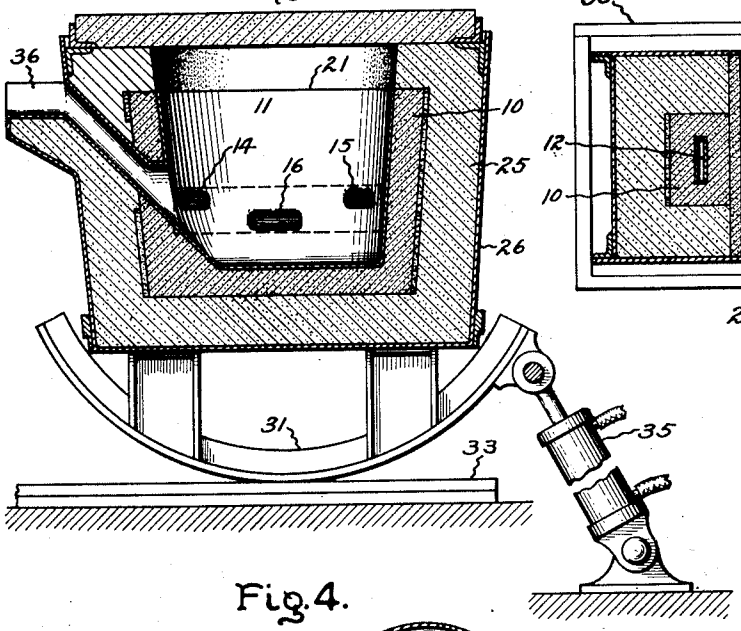


Fig. 3.

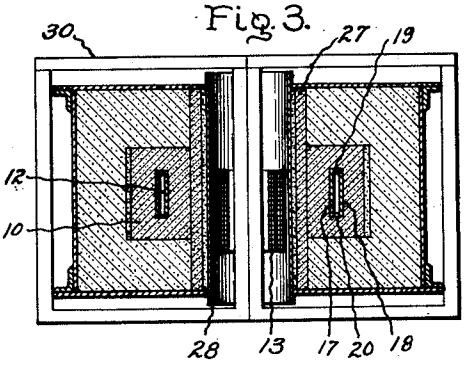


Fig. 5.

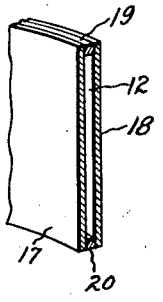
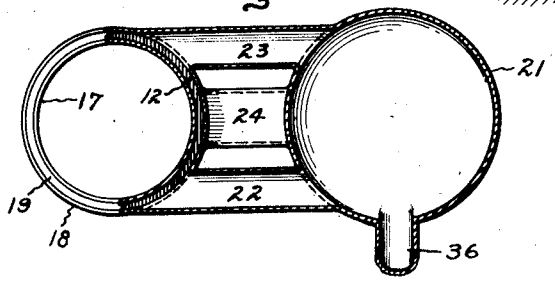


Fig. 4.



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UNITED STATES PATENT OFFICE.

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APPARATUS FOR REFINING METALS.

Application filed December 31, 1925. Serial No. 78,667.

My invention relates to apparatus for refining metals such, for example, as the making of alloys, and has for its object the provision of apparatus whereby the metal may be purified and its composition controlled.

More particularly my invention relates to the production and refining of silicon steel although it obviously has other applications. One of the greatest difficulties incident to the making of silicon steel is the regulation or control of the silicon content so that the product may be of uniform quality as well as having the desired silicon content. In order to do this with certainty it is necessary to hold the steel in a molten condition for a sufficient interval of time to enable the steel to be analyzed to determine the amount of silicon and the amount of silicon regulated if necessary. Furthermore, molten steel as received from the open hearth furnace or the Bessemer converter has been found to contain a considerable amount of gas which it has absorbed. The volume of this absorbed gas at atmospheric pressure may be many times the volume of the steel by which it is absorbed. It is a further object of my invention to provide means whereby the steel may be maintained molten for a considerable interval to permit this gas to escape.

In carrying out my invention in one form I reduce the molten steel into a ladle in which it remains for a considerable interval to provide for the escape of gas and for analysis. Associated with the ladle I have provided inductive means whereby the steel may be heated to maintain its temperature or give it any desired superheat, the inductive means being also so arranged as to produce a circulation, and thereby thorough mixing, of the molten metal by electromagnetic repulsion.

For a more complete understanding of my invention reference should be had to the accompanying drawing in which Fig. 1 is a vertical sectional view of apparatus for refining silicon steel embodying my invention; Fig. 2 is a sectional view along the line 2—2 of Fig. 1 looking in the direction of the arrows; Fig. 3 is a sectional view along the line 3—3 of Fig. 1 looking in the direction of the arrows; while Figs. 4 and 5 are views showing details of construction.

Referring to the drawing, in one embodiment of my invention I provide a ladle in which the molten steel is introduced and maintained for a considerable interval for refining. This ladle comprises an inner heat insulated crucible 10 which is shaped to provide a reservoir 11 for the metal and an annular channel 12 in which a portion of the molten metal forms a closed secondary for a primary winding 13 associated therewith. The annular channel is arranged in a horizontal position, i. e., with its axis substantially vertical at one side of the reservoir 11 a slight distance above the bottom of the reservoir. It is connected with the reservoir through three ducts provided in the refractory material of the crucible, two of these ducts 14 and 15 connecting the upper axial end of the channel with the reservoir and the third duct 16 connecting the lower axial end of the channel with the reservoir. The two ducts 14 and 15 are each substantially one half the cross sectional area of the duct 16 and are spaced apart laterally, i. e., in a direction at right angles to the axis of the channel, so as to communicate at opposite sides of the upper end of the channel. The lower duct 16 is situated laterally substantially midway between the two upper ducts, it being spaced axially with respect to the other two ducts as previously noted.

The crucible 10 is made from a suitable refractory material such as a mixture of fused magnesia, calcined magnesia, and a binder, such as magnesium sulphate, as described and claimed in Patent No. 1,444,527 to Scharschu dated February 6, 1925. These materials are mixed in granulated or powdered form, sufficient water being added to make a plastic mixture and the mass thus formed is rammed in place around a suitable core which defines the reservoir, the channel and the ducts. Preferably a hollow metallic core is used which can subsequently be filled with molten steel and melted out. As shown, the core for the annular channel consists of two concentric tubes 17 and 18 which are secured in spaced relation by means of steel rings 19 and 20 at their ends, the tubes and rings being welded together to form a hollow annular member. A steel receptacle-like member 21 is provided as a core for the reservoir and the annular core is connected to it by means of steel tubes

22, 23 and 24 which define the ducts. The ends of the tubes are butted or welded to the outer tube 18 and the receptacle 21, and communicate with the interiors thereof as indicated in Fig. 4.

Surrounding the crucible 10 is a layer of suitable refractory heat insulating material 25, the whole being enclosed by an outer metallic casing 26. In constructing the ladle the insulating material 25 is built up inside the casing 26, sufficient space being left for the crucible 10. The bottom layer of the crucible is then rammed in place after which the steel core for the channel, ducts and reservoir is placed on this bottom layer and the ramming in of the crucible continued until the desired thickness of material has been formed around the core. The heat insulating material around the upper portions of the crucible is then filled in and the remaining upper portions of the casing secured in place.

An aperture for the primary winding 13 is provided by means of a heat refractory cylinder 27, made of high grade fire clay, preferably having a high alumina content. This refractory cylinder 27 effectively protects the primary winding from contact with the molten metal in case of a leak through the rammed crucible 10. A further protection is provided by a metallic tube 28 inserted inside the refractory tube 27, this tube 28 being split longitudinally at 29 to prevent its acting as a closed secondary for the primary winding. As shown, the primary winding is mounted on a three legged core 30, the middle leg on which the primary winding is secured passing through the metallic tube 28.

The ladle is mounted on suitable rockers 31 and 32 which rest on tracks 33 and 34, and it may be tilted by means of a suitable hydraulic motor 35 in order to pour the metal from the spout 36.

After the crucible 10 is rammed it is allowed to dry, this operation being completed by the application of heat. The drying or burning operation is carried out by means of suitable blow torches which are applied to the inner wall of the hollow core member, the flame of the torch being carried around through the hollow portions of the core member forming the ducts 14, 15 and 16, and the annular channel 12. The annular portion of the core member may be further heated by means of currents induced in it from the primary winding. During this drying or burning operation the hollow core member serves to protect the inner surface of the rammed material from injury by reason of direct contact with the flame of the blow torch and also serves to support the material. The material has a stage of great weakness during the drying or burning operation so that it might crumble if it were unsupported. The hollow core member thus makes it possible to apply heat to dry the rammed material and at the same time it acts as a support for the material.

After the crucible has been dried, the ladle may be put in operation by pouring in a charge of molten steel which fills the hollow core member defining the channel and the ducts. The primary winding is then energized whereby heating currents are induced in the section of the core forming the channel and in the molten metal contained therein. The core member is thus melted and mixed with the charge.

In utilizing the ladle the molten steel may be introduced either from an open hearth furnace or Bessemer converter, or an electric furnace, a relatively small quantity being introduced at each time. For example, with a 24 ton ladle the ladle will be initially filled and 8 tons poured at the end of the refining operation leaving 16 tons, and thereafter 8 tons will be added to the ladle. The steel is left in this ladle for a considerable interval, for example, three or four hours during which time the absorbed gases are caused to escape and the composition of the metal can be determined and regulated as desired.

During this period the metal will be maintained molten or superheated to a desired temperature by means of heat generated by the induced currents in the portion of the metal in the annular channel, these currents being induced by the primary winding. Furthermore, the primary winding is so associated with the molten metal in the channel that a circulation is produced by electromagnetic repulsion. For example, the primary winding may be displaced axially downward so as to exert an upward repulsive force. In other words, the primary winding as shown in the drawing has its lower end projecting below the secondary channel so that its axial center is below the axial center of the secondary. This disposition of the primary winding results in upwardly directing the repulsive forces acting on the molten metal in the channel, these forces being cumulative in an upward direction so that the metal in the upper axial end of the secondary channel is under a greater pressure than that at the lower end. This causes the metal to flow out of the secondary channel into the reservoir through the upper ducts 14 and 15, a return flow of molten metal from the reservoir to the channel through the duct 16 being thereby produced. The circulation of the molten metal thoroughly mixes it as well as distributing heat generated in the channel. The mixing effect produced by the inductive heating apparatus is of great importance since the molten metal is maintained of uniform quality and any additional metal such as silicon

added to raise the silicon content, is thoroughly mixed with the metal already in the crucible.

In order to provide for the rapid escape of the gases from the molten metal, the metal is preferably allowed to cool almost to the point of solidification after which its temperature is raised quickly for pouring.

While I have described my invention as embodied in concrete form and as operating in a specific manner in accordance with the provisions of the patent statutes, it should be understood that I do not limit my invention thereto, since various modifications thereof will suggest themselves to those skilled in the art without departing from the spirit of my invention, the scope of which is set forth in the annexed claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A crucible for molten metal comprising refractory material forming a reservoir for the charge and an annular channel in which a portion of the charge forms a closed secondary, said refractory material providing two openings spaced in a direction at right angles to the axis of said channel connecting one end of said channel with said reservoir, and a single opening connecting the opposite end of said channel with said reservoir, and a primary winding arranged to induce heating currents in said secondary and produce circulation of molten charge by electromagnetic repulsion.

2. A mixing and refining crucible for molten metal comprising refractory material forming a reservoir for the charge and an annular channel having its axis arranged substantially vertical in which a portion of the charge forms a closed secondary, said refractory material providing two laterally spaced openings connecting the upper end of said secondary with said reservoir at lateral extremities of said channel and reservoir and a single opening connecting the lower end of said channel with said reservoir at a point laterally intermediate said upper openings, and a primary winding arranged to induce heating currents in said secondary and produce circulation of molten charge between said channel and reservoir by electromagnetic repulsion.

3. Electric induction heating apparatus comprising heat refractory material forming a reservoir for a charge and an annular channel having its axis arranged substantially vertical in which a portion of the charge forms a closed secondary, said refractory material providing spaced openings connecting the upper end of said channel with said reservoir and a single opening connecting the lower end of said channel with said reservoir, and a primary winding inserted in said secondary, said primary winding being axially displaced in a downward direction with respect to said channel whereby a magnetic repulsive force is exerted on said secondary in an upward direction to produce a circulation of molten charge between said secondary and said reservoir.

In witness whereof, I have hereunto set my hand this 28th day of December, 1925.

MAGNUS UNGER.