May 18, 1937. F. E. MILLER 2,080,625

APPARATUS FOR PURIFYING AND REFINING MOLTEN METALS

Filed Sept. 19, 1934 2 Sheets-Sheet 1

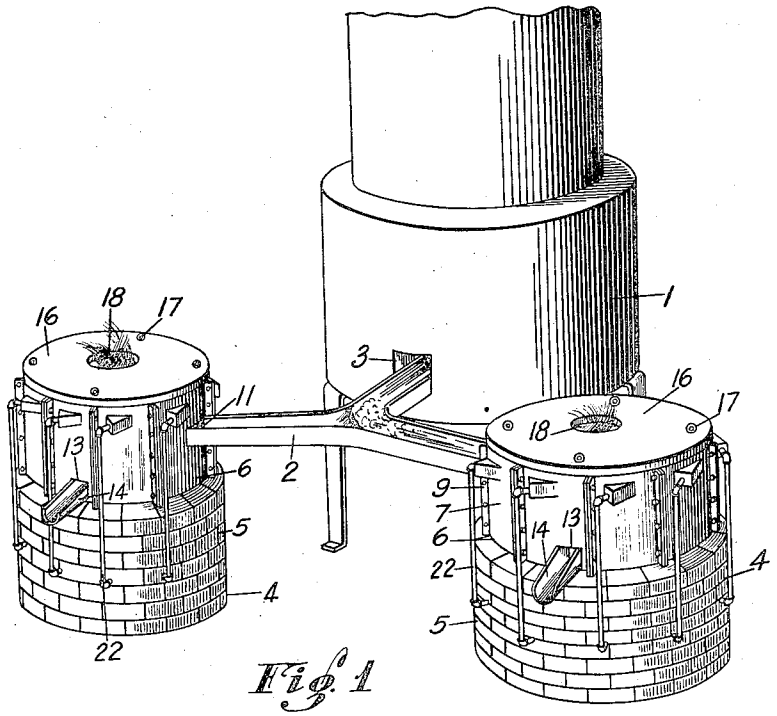


Fig. 1

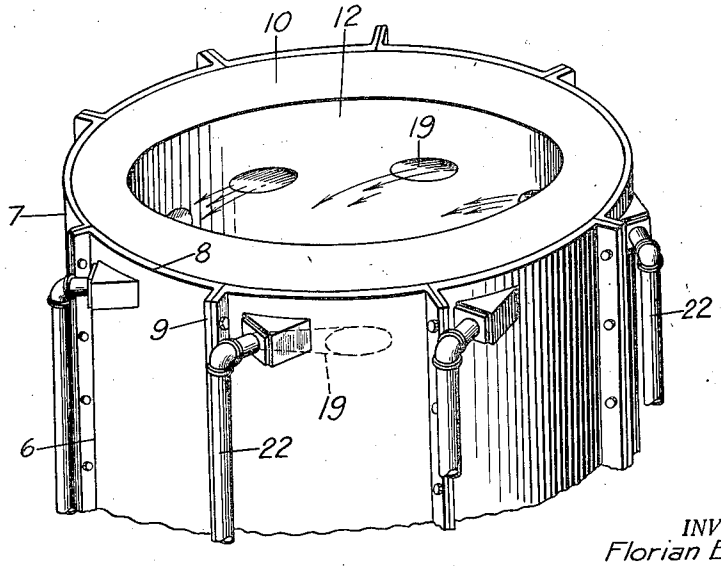


Fig. 2

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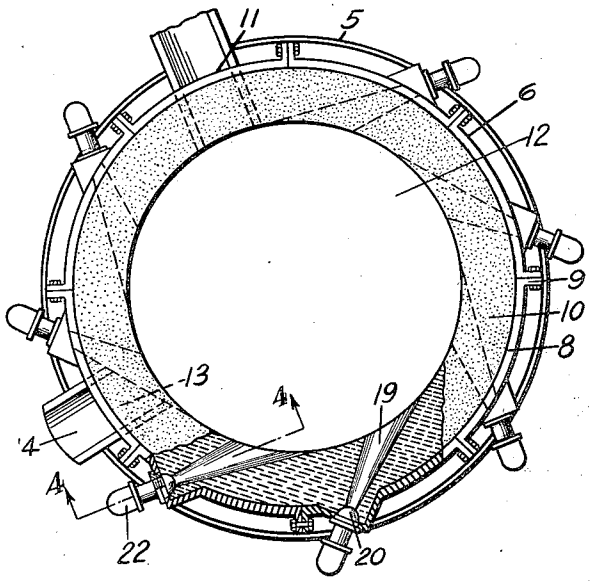


Fig. 3

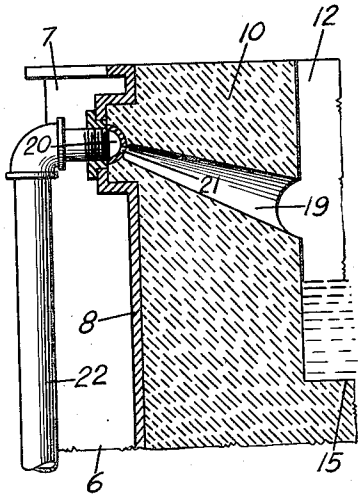


Fig. 4

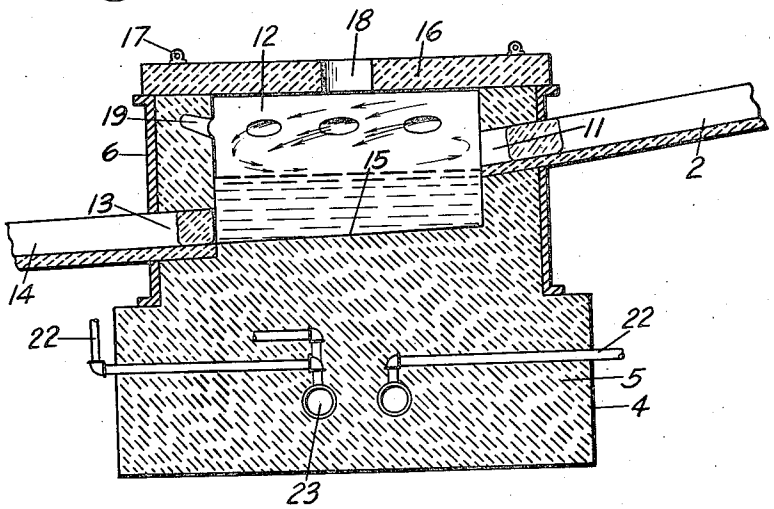


Fig. 5

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APPARATUS FOR PURIFYING AND REFINING MOLTEN METALS

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Application September 19, 1934, Serial No. 744,696

5 Claims. (Cl. 266—34)

My invention relates to apparatus for purifying and refining molten metals. It has to do, more particularly, with apparatus for purifying and refining molten metals which is of such a nature that it is possible to produce a metal with a controlled analysis and at a low cost.

The only satisfactory way for producing metals with a controlled analysis, in the past, has been by the use of an electric furnace. However, it is well known that the cost of operating an electric furnace is very great. This is especially true when the furnace is located in a foundry where there is insufficient production to keep the furnace operating at full capacity at all times.

Because of the excessive operating cost of electric furnaces, other methods are commonly used in the art in an attempt to produce metals or alloys of a satisfactory nature. However, with these methods it is impossible to remove the impurities from the metals and to control the analysis thereof with any degree of success comparable to that obtainable with an electric furnace.

In some few cases in the past when not using an electric furnace, the metal has been melted in a cupola or other ore reducing furnace and then run into a second furnace which is provided with one or two burners for maintaining, but not increasing, the temperature of the metal so that it could subsequently be poured into molds. In this second furnace, the molten iron is sometimes treated with a substance, such as sodium carbonate, which desulphurizes the iron. However, since the temperature of the molten iron is not increased and the iron in the furnace is not agitated to cause the sodium carbonate to thoroughly mix therewith, it has been impossible to reduce the sulphur content as low as desirable. Also, with such a method, it has been impossible to reduce the carbon content and to remove other impurities to a desirable low percentage.

In alloying the molten iron with other metals, it has been customary to merely add the metals to be alloyed with the iron by dropping the alloys in the ladle in which the molten iron has been poured or dropping them in the molten iron in the cupola. However, with this method, the alloys are not thoroughly mixed with the iron and the resulting metal produced is not homogeneous throughout. As soon as the alloy metals are added to the molten iron, its temperature is suddenly decreased. Because of this rapid decrease in temperature and because the alloy metals are not thoroughly mixed with the molten iron by proper agitation, the resulting metal alloy does not have the desired uniform characteristics.

There have been other methods and devices provided in the past for obtaining metal with the impurities removed therefrom and with a controlled analysis and at a low cost. However, these methods and devices have not proved practical and are not used commercially. Up to the present time, the most practical device for this purpose is the electric furnace. However, as previously stated, the cost of operating an electric furnace is excessive as compared to the cost of operation of other furnaces such as gas furnaces.

One of the objects of my invention is to provide apparatus for purifying and refining molten metals which is of such a nature that it is possible to produce a metal with the impurities therein reduced to a very low degree and with a controlled analysis.

Another object of my invention is to provide apparatus of the type indicated whereby it is possible to obtain a metal of the highest quality at a very low cost.

Another object of my invention is to provide apparatus which is of a very simple nature and which may be used for purifying and refining molten metal in a simple and economical manner.

The method which I preferably use contemplates the production of a metal of the desired characteristics by first producing in a cupola or similar apparatus, the molten iron. The iron is then conducted to an independent furnace where the impurities are removed and other metals may be alloyed therewith.

The independent furnace embodies a cylindrical chamber into which the molten iron is run. A series of tuyères are arranged in the walls of this furnace above the layer of the molten iron. These tuyères are preferably arranged chordal to the annular wall of the said chamber and are directed downwardly so that they will discharge hot products of combustion on the surface of the molten metal and under considerable pressure. This causes a vigorous swirling action to be imparted to the molten metal in the chamber and also causes agitation of the metal in such a manner that the upper and lower portions of the layer thereof will be constantly interchanging. Consequently, the entire mass of the molten metal will be thoroughly mixed and the temperature of the entire mass will be uniform.

When the molten iron is passed from the cupola to the independent furnace having the tuyères disposed in the wall thereof, its temperature is increased considerably after it has been in the furnace a short time. The temperature of the furnace is preferably considerably greater than

the temperature of the molten iron at the time it is charged thereinto. Thus, when the molten iron runs into the furnace, its temperature is increased and it is subjected to a vigorous swirling action and vigorous agitation. I have found that the increase in temperature of the molten iron and the vigorous agitation will reduce the percentages of impurities therein to a very low degree. Also, it is possible to add metals to the molten iron in the furnace and they will be alloyed with the iron in a very efficient manner. Because the temperature of the molten iron is raised and because of the swirling and agitation of the molten iron, the alloy metals will be thoroughly mixed therewith and a homogeneous mass will be produced.

The apparatus which I preferably use is illustrated in the accompanying drawings wherein similar characters of reference designate corresponding parts and wherein:

Figure 1 is a perspective view of a cupola associated with two of the furnaces which I have devised for removing the impurities from the molten iron and for use in alloying other metals with the iron.

Figure 2 is a perspective view of a portion of one of the furnaces illustrated in Figure 1 and showing the tuyères formed in the wall thereof, the top of the furnace being removed.

Figure 3 is a plan view of the furnace shown in Figure 2 and illustrating how the tuyères are disposed relative to the annular wall of the chamber therein.

Figure 4 is a detail in section illustrating the type of burner which I preferably use and showing it in position at the outer end of one of the tuyère openings.

Figure 5 is a vertical section taken through the furnace but being more or less diagrammatic.

With reference to the drawings, and particularly to Figure 1, I have illustrated diagrammatically a cupola 1 which may be of any suitable type. The iron is adapted to be melted in this cupola 1 in the usual manner. An inclined trough 2 leads from within the cupola 1 through a tap hole 3. This trough is shown as having branches leading to each of two furnaces 4. However, either a single furnace or any desired number of these furnaces may be provided.

When the iron is being melted in the cupola 1, the opening 3 will be plugged so that the molten iron will not flow therefrom through the trough 2. However, when the plug is removed from the opening 3, the molten iron will flow from within the cupola through the trough 2 to each of the furnaces 4.

Each of the furnaces 4 comprises a base 5 composed of fire-brick or other suitable refractory material. The base 5 is of cylindrical form and supports a substantially cylindrical container 6 which is to receive the molten iron.

This container 6 embodies an outer annular shell 7 which may be formed of a plurality of steel sheets 8 suitably bolted together at their edges as at 9. This shell 7 is lined with an annular wall 10 of refractory material which is comparatively thick. An inlet opening 11 is provided in the wall of the container 6 and the trough 2 extends therethrough. Thus, the molten iron may pass through the trough 2 into the cylindrical chamber 12 formed within the container 6.

A tap hole 13 is provided in the wall of the container 6 and an inclined spout 14 leads therefrom. The inlet opening 11 will be disposed above the layer of the molten metal in the chamber 12 as indicated in Figure 5. The tap hole 13 will be disposed at the bottom of the chamber 12. The bottom 15 of the chamber 12 is sloped from the point where the opening 11 is disposed in all directions to the point where the tap hole 13 is disposed as indicated in Figure 5. During operation of the furnace 4, both the opening 11 and the tap hole 13 will be plugged. When it is desired to charge the molten iron into the chamber 12 of the furnace, the plug in opening 11 will be removed but the plug in tap hole 13 will be in position. When it is desired to remove the molten metal from the chamber 12, the plug in tap hole 13 will be removed and all of the metal will flow from the chamber 12 through the spout 14.

The upper end of the chamber 12 is closed by a cover 16. This cover is comparatively thick and heavy and is preferably made of refractory material. It is of sufficient weight to insure that it will not be displaced by the pressure generated in chamber 12, in a manner to be subsequently described. The cover 16 is provided with a plurality of loops 17 by which it may be removed and replaced with the aid of suitable tools. Substantially at the center of the cover 16 and at the center of the chamber 12, an opening 18 is formed in the cover. This opening 18 permits the escape from the chamber 12 of impurities removed from the molten metal by my process. Also, it provides an opening into the chamber 12 through which other metals may be dropped so that they will alloy with the iron.

In order to raise the temperature of the molten iron after it enters the chamber 12, to remove impurities from the iron, and if any metals are alloyed therewith, to insure thorough mixing thereof with the iron, I provide a series of tuyères 19 formed in the wall of the chamber 12. These tuyères, as indicated in Figure 3, are spaced around the wall of chamber 12. I have shown seven of these tuyères although any suitable number may be provided depending on the diameter of chamber 12. They extend at an angle into chamber 12 and are disposed chordal with relation to the annular inner wall of this chamber, and are so arranged that if the longitudinal center lines of these tuyères were continued, the center lines of adjacent tuyères would intersect with each other. The tuyères 19 are further directed downwardly at an angle. Their lower ends are spaced above the top surface of the layer of molten metal in the chamber 12 as indicated in Figure 4.

As shown in Figure 4, the tuyères 19 are wider at their inner or lower ends than they are at their outer or upper ends. At the extreme outer end of each of the tuyères 19, a burner 20 is disposed. This burner is a type that will burn gas although other fluid or pulverized fuels may be used. The burner 20 is preferably of the "button" type. It is set in the refractory liner 10 as indicated in this figure so that it will not be injured by excessive heat around its outer surface. This type of burner is more economical to use and better combustion can be obtained by using it. The burner 20 is provided with a small opening 21 which is formed off-center and through which the gas and air mixture issues. Because the burners 20 are disposed in the outer ends of the tuyères 19 and because the tuyères are comparatively long, complete combustion will occur within these tuyères. Thus the combustion takes place inside the tuyères and not in the chamber 12 and, consequently, more heat units are obtained.

A pipe 22 leads to each of the burners 20, and is adapted to conduct a suitable mixture of air and gas thereto. This mixture of air and gas will be under considerable pressure. The pipes 22 are arranged in two sets, each set being connected to a separate manifold 23. Consequently, the burners are arranged in two sets. This facilitates lighting of the burners since one set may be ignited first and the other set later, thus reducing danger of explosion. Also, when the molten metal has been raised to a predetermined temperature, one set of the burners may be rendered inoperative if desired.

In using my apparatus, the iron is preferably first melted in the cupola 1. The plug is then removed from the tap hole 3 to allow the molten iron to flow from the cupola through the trough 2. The plugs are also removed from the inlet openings 11 of the furnaces 4 to permit the molten iron to flow into the chamber 12 of each furnace. At the time the molten iron leaves the cupola, it has a temperature of from 2500° to 2600° F. Each of the furnaces 4 preferably has been operating a considerable length of time before the molten iron is discharged thereinto so that its chamber will have a temperature which is higher than that of the molten iron.

The layer of molten iron in the furnace 4 is preferably comparatively shallow so that the tuyère members will easily cause swirling of the entire mass of molten metal in the chamber 12. When a charge of molten iron is in the chamber 12, the inlet opening 11 is plugged. The cover 16 will be in place over the upper end of the chamber 12.

The hot products of combustion which are discharged from the tuyère members in directions chordal to the annular wall of chamber 12 and which are discharged downwardly with considerable force against the upper surface of the layer of molten metal, cause the entire mass of molten metal to swirl around in the chamber 12. Furthermore, because the hot products of combustion are directed downwardly at an angle against the molten metal, the metal will be agitated in such a manner that the upper and lower portions of the layer thereof will be constantly interchanging. The vigorous swirling action and the constant agitation cause the entire mass of metal to have a uniform temperature. Also, the swirling action and agitation cause various impurities to be effectively removed from the metal.

It will be apparent that the hot products of combustion will strike the surface of the metal adjacent the peripheral wall of the chamber 12. Because the hot products of combustion are under pressure and the layer of molten metal is comparatively shallow, the entire mass of metal will be swirled around in the chamber 12. Considerable pressure will be built up in the chamber 12 between the surface of the metal and the lower surface of the cover 16. However, the opening 18 at the center of the cover will permit escape of part of the hot products of combustion under considerable pressure. This will cause the impurities to be blown from the chamber 12 and to be discharged into the atmosphere.

The furnace is operated for a considerable length of time so that various impurities in the iron will be removed to a very low percentage. I preferably increase the temperature of the molten iron to approximately 2950° F. in order that all the impurities will be reduced to a very low percentage. The temperature of the molten iron should not be increased to 3000° F. inasmuch as this is the oxidation point of the iron. I have found that by increasing the temperature of the molten iron and subjecting the metal to the swirling action and agitation, the impurities may be removed very effectively. For example, I have found that with this method, it is possible to reduce the carbon content of the iron to a low percentage of from 2.50% to 2.90%. The sulphur content is reduced by dropping sodium carbonate or other desulphurizing agents through the opening 18 into the swirling mass of molten iron. Since the temperature of the molten iron has been increased and since the swirling action will cause the sodium carbonate to thoroughly mix with the molten iron, it is possible to reduce the sulphur content to a much lower degree than has been possible heretofore. In the past, it has only been possible to reduce the sulphur content to about .03%. However, with my method, I have been able to reduce the sulphur content to .02% or lower.

Apparently because the opening 18 is provided in the center of the cover and consequently the pressure on the center of the layer of molten metal is less than the pressure on the layer of metal towards the periphery of the chamber, the carbon, sulphur and other impurities rise from the mass of metal at this central point. As previously stated, the hot products of combustion under considerable pressure escape through the opening 18. Consequently, the impurities, such as carbon, sulphur, and other gases which escape from the center of the molten mass, will be blown upwardly through the opening 18 by the stream of fluid rushing through this opening and discharged into the atmosphere. Also, any dross or slag which collects at the center of the molten mass on the upper surface thereof will be blown upwardly through the opening 18 and thrown in all directions.

Although I have stated that this method removes carbon, sulphur and slag from the iron, various other impurities also are removed from the iron. The longer the furnace is operated, the greater will be the percentage of impurities removed from the molten iron.

In the event that it is desired to alloy other metals with the iron, they may be dropped through the opening 18 into the molten mass. Because of the fact that the mass of iron will have a high temperature and is constantly subjected to a swirling action and to vigorous agitation, the alloy metals will be thoroughly mixed with the iron. A homogeneous molten mass of metal will be produced. Furthermore, because of the plurality of tuyère members and the arrangement thereof, when the alloy metals are added to the molten iron, the temperature thereof will not be reduced to any considerable extent. If it is reduced slightly, it will quickly be brought to a high temperature again.

It will be apparent from the above description that I have provided apparatus for purifying and refining molten metals having many desirable characteristics. With this apparatus, it is possible to produce a metal with a controlled analysis and with the impurities therein reduced to a much lower percentage than is possible with prior art methods. With my apparatus it is possible to obtain the same results obtained by the use of an electric furnace but at a much lower cost. By raising the temperature of a molten iron and subjecting the entire mass thereof to

the constant swirling and agitation, it is possible to effectively remove the impurities therefrom or to effectively alloy other metals therewith.

The apparatus which I have provided is of a very simple nature and is very efficient and economical in operation. The burners are set in the refractory liner so that they will not be subjected to intense heat. Furthermore, the burners are so arranged relative to the tuyères that complete combustion occurs in the tuyères thereby rendering the furnace more efficient. By arranging the burners in two sets as described, added safety is obtained and it is possible to render one set inoperative after the temperature of the metals has been raised to the desired extent. Thereafter one set of burners may be used for maintaining the temperature, if desired. Consequently, operation of the furnace is made more economical.

Having thus described my invention, what I claim is:

1. Apparatus for purifying and refining molten metal comprising a chamber in which a layer of metal is to be disposed and which is of substantially cylindrical form, said chamber being lined with refractory material and having a substantially flat bottom which is inclined towards a tap hole so that the molten metal will run from the chamber when the tap hole is open, a plurality of tuyère members disposed wholly within the refractory liner and adapted to direct fluid under pressure on the surface of the molten metal to cause swirling of the entire layer of molten metal in said chamber, said tuyère members being directed downwardly at an angle and being disposed in directions chordal to the annular wall of said chamber, the lower ends of said tuyère members being so disposed that they will be above the upper surface of the layer of metal placed in said chamber, each of said tuyère members being provided with a burner having its tip disposed substantially at the outer end thereof so that substantially complete combustion will occur within the tuyère member, said burners being arranged in a plurality of independent sets, a cover for substantially closing the upper end of said chamber, said cover having a comparatively small opening therein substantially at the center of said chamber which is continuously open during the discharge of hot products of combustion under pressure on the molten metal to permit the hot products to escape and to blow out the impurities removed from said metal.

2. Apparatus for purifying and refining molten metal comprising a chamber in which a layer of metal is to be disposed and which is of substantially cylindrical form, said chamber being lined with refractory material and having a substantially flat bottom which is inclined towards a tap hole so that the molten metal will run from the chamber when the tap hole is open, a plurality of tuyère members disposed wholly within the refractory liner and adapted to direct fluid under pressure on the surface of the molten metal to cause swirling of the entire layer of molten metal in said chamber, said tuyère members being directed downwardly at an angle and being disposed in directions chordal to the annular wall of said chamber, the lower ends of said tuyère members being so disposed that they will be above the upper surface of the layer of metal placed in said chamber, each of said tuyère members being provided with a burner having its tip disposed substantially at the outer end thereof so that substantially complete combustion will occur within the tuyère member, a cover for substantially closing the upper end of said chamber, said cover having a comparatively small opening therein substantially at the center of said chamber which is continuously open during the discharge of hot products of combustion under pressure on the molten metal to permit the hot products to escape and to blow out the impurities removed from said metal.

3. Apparatus for purifying and refining molten metal comprising a chamber in which a layer of metal is to be disposed and which is of substantially cylindrical form, said chamber being lined with refractory material and having a substantially flat bottom, a plurality of tuyère members disposed wholly within the refractory liner and adapted to direct fluid under pressure on the surface of the molten metal to cause swirling of the entire layer of molten metal in said chamber, said tuyère members being directed downwardly at an angle and being disposed in directions chordal to the annular wall of said chamber, the lower ends of said tuyère members being so disposed that they will be above the upper surface of the layer of metal placed in said chamber, each of said tuyère members being provided with a burner having its tip disposed substantially at the outer end thereof so that substantially complete combustion will occur within the tuyère member, a cover for substantially closing the upper end of said chamber, said cover having a comparatively small opening therein substantially at the center of said chamber which is continuously open during the discharge of hot products of combustion under pressure on the molten metal to permit the hot products to escape and to blow out the impurities removed from said metal.

4. Apparatus for purifying and refining molten metal comprising a chamber in which a layer of metal is to be disposed and which is of substantially cylindrical form, said chamber being lined with refractory material and having a bottom with a continuous uninterrupted surface on which the layer of metal is supported, a plurality of tuyère members extending through the refractory liner and adapted to direct fluid under pressure on the surface of the molten metal to cause swirling of the entire layer of molten metal in said chamber, said tuyère members being directed downwardly at an angle and being disposed in directions chordal to the annular wall of said chamber, the lower ends of said tuyère members being so disposed that they will be above the upper surface of the layer of metal placed in said chamber, each of said tuyère members being provided with a burner, a cover for substantially closing the upper end of said chamber, said cover having a comparatively small opening therein substantially at the center of said chamber which is continuously open during the discharge of hot products of combustion under pressure on the molten metal to permit the hot products to escape and to blow out the impurities removed from said metal.

5. Apparatus for purifying and refining molten metal comprising a chamber in which a layer of metal is to be disposed and which is of substantially cylindrical form, said chamber being lined with refractory material, a plurality of tuyère members extending through the refractory liner and adapted to direct fluid under pressure on the surface of the molten metal to cause swirling of the entire layer of molten metal in said chamber, said tuyère members being di-

rected downwardly at an angle and being disposed in directions chordal to the annular wall of said chamber, the lower ends of said tuyère members being so disposed that they will be above the upper surface of the layer of metal placed in said chamber, each of said tuyère members being provided with a burner, a cover for substantially closing the upper end of said chamber, said cover having a comparatively small opening therein substantially at the center of said chamber which is continuously open during the discharge of hot products of combustion under pressure on the molten metal to permit the hot products to escape and to blow out the impurities removed from said metal.

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