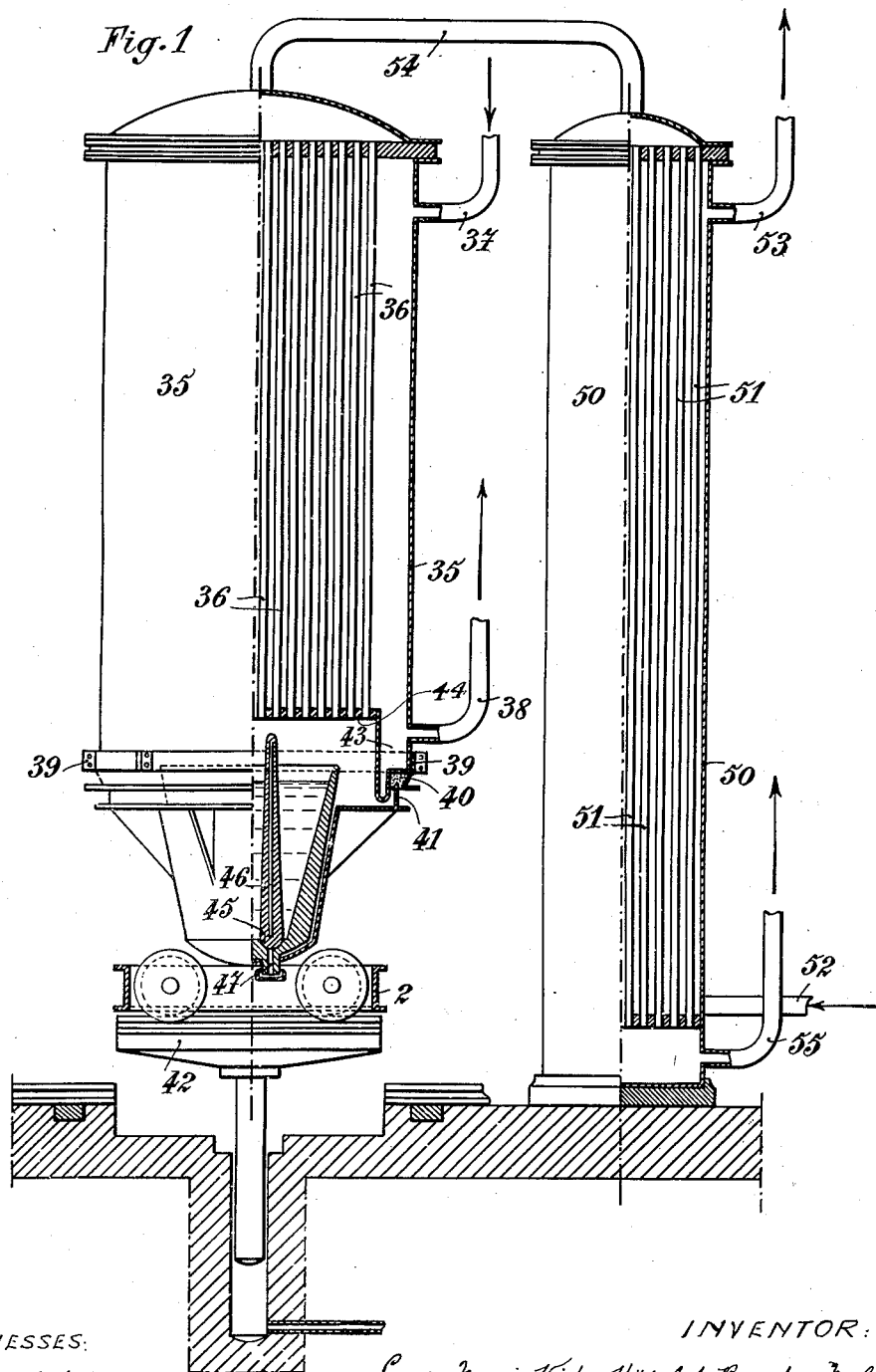


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 APPLICATION FILED MAR. 29, 1912.

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WITNESSES:

Fred White
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INVENTOR:

Louis Marie Victor Hippolyte Baraduc-Muller,
 By his Attorneys:

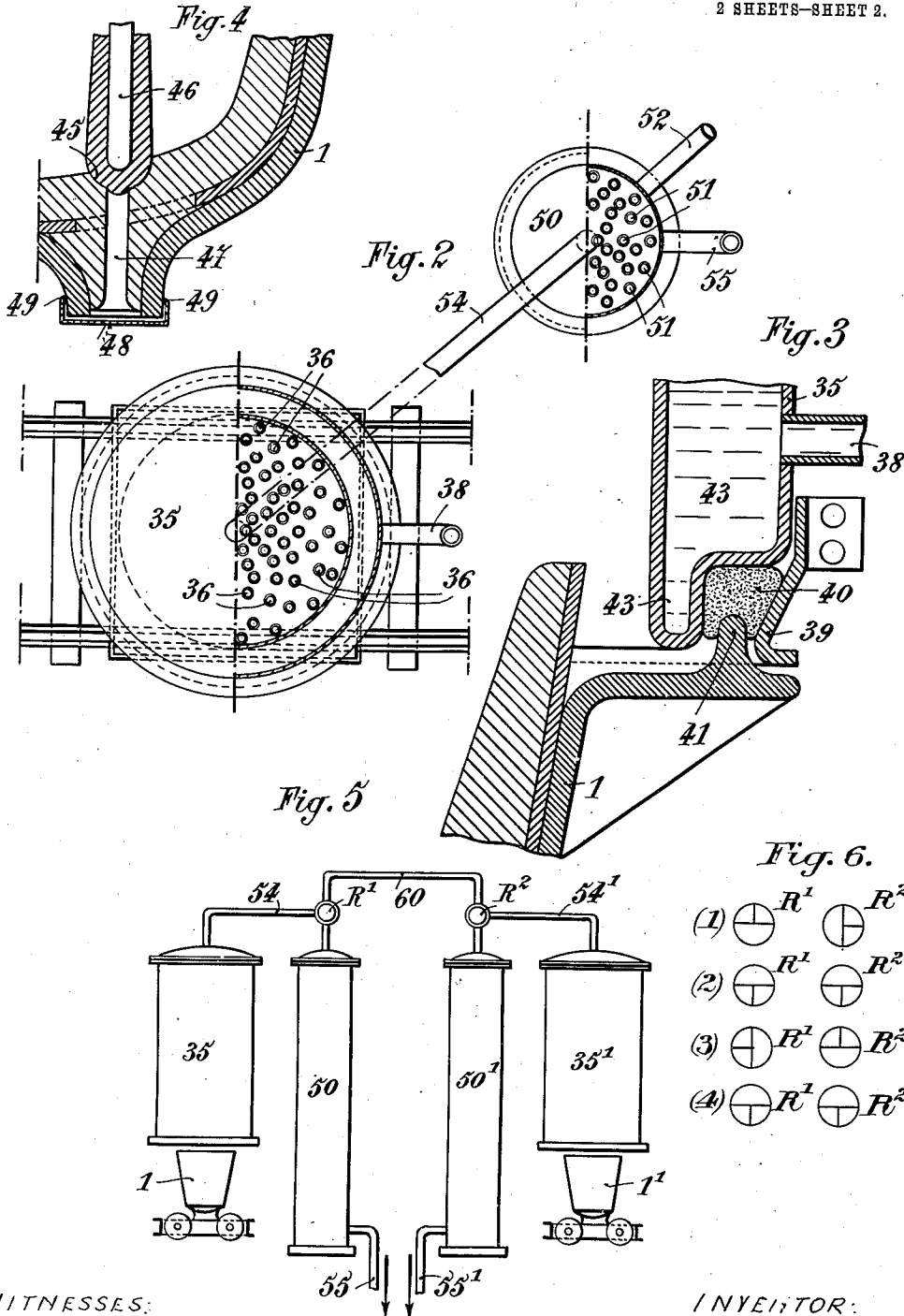
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UNITED STATES PATENT OFFICE.

LOUIS MARIE VICTOR HIPPOLYTE BARADUC-MULLER, OF PARIS, FRANCE.

APPARATUS FOR TREATING MOLTEN METALS, ALLOYS, AND STEELS.

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Specification of Letters Patent.

Patented Nov. 4, 1913.

Original application filed August 16, 1911, Serial No. 644,384. Divided and this application filed March 29, 1912. Serial No. 687,009.

To all whom it may concern:

Be it known that I, LOUIS MARIE VICTOR HIPPOLYTE BARADUC-MULLER, a citizen of the Republic of France, residing in Paris, France, have invented certain new and useful Improvements in Apparatus for Treating Molten Metals, Alloys, and Steels, of which the following is a specification.

The present application is a division of my application Serial No. 644,384, filed August 16, 1911, and describes and claims an apparatus described and claimed in said application.

There are two sources of the gases which exist in metals and alloys and in particular cast steels. One of these is the conditions under which the melting furnace (crucible furnace, acid or basic Siemens-Martin furnace) is operated, or the conditions under which the refining furnace (Siemens-Martin, acid or basic furnace, acid or basic Bessemer converter) is operated. The other source is the internal chemical reactions which give rise to gases (for example the chemical reactions of carbonaceous matter on the oxids fused or dissolved in the liquid metal). It is not possible to distinguish sharply between these sources of gases since they exist concomitantly and vary only in their respective intensities. However this may be, for a given thermal and chemical treatment to which a given metal is subjected at a given temperature in a given melting or refining furnace there is produced an equilibrium between the quantities of gases derived from the first and second sources respectively, an equilibrium which corresponds with the maximum quantity of gas dissolved in the fused metal or alloy and of which an important portion remains in the cold solidified metal.

The gases which are most generally found in cold metals, alloys and steels after they have been subjected to igneous fusion, are hydrogen, nitrogen, carbon-monoxid, and carbon-dioxid. It is logical to admit that these same gases existed in solution in the melted metals, alloys and steels and that only the total quantity, and the relation of each to this total, vary, owing to the fact that the gases escape during the cooling. A study of the formation of these gases and an attempt to realize the condition in which they exist in metals generally show that they are simply dissolved and not in the

form of stable chemical combinations. In fact the quantity of dissolved gases depends on the nature and the temperature of the fused alloy, on the pressure and on the chemical composition of the external gaseous atmosphere, in such a manner that the quantity may be represented by

$$Q = Kf(MTP)$$

in which K is a co-efficient dependent on the nature of the metal, on the composition of the gases and on the surface of the metal in contact therewith, M is the mass of the melted alloy, T the temperature of the metal, P the pressure. The higher the temperature the farther apart are the molecules of the metal owing to dilatation and in consequence the greater is the intermolecular volume available for the gases passing into solution. Moreover, the higher pressure of the gases in the atmosphere to which the melted metal is exposed the greater the quantity of gases which will dissolve. This explains the fact that metals, alloys and steels melted in a blast crucible furnace contain more gases than the same metal melted in a crucible furnace operated by natural draft and that steel made in an acid or basic converter contains more gas than steel of the same composition prepared in an acid or basic Siemens-Martin furnace. In fact in the Bessemer converter or the Thomas converter the pressure of the blast exceeds that of the atmosphere by about 1.5 kilo, so that there is gaseous supersaturation and super-oxidation.

When at the finishing point the oxid produced is reduced by carbon, the gases generated at this moment dissolve in greater part and increase the proportion of gases in solution in the hot metal. When the liquid metals, alloys and steels cool, they contract, and the pressure set up by the diminution of the volume of the metal increases, at each instant of the cooling, the pressure of the dissolved gases, until this pressure becomes sufficiently great to overcome the atmospheric pressure and the internal friction, which oppose the escape of the gases. From this moment the gases escape regularly into the atmosphere until the internal friction, which increases rapidly as solidification proceeds, prevents more and more this escape. Finally the escape of the gases becomes extremely slow or even im-

possible. Thus the state of equilibrium is attained for ordinary temperature and pressure, and corresponds with a certain proportion of gas occluded in the cold ingot, the quantity being dependent on, among other things, the conditions of cooling. When a rapid and complete superficial solidification prevents the gases from escaping freely into the atmosphere above the metal there are formed in the subjacent still liquid metal pockets wherein the pressure of the gases may be very much higher than that of the atmosphere even when the ingot is cold. Finally a mechanical agitation, notably a gyratory movement, by creating in a liquid metal a centrifugal force, engenders an accumulation of the metal at the periphery and increases the pressure in the metal. This pressure is transmitted to the dissolved gases and expels them in the form of bubbles which escape principally at the periphery of the moving metal. These phenomena prove the simple dissolution of the gases in the melted metals and the unstable state of equilibrium in which they are until the metal has completely cooled, a state of equilibrium of dissolution which is only attained owing to the influence of atmospheric pressure which opposes all premature disengagement of the gases. It is logical therefore to admit that if one could upset this equilibrium of dissolution by diminishing the external pressure tangentially to the same of the alloy while this is still liquid, it should be possible to extract from the melted alloy all the dissolved gases whatever may be their source. The problem is particularly worthy of being solved in the case of steels produced in acid or basic converters for such steels may contain, even when they are cold 4, 5 or even 10 times their volume of gas according to their chemical composition and the duration of the thermal treatment and the cooling operation to which they are subjected.

The present invention has for its object to provide an apparatus for removing from metals, alloys and steels not only the gases which may be disengaged by the cooling of the metal but those which remain actually occluded in the cold ingots of metal, alloy or steel which have undergone igneous fusion whatever may be the character of the melting furnace or refining furnace used. For this purpose the gases are extracted from the metal, alloy or steel while they are still liquid, that is to say under the best conditions for facilitating the disengagement of the gases, so that ingots or castings are obtained which are free from dissolved occluded gases and therefore have a very high degree of compactness and homogeneity. In this manner blow holes and pockets which form in the head of the ingot and thus depreciate the value of the head to

such an extent that this portion has to be separated, are avoided; a considerably larger yield of the metal, alloy or steel is therefore obtained.

The gases contained in the metals, alloys or steels are removed while they are in a liquid state and after, any solid liquid or gaseous materials designed for refining the metals and giving them a desired composition have been added in the course of the metallurgical treatment. This removal of the gases from the liquid metals is accomplished by producing in the apparatus above the surface of the liquid metal, alloy or steel a vacuum substantially complete, for instance, a vacuum represented by 1 mm. of mercury or thereabout. Under this high vacuum the gases are extracted from the perfectly liquid metal, alloy or steel at a high temperature.

The gases contained in the melted steel or other metal are extracted under a high vacuum produced by high power reciprocating or rotary pumps, water ejectors, steam or air ejectors, or other suitable apparatus of high power, and the withdrawn gases are energetically chilled as soon as they are extracted from the liquid metal. This energetic chilling of the gases extracted, before they arrive at the extracting apparatus, may be produced in different manners such as by atomizing them with steam or cold water, by circulating them through apparatus analogous to gas washers, or by passing them through bundles of tubes around which cold brine or other liquid or cold air, gases or vapors are circulated. It is essential to insist on the special part which this chilling of the gases issuing from the liquid metals plays, because, owing to this the volume of the gases is very much reduced so that the extracting apparatus can remove per unit time a much more considerable weight of gas owing to the small volume of the gas.

The arrangement of the pumps may be varied according to circumstances. Thus they may be in series or in parallel and combined or not with water pumps or ejectors.

A combination which gives very good results comprises the application for the extraction of the gases of pumps, which in the first place lower the pressure to a value corresponding with the maximum useful effect of the pumps and then substituting automatically for these pumps vacuum ejectors operated by water or better by steam or compressed air, and adapted to produce finally a substantially absolute vacuum above the liquid metal, alloy or steel, the pressure being thus reduced to a millimeter of mercury or thereabout.

An embodiment of the invention is illustrated in the accompanying drawings, wherein—

Figure 1 illustrates a front elevation of

the apparatus with parts in section. Fig. 2 shows a plan of the apparatus with parts in section. Figs. 3 and 4 illustrate details of the apparatus. Fig. 5 illustrates diagrammatically two sets of apparatus arranged to work in coöperation. Fig. 6 is a diagram illustrating different positions of valves in certain stages of the working of the apparatus illustrated in Fig. 5.

10 Referring to the drawings, the apparatus comprises a vertical cylinder 35 of sheet steel autogenously soldered, containing a bundle of tubes 36 analogous to that of a tubular boiler. These tubes are surrounded
15 by a cooling fluid which may enter at the top of the cylinder in 37 and leave at the bottom thereof at 38 after having been more or less heated by the bundle of tubes.

The lower part of the cylinder 35 is surrounded by a collar or sleeve 39 (see Fig. 3) made in several segments bolted together. This collar or sleeve is constricted to accommodate between itself and the lower part of the cylinder a washer ring of rubber or
25 other suitable material 40, for the purpose of making a tight joint. Against this washer ring may be applied a circular flange 41 of the ladle 1 containing the liquid metal or steel which is to be deprived of gases. In
30 order to hermetically close the joint it suffices to mount the ladle 1 on a suitable press and force the said circular flange 41 against the under surface of the rubber washer; for instance the carriage 2 carrying the casting
35 ladle may be brought onto the platform of a hydraulic press 42 situated below the cylinder 35. As soon as the proper degree of pressure has been applied by the hydraulic press the vacuum pumps may be put in
40 action.

The bottom of the cylinder 35 (see Figs. 1 and 3) is preferably inwardly curved so as to form a sleeve of water 43 in contact with the rubber washer 40, so as to prevent alteration of the joint by heat radiated from the ladle.

The lower tube plate 44 within the cylinder 35 is situated at such a height in the latter that there is left a space between the surface of the melted metal and this plate sufficient to insure that particles of melted metal which may be ejected from the mass by ebullition due to escape of gas shall not strike against the tube plate.

55 To avoid entrance of air through the seat 45 of the plug 46 which stops the casting hole 47 of the ladle (see Fig. 4), there is first soldered or otherwise fixed at the discharge opening of the casting hole a thin sheet of suitable material 48, such that when afterward the plug is withdrawn the sheet is perforated by the jet of liquid steel and it may be also detached by the fusion of the fixing solder 49. The gases issuing from
60 the liquid metal under action of the vacuum

are cooled in the bundle of tubes so that their temperature falls from say 1450°-1500° to 350°-300° C.

For the purpose of more completely cooling the gases there may be combined with
70 the cooler just described a second apparatus comprising a cylinder 50 containing a bundle of tubes 51. Cooling fluid, such as chilled brine, is admitted into the bottom part of this cylinder by 52 and leaves the
75 latter at the upper part at 53. The two cylinders 35 and 50 are connected at the top by a suitable pipe 54 so that the gases which are cooled in the first cylinder descend in the second through the tubes 51 which are
80 chilled by the circulating fluid and issue from this second cylinder at its lower part where the pipe 55 communicates with the vacuum pumps. This second apparatus may lower the temperature of the gases to 15° C.
85 or less. The gases then enter the vacuum pumps and the ejectors.

When the extraction of the gases from the molten metal is finished, which is known by the constancy of the vacuum as indicated
90 by a gage, air is admitted into the cylinder 35 above the casting ladle little by little, either by opening the cylinder directly to the atmosphere or, which is better, connecting it with a second evacuating apparatus
95 mounted in series with the first so that the vacuum in the one cylinder may serve to evacuate partially the other, so as to diminish the work of the vacuum pumps in extracting gas from the second
100 evacuating apparatus. When atmospheric pressure is finally reëstablished in the apparatus the hydraulic platform 42 is lowered and the casting ladle 1 which now contains a charge of liquid metal free from
105 gas is conducted to the ingot molds.

The construction of the apparatus arranged to work in series is shown diagrammatically in Fig. 5. Two sets of apparatus are shown as working together. Two three-way
110 cocks are placed one in each of the pipes 54, 54' connecting the vacuum cylinders 35, 35' with the auxiliary cooling cylinders 50, 50'. These three-way cocks are connected by a pipe 60.
115

(1) When it is desired to begin the exhaustion of gases from the metal of ladle 1, the cocks R¹, R² are turned to the position
120 (1) Fig. 6. In this position the two vacuum cylinders 35, 35' are placed in communication and the pressures therein can equalize. The cocks R¹, R² are then turned to the position (2) Fig. 6. This cuts off the vacuum cylinder 35 from the vacuum cylinder 35' and places it in communication with its
125 evacuating pumps and ejectors through the pipe 55. The removal of the gases in ladle 1' having been completed the ladle is then removed.

(2) Conversely when the removal of gases 130

from the metal of ladle 1 has been completed and it is desired to begin the removal of the gases from the metal in ladle 1', the cocks R¹ and R² are turned to the position (3) Fig. 6. This places the rarefied vacuum chamber 35 in communication with the vacuum cylinder 35' in which the evacuation has not yet begun, and there results an equalization of pressures, the vacuum in cylinder 35 being partially reduced and a partial vacuum being produced in cylinder 35'. The cocks are then turned to the position (4) Fig. 6, in which position the cylinder 35' is cut off from the cylinder 35 and connected with its evacuating pumps and ejectors through the pipe 55'. The ladle 1 is then removed from its vacuum cylinder.

What I claim is:—

1. Apparatus for removing gases from steel and the like, comprising in combination a vertical vacuum chamber having an open bottom, a removable receptacle for the molten metal adapted to make an air-tight joint with the bottom of said vacuum chamber, means for pressing said receptacle upwardly against the under side of said vacuum chamber, means for evacuating said vacuum chamber, and means for rapidly and extensively cooling the air and gases evacuated from said chamber prior to reaching said evacuating means.

2. Apparatus for removing gases from steel and the like, comprising in combination a vertical vacuum chamber, a receptacle for the molten metal adapted to make an air-tight joint with the bottom of said vacuum chamber, means for evacuating said vacuum chamber, and means for rapidly and extensively cooling the air and gases evacuated from said chamber prior to reaching said evacuating means, said means having a capacity of cooling said air and gases to a temperature of approximately 0° C.

3. Apparatus for removing gases from steel and the like, comprising in combination a vertical vacuum chamber having an open bottom, a receptacle for the molten metal adapted to make an air-tight joint with the bottom of said vacuum chamber, means for pressing said receptacle upwardly against the under side of said vacuum chamber, means for evacuating said vacuum chamber, and means for rapidly and extensively cooling the air and gases evacuated from said chamber prior to reaching said evacuating means, said means comprising a cylinder having tubes therein for the passage of gases and adapted to contain a cooling fluid around said tubes.

4. Apparatus for removing gases from steel and the like, comprising in combination a vertical vacuum chamber having an open bottom, a removable receptacle for the molten metal adapted to make an air-tight joint with the bottom of said vacuum chamber,

means for pressing said receptacle upwardly against the under side of said vacuum chamber, means for evacuating said vacuum chamber, means for rapidly and extensively cooling the air and gases evacuated from said chamber prior to reaching said evacuating means, said means comprising a compartment in the upper part of said vacuum chamber adapted to contain a cooling fluid, and tubes passing through said compartment through which the air and gases to be cooled are adapted to pass.

5. Apparatus for removing gases from steel and the like, comprising in combination a vertical vacuum chamber, a removable receptacle for the molten metal adapted to make an air-tight joint with the bottom of said vacuum chamber, means for evacuating said vacuum chamber, said vacuum chamber having a plastic washer-ring at its lower end and means for cooling said washer-ring and said receptacle having a circular flange adapted to fit against said washer, and means for rapidly and extensively cooling the air and gases evacuated from said chamber prior to reaching said evacuating means.

6. Apparatus for removing gases from steel and the like, comprising in combination a vertical vacuum chamber, a receptacle for the molten metal adapted to make an air-tight joint with the bottom of said vacuum chamber, and means for evacuating said vacuum chamber, said vacuum chamber having a water jacket at its lower end to prevent the heat from said molten metal-receptacle affecting the joint between said receptacle and chamber.

7. Apparatus for removing gases from steel and the like, comprising in combination a vertical vacuum chamber, a receptacle for the molten metal adapted to make an air-tight joint with the bottom of said vacuum chamber, means for evacuating said vacuum chamber, means for rapidly and extensively cooling the air and gases evacuated from said chamber prior to reaching said evacuating means, said means comprising a compartment in the upper part of said vacuum chamber adapted to contain a cooling fluid, and tubes passing through said compartment through which the air and gases to be cooled are adapted to pass, and a second cooling apparatus outside of said vacuum chamber comprising a tubular cylinder having pipes therein for the passage of the air and gases surrounded by a cooling medium.

8. Apparatus for removing gases from steel and the like, comprising in combination a vertical vacuum chamber, a receptacle for the molten metal adapted to make an air-tight joint with the bottom of said vacuum chamber, and means for evacuating said vacuum chamber, said receptacle having a tap-hole therein, a refractory plug for closing said tap-hole, and a metal cap outside of

said plug adapted to seal said tap-hole against the entrance of air and adapted to be pierced by the molten metal after the refractory-plug is withdrawn.

- 5 9. Apparatus for removing gases from steel and the like, comprising in combination two vertical vacuum chambers, two receptacles for molten metal adapted to make airtight joints with the bottoms of said vacuum
10 chambers, and means for evacuating said vacuum chamber, said vacuum chambers being adapted to be placed in communication with one another whereby air in one cham-

ber, before the beginning of the evacuating operation therein, may be evacuated into said other chamber after the evacuating operation is completed therein.

In witness whereof, I have hereunto signed my name in the presence of two subscribing witnesses.

LOUIS MARIE VICTOR HIPPOLYTE
BARADUC-MULLER.

Witnesses:

LUCIEN MEMMINGER,
CHARLES MARDELET.