Nov. 2, 1965 K. C. TAYLOR 3,215,423

DEGASSING SYSTEM FOR METAL ALLOY FURNACE

Filed Aug. 1, 1962 3 Sheets-Sheet 1

FIG. 1

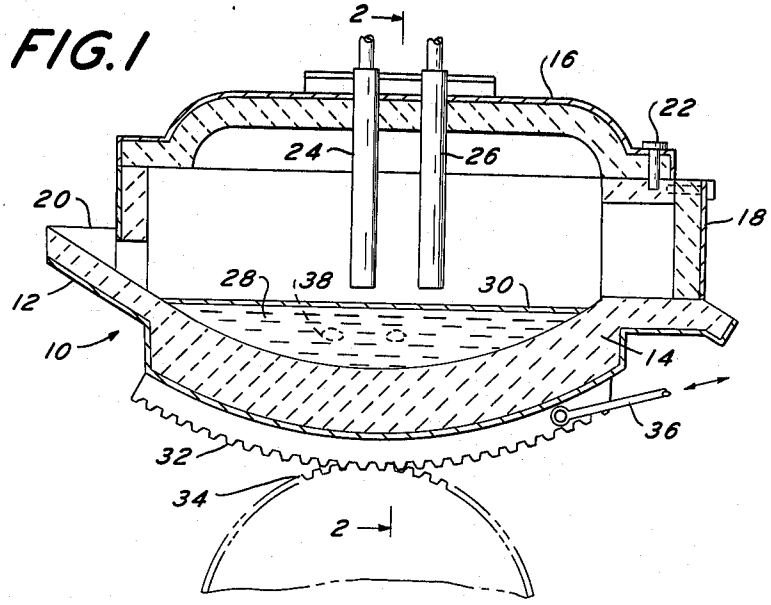


FIG. 2

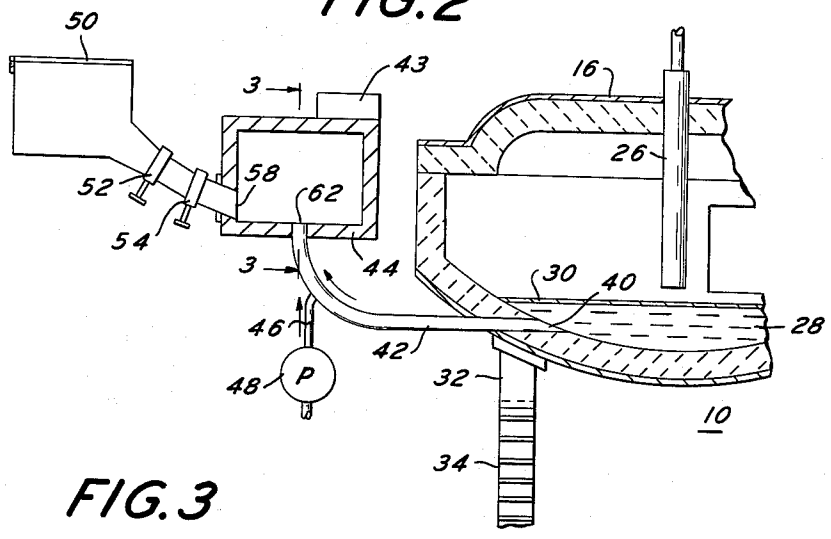
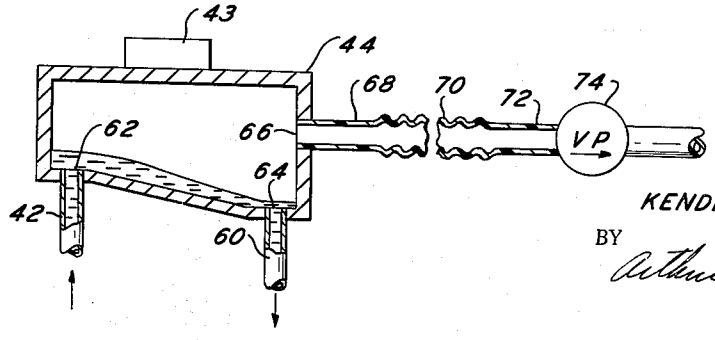


FIG. 3



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FIG. 4

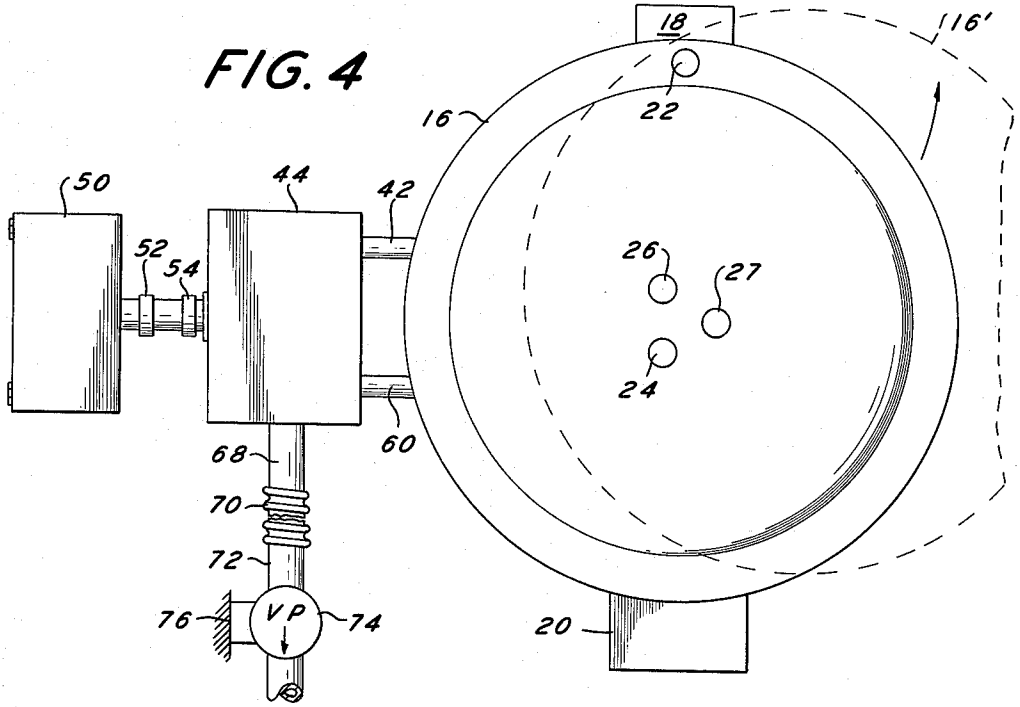
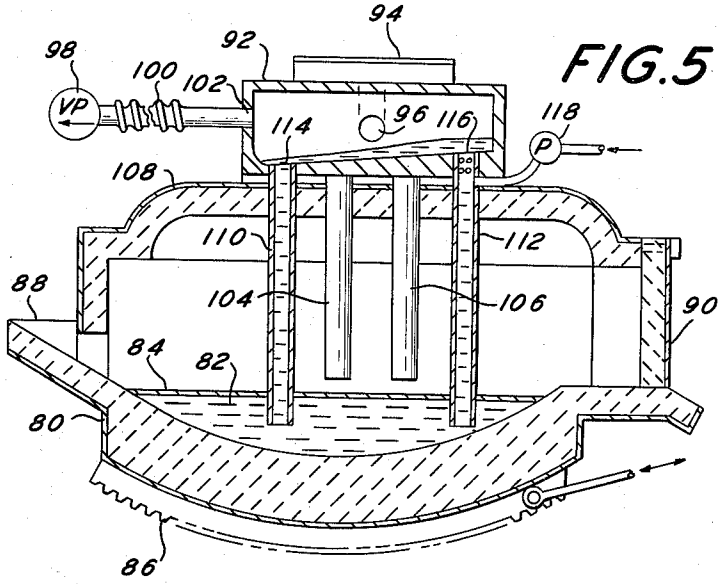


FIG. 5



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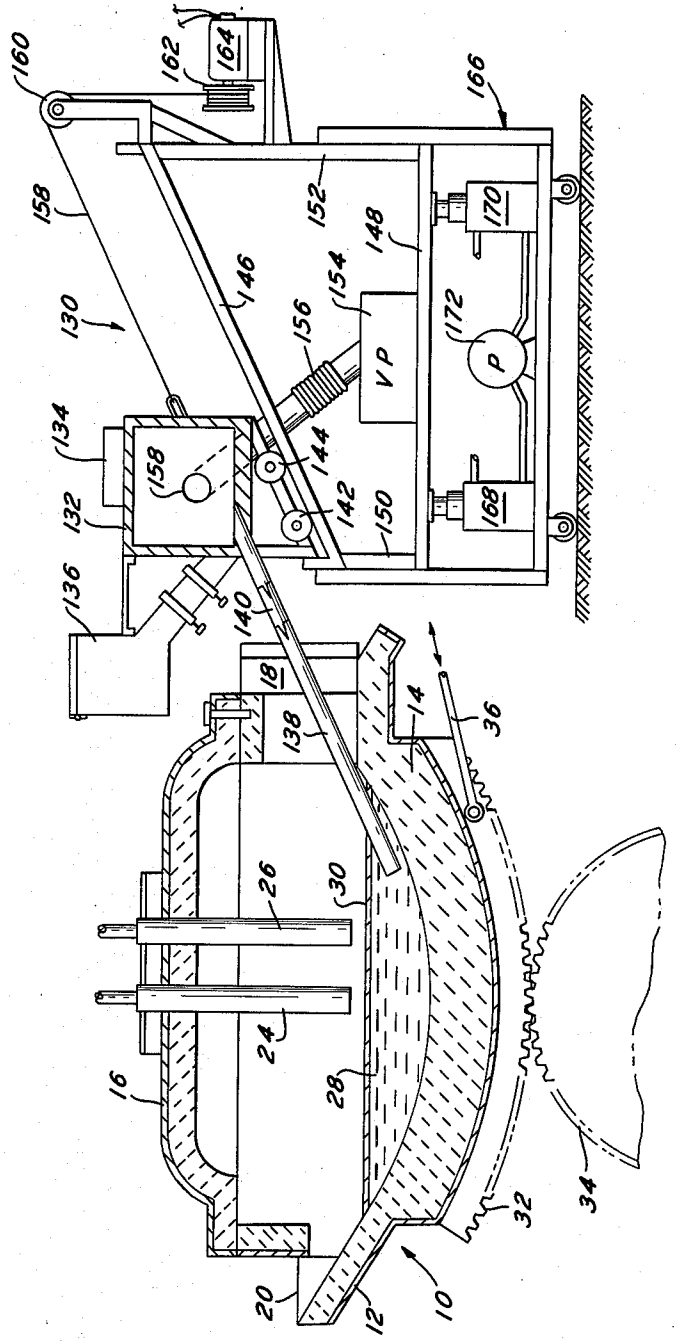


FIG. 6

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DEGASSING SYSTEM FOR METAL ALLOY FURNACE

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12 Claims. (Cl. 266—34)

In general, this invention relates to a new system for applying chamber degassing to a metal alloy furnace and, more particularly, to the application of vacuum degassing to electric furnaces.

In the past, vacuum degassing of a molten metal alloy bath was accomplished after the alloy had been produced in a furnace. Degassing equipment was placed over a ladle which had received the molten alloy from the furnace. This created problems as the molten alloy lost heat in the transfer between the furnace and the ladle. It has been suggested that the loss of heat be rectified by inductively heating the molten metal as it moves through a conduit between the ladle and the vacuum chamber. This system of reheating was found to unsatisfactory because it resulted in superheating the molten metal which changed its metallurgical properties, was very expensive, and was difficult to control.

Additionally, contamination often occurred in the metal alloy between the transfer from the furnace to the ladle and the degassing therein. The chamber in which the degassing is accomplished requires valuable floor space in the craneway in a mill which is extremely expensive. Furthermore, since the alloy additive was supplied to the molten metal charge before it was degassed, elements in the molten metal bath such as oxygen combine with the alloy addition to form undesirable compounds which change or damage the metallurgical properties of the resultant alloy metal.

It is the general object of this invention to avoid and overcome the foregoing and other difficulties of the prior art practices by the provision of a better and more simple vacuum degassing system for a metallurgical furnace.

Another object is to provide a better method of manufacturing metal alloys in which oxides and other contaminates in the molten bath are reduced during vacuum degassing prior to the addition of the alloying material.

Another object of this invention is to provide a new and novel metallurgical furnace having an integral vacuum degassing unit attached thereto.

Another object of this invention is to provide a unitary heater and vacuum degassing chamber combination which may be utilized with a plurality of metallurgical furnace hearths.

Other objects will appear hereinafter.

For the purpose of illustrating the invention there is shown in the drawings forms which are presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIGURE 1 is a cross sectional view of an electric arc furnace embodying the principles of the present invention.

FIGURE 2 is a partial cross sectional view of the furnace of FIGURE 1 taken along lines 2—2.

FIGURE 3 is a partial cross sectional view of the degassing chamber shown in FIGURE 2 taken along lines 3—3.

FIGURE 4 is a top plan view of the electric arc furnace shown in FIGURE 1.

FIGURE 5 is a cross sectional view of a second embodiment of the present invention.

FIGURE 6 is a cross sectional view of an electric arc furnace with a portable vacuum degassing chamber in

accordance with another embodiment of the present invention.

In FIGURE 1, there is shown one embodiment of the present invention utilized in conjunction with an electric arc furnace. The electric arc furnace shown in FIGURE 1 is generally designated by the numeral **10**.

The furnace **10** has a steel outer surface **12** surrounding a refractory hearth **14**. The hearth **14** is shaped so as to receive the molten metal charge. The furnace **10** has a pivotal roof **16** through which extend electrodes **24**, **26** and **27**. The electrodes **24**, **26** and **27** are adapted to be connected to a three-phase Y–Δ connected transformer. In larger sized electric arc furnaces, six such electrodes could be utilized.

Metal is placed in the furnace through the open roof or the sliding door **18** and is poured from the hearth **14** through a spout **20** on the side opposite the door **18**. The roof **16** is pivotally mounted about an axis **22** located on top of the furnace. If necessary, the roof **16** can be pivoted to a position as shown in phantom in FIGURE 4. In this position, the roof **16** has been numbered **16'**, and metal can be added to the hearth.

The molten metal **28** is placed at the bottom of the furnace **10** in the hearth **14**. A layer of slag **30** forms on top of the molten metal **28**. The slag normally consists of combinations of acid, neutral and basic oxides, and other non-metallics.

The metal **28** is heated by supplying current to the electrodes **24**, **26** and **27**. The electrodes extend into the molten metal **28**. The electrical current will strike an arc between the electrode and the molten metal **28**. The slag **30** offers a higher resistance than the molten metal. The power input to the electrical arc furnace is controlled by the distance between the electrodes and the molten steel. The selected voltage is normally taken care of by automatic adjustment. The slag, by its presence, shields the molten metal from the atmosphere and conserves the heat thereof. There is a slight motor or stirring effect produced in the bath by the current, and this also helps in distributing the heat.

The vacuum degassing chamber **44** is provided to be utilized with the electric arc furnace **10**. The vacuum degassing chamber **44** is connected from ports **38** and **40** below the level of molten metal in the hearth **14** through pipes **42** and **60** to ports **62** and **64** in the bottom of the degassing chamber **44**. Heater means **43** which may be electric coils or a gas burner is provided on chamber **44**.

A pump **48** is also in communication with conduit **42** through a pipe **46** located below the port **62**. An alloy material hopper **50** is also in communication with the degassing chamber **44** through a port **58** in the wall of the degassing chamber **44**. Supply valves **52** and **54** control the feed of alloy material from the hopper **50**. Additionally, a vacuum port **66** in communication with the interior of the chamber **44** connects a vacuum pump **74** to the chamber **44** through a rigid pipe **68**, expansible bellows **70**, and rigid pipe **72**.

The operation of the degassing chamber **44** is as follows: The chamber **44** is preheated by heater means **43** so that there is little difference between the temperature in the furnace and the temperature of the chamber. Vacuum pump **74** evacuates chamber **44** through conduits **68**, **70** and **72**. This causes molten metal to rise in conduits **42** and **60**. Pump **48** is then turned on to supply a gas under pressure through conduit **46**. This gas may be hydrogen, methane, carbon monoxide, other carbonaceous gases, hydrides, halogens or volatile halides, vapors of strongly reducing volatile and relatively insoluble metals or metalloids, such as sodium zinc and phosphorus, inert noble gases, or active gases. The particular gas used depends upon the effect desired upon the

molten metal. For instance, if it is desired to de-oxidize the molten metal, a reducing gas such as carbon monoxide would be pumped through conduit **46**. The gas in conduit **42** lowers the density of the resultant mixture in the conduit. This causes the molten metal in conduit **42** to rise to a higher level than the molten metal in conduit **60**. Thus, the molten metal acts upon the well-known principle of the "gas lift" and ultimately overflows the top of conduit **42**. This action is accentuated by the reduced pressure created by the pump **74**.

The gases which have been introduced into the tube **46** bubble upwardly through the metal in the conduit **42** and in the course of this operation, they become intimately mixed with the liquid metal. The conduit **42** is preferably provided with internal turbulence causing projections which will insure active mixing and provide a more active flow of the metal.

The gases cause the liquid metal to spill over at the upper end of the riser conduit **42** from which the metal gravitates into the open end **64** of the return tube **60**. The gases and all other gases which are separated from the metal are then carried away through the vacuum conduit **68**, **70** and **72** by vacuum pump **74**.

The metal which is delivered into the return conduit **60** passes downwardly into the molten charge **28** through port **38**. The conduits **42** and **60** form barometric columns which are continuously maintained by the vacuum in the chamber **44**.

After the molten metal has been completely treated with the gas from the pump **48**, an inert gas such as argon is introduced in place of the active gas, if such was used. The inert gas does not react with the molten metal, but instead continues the metal flow through the degassing chamber. At this point, the alloying material which may be silicon, carbon or the like, is fed into the chamber **44** from the hopper **50**. The alloy feeding is done through the use of a trap valve system including valves **52** and **54**. Valve **52** is first opened with valve **54** closed to place a given amount of alloy material between the two valves. Then valve **52** is closed and valve **54** opened and the alloy material allowed to flow into the chamber **44**. The vacuum system will aid in the flow of the alloy material into the chamber **44**. Since the molten metal is flowing continuously in the bottom of the chamber **44**, the alloy material will be given a large surface area to combine with the molten metal. Additionally, since the contaminating gases have been removed from the molten metal, there will be no undesirable chemical reaction between such gases and the alloy material before the metallurgical combination with the molten metal.

The alloying agents which might be utilized could be silicon, chromium, aluminum, manganese, titanium, vanadium, etc. These metals in their pure form can dissolve in the alloy solution without forming contaminating oxidation by-products. The turbulence of the flowing metal as it leaves port **62** increases the area of contact with the dissolving alloy materials. An inert gas may be utilized to protect the molten metal charge at the base of the hearth from contact with the air. This can be done by the introduction into the furnace **10** of a blanket of gas which is inert to the metal being treated and which is relatively insoluble in the collected metal.

The furnace **10** has two arcuate gear members **32** on the base thereof on either side of the furnace **10**. These arcuate gear members **32** mesh with similarly spaced gears **34** fixedly supported on the floor of the mill. A motor (not shown) drives a connecting arm **36** rotatably secured to the base of the furnace **10**. Movement of the arm **36** causes tilting of the furnace **10** in one of two directions. When it is necessary to pour the molten metal from the furnace **10**, the connecting arm **36** is moved to the right tilting the furnace and allowing the metal to flow out of spout **20**. When the slag **30** need be removed, the furnace is tilted in the other direction

and the door **18** opened so as to allow the slag to be removed.

A new charge of metal can be fed to the furnace through door **18** or by rotating roof **16** to the position indicated in FIGURE 5.

The degassing chamber **44** and hopper **50** are mounted directly on the furnace **10** and move with it. Vacuum pump **74**, however, is mounted separately and therefore, it is necessary to have the flexible bellows **70** which connects the two pipes **68** and **72**. Thus, when metal is poured, the bellows contracts and when slag is removed, the bellows expands without loss of vacuum.

In FIGURE 5, there is shown a second embodiment of the present invention. In this embodiment, the furnace **80** has molten metal **82** and slag **84** in the bottom thereof. The furnace **80** is also rotatable about curved gears **86**. The furnace **80** has a spout **88** and a gate **90**.

A degassing chamber **92** is mounted directly on the roof **108** of the furnace **80**. The roof **108** is removable from the furnace **80**. A hopper **94** feeds the degassing chamber **92** through a port **96**. The vacuum pump **98** is connected through a flexible conduit **100** to a port **102** in the degassing chamber **92**.

Electrodes **104** and **106** are also mounted on the roof **108**. Riser tube **112** is connected from a point below the level of the molten metal **82** to a port **116** in the chamber **92**. A return tube **110** is connected from a port **114** lower in level than the port **116** to the molten metal bath **82**. A pump **118** supplies gas under pressure to riser tube **112**.

The operation of the electric arc furnace and degassing unit shown in FIGURE 5 is in all ways similar to that shown in FIGURES 1–4. However, the unit in FIGURE 5 has one distinct advantage. In this unit, the degassing chamber **92** and its auxiliaries may be lifted from the furnace **80** and placed on a different furnace while furnace **80** is cleaned and refilled. Therefore, chamber **92** and its associated apparatus may be utilized by more than one furnace and effect a considerable saving for the user.

In FIGURE 6, there is illustrated the furnace **10** and a portable vacuum degassing unit **130** associated therewith for degassing the molten bath **28** therein. The unit **130** includes a vacuum chamber **132** having a preheater **134**. A hopper **136**, identical with hopper **50**, is associated with the chamber **132**. Conduits **138** and **140** extend from chamber **130** into the bath **28**. The conduits **138** and **140** are parallel to each other and are connected to chamber **130** in the same manner as conduits **112** and **110**, respectively, are connected to chamber **92**. Hence, the bath **28** will flow up leg **138** through chamber **132**, and down leg **140**.

To facilitate introduction of the conduits **138** and **140** in the bath **28**, the door **18** on furnace **10** has been moved to an open disposition. The chamber **132** is mounted on a carriage having wheels **142** and **144** which ride on an inclined track **146**. Track **146** is parallel to conduits **138** and **140**. If desired, an inclined rack and pinions may be substituted for the track **146** and wheels **142** and **144**. The ends of track **146** are supported by standards **150** and **152** on platform **148**.

A vacuum pump **154** is supported by platform **148**. Pump **154** is in communication with port **158** in chamber **132** by flexible conduit **156**. The chamber **138** is selectively reciprocated along track **146** by a cable **158**. One end of cable **158** is secured to chamber **132**. Cable **158** extends around pulley **160** and is wound on spool **162**. Spool **162** is selectively wound or unwound by operating motor **164**.

The above mentioned elements of the unit **130** are supported by a portable wheel mounted dolly **166**. Platform **148** is adapted to be raised or lowered by hydraulic jacks **168** and **170** and pump **172**. Dolly **166** is provided with suitable guides to limit movement of the platform **148** to vertical reciprocation.

Thus, it will be seen that the unit **130** is portable and may be moved from furnace to furnace. The jacks **168** and **170** enable the chamber **132** to be raised or lowered to accommodate the unit to different makes of furnaces. When chamber **132** is at the proper height and supported at the top of track **146**, door **18** is opened. Thereafter, conduits **138** and **140** are introduced into the bath **28** by reciprocating chamber **130** toward furnace **10**. Degassing of the bath **28** and addition of alloy metals are accomplished as set forth above. If desired, unit **130** may be suspended from an overhead track.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. A method of forming a metal alloy comprising the steps of heating metal in a furnace to form a molten metal bath, lifting metal from below the surface of the metal bath into a vacuum chamber, feeding alloy agents into the molten metal to form an alloy with the molten metal, returning the metal from the vacuum chamber to a point below the surface of the metal bath, and effecting said lifting and returning steps in a continuous metal flowing cycle, said lifting step including the step of forcing an active gas through the metal to act on the metal, and stopping the forcing of the active gas through the metal prior to the step of feeding the alloy agents into the metal and forcing an inert gas through the metal during the alloy feeding step.

2. The method of forming a metal alloy of claim **1** wherein the step of feeding alloy agents includes the step of measuring a desired amount of alloy agent in a closed receptacle connected to the vacuum chamber prior to opening the closed receptacle to the vacuum chamber to feed the alloy agents to the molten metal in the vacuum chamber.

3. A metal furnace comprising a hearth for receiving metal to be heated, heating means for heating metal in the hearth, a vacuum degassing chamber spaced from and higher than any metal in the hearth, vacuum degassing means for circulating metal from said hearth through said chamber and back to said hearth for degassing the metal, a roof mounted on said hearth, said chamber being mounted on said roof, said vacuum degassing means including a vacuum pump mounted exterior from said hearth and roof, and flexible conduit means connecting said vacuum pump to said chamber.

4. A metal furnace comprising a hearth for receiving metal to be heated, heating means for heating metal in the hearth, a vacuum degassing chamber spaced from and higher than any metal in the hearth, vacuum degassing means for circulating metal from said hearth through said chamber and back to said hearth for degassing the metal, a roof on said hearth, and means for mounting said heating means and said chamber on said roof.

5. A metal furnace comprising a hearth for receiving metal to be treated, heating means for heating the metal in the hearth, a vacuum degassing chamber spaced from and higher than any metal in the hearth, vacuum degassing means for continuously circulating metal from said hearth through said chamber and back into said hearth

for degassing the metal, said last-named means including first and second conduits connected to said hearth below the surface of the metal in said hearth, said first and second conduits also being connected to said chamber, said first conduit having its chamber end higher than the chamber end of said second conduit, said vacuum degassing means including a vacuum pump connected to said chamber, and a gas supply means connected to said first conduit between said chamber and said hearth.

6. The metal furnace of claim **5** wherein said hearth is arcuately movable to receive and pour out molten metal, said chamber and said conduits being rigidly mounted on said hearth, and said vacuum pump being mounted separate from said hearth and flexibly connected to said chamber.

7. A metal furnace comprising a hearth for receiving metal to be heated, heating means for heating metal in the hearth, a vacuum degassing chamber spaced from and higher than any metal in the hearth, and vacuum degassing means for circulating metal from said hearth through said chamber and back to said hearth for degassing the metal, and means supporting said chamber for movement toward and away from said bath along a linear, inclined path.

8. A furnace in accordance with claim **7** including a pair of conduits communicating with said chamber, said conduits having their longitudinal axis substantially parallel to said inclined path and the ends of said conduits extending into said bath.

9. A portable degassing unit comprising a movably mounted support frame, a vacuum degassing chamber reciprocably supported by said frame for movement along a linear, inclined path, means for evacuating said chamber, inlet and outlet conduits communicating with said chamber, said inlet conduit communicating with said chamber at a point higher than the point at which said outlet conduit communicates with said chamber, and the longitudinal axes of said conduits being substantially parallel to said inclined path.

10. A unit in accordance with claim **9** including a preheater for said chamber for preheating said chamber prior to the introduction of molten metal into said chamber.

11. A unit in accordance with claim **9** including a hopper selectively communicating with said chamber and mounted for movement with said chamber.

12. A unit in accordance with claim **9** including elevating means for raising and lowering said chamber.

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