May 11, 1965 R. F. OBENCHAIN 3,182,985

APPARATUS FOR MAKING STEEL

Filed Nov. 13, 1962 4 Sheets-Sheet 1

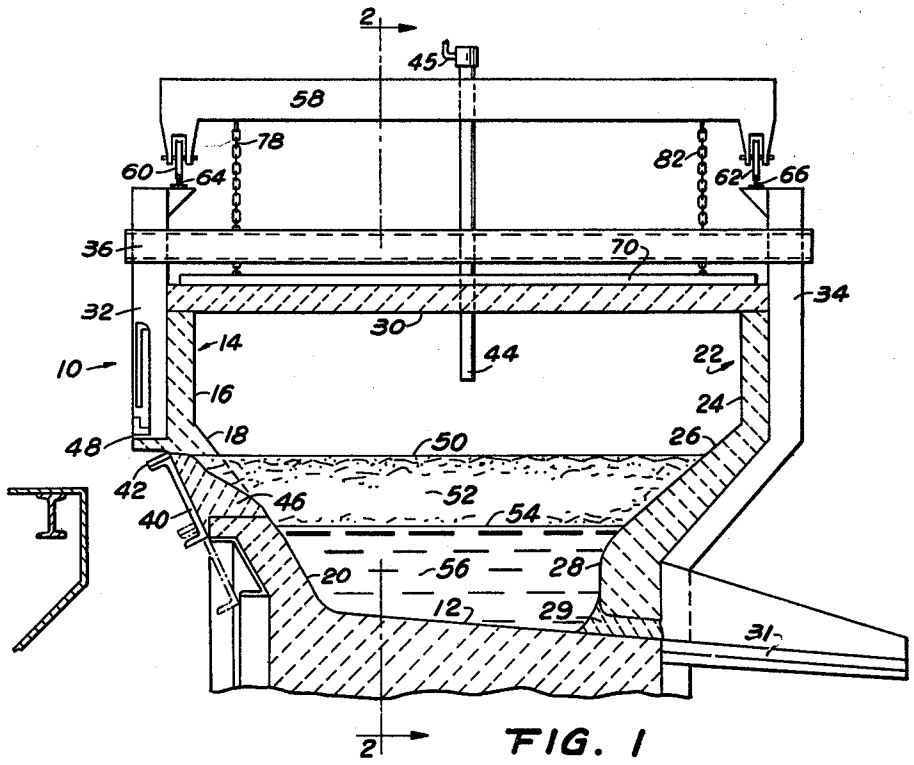


FIG. 1

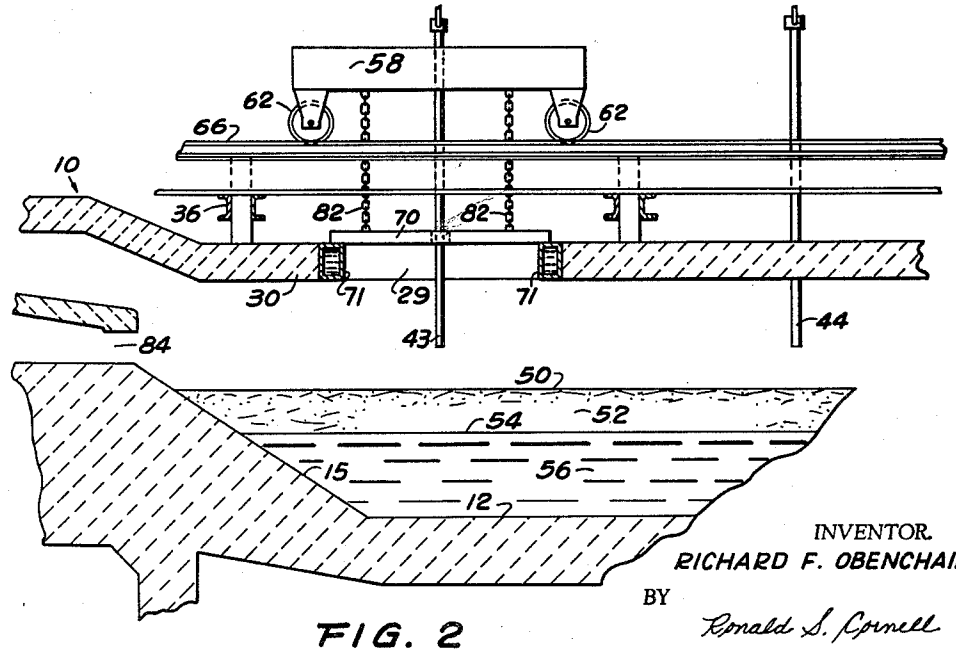


FIG. 2

INVENTOR.
RICHARD F. OBENCHAIN
BY
Ronald S. Cornell
his ATTORNEY

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APPARATUS FOR MAKING STEEL

Filed Nov. 13, 1962 4 Sheets-Sheet 2

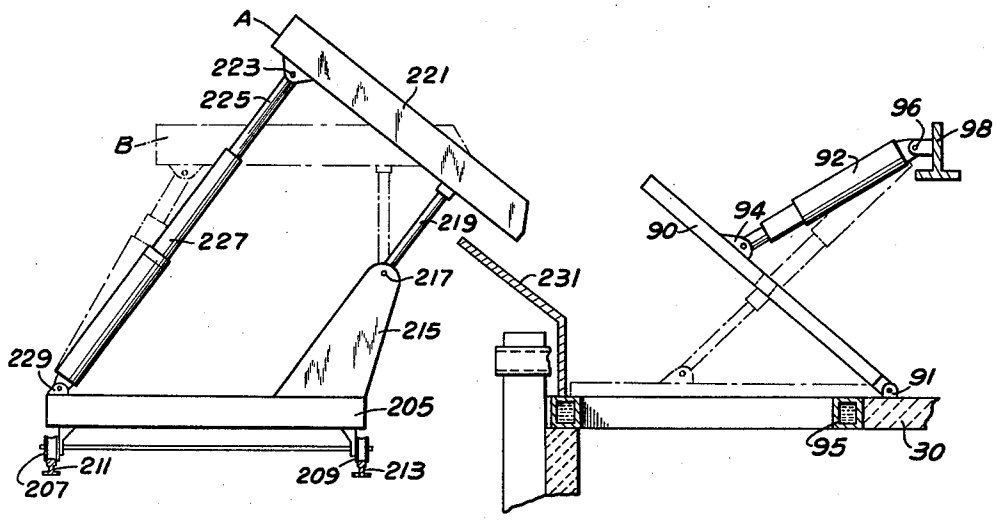


FIG. 3

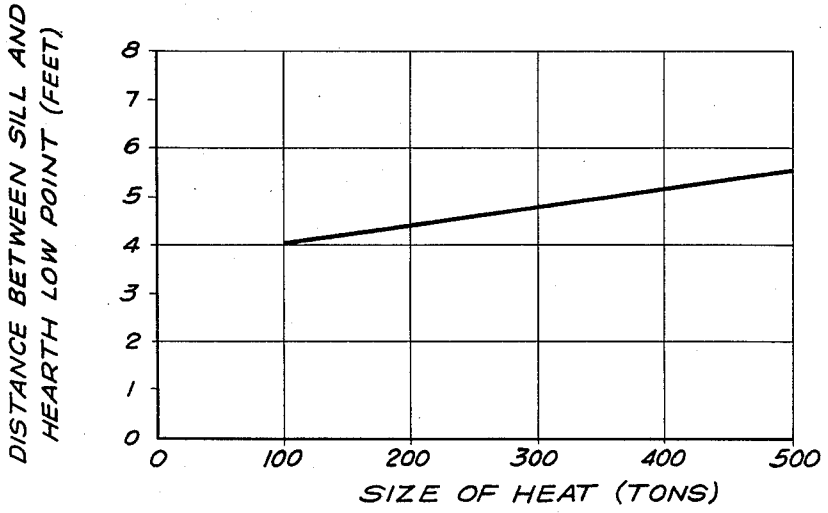


FIG. 6

INVENTOR.
RICHARD F. OBENCHAIN
BY
Ronald S. Cornell
his ATTORNEY

May 11, 1965 R. F. OBENCHAIN 3,182,985

APPARATUS FOR MAKING STEEL

Filed Nov. 13, 1962 4 Sheets-Sheet 3

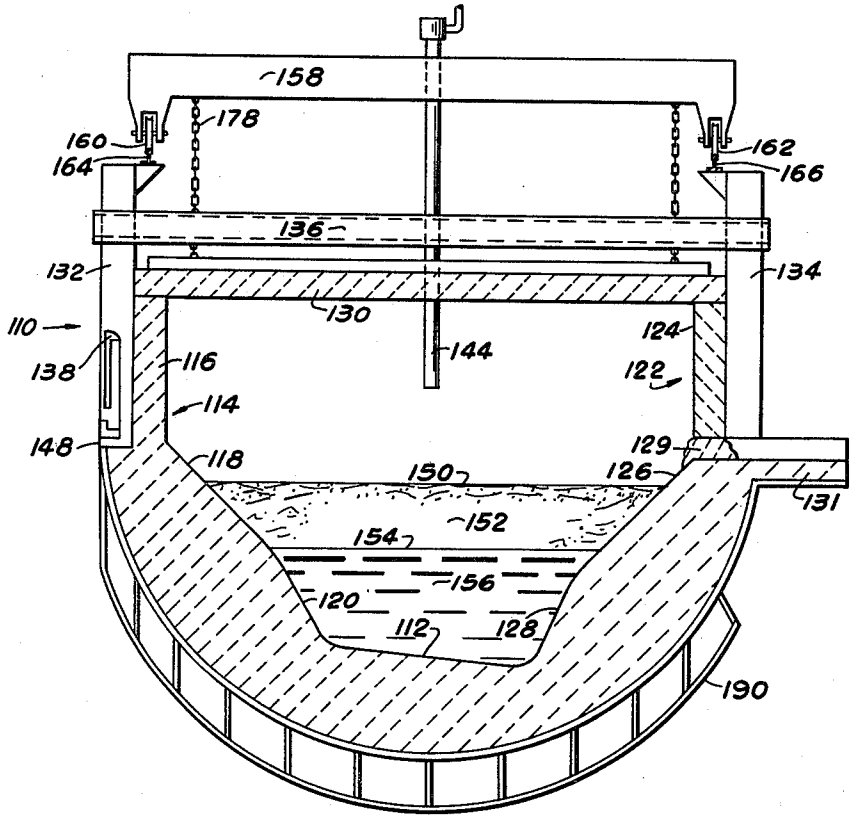


FIG. 4

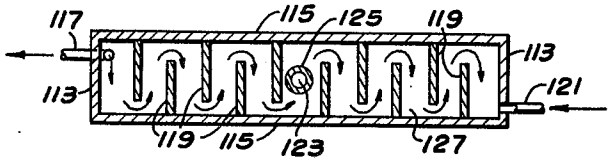


FIG. 5

INVENTOR.
RICHARD F. OBENCHAIN
BY
Ronald S. Cornell
his ATTORNEY

May 11, 1965 R. F. OBENCHAIN 3,182,985

APPARATUS FOR MAKING STEEL

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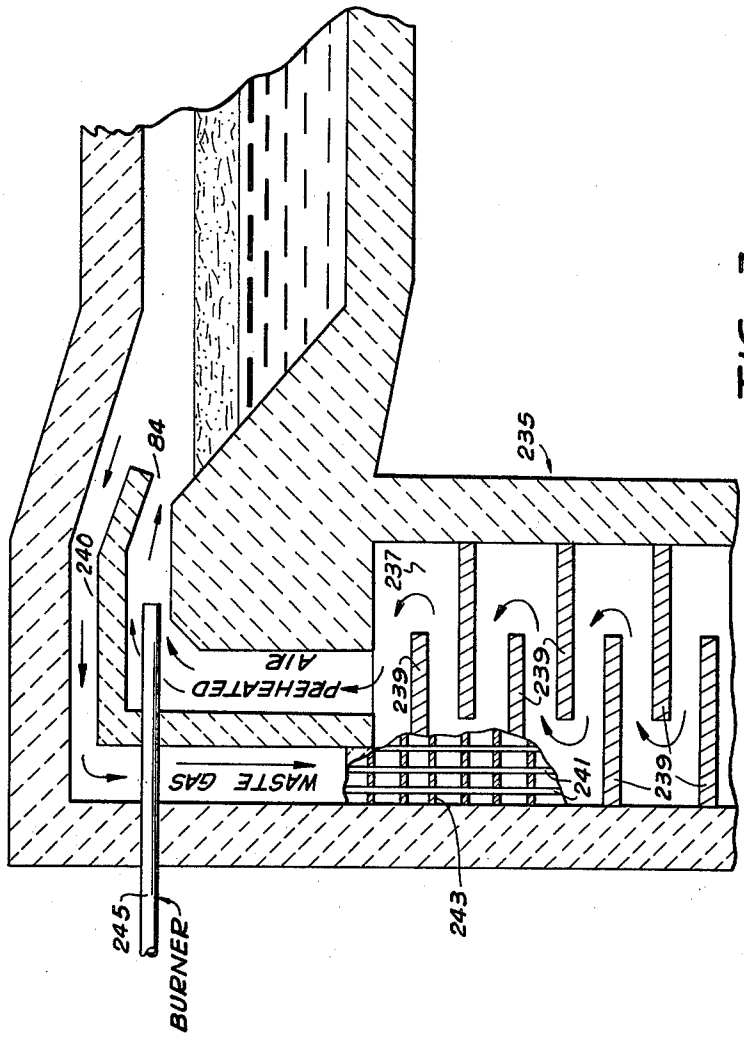


FIG. 7

INVENTOR.
RICHARD F. OBENCHAIN
BY
Ronald S. Cornell
his ATTORNEY

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3,182,985

APPARATUS FOR MAKING STEEL

Richard F. Obenchain, Pittsburgh, Pa., assignor to Koppers Company, Inc., a corporation of Delaware

Filed Nov. 13, 1962, Ser. No. 237,147
10 Claims. (Cl. 266—34)

This invention relates to an improved method and apparatus for making steel, and more particularly, to a method and apparatus which eliminates the disadvantages of both the open hearth and the basic oxygen furnace steel-making processes.

Briefly, this invention comprises a furnace arrangement for the refining of a ferrous metal. The furnace opening is generally elliptical in cross-section. The side walls of the furnace slant inwardly and downwardly at an angle to the horizontal; the angle, however, being less than the angle of repose of heat-resistant material, which is conventionally applied to such walls. The front walls and back walls depend downwardly in a generally vertical direction for a substantial distance and then slant inwardly and downwardly at about the same angle as do the side walls. Thereafter these walls slant downwardlly and inwardly at a greater angle with respect to the horizontal thus affording a deep bath chamber for holding the molten metal. A novel feature of this arrangement is that this deep bath of molten metal permits oxygen to be injected into the furnace at an extremely high rate without the oxygen reaching the bottom of the furnace and causing deterioration thereof. In accordance with this invention, the injection of the oxygen is, in fact, terminated at a distance of at least a foot above the molten bath which accumulates above the molten metal. The furnace is covered with a roof which includes the charging ports and novel arrangements for opening and closing the charging ports. In addition, there is provided in the walls of the opening a novel arrangement for tapping the slag from the molten metal.

It will be noted that certain of the features of this novel furnace have a similarity to the conventional and well-known open hearth furnace. Other features have a similarity to the well-known basic oxygen converter. In each case, however, these features coact to function in a manner entirely unrelated to its function in the open hearth furnace and basic oxygen converter as will be apparent hereinafter.

In a conventional open hearth apparatus, the design must conform to certain rigid standards. For example, in order to gain all possible advantages of heat from the burner and to balance against loss of refractory which could shut down the operation, the size of flues, checker chambers, monkey walls, and the height and shape of the roof have been considered to be of critical importance. In recent times, there has been a trend toward the use of a fuel-oxygen burner for melting scrap in the open hearth, and the bulk of the remaining work after the hot metal is charged, has been done with oxygen or fuel-oxygen mixtures, with the end burner being used as a secondary heat source. Heretofore, it was also believed that an open hearth furnace must have a lengthy scrap charging period since cold scrap has a cooling effect on the hot metal, and could cause the furnace to freeze up.

In conventional open hearth design, an attempt is made to keep the surface area of the bath as large as possible while maintaining a low depth of bath. Generally, in the open hearth, the depth of the bath has been relatively shallow. A shallow bath has been considered advisable from a heat transfer standpoint, and also, because open hearth reactions are, to a large extent, dependent upon the melting and reducing of iron oxides below the bath, a subsequent reaction of the elements in the bath with

these oxides, and also reactions between the slag and the bath at the surface of the bath. However, when using an oxygen lance in a furnace having such a shallow bath, these same features become a disadvantage, since the reaction zones are limited to the area around the lance, leaving a large part of the bath retarded in respect to oxidation of undesirable elements.

In a conventional open hearth furnace, the surface of the bath is normally not more than from four to six inches below the sill line of the hot metal charging door. To gain additional slag capacity, a dam is placed on top of the door sill to raise the upper slag surface as much as eight to ten inches above the sill. This is satisfactory in conventional open hearth practice, but severely limiting to the amount of oxygen which can be blown through a lance because, as the blowing rate increases, slag volume swells and agitation of bath and slag increases. These effects reach a point where the slag and metal can no longer be contained in a conventional furnace.

In conventional open hearth furnaces, the front wall is vertical and the end walls and back wall all slope. The vertical surface of the front wall is deleterious since erosion forms on the vertical wall. This erosion causes the vessel to be taken out of service in shorter periods than would otherwise be necessary. The use of a vertical surface in basic oxygen furnace vessels presents the same problem.

An open hearth can charge from 100 percent cold metal to nearly 100 percent hot metal. The basic oxygen furnace process, however, like all pneumatic processes, is limited in its use of scrap and ore by the total available heat from the chemical reactions during the blow. To rectify this problem, a process of supplying external heat to a basic oxygen furnace process has been proposed to allow for increased absorption of scrap or iron oxides, but, this is time consuming and has not operated successfully.

The use of a gas-oxygen lance in a basic oxygen furnace process has inherent difficulties due to the geometry of the vessel. Because of the small diameter of the vessel, a large scrap charge will occupy a large portion of the vessel. The fuel-oxygen lance has a tremendous flame which must be applied at some distance away from the metal; and such room may not be available with the lance inside the furnace.

The conventional basic oxygen furnace process can efficiently make most carbon ranges up to 0.30 percent. However, higher carbon contents are time consuming and more difficult. The open hearth process, however, has an innate ability to slow down reactions and to make heat corrections, and is quite versatile with regard to product.

Both the basic oxygen furnace process and the open hearth process present difficulties in charging of the furnace. A modern, well designed open hearth requires at least an hour for charging before hot metal can be added, and in addition to this major difficulty, it is not uncommon for the scrap charging operation on one furnace to interfere with as many as two other furnaces, seriously handicapping overall output. The basic oxygen furnace process with large scrap charging boxes, single hot metal ladle charging, and gravity feed of fluxing materials, is generally believed to be well suited from a charging standpoint. However, the basic oxygen furnace process has the disadvantage that the mouth is of limited size, and the volume of the vessel limits the process so that light and ill-prepared scrap cannot be used, and in addition, the charging requires a number of complicated mechanisms which fail upon occasion, and slow down operation.

The basic oxygen furnace process has, to this date, shown little resistance to increased flow rate of oxygen,

and therefore, the basic oxygen furnace process has the inherent ability to make a fast heat. However, the open hearth has severely limited the blowing rate to somewhere in the neighborhood of a thousand cubic feet per minute of oxygen because of the inability to contain the metal and fluxes. In the open hearth process the lances are submerged in the bath thus further limiting the blowing rate.

The small bath area of the basic oxygen furnace process is not a handicap where a small heat is being made, but as the heats increase in size, the blowing rate must increase to assist in any increase in total production, and difficulties are then encountered. These difficulties are caused by inability to provide a proper impingement pattern of oxygen on the bath at large oxygen volumes, and the inability of the restricted area over the bath to contain a violently agitated bath and slag while blowing at high rates. In a conventional open hearth furnace, however, the bath surface area is large and the reactions caused by the oxygen from the lance are localized. The open hearth bath is shallow, however, thereby precluding high blowing rates since a high blowing rate will have a deleterious effect on the hearth.

By virtue of the invention, these difficulties can now be disposed of in a practical and economical manner. The invention contemplates an elongated furnace having a hearth; sloping front, back, and side walls; hot metal charging doors in the front wall; a plurality of oxygen lances, and a plurality of fuel-oxygen lances, and a roof which is sufficiently high to allow for the high piling of scrap and to reduce the impact of heat and splash on the roof material. Ports in the roof of the furnace permit the charging of scrap. The door covering each charging port is lifted by a handling device to uncover a substantial section of the furnace to allow for top charging. The door is preferably comprised of water-cooled, steel panels, but may be of refractory material.

The scrap is placed in a charging machine from large scrap boxes, and the charging machine is then propelled to the proper location at the charging ports, where the scrap is dumped through the charging ports. Fluxing materials may also be charged either alone or with the scrap through the roof doors.

A deep bath with restricted surface area is also provided so that the oxygen from lances may be blown from above the bath at high blowing rates. The deep bath and the high blowing rate of the oxygen and fuel-oxygen mixtures allows larger heats than in conventional open hearth design. In the invention, the surface of the bath is lowered to at least twelve inches below the sill, thereby providing additional slag capacity in the furnace.

The front and back walls slope outwardly and upwardly in such a manner that above the bath surface, the walls rise at an angle such as to ensure their retaining their covering of lining material. The angle of the walls must therefore be not greater than the angle of repose of the lining material. The wall below the surface of the bath will have a steeper slope. The slope of the walls provides a deep bath with restricted bath surface area and the slope of the walls is ideally suited to minimize refractory deterioration. The sloping walls also facilitate repair or patching of the walls since the patching material remains on the sloping areas and because of the slope, stays in place to effect a good patch.

In order to obtain a bath of the required depth the distance between the sill line and the lowest point of the hearth is substantially greater than in normal open hearth furnaces. The depth must be related to the size of the heats to be made in the furnace. Accordingly, there is used for example, a distance of more than 4.0 feet from the sill line of the hot metal charging door to the lowest point of the hearth for a 100 ton heat, or 5.5 feet for a 500 ton heat. In any event there must always be at least one foot between the sill line and the top of the molten steel bath.

By providing a bath of sufficient depth to accommodate a high blowing rate of oxygen, sloping walls to accommodate the large volumes of slag, and a high roof to avoid the deleterious action of heat and splash, it becomes possible and desirable to blow the oxygen at a rate of between 1,500 to 6,000 cubic feet/minue or even higher. A preferred rate of blow is 2,200 to 4,000 cubic feet/minute. With the use of a plurality of lances in a single furnace, each lance blowing at this high rate, great economy is achieved.

The lances are blown from above the bath as contrasted with open hearth systems which heretofore have submerged the lance in the bath. The nose of the lance must be placed at least one foot and preferably three to four feet above the bath.

The invention further contemplates the use of either a tilting or a stationary furnace. The stationary furnace is provided with mechanically actuated, water-cooled side doors for a quick slag flush. These doors can be opened by lowering the door to the bath line in small increments. These doors, when closed, allow the operator to install a refractory material, such as burnt dolomite, behind the door to protect it from the heat of the furnace, and from attack by slag or metal. The furnace of this invention can tap multiple ladles, and it is possible for a ladle to be tapped to a predetermined chemical specification, after which the tap hole can be closed and the metal further refined. Under such circumstances, either a tilting furnace is required, or in a stationary furnace a mud gun is needed to close the tap hole. In a tilting furnace there is no need for a flush hole or tap hole below the slag or metal line and both slag flush and tapping takes place through a tap hole above the slag line. The furnace of this invention retains the conventional open hearth doors, whereby a conventional charging machine is used to charge certain materials, such as iron ore, alloying material, etc. These doors are also used to inspect, take samples, take the temperature of the heat, and also to enable control of the end chemical and metallurgical characteristics. Bottom maintenance is also accomplished through these doors. The invention further contemplates the use of a novel charging machine for charging scrap through the water-cooled roof doors.

This invention also includes a method of operating the improved furnace of the invention.

In operation, ore and scrap are charged into the furnace the scrap being charged through a door in the roof of the furnace. This charging operation consumes a period of from 10–30 minutes. After the ore and scrap have been charged to the furnace, a fuel-oxygen mixture may be burnt to melt the scrap. This step will consume up to 30 minutes, however, in some instances it will not be necessary to use the fuel-oxygen mixture. Hot metal is then added which addition consumes approximately ten minutes. At this point, oxygen ignition takes place which requires approximately one minute. Fluxes may then be added by chute from overhead bins which require another minute. The oxygen blow period then begins. This requires from 10–45 minutes. If necessary, excess slag may be removed requiring approximately five minutes. The temperature of the bath will then be tested and a sample of the bath will be taken. If necessary at this point, slight changes in the composition of the bath may be made such as by the addition of alloying materials. The bath is then tapped requiring approximately five minutes and the slag is removed also requiring approximately five minutes. It can be seen that by the process of this invention, a complete heat can be made in less than two hours. Hearth and tap hole maintenance can then be completed and the cycle begun again. The end burners are on as required to maintain the furnace temperature. It is expected that these end burners provide very little external source of heat for the reactions.

The foregoing and further objects will be apparent from

the following specification when read in conjunction with the attached drawings wherein:

FIGURE 1 is a vertical, cross-sectional view through a preferred embodiment of the furnace of this invention;

FIGURE 2 is a partial longitudinal cross-sectional view taken on lines 2—2 of FIGURE 1;

FIGURE 3 is a partial cross-sectional view through another embodiment of the furnace of this invention and further showing the novel scrap charging machine of the invention;

FIGURE 4 is a vertical cross-sectional view of a tilting furnace of this invention;

FIGURE 5 is a cross-sectional view of a water cooled roof door; and

FIGURE 6 is a graphical illustration of the correspondence between the size of a heat to be processed and the distance between the sill and the lowest point of the hearth.

FIGURE 7 is a cross sectional view with parts broken away of the recuperator.

The furnace **10**, FIGURE 1, includes a hearth **12**, side wall **15** (FIGURE 2), a front wall **14** having upper portion **16**, intermediate portion **18**, and lower portion **20**, and a back wall **22** having an upper portion **24**, intermediate portion **26**, and the lower portion **28**. The walls and hearth **12** define a chamber for containing slag **52** and molten metal **56**. Both the front and back walls are vertical above about the sill **48**. Between the sill **48** and the slag-metal interface **54**, both the front and back walls slope at an angle of between about 36° and 60° preferably around 52° to the horizontal. Below approximately the slag-metal interface **54**, the front and back walls have an increased slope thereby allowing a greater depth of bath. At the base of the back wall, there is provided at least one tap hole **29** which connects the interior of the furnace with a tapping spout **31**. The tap hole **29** is closed with a refractory material such as dolomite during the operation of the furnace, and the dolomite is removed at the end of a heat to allow the molten purified metal to be removed from the furnace.

The furnace is further provided with a roof **30** raised more than eight feet above the conventional roof. The advantage of having a roof this high above the sill is that it allows a higher piling of scrap and also reduces the impact of heat and splash on the roof material, thus giving the roof a longer life. Furthermore, the end burner **84** is utilized only as auxiliary heat source, and therefore it is no longer necessary that the roof be maintained close to the sill **48**.

The roof **30** is provided with openings **29** (FIGURE 2) for charging scrap into the furnace. The openings **29** have water-cooled side supporting members **71** for support of the roof door **70**. Rails **64**, **66** are provided above the roof **30** for support of wheels **60**, **62** of door crane **58**. Crane **58** is provided with suitable lifting means such as chains **78**, **82** for lifting the roof door **70** above the surrounding steel work. The door crane **58** is then moved longitudinally to uncover a substantial section of the furnace to allow for top charging.

In the alternate embodiment shown in FIGURE 3, the door **90** is mounted on pivot means **91** on roof **30** and is raised and lowered by air cylinder **92**, which air cylinder **92** is supported by pivot means **96** on steel work **98**, and attached to the door **90** by pivot means **94**. The door is supported on water-cooled side supporting member **95**. The apparatus for charging scrap through this door comprises a platform **205** supported on wheels **207**, **209** which in turn are supported by rails **211**, **213**. Stationary member **215** is carried by platform **205**. Stationary member **215** supports a pin **217** to which is pivotally attached a rod **219** which is fixedly attached to an open ended scrap box **221** at one end thereof. At the other end the scrap box **221** is pivotally attached by means of pivot **223** to the plunger **225** of an air cylinder **227**. The shell of air cylinder **227** is pivotally attached by pivot **229** to

the platform **205**. In operation the open ended scrap box **221** is lowered to position B and the scrap is loaded into the box **221**. The air cylinder is then actuated by suitable control means (not shown) to raise the rear of the scrap box while tilting same towards the charging door **90**. The scrap slides from the scrap box **221** and falls into the opening in the roof. To ensure that all the scrap enters the furnace, a plate **231** is provided to guide the scrap into the furnace.

A preferred type of roof door of this invention is shown in FIGURE 5 and includes end walls **113**, side walls **115**, top wall **127** and a top wall (not shown) and further includes cooling water inlet means **117**, baffle plates **119** to direct the flow of cooling water and cooling water outlet means **121**. The roof door **70** further includes an opening **123** surrounded by circular plate **125** to provide for the insertion of a fuel-oxygen lance through the door.

Structural members for support of the furnace include buckstays **32**, **34** and structural member **36** (FIGURE 1). At least one and preferably five open hearth type charging doors, such as door **38**, is provided for the purpose of charging certain materials such as hot metal. These doors are also used for inspecting, sampling and taking the temperature of the heat, as well as controlling the end chemical and metallurgical characteristics of the bath through these doors. Fettling and bottom maintenance are also accomplished through doors **38**.

A slag flush door **40** is provided for removing slag to take out impurities and to reduce slag volume when it is no longer necessary. Door **40** is preferably a water cooled door which opens in a downward direction, and which lowers gradually to the bath line. When the door is closed the operator installs a refractory material such as burnt dolomite behind the door to protect it from the heat of the furnace, and from slag and metal attack. The door **40** is provided with a replaceable casting means **42** at the top thereof. The casting **42** has an indentation therein which gives a funnel effect whereby as the door **40** is lowered the means **42** provides a guide for the slag.

Fuel-oxygen mixtures are introduced into furnace **10** through a plurality of fuel-oxygen lances **43** (FIGURE 2) which are inserted into the furnace through the roof doors **70** so that the flames from these lances impinge directly upon the piles of scrap to melt the scrap. Oxygen is introduced into furnace **10** through a plurality of lances **44** inserted through roof **30**, spaced at least a foot above the bath, and spaced along the length of the furnace. Each lance **44** is provided with means **45** whereby oxygen can be introduced into the furnace. The oxygen may be introduced prior to the hot metal addition during the melt down period to speed up the melting and oxidation of the scrap, but are normally used for refining the bath after hot metal addition. The fuel-oxygen mixture may also be used, if desired, during the refining of the bath after the addition of hot metal. The use of oxygen and fuel-oxygen mixtures in the furnace reduces the amount of end firing with fuel and air that is necessary. The end burner channel **84** is provided for maintaining the furnace temperature between heats and for controlling bath temperature at the end of the heat.

The end burner channel **84** (FIGURE 7) is provided with air preheated in a recuperator **235**. It is possible to use a recuperator instead of expensive regenerators because the furnace does not require a large quantity of heat from these end burners **84** since the major portion of the heat is supplied by the oxygen lances. The recuperator **235** includes a plurality of metal heat exchange plates such as plate **237** which plates divide the recuperator into a plurality of shallow rectangular spaces. Air to be preheated is passed through alternate spaces provided with metal baffle plates **239** to direct the flow of air. Opposite spaces are provided with tubes **241** and spacers **243**. The hot waste gas from the furnace passes through channel **240** and through tubes **241** and gives up its heat to the air flowing through the alternate spaces.

The thus preheated air is then passed into end burner channel **84** where it is mixed with fuel from burner tube **245**.

During the scrap melting period, there advantageously may be three piles of scrap along the furnace with a fuel-oxygen lance directed at each scrap heap to melt the scrap. The hot metal addition will take place between the three scrap piles and an oxygen lance will advantageously be directed at each area where hot metal is added.

In another embodiment of this invention there is provided a tilting furnace **110** (FIGURE 4) having a hearth **112**; a front wall **114** with upper portion **116**, intermediate portion **118**, and lower portion **120**; a back wall **122** with an upper portion **124**, intermediate portion **126** and lower portion **128**, and side walls (not shown). The walls and hearth **112** define a chamber for containing slag **152** and molten metal **156** wherein the surface of the slag **150** is maintained below the sill line and a slag-metal interface **154** is maintained at about the change in angle between the intermediate portion and the lower portion of the front and back walls. Both the front and back walls are vertical above the sill **148**, and between the sill **148** and the slag metal interface **154**, both the front and back walls slope at an angle of between about 36° and 60° to the horizontal, equivalent to the maximum angle of repose of the patching material which is applied between heats. Below the slag metal interface **154**, the front and back walls slope at a steeper angle to the horizontal to obtain a deep bath **156**. At the back wall between the upper portion **124** and the intermediate portion **126**, there is provided at least one tap hole **129** which connects the interior of the furnace with a tapping spout **131**. This tap hole is used to remove either slag or molten metal, as desired, from the furnace. The tap hole **129** is closed with a refractory material such as dolomite during the operation of the furnace. The dolomite is removed when the slag or the molten purified metal is to be removed from the furnace.

The furnace is provided with a high roof **130**. Buckstays **132, 134** and **136** provide support for the rails **164, 166** which in turn support wheels **160, 162** of roof crane **158**. The buckstays **132, 134** and structural member **136** also provide support for the walls of the furnace. The entire furnace is supported on suitable means **190** (shown schematically) for tilting the furnace. When charging of the scrap is to begin, the roof door crane **158** raises lifting members such as chains **178, 182**, thereby raising the roof door **170** above the structural steel elements **136** and the roof door crane then moves longitudinally to displace the roof door **170** from above the roof door opening. Following scrap charging through the roof opening, fuel-oxygen lance **144** may be inserted through the roof door **170** and the blowing of a fuel-oxygen mixture is commenced.

At least one and preferably five open hearth type charging doors, such as door **138**, are provided for the purpose of charging hot metal into the furnace. Doors **138** are also used for inspecting, sampling, and taking the temperature of the heat as well as control of the end chemical and metallurgical characteristics of the bath through these doors. Fettling as well as bottom maintenance between heats is also accomplished through doors **138**.

Generally, where five open hearth type doors **138** are being used, a roof door **170** is provided above each of the odd numbered open hearth type doors **138** so that scrap charging may occur through the roof adjacent the end doors and the middle door of the furnace. A fuel-oxygen lance is inserted through each of these roof doors. Hot metal additions are added to the furnace through the even numbered doors (the second and fourth doors) and an oxygen lance is inserted through the roof at a position adjacent each of these even numbered doors. Since, in the preferred embodiment, five lances may be blowing at the same time, operation of the furnace of this invention enables more gas and/or oxygen to be blown into the furnace than has heretofore been possible in either a basic oxygen furnace process or in an open hearth process. The blowing rate of each lance will be above 1500 cubic feet per minute, and preferably, between about 3000 cubic feet per minute and 8500 cubic feet per minute. Higher blowing rates are also possible in the furnace of this invention.

FIGURE 6 graphically shows the relation between the size of the heats to be carried out in a furnace and the minimum distance required between the sill of the hot metal charging door and the lowest point of the hearth for providing an adequately deep bath. If the distance between the sill and the hearth is less than that shown on the graph for a furnace of the stated size the bath will not be deep enough to avoid destruction of the hearth from the oxygen blast. In addition the furnace will not be large enough to contain the slag as it is frothed by the oxygen blast.

I claim:

1. A furnace arrangement for the refining of a ferrous metal comprising a structure having a chamber of a generally elliptical cross-section whose side walls slant inwardly and downwardly at an angle to the horizontal, said walls being adapted to be faced with a heat-resistant patch material, said angle being less than the angle of repose of the heat-resistant patch material, and whose front and back walls depend downwardly for a distance in a generally vertical direction and then slant inwardly and downwardly at about the same angle as said side walls, and thereafter slant downwardly and inwardly at a greater angle with respect to the horizontal so as to afford a deep bath for holding a molten metal, at least one lance mounted above said structure for introducing oxygen into the furnace and adapted to terminate at a distance of at least a foot above the slag layer which accumulates above said molten metal, the height of the molten metal in said bath being such that the oxygen will not reach the bottom of the furnace to deteriorate the same, a recuperator fixed to said structure, means for inflowing air into said furnace through said recuperator, and means for outflowing gas from said furnace through said recuperator whereby said outflowing gases heat said inflowing air.

2. A metal refining furnace comprising a chamber adapted to contain a bath of molten metal with a slag layer, said slag layer and metal bath at the place of contact forming a slag-metal interface, the front wall and back wall of said chamber inclining upwardly and outwardly to above the top of said slag layer, said walls sloping outwardly from said slag metal interface to above the top of said slag layer at a predetermined angle, and said wall having a steeper slope below said slag metal interface.

3. A charging arrangement for a furnace for the refining of ferrous metal, said furnace having a chamber therein adapted to hold a bath of molten metal and a roof for covering said chamber, ports in said roof for the charging of material into said chamber, the inner periphery of said ports being fitted with a water-cooled annular member, a door for covering said port, and means for moving said door, said last-named means including a car mounted for movement on said cover above said door, and means connecting said door and said car for moving the cover relative to said car.

4. A charging arrangement for a furnace for the refining of ferrous metal, said furnace having a chamber therein adapted to hold a bath of molten metal and a roof for covering said chamber, ports in said roof for the charging of material into said chamber, the inner periphery of said ports being fitted with a water-cooled annular member, a door for covering said port, and means for moving said door, said last named means including an actuator having one end fixed, and the other end connected to said door whereby movement of said actuator opens and closes said door.

5. A furnace arrangement for the refining of a ferrous metal comprising a structure having a chamber of a

generally elliptical cross-section whose side walls slant inwardly and downwardly at an angle to the horizontal, said walls being adapted to be faced with a heat-resistant patch material, said angle being less than the angle of repose of the heat-resistant patch material, and whose front and back walls depending downwardly for a distance in a generally vertical direction and then slant inwardly and downwardly at about the same angle as said side walls, and thereafter slant downwardly and inwardly at a greater angle with respect to the horizontal so as to afford a deep bath for holding a molten metal, at least one lance mounted above said structure for introducing oxygen into the furnace and adapted to terminate at a distance of at least a foot above the slag layer which accumulates above said molten metal, the height of the molten metal being in said opening being such that the oxygen will not reach the bottom of the furnace to deteriorate the same.

6. The furnace arrangement of claim 5 wherein said furnace is adapted to be tilted whereby said molten metal and slag may be removed from the furnace through a tapping spout in the back wall when said furnace is tilted.

7. The furnace of claim 5 including a roof for covering said chamber, charging ports in said roof, said charging ports being blocked by doors, and means for removing said doors so as to introduce a charge of material into said furnace.

8. The furnace arrangement of claim 5 including a door in the intermediate sloping portion of said front wall for removing slag from the furnace.

9. The furnace of claim 5 including a door in the front wall thereof for removing slag from the furnace.

10. The furnace of claim 5 including a recuperator means for inflowing air into said furnace, and means for outflowing gases from said furnace into indirect contact with said inflowing air whereby said gases transfer heat to said inflowing air to heat said inflow air.

References Cited by the Examiner

UNITED STATES PATENTS

2,182,064	12/39	Vogt	266—34
2,579,409	12/51	White	214—18
2,962,174	11/60	Shekek	214—18
2,965,370	12/60	Kesterton et al.	266—34
3,084,039	4/63	Baum	75—60 X

MORRIS O. WOLK, *Primary Examiner.*

JAMES H. TAYMAN, JR., *Examiner.*