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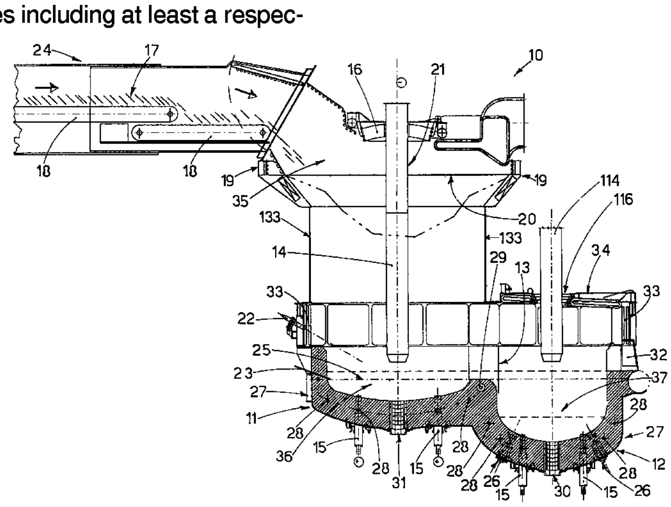
(54) Double hearth electric arc furnace for continuous melting

(57) Electric arc furnace to continuously melt steel and its alloys including at least a first body (11) comprising an upper zone (35) for the loading of the raw material (17) and a lower zone (36) for the melting and the first refining of the molten metal, and at least a second body (12) including a zone (37) with the function of decanting and refining the liquid metal and with a tapping hole (30) for the liquid metal, the first (11) and second (12) bodies forming a single body connected by means of a channel (13) through which the liquid metal is transferred, the upper zone (35) of the first body (11) cooperating at least with loading means (24), the first (11) and second (12) bodies including at least a respective central and vertical electrode (14,114) and relative anodes (15) located on the bottom part, the first body (11) including on the side walls heating burners (22) and supersonic lances (23) to blow in oxygen and the second body (12) including on the bottom part tuyères (26) to blow in carbon, the loading means (24) to load the raw material (17) being of the continuous type and associated with means to stir and distribute (19, 20) the raw material (17) in a homogeneous manner, the channel (13) being associated with means to regulate the flow from one body (11) to the other (12).



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Description

This invention concerns an electric arc furnace for the continuous melting of steel and its alloys as set forth in the main claim.

The invention is applied to the field of steel production and to be more exact, to electric arc furnaces for the continuous melting of raw material of various types, such as for example, scrap, iron rejects from mechanical processing, iron briquettes, solid or liquid cast iron, sponge iron or any other type.

The invention is applied particularly to furnaces fed with alternating current.

The state of the art covers electric arc furnaces fed with direct or alternating current which use alternative energy sources such as burners, supersonic lances, tuyères situated under the bath of molten metal, and other sources.

These furnaces are used to produce steels starting from scrap materials of various kinds such as waste metal, chips and off-cuts from mechanical processing, steel returns, iron salvage materials etc. At present, as well as these salvage materials and iron alloys, other raw materials are used, such as sponge iron, solid or liquid cast iron or other materials, because the pollution they cause is limited.

Both the salvage materials and the other above-mentioned materials can be loaded into the furnace in a single lot, or also in a semi-continuous manner by using loading baskets, or in a continuous manner by using transporter belts and loading and distribution means.

At present, in order to increase the productivity of these furnaces, there is an attempt to load the furnace continuously, in order to be able to tap the liquid steel in a substantially continuous manner and thus reduce the times of the operating cycle.

In furnaces of a conventional type, however, this condition cannot be achieved, as the refinement of the steel and the subsequent tapping can be completed only after the raw material has been completely melted.

Attempts have been made to achieve furnaces subdivided into two bodies, where a first body is used to load and melt the raw material and a second body is used to refine and tap the molten steel.

These attempts have not given satisfactory results because in the first body the raw material tends to arrange itself inside the furnace forming heaps piled up against one side; the raw material melts progressively from the base, which is of a considerable size, upwards towards the apex. Moreover, in furnaces known to the art, the presence of these piles of material prevents the heat from being distributed evenly throughout the metal in the furnace, which compromises the efficiency of the process and also the productivity of the plant.

Furthermore, the transfer of the molten metal from the first to the second body takes place when the melting process is complete, and this increases the times of the operating cycle.

Moreover, this transfer takes place through a refractory channel which, because of the high temperature, is easily subject to wear.

Another shortcoming which businessmen in this field complain of is that furnaces of the type known to the art, because of their particular conformation, have a particularly high energy consumption.

A further shortcoming derives from the difficulties met in the tapping step, because of the solidification of the molten steel inside the tapping conduit.

The state of the art includes FR-A-1.482.929 which proposes a system of continuous loading, by means of briquettes, between the electrodes, transferring the molten steel to a second furnace where the temperature of the melted metal is raised and where the composition of the melted metal is corrected before being tapped.

DE-A-2.504.911 proposes a continuous loading tower at the base of which a plurality of burners melt the metal which is transferred by means of the source method into a second furnace where electrodes provide to raise the temperature before the metal is tapped.

AT-B-344.215 proposes a system similar to the previous one, but the transfer of the liquid metal is controlled by a system of magnetic fields.

DE-U-8.412.739.2 and EP-A-170.809 show continuous loading systems associated with an electric furnace to control the temperature of the liquid metal.

EP-A-240.485 and EP-A-548.041 show continuous loading towers with axially movable burners at their base; the burners melt the metal which is transferred to an electric furnace, which serves to control the temperature of the molten metal and to refine it before tapping.

WO-A-96/19592 provides for two twin electric melting furnaces, of which the main one is associated with a tower to continuously load the scrap.

WO-96/32505 provides for a furnace associated with a central well device to continuously feed and pre-heat cast iron produced by the blast furnace; around the furnace there are four electrodes arranged obliquely with respect to the vertical axis of the furnace.

This device with the feeder well is associated with a loading and pre-heating well inside which the material to be melted is unloaded; the melted metal is then transferred into another container equipped with auxiliary heating means, from which spilling takes place.

The passage of the liquid metal between the two containers is not regulated, so that it is not possible to ensure an adequate and constant control of the flow or of the slag which is present above the liquid metal; nor is it possible to ensure that a part of the load is maintained in a solid state in the loading and pre-melting well.

The present applicants have designed, tested and embodied this invention in order to overcome the shortcomings of the state of the art, and to obtain further advantages.

This invention is set forth and characterised in the main claim, while the dependent claims describe variants of the idea of the main embodiment.

The purpose of the invention is to obtain an electric arc furnace able to ensure a continuous production of high quality or any quality steel, with reduced operating times.

A further purpose is to achieve a furnace and a method able to provide a considerable saving of energy.

The invention includes the use of an electric arc furnace, fed with direct current, equipped with two intercommunicating main bodies and constituting a single, integrated structure: a first body, used to continuously load the raw material, to carry out a first melting thereof and to perform a first refining of the liquid metal, and a second body for the definitive refining, the decantation and the tapping of the molten steel.

According to the invention, the furnace is fed with direct current so as to exploit the greater stability of the electric arc compared with the electric arc obtained in furnaces fed with alternating current; this gives a more efficient melting of the raw material and also a reduction in the disturbances on the outside electric line.

According to the invention, there is both a cathode positioned at the central part of the first body of the furnace and also another one positioned at the central part of the second field, both of which cooperate with one or more anodes arranged on the hearth or with other equivalent and suitable means to ensure the passage of the electric current.

The central position of the cathode makes it possible to obtain a peripheral distribution of the load, ensuring uniformity and homogeneity in the distribution of the material inside the furnace and preventing material from accumulating in particular zones of the furnace.

According to a variant, the first body of the furnace has two or more cathodes arranged symmetrically with respect to the furnace.

The method according to the invention includes a substantially continuous loading of the materials which comprise the load, advantageously in such a way that there is always a part of the load in a solid state in the first body.

For this purpose, there are loading means cooperating with means to distribute the raw material evenly within the first body of the furnace.

The raw material consists of scrap which can be integrated with cast iron ingots, sponge iron and iron carbide.

According to one embodiment of the invention, these means cooperate with a distribution zone located in the upper part of the furnace and associated with the appropriate thrust means able to load the raw material into the furnace as soon as a condition of even distribution is achieved in that zone.

According to one embodiment of the invention, the two bodies of the furnace have a substantially circular section and a high ratio of height to diameter.

To be more exact, at least the first body of the furnace, that is, the one for loading and melting, has a column-shaped body which exploits the re-use of energy to pre-heat the scrap and the other raw material loaded.

This makes it possible to recoup a considerable amount of energy by exploiting the counter-flow of the discharge fumes through the loaded material in the first and second body, and also by exploiting the heat inside the furnace.

This recovery of energy is also ensured by the inclusion of cooling and insulation panels arranged on the sides of the walls of the column-shaped body and on the roof of the furnace.

To be more exact, according to a variant, the panels located on the roof of the furnace are arranged so as to induce a discharge of the fumes generated during the cycle with a cyclonic development in order to increase the time they remain inside the furnace; in this way, the efficiency of the pre-heating of the raw material loaded is increased and at the same time, the fumes are cooled as heat is transferred to the load material.

In one embodiment of the invention, the roof of the second body of the furnace is inclined in the direction of the first body so as to assist the flow of the discharge fumes into the first body, thus increasing the efficiency of the pre-heating of the scrap metal and raw material to be loaded.

The method according to the invention includes the use of burners which make the temperature of the first body of the furnace homogeneous and thus improve the melting of the raw material; they also cooperate with the aforesaid means to load and distribute the raw material so as to guarantee a better and more regular descent of the raw material into the furnace, thus assisting the continuous loading.

According to one embodiment of the invention, the burners are of the oxygen-fuel type, with a carbon-based or hydrocarbon-based fuel and at certain stages of the melting cycle they emit only oxygen.

According to a variant, both in the first and second body there are supersonic lances and also tuyères to inject oxygen into the lower part of the furnace and/or under the level of the bath.

Furthermore, at least the second body includes means to blow carbon into the bath of molten metal.

In order to assist and accelerate the chemical reactions for the melting of the scrap, according to one embodiment of the invention the furnace is made to work with a "swamp" method, that is to say, with a liquid foot always present on the bottom of the furnace.

According to the invention, the transfer from the first to the second body takes place through an appropriate channel.

According to a first embodiment, the passage takes place when the liquid in the first body overflows as soon as it reaches and surpasses a pre-determined level.

According to a variant, the passage of the liquid metal in the refractory channel is regulated by the appropriate means, which may be mechanical, electromagnetic or other means which allow or prevent the passage of the molten metal and possibly regulate the flow thereof; they also regulate the passage of the slag from the first to the second body.

This channel moreover permits the passage of the fumes from the second to the first body, thus allowing these fumes to be used in their counter-flow to pre-heat the loaded raw material.

According to a variant, the fumes produced in the second body are recovered and sent to the zone where the raw material is distributed, by means of the appropriate conduits.

In one embodiment of the invention, the channel is also equipped with wear-resistant means, of a mechanical, electromagnetic, mixed or other type which, apart from preventing wear on the refractory material, assist and regulate the passage of the liquid metal.

The passage of the liquid metal from the first to the second body takes place when the liquid metal is melted and is at the first step of refining, that is, it has attained a first degree of dephosphorization and is partly decarburized.

In the second body, the liquid metal is subjected to complete refining and reaches the desired stage of complete desulphurization and decarburization, whereas in the first body the melting of the raw materials, as they are gradually loaded, continues without interruption.

According to the invention, in order to make the bath of molten metal homogeneous and to accelerate the chemical reactions of the process, both the first and the second body are equipped, in cooperation with the lower shell, with means to mix and stir the liquid metal, which can be of a mechanical, electromagnetic or other type.

The tapping of the liquid steel from the second body is achieved by means of the appropriate means, located on the hearth or on the wall of the second body, and cooperate with a mating tapping conduit.

According to the invention, these tapping means cooperate with the appropriate heating means suitable to liquefy any metal which may have solidified in the discharge channel.

In the furnace according to the invention, the cathode is normally composed of an upper metallic portion equipped with a cooling system using water or liquid metal, and by a lower consumable part made of graphite. The anodes too are equipped, in one embodiment of the invention, with a cooling system using water or liquid metal.

The attached figure is given as a non-restrictive example and shows a preferred embodiment of an electric arc furnace using the method of continuous melting according to the invention.

The electric arc furnace 10 is substantially composed of two bodies, respectively a first body 11 where the raw material is loaded, melted and the molten metal undergoes its first refining, and a second body 12, in this case smaller in diameter than the first, where the molten metal is completely refined and tapped.

The first 11 and second 12 bodies are in this case achieved in a single body, define a single structure and are inter-communicating by means of a channel 13.

According to the invention, the electric arc furnace 10 is fed with direct current and is equipped respectively with a cathode 14 for the first body 11 and a cathode 114 for the second body 12.

In a variant which is not shown here there are at least two cathodes 14 of the first body 11 and are arranged vertical and symmetrical on the roof of the first body 11.

In the case shown here, the cathodes 14 and 114 cooperate with four anodes 15 located on the hearth of the furnace and symmetrical with the longitudinal axis of the respective cathodes 14 and 114, in such a way as to distribute the current more evenly in the scrap 17.

There may be less than four anodes 114 of the second body 12, for example one or two.

The cathodes 14 and 114 are located in a housing seating 16 which facilitates the removal of the cathodes 14, 114 for operations of replacement and/or maintenance; furthermore, the seating 16 protects the cathode 14 from falling scrap 17 in cooperation with the appropriate protection means 21.

The scrap 17 is loaded continuously in the upper zone 35 of the first body 11 by means of the appropriate loading means 24, in this case conveyor belts 18 arranged in sequence.

Apart from this scrap 17, the furnace 10 may also be loaded with other raw materials such as cast iron, iron briquettes, sponge iron, all loaded by means of the same conveyor belts 18 or by other loading means of a known type.

In the upper zone 35 of the first body 11 there are means 19 to stir the scrap 17, these means 19 being suitable to distribute the scrap 17 evenly inside the first body 11.

In this case, the stirring means 19 locate the scrap 17 in a desired zone of a distribution surface 20, in this case shaped like a circular crown.

When the correct unloading position is reached, the stirring means 19 are stopped and the scrap 17 is unloaded by means of the appropriate unloading means (which are not shown here), either all at once or in several stages, so as to obtain a homogeneous distribution of the scrap 17 inside the first body 11.

According to a first embodiment, the stirring means 19 are electromagnetic; according to a variant, the stirring means 19 are mechanical, for example of the vibratory type.

Both the first body 11 and the second body 12 are circular in section and their ratio of height to diameter is such as to allow the maximum possible exploitation of the heat generated by the discharge fumes to pre-heat the scrap 17 which is temporally stationed on the distribution surface 20 or in any other position on the upper portion of the first body 11.

The first body 11 and the second body 12 include respective lower zones 36 and 37 to contain the liquid metal, above which there are lateral cooling panels 33.

In the second body 12, immediately above the lateral panels 33, there is a cooled roof 34.

In the first body 11, above the cooling panels 33, there is a cooled containing wall 133 to contain the unloaded scrap 17; in this zone, the scrap 17 is affected by the discharge fumes as they arrive from the first body 11 and the second body 12, and therefore the scrap 17 is preheated.

In order to obtain a homogeneous distribution of the temperature, and also to improve and accelerate the descent of the scrap 17 into the first body 11, there are burners 22 arranged at one or two levels on the sidewall of the first body 11.

The first body 11 is also equipped with supersonic lances 23 to inject oxygen into the lower zone of the first body 11; and with tuyères, which are not shown here, to blow oxygen into the liquid metal from the bottom.

The second body 12 is equipped with sources of alternative energy and with means designed to assist and accelerate the refining of the steel.

For this purpose, one embodiment of the invention includes the immission of additives, either powders or gases, which assist and accelerate the processes of desulphurization and decarburization of the molten metal.

In this case, on the hearth of the second body 12 there are tuyères 26 to blow carbon into the liquid steel and, in whatever position under the level of the liquid steel, there are tuyères and supersonic lances, which are not shown here, to inject oxygen. The oxygen is blown from the bottom with a maximum pressure of 20 bar, and advantageously between 8 and 12 bar.

In the solution shown, the channel 13 enables the liquid metal to be transferred from the first body 11 to the second body 12 as soon as the liquid metal goes over an overspill level 25.

This level 25 is arranged in such a way that the liquid metal in the first body 11, at the moment it spills into the second body 12, has already completed a first step of refining and attained at least a first degree of dephosphorization and decarburization.

The channel 13 is equipped with the appropriate wear-resistant means which, apart from limiting the wear on the refractory material, assist the passage of the liquid metal.

In a first embodiment of the invention, the wear-resistant means are composed of a device 29 to generate a magnetic field suitable to raise the liquid metal from the bottom of the channel 13 as it passes through.

According to a variant, the wear-resistant means are mechanical and cooperate with the bottom of the channel 13.

Stirring means 27 are included in cooperation with the lower zones 36 and 37 of both bodies 11 and 12, in order to obtain an efficient mixing of the molten metal so as to achieve a homogeneous bath and an even temperature, and also to accelerate the chemical reactions.

In this case, the stirring means 27 are of the electromagnetic type and include spirals 28 inside the lower shell of the furnace 10. When the spirals 28 are fed, they generate a magnetic field which interacts with and mixes the liquid metal.

According to a variant which is not shown here, the stirring means 27 are of the mechanical or mixed type.

The steel is tapped from the second body 12 by means of a hole 30 situated on the bottom of the second body 12.

This tapping operation, in one embodiment of the invention, is performed continuously.

According to a variant, the tapping is performed periodically at pre-determined intervals.

The hole 30 cooperates with tapping means, which are not shown here, suitable to open and close the hole 30 and thus regulate the flow of steel.

In one embodiment of the invention, the tapping means are of the siphon type and cooperate with a hermetic door, for example of the sliding type.

According to a variant, the tapping means comprise a hermetic door and cooperate with appropriate cooling means; in this case heating means are included, for example, of the induction type, and are used to melt the metal which has solidified inside the hole 30.

The furnace 10 is also equipped, in correspondence with the first body 11, with a second hole 31 which can be used for cleaning operations, and a door 32 to remove the waste which accumulates on the surface of the molten metal.

Claims

1. Electric arc furnace for the continuous melting of steel and its alloys including at least a first body (11) comprising an upper zone (35) where the raw material (17) is loaded and a lower zone (36) where the metal is melted and a first refining of the molten metal is performed, and at least a second body (12) including a zone (37) with the function of decanting and refining the molten metal and with a tapping hole (30) for the molten metal, the first (11) and second (12) bodies forming a single body and connected by a channel (13) for the transfer of the liquid metal, the upper zone (35) of the first body (11) cooperating with loading means (24), the furnace being characterised in that the first (11) and the second (12) bodies include at least a respective central and vertical electrode (14, 114) and relative anodes (15) located on the bottom, and in that the first body (11) includes on the sidewalls heating burners (22) and supersonic lances (23) to blow in oxygen and the second body (12) includes on the bottom tuyères (26) to blow in carbon, the loading means (24) for the raw material (17) being of the continuous type and associated with means (19,

20) to stir and distribute the raw material (17) homogeneously, the channel (13) being associated with means to regulate the flow from one (11) to the other (12) body.

2. Furnace as in Claim 1, in which above the lower zone (36) of the first body (11) and above the lower zone (37) of the second body (12) are included lateral cooling panels (33), there also being present above the lateral cooling panels (33) of the second body (12) a roof of cooled panels (34) inclined upwards in the direction of the first body (11), there being included a cooled containing wall (133) above the side panels (33) of the first body (11).

3. Furnace as in any claim hereinbefore, in which in cooperation with the lower zone (36) of the first body (11) and/or with the lower zone (37) of the second body (12) there are stirring means (27) for the molten metal.

4. Furnace as in Claim 3, in which the stirring means (27) are of the magnetic type (28).

5. Furnace as in Claim 3,in which the stirring means are mechanical.

6. Furnace as in any claim hereinbefore, in which the upper zone (35) of the first body (11) includes means (19) to stir the raw material (17) cooperating with a homogeneous distribution surface (20) in the shape of a circular crown.

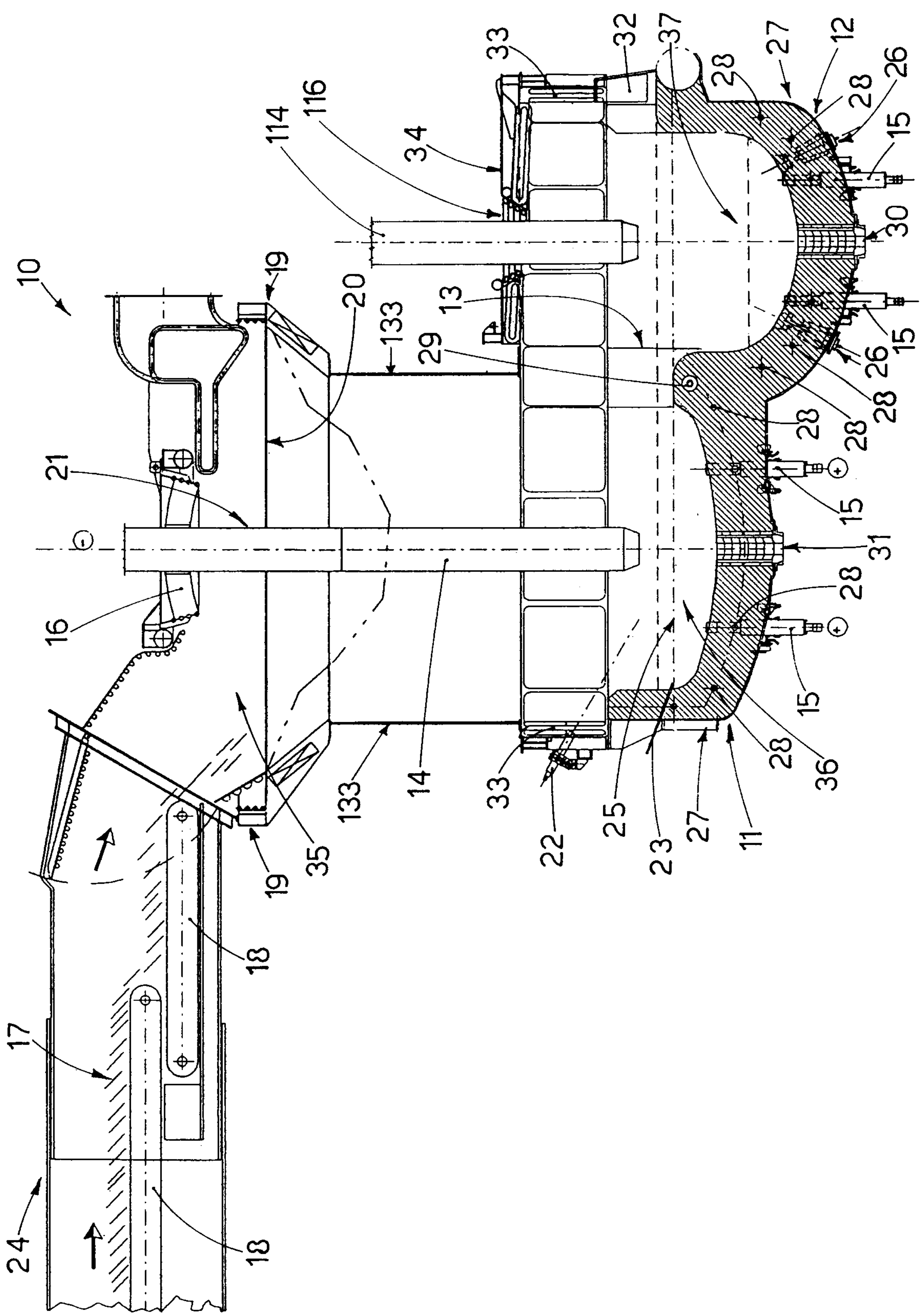
7. Furnace as in Claim 6, in which the homogeneous distribution surface (20) is associated with means for the controlled unloading of the raw material (17) into the first body (11).

8. Furnace as in Claim 7, in which the controlled unloading means (19) are electromagnetic.

9. Furnace as in Claim 7, in which the controlled unloading means (19) are of the mechanical type.

10. Furnace as in any claim hereinbefore, in which the first (11) and/or the second (12) bodies include tuyères at the bottom part for the immission of oxygen.

11. Furnace as in any claim hereinbefore, in which the first body (11) includes on its bottom part at least a hole for cleaning and inspection (31).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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 11 9472

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	EP 0 240 485 A (VOEST ALPINE AG) 7 October 1987 * abstract; claims; figures *	1-10	C21C5/52 C21C5/56 F27D13/00 C22B1/00
Y	EP 0 548 041 A (VOEST ALPINE IND ANLAGEN) 23 June 1993 * abstract; claims; figures *	1-10	
Y,D	WO 96 19592 A (ARCMET TECHNOLOGIE GMBH ;FUCHS GERHARD (DE); EHLE JOACHIM (DE)) * page 9, line 5 - page 10, line 6; claims; figures 4,6 *	1-10	
Y,D	FR 1 482 929 A (UNSTITUT DE RECHERCHES DE LA SIDERURGIE FRANCAISE (IRSID)) * page 3, left-hand column, paragraph 1 - paragraph 7; figure *	1-10	
A	EP 0 451 323 A (BLUFIN SRL) 16 October 1991 * abstract; claims; figures *	1	**TECHNICAL FIELDS SEARCHED (Int.Cl.6)**
A	EP 0 626 549 A (LORRAINE LAMINAGE) 30 November 1994 * abstract; claims; figures *	1-10	C21C F27D
A,D	WO 96 32505 A (VOEST ALPINE IND ANLAGEN ;DIMITROV STEFAN (AT); RAMASEDER NORBERT) 17 October 1996 * abstract; claims; figures *	1-10	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 February 1998	Oberwalleney, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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