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(54) Process and relevant equipment for carrying out the continuous casting of steel in the complete absence of oxidating agents.

(57) Process for carrying out the process of continuous casting of steel, and in particular of killed steel, consisting in carrying out all the operating steps of the casting in which the liquid steel is in contact with air in a closed chamber, free from oxygen, in maintaining inside said chamber an atmosphere of an inert gas, and in providing closed-loop conditioning means in order to eliminate heat, fumes and vapours generated by the process.

In order to carry out such a process, an equipment is provided, which is constituted by an air-tight chamber, with a portion of the walls of said air-tight chamber being made from a transparent material, and with said air-tight chamber (14) enclosing all the casting areas wherein liquid steel (4) is in contact with atmosphere, means for maintaining inside said chamber an inert atmosphere, free from oxygen, closed-loop conditioning means for eliminating heat, fumes and vapours released by the casting process being furthermore provided, as well as means to allow attending personnel, equipped with mask or tight suit to enter the chamber and control the process.

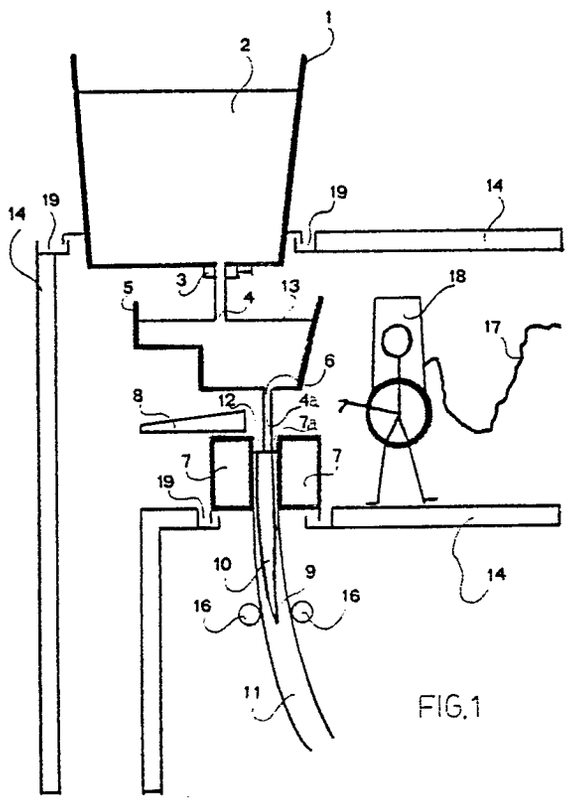

FIG.1

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PROCESS AND RELEVANT EQUIPMENT FOR CARRYING OUT THE CONTINUOUS CASTING OF STEEL IN THE COMPLETE ABSENCE OF OXIDATING AGENTS

The object of the present invention is a process for carrying out the continuous casting of steel under such operating conditions, as to prevent the oxidation of liquid steel during all casting steps.

Within the scope of the present invention, also a particularly suitable equipment for carrying out said continuous casting process falls.

It is known that the facilities for the continuous casting of molten steel by the electrical-furnace process are based on the principle of continuously casting all the liquid steel contained in a casting ladle, so as to obtain one or more continuous bars of solidified metal, which have a variable cross-section according to the requirements imposed by the subsequent plastic processings, such as, in particular, rolling and/or hot forging.

Normally, a facility for continuous casting comprises a tundish, or distributor body, internally lined with a refractory material, which receives the liquid metal from a overhanging casting ladle, one or more ingot moulds or crystallizers, usually of copper, constantly cooled by water circulation, wherein a partial and quick solidification of the metal occurs, and, on line with said ingot moulds, cooling areas wherein the complete solification takes place by means of water jets.

The bar leaving said cooling areas is made advance by means of withdrawal rolls and is then cut to the desired lengths.

According to the modalities of solidification adopted, generally "killed steels" and "balanced steels" are obtained.

In particular, in order to obtain killed steels, liquid steel has to be deoxidated by means of the addition of deoxidizers based on aluminum, silicon, or the like.

In order to prevent liquid steel and deoxidizers contained thereof, which are strongly oxidizable, oxidixe in the presence of the oxigen of the air, ceramic shrouds are used and coating products or powders, similar to low-melting glasses in the molten state, are provided on all the exposed steel surfaces during the casting, and, more precisely on the exposed steel surface in the ingot moulds, and on the exposed steel surface inside the tundish. Furthermore, the steel cast from the ladle to the tundish and the steel cast from the tundish to the ingot mould is usually enclosed inside shrouds of ceramic material or the like, in order to prevent steel from getting oxidized during casting. It is known that such shrouds are affected by the drawback of being fragile, expensive and of requesting a replacement for each casting. Furthermore the contact between the ceramic shroud and the nozzle is poor and often there is air suction owing to Venturi effect.

In particular, in order to control the structural grain of the steel,the steel is killed by means of aluminum, which, when comes into contact with atmospheric oxygen, forms aluminum oxide (Al_2O_3); this latter, by being solid at the temperature of liquid steel, and insoluble in this latter, causes the formation of crusts and agglomerates which clog the ducts of the casting facility, and, in particular, the nozzles positioned at the bottom of the tundish, as well as said ceramic shrouds.

A purpose of the present invention is to realize a process for the continuous casting of steel, so conceived as to obviate the drawbacks caused by the fast oxidation of steel in the presence of air and, in particular, of the aluminum for obtaining killed steels, without altering the normal operating conditions of continuous casting by one or more casting lines, and operating in free stream.

Another purpose of the invention is to provide a process for the continuous casting of steel which can be wholly carried out in the complete absence of air oxygen, with evident advantages as regards the quality of the solidified steel, the safety of the casting facility and the saving in costs consequent to the elimination of the coating powders and of the shrouds of ceramic material, or the like.

A further purpose of the present invention is to provide an equipment for carrying out the above-said process of continuous casting, which is structurally simple, highly reliable, and can be used both on already existing facilities, and on newly-built facilities.

These and still further purposes, which will be better evidenced by the following disclosure, are achieved by a process for carrying out the continuous casting of steel and, in particular, of killed steel, using a feeding tundish, one or more ingot moulds, means for cooling the bar in the solidification step, and means for the withdrawal of the same bar, which process consists, according to the present invention, in carrying out the operating casting steps, and in particular all those casting steps in which liquid steel is in contact with air, inside a closed chamber, free from oxygen, in circulating inside said chamber at least one inert, non-toxic gas, such as nitrogen, carbon dioxide, argon and their mixtures, maintained under a slight overpressure, and in using closed-loop conditioning means in order to continuously remove from said inert gas the heat, the fumes and the vapours which are released during the casting steps.

In order to practice said process, according to the present invention an equipment is provided, which is constituted by an air-tight chamber, with at least a portion of the walls of said air-tight chamber being constituted by a transparent material, so designed as to enclose all those portions of the casting facility in which liquid steel is in contact with atmosphere, means being provided for maintaining inside said chamber an atmosphere of nitrogen, or of another inert, non-toxic gas, such as carbon dioxide, argon, and their mixtures, under a slight overpressure and free from oxygen, as well as closed-loop conditioning means being provided, in order to remove from said inert gas the heat, the fumes and the vapours released during the casting process, with said chamber means of connection with the external atmosphere being furthermore associated, in order to allow attending personnel, equipped with a breathing mask, to enter the chamber in order to control the casting process or to control the process by means of tight gloves, handling means and the like.

More particularly, said air-tight chamber is preferably provided with at least one wall fully made from a transparent material, and with at least one other wall made from a fast-breakage material, for emergency cases.

The air-tightness between the ladle and the casting machine and the walls of the chamber can be preferably achieved by means of suitable water-sealed, sand-sealed labyrinth seals, or the like.

The invention is now disclosed in greater detail according to a preferred, non-exclusive form of practical embodiment thereof, with reference to the hereto attached drawing table, given for merely indicative and non-limitative purposes, wherein the single figure shows, in a schematic form, an equipment realized according to the present invention, associated to a traditional facility for continuous steel casting. Referring to said figure, a facility for the continuous casting of steel is constituted by a casting ladle 1 containing liquid steel 2 produced, for example, by an electric-furnace. Liquid steel 4 flows by gravity through e gate valve 3 into a tundish, or distributor, 5, wherein steel is maintained at a constant level. From the tundish 5 steel flows, through one or more nozzles 6, into a same number of ingot moulds 7. The switch 8 of the liquid steel cast 4a which feeds each moulding line, performs also the function of tightly sealing the opening 7a of the ingot mould 7 in the presence of first-line leakages, and of preventing that, in case the casting is discontinued, from said opening the inert gas may escape, which is contained inside the chamber.

The crystallizer 7, generally supplied with a vertical oscillatory movement, is normally made of copper, and is fitted with means for a vigorous water-cooling, not depicted in the figure; inside the crystallizer, liquid steel undergoes a partial and fast solidification. In the figure, by the reference numeral 9 the portion of steel solidified inside the crystallizer, and by the reference numeral 10, the inner, still liquid, conical portion, of the bar, are indicated.

When leaving the crystallizer 7, the bar 11 runs through cooling means (not depicted in the figure), which complete the solidifcation thereof. The bar (or the bars, in case with the tundish a plurality of crystallizers are associated) runs downwards with a speed controlled by the withdrawal rolls 16.

At present, in order to prevent liquid steel (which, as known, is strongly prone to oxidation) oxidizes in contact with air oxygen, on the exposed steel surface 12 of steel contained inside the moulds 7, and on the exposed steel surface 13 in the tundish 5, protecting compound are spread, consisting in covering powders.

Furthermore, as those skilled in the art know very well, in the event of production of the so-said "killed steels", to the ladle deoxidizers based on aluminum (or also of silicon) are charged; therefore, steel contains aluminum and this latter, in contact with air oxygen, generates alumina (Al_2O_3) which, by being insoluble in steel, generates crusts and agglomerates which clog the casting ducts and, above all, the nozzles and the shrouds.

In order to get rid of these drawbacks, the present invention provides an equipment, which is constituted by an air-tight chamber 14, which encloses all those areas of the facility, in which high-temperature, liquid steel is in contact with air, i.e., all the equipment pieces which are comprised between the bottom of the ladle 1 and the basis of the moulds 7. The air-tightness between the ladle 1 and the basis of the mould 7 and the walls of the chamber 14 is achieved by means of labyrinth sealing means 19. Inside said chamber, an atmosphere is maintained, which is constituted by nitrogen or carbon dioxide or argon, or by a mixture of said gases, or of similar gases, free from oxygen, under a slight over-pressure, which thus prevents steel of exposed steel surfaces 12, 13, and possibly 15, from being oxidized.

With said chamber, a closed-loop conditioning system (not shown in figure) is furthermore associated, which is fitted with suitable sucking and circulation means, the function of which is of removing the heat, the fumes and vapours generated during the casting step. With said chamber, check and control means are associated, as well as sensors are provided (not depicted in the figure), such as to render fully automated the operation of the casting. However, in order that, from time to time, closer checks, as well as extraordinary, manual, intervention, may be carried out, said chamber is

fitted with at least one flexible hose 17, or the like, which connects the external environment with the interior of the same chamber, and which allows the attending personnel to enter the same chamber, by using, e.g., a protection mask, or a tight suit, 18, connected with the external atmosphere, or with other ventilation means, so that the necessary and suitable switching and checking actions can be carried out.

In order that a general visual check can be performed from the outside, at least one wall of the chamber is made from a transparent material, and at least a further wall, or the entrance door, are made from a fast-breakage material, in order to allow any emergency interventions to be performed.

The walls of said chamber 14 are made from a material particularly resistant to heat and to the possible drops of liquid steel.

By means of the process and of the equipment which constitute the object of the present invention, the use of the covering powders is eliminated, and the metal portion of the tundish, which is generally lined with a refractory material, is also prevented from being perforated, in case the refractory is broken or cracked; in fact, owing to the contact of high-temperature liquid steel - seeped through the refractory - with the metal wall of the tundish, this latter gets overheated, and would rapidly react with air oxygen - if present -, melting, and consequently causing liquid steel to escape.

It is furthermore evident that the equipment according to the present invention can be realized both for newly-built continuous casting facilities, and for already existing facilities, with no need of resorting to expensive and complex operations of adaptation and rearrangements.

Claims

1. Process for carrying out the continuous casting of steel and, in particular, of killed steel, characterized in that it consists in carrying out the operating casting steps and, in particular, all those casting steps in which liquid oxygen is in contact with air, inside a closed chamber, free from oxygen, in circulating inside said chamber at least one inert, non-toxic gas, such as nitrogen, carbon dioxide, argon and their mixtures, maintained under a slight overpressure, and in using closed-loop conditioning means in order to continuously remove from said inert gas the heat, the fumes and the vapours which are released during the casting steps.

2. Equipment for carrying out the continuous casting process according to claim 1, characterized in that it is constituted by an air-tight chamber, with at least a portion of the walls of said air-tight chamber being constituted by a transparent material, so designed as to enclose all those portions of the casting facility in which liquid steel is in contact with atmosphere, means being provided for maintaining inside said chamber an atmosphere of nitrogen, or of another inert, non-toxic gas, such as carbon dioxide, argon, and their mixtures, under a slight overpressure, and free from oxygen, as well as closed-loop conditioning means being provided, in order to remove from said inert gas the heat, the fumes and the vapours released during the casting process, with said chamber, means of connection with the external atmosphere being furthermore associated, in order to allow attending personnel, equipped with mask, to enter the chamber in order to control the casting process.

3. Equipment according to claim 2, characterized in that said chamber is provided with at least one wall at least partially made, and preferably fully made, from a transparent material.

4. Equipment according to claim 2, characterized in that at least one wall or at least a part thereof is made from a fast-breakage material, for emergency cases.

5. Equipment according to claim 2, characterized in that it is provided with automatic sensors, and with visual inspection means of known type for checking the casting steps.

6. Equipment according to claim 2, characterized in that the air tightness between the ladle and the casting machine and the walls of said chamber is achieved by means of labyrinth seals with water, sand, and the like.

7. Equipment according to claim 2, characterized in that said switch for the liquid steel cast between the tundish and the mould also ensures the tight sealing of the opening of the ingot mould in case the casting is discontinued, and prevents the inert gas from escaping from said air-tight chamber.

8. Equipment according to claim 2, characterized in that the walls of said chamber are made from a material resistant to heat, and to the possible drops of liquid steel.

9. Equipment according to claim 2, characterized in that it can be used on already existing continuous casting facilities, as well as on newly-built continuous casting facilities.

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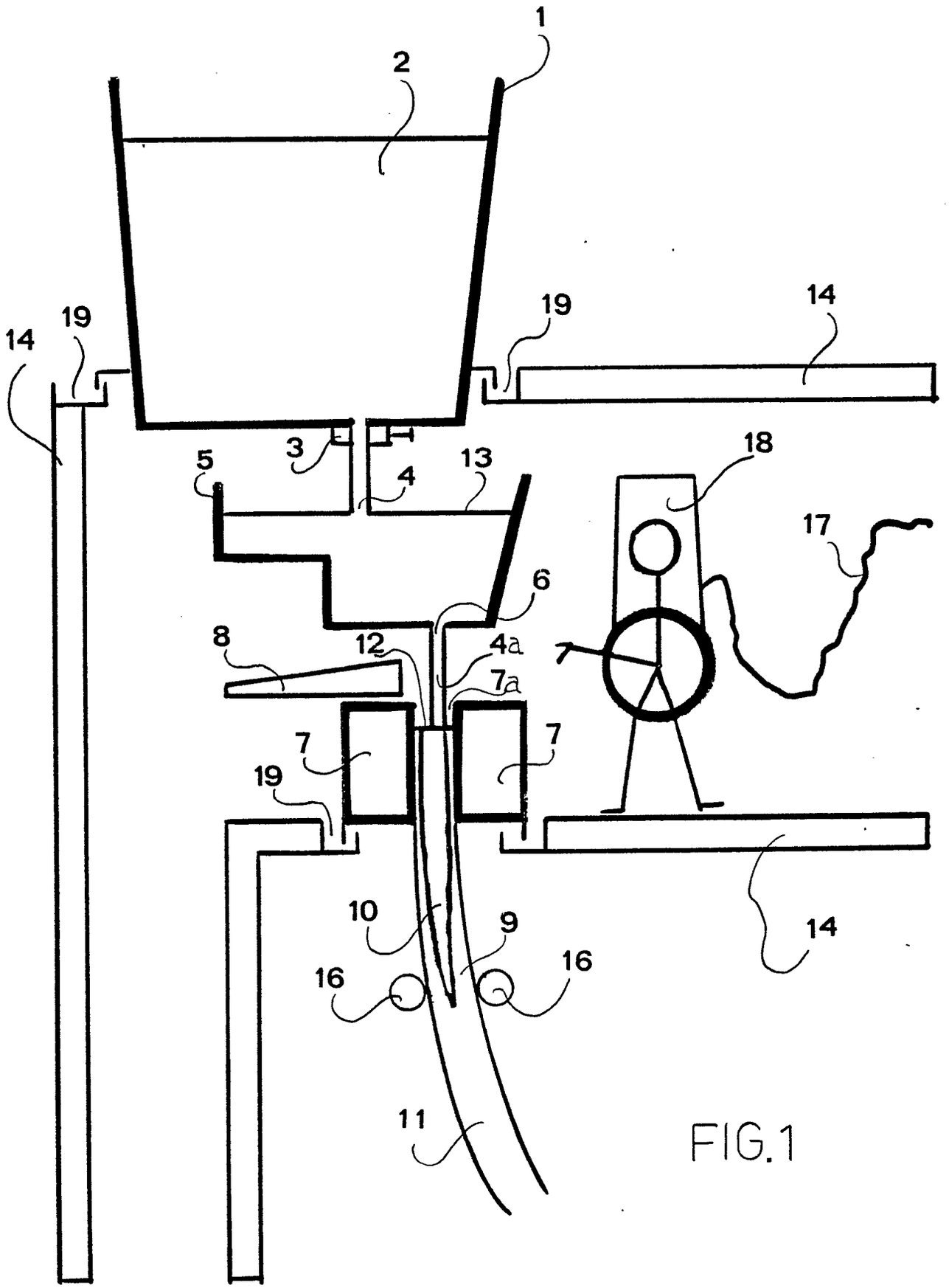

FIG.1

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EUROPEAN SEARCH REPORT

Application Number

EP 88 11 2281

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.4)
A	DE-A-2 839 870 (BRITISH STEEL) * claim 7 * ---	1,3	B 22 D 11/10 B 22 D 27/00
A	DE-A-2 607 070 (VOEST ALPINE) * claims 1,3 * ---	1,3	
A	EP-A-0 005 820 (CONCAST AG) * claims 1,4,9 * -----	1,2	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

B 22 D 11/00
B 22 D 27/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	16-03-1989	GOLDSCHMIDT G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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