(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 411 135 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
21.04.2004 Bulletin 2004/17

(21) Application number: **02736124.5**

(22) Date of filing: **17.06.2002**

(51) Int Cl.^{7}: **C21B 13/10**

(86) International application number:
PCT/JP2002/005996

(87) International publication number:
WO 2003/010342 (06.02.2003 Gazette 2003/06)

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **24.07.2001 JP 2001223266**

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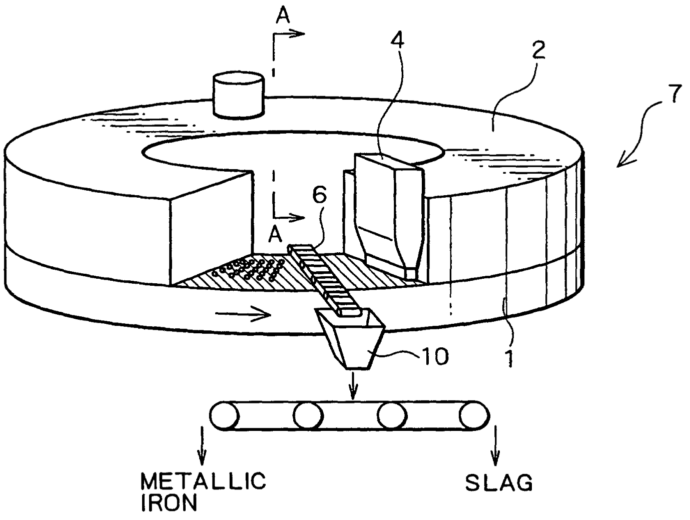
(54) METHOD FOR ACCELERATING SEPARATION OF GRANULAR METALLIC IRON FROM SLAG

(57) The present invention is intended to provide a method for accelerating separation of granular metallic iron as an objective product and slag as a by-product when the granular metallic iron is produced with reduction melting of raw-material agglomerates that contain an iron-oxide containing material and a carbonous reducing agent, thereby producing metallic iron of a high iron grade in which slag is satisfactorily separated and removed.

The present invention resides in a method for accelerating separation of granular metallic iron and slag, the method being employed to produce the granular metallic iron with reduction melting of raw-material agglomerates that contain an iron-oxide containing material and a carbonous reducing agent, wherein a mixed solid of the granular metallic iron produced with the reduction melting and the slag produced as a by-product are quickly cooled to accelerate separation of the granular metallic iron and the by-product slag from each other.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a method for accelerating separation of granular metallic iron as an objective product and slag as a by-product when metallic iron is produced with reduction melting of raw-material agglomerates that contain an iron-oxide containing material and a carbonous reducing agent. More specifically, the present invention relates to an improved method for easily separating a mixed solid of granular metallic iron, which is produced by supplying raw-material agglomerates to a reduction melting furnace and reducing, melting and aggregating iron oxides in the raw-material agglomerates, and slag, which is produced as a by-product, into the granular metallic iron and the slag.

Background Art

[0002] When metallic iron of a low iron grade (in which large amounts of slag components, such as SiO_2, Al_2O_3 and CaO, are contained as a veinstone component in iron ore and ash in a carbonous material, which are used as raw materials) is supplied as raw materials for iron melted in a steel-making furnace, e.g., a converter or an electric furnace, many problems occur in that operability of the electric furnace is adversely affected with an increase of the slag amount, the iron yield is reduced because of mixing of iron into slag, energy consumption per unit product is increased, and productivity is lowered. Accordingly, metallic iron of a high iron grade with a less content of slag components is demanded as raw materials for molten iron. As a process for producing such metallic iron of a high iron grade, it is known to improve, for example, a direct iron-making method such as a shaft furnace method in which metallic iron is produced by directly reducing an iron-oxide containing material, such as iron ore and/or iron oxides, with a carbonous material and a reducing gas, and a method for producing metallic iron with steps of mixing a carbonous material and powdery iron oxides into the form of agglomerates or pellets, and reducing the mixture on a rotary hearth under heating, as disclosed in, e.g., U.S. Patent No. 3,443,931. By using such improved methods, metallic iron of a high iron grade is produced.

[0003] For example, Japanese Unexamined Patent Application Publication No. 2000-144224 is known as an iron-making method for obtaining high-purity metallic iron with reduction melting of raw-material agglomerates that contain an iron-oxide containing material, such as iron ore and/or iron oxides, and a carbonous reducing agent such as coke. In the technology for obtaining granular metallic iron with reduction melting of raw-material agglomerates by using a reduction melting furnace of the moving hearth type, as disclosed in that Publication, the iron oxides in the raw-material agglomerates are reduced while the raw-material. agglomerates are held in a solid state. Then, metallic iron and slag as a by-product are rendered to melt and aggregate separately. Thereafter, by cooling the molten metallic iron and the molten slag (with a primary cooling step in which they are cooled down to, e.g., about 1100 to 900 °C), the molten metallic iron and the molten slag are brought into solidified states (called respectively "granular metallic iron" and "slag granules"). After the cooling and the solidification, the granular metallic iron and the slag granules are discharged out of the furnace. After being discharged, the granular metallic iron and the slag granules are left to stand for natural cooling (secondary cooling). Further, the granular metallic iron and the slag granules are selectively separated from each other by any suitable separating means such that only the granular metallic iron is employed as raw materials for molten iron supplied to a steel-making furnace, etc.

[0004] In the above-mentioned metallic iron producing method, the cooling is divided into a first cooling stage in which the metallic iron and the slag are cooled for solidification to a level lower than the solidifying point thereof, and a second cooling stage in which the temperature is further lowered for subsequent transportation and selection of the metallic iron.

[0005] Although the first cooling stage is performed in the reduction melting furnace in many cases, the slag granules are often present after the first cooling stage in such a non-separated state (called a "mixed solid") that the slag granules are adhered to the granular metallic iron. Also, in the second cooling stage in which the granular metallic iron and the slag granules are left to stand outside the furnace for natural cooling, the metallic iron and the slag are not sufficiently separated from each other. For those reasons, it has been difficult to separately collect only the granular metallic iron at high efficiency with magnetic screening, a sieve, etc., and to avoid a substantial amount of slag from mixing into the granular metallic iron. Even with the metallic iron having a high purity in itself, therefore, an amount of molten slag generated in the steel-making furnace is increased because of the slag components that are unavoidably mixed in the metallic iron without being completely separated, thus resulting in adverse effects upon operability and product quality. From those situations in the art, there is demanded a technique capable of separating metallic iron and slag as a by-product at high efficiency before they are subjected to screening for separation.

[0006] In view of the above-described problems in the related art, an object of the present invention is to provide a method for accelerating separation of granular metallic iron as an objective product and slag as a by-product when the granular metallic iron is produced with reduction melting of raw-material agglomerates that contain an iron-oxide containing material and a carbonous reducing agent, thereby producing metallic iron of a high iron grade in which slag is satisfactorily separated and removed.

Disclosure of the Invention

[0007] The present invention having succeeded in solving the above-described problems resides in a method for accelerating separation of granular metallic iron and slag, the method being employed to produce the granular metallic iron with reduction melting of raw-material agglomerates that contain an iron-oxide containing material and a carbonous reducing agent, wherein a mixed solid of the granular metallic iron produced with the reduction melting and the slag produced as a by-product are quickly cooled to accelerate separation of the granular metallic iron and the by-product slag from each other. When practicing the method of the present invention, it is recommended to quickly cool the mixed solid using a coolant. It is also recommended that the mixed solid be quickly cooled at a cooling rate of preferably not less than 250 °C/min, more preferably not less than 350 °C/min, in at least a part of the range from a solidifying temperature of the granular metallic iron to 150 °C. In a preferred embodiment of the present invention, water is employed as the coolant, the quick cooling of the metallic iron is stopped until reaching 150 °C, and moisture residing on and attached to the metallic iron is dried.

Brief Description of the Drawings

[0008]

Fig. 1 is a schematic explanatory view showing one example of a reduction melting furnace of the circular moving hearth type to which the present invention is applied.
Fig. 2 is a sectional view taken along the line A-A in Fig. 1.
Fig. 3 is an explanatory view showing a section of the reduction melting furnace in the developed form as viewed in the rotating direction of a moving hearth in Fig. 1.
Fig. 4 is a schematic explanatory view showing a manner of cooling a mixed solid with water sprays.
Fig. 5 is a schematic explanatory view showing a manner of cooling the mixed solid with dipping in water.
Fig. 6 is a schematic explanatory view showing a manner of cooling the mixed solid with a nitrogen gas.
Fig. 7 is a schematic explanatory view showing a manner of cooling a mixed solid with water.

Best Mode for Carrying Out the Invention

[0009] As a result of carrying out intensive studies to solve the problems in the related art, the inventors have accomplished the present invention based on the finding that, by quickly cooling a mixed solid of granular metallic iron, which is produced with reduction melting of raw-material agglomerates that contain an iron-oxide containing material and a carbonous reducing agent, and slag produced as a by-product, separation of the granular metallic iron and the by-product slag is remarkably accelerated.

[0010] In the present invention, the raw-material agglomerates contain an iron-oxide containing material, such as iron ore and iron oxides or partly reduced materials thereof, and a carbonous reducing agent, such as coke and coal. The raw-material agglomerates may contain any suitable additive, etc. if necessary. Also, the raw-material agglomerates are not limited in shape to a particular one, but can be prepared in the form of pellets, briquettes, etc. Further, the raw-material agglomerates can be formed by any suitable method depending on the agglomerate shape. In addition, a mixing ratio of the iron-oxide containing material to the carbonous reducing agent is not limited to a particular value, but can be selected to a proper value depending on the purpose for use. The size of the raw-material agglomerates is also not limited to a particular one.

[0011] The granular metallic iron is produced with reduction melting of the raw-material agglomerates described above. A practical method for the reduction melting is not limited to a particular one, but can be carried out using a well-known reduction melting furnace. It is to be noted that while the present invention will be described below in connection with, for example, a method for producing metallic iron using a reduction melting furnace of the moving hearth type, the present invention is not limited to the following description and the illustrated examples. The present invention will be described in detail with reference to the drawings showing a practical construction of the reduction melting furnace.

[0012] Figs. 1 to 3 are schematic explanatory views showing one example of a reduction melting furnace of the moving hearth type developed by the inventors, to which the present invention is applied. The furnace is of a dome-shaped structure having a rotary moving hearth in the doughnut form. Specifically, Fig. 1 is a schematic perspective view, Fig. 2 is a sectional view taken along the line A-A in Fig. 1, and Fig. 3 is a schematic explanatory view showing a section of the reduction melting furnace in the developed form as viewed in the rotating direction of the rotary hearth in Fig. 1 for easier understanding. In the drawings, numeral 1 denotes a rotary hearth, and 2 denotes a furnace body covering the rotary hearth. The rotary hearth 1 is constructed such that it can be driven by a driving device (not shown) to rotate at a proper speed.

[0013] As a matter of course, however, the construction of the reduction melting furnace of the moving hearth type, to which the present invention is applied, is not limited to the shape and structure shown in Figs. 1 to 3. So long as the reduction melting furnace includes a moving hearth as a constituent element, various reduction melting furnaces of the moving hearth type having any other structures, e.g., the straight grate type, can also be effectively employed in the present invention.

[0014] A plurality of combustion burners 3 are disposed at appropriate places in a wall surface of the furnace body 2. Combustion heat and radiation heat generated by the combustion burners 3 are transmitted to the raw-material agglomerates on the rotary hearth 1 for performing heating reduction of the raw-material agglomerates. In a preferred example of the furnace body 2 as shown, the interior of the furnace body 2 is divided by three partition walls K_1, K_2, K_3 into a first zone Z_1, a second zone Z_2, a third zone Z_3, and a fourth zone Z_4. A raw-material supply means 4 is disposed in an opposed relation to the rotary hearth 1 at the most upstream side in the rotating direction of the furnace body 2, and a discharging means 6 is provided at the most downstream side in the rotating direction (in other words, at the side immediately upstream of the supply means 4 because of the rotary structure).

[0015] In operation of such a reduction melting furnace, the rotary hearth 1 is rotated at a predetermined speed, and the raw-material agglomerates are supplied from the supply means 4 onto the rotary hearth 1 such that a layer of the raw-material agglomerates has a proper thickness. The raw-material agglomerates charged on the rotary hearth 1 are subjected to combustion heat and radiation heat generated by the combustion burners 3 while moving in the first zone Z_1. Iron oxides in the raw-material agglomerates are reduced under heating, while maintaining a solid state, with the aid of the carbonous material in the raw-material agglomerates and carbon monoxide generated upon combustion of the carbonous material. Then, the raw-material agglomerates are further reduced under heating in the second zone Z_2, whereby metallic iron is produced with almost complete reduction of the iron oxides. The generated metallic iron is further heated in the third zone Z_3, and hence it is carburized and melted. The thus-produced molten metallic iron and molten slag as a by-product are present in such a state that the molten slag lies on the molten metallic iron, because of a difference in specific gravity between them. The molten metallic iron and the molten slag are cooled by any suitable cooling means C down to temperature not higher than the solidifying point thereof in the fourth zone Z_4 for solidification. The solidified metallic iron and slag are successively discharged by the discharging means 6. With the cooling and the solidification, the molten metallic iron and the molten slag are mostly separated into granular metallic iron and slag granules, but there also exists granular metallic iron (mixed solid) including slag adhered to the iron because of incomplete separation. Therefore, the granular metallic iron, the slag granules and the mixed solid are discharged to the outside of the furnace. The mixed solid, etc. (hereinafter "the mixed solid, etc." means not only the mixed solid, but also the granular metallic iron and the slag granules) discharged at that time are in a relatively high temperature state (e.g., approximately from the solidifying temperature to 900 °C).

[0016] In the present invention, the mixed solid discharged in such a relatively high temperature state is quickly cooled to accelerate separation of the metallic iron and the slag from each other by utilizing a difference in shrinkage rate between the metallic iron and the slag both contained in the mixed solid. As a result, the mixed solid is separated into the granular metallic iron hardly containing slag components and the slag granules (made up of slag components, such as SiO_2, Al_2O_3 and CaO, contained as a veinstone component in iron ore and ash in a carbonous material, which are used as raw materials).

[0017] In the present invention, the term "quick cooling" means quicker cooling than in the case of leaving the mixed sold to stand in the atmosphere for natural cooling. It is, however, particularly recommended to quickly cool the mixed solid using a coolant, for example, and to apply thermal impacts to the mixed solid from the viewpoint of increasing the effect of accelerating separation of the metallic iron and the slag from each other. Also, quick cooling of the mixed solid at a cooling rate of not less than 250 °C/min is preferred in that distortions occur in contact areas between the metallic iron and the slag because of a sudden change in shrinkage rate (i.e., difference in thermal expansion coefficient) between the metallic iron and the slag both contained in the mixed solid, whereby separation of the metallic iron and the slag is accelerated. A more preferable cooling rate is not less than 350 °C/min. The cooling rate can be calculated by continuously measuring a temperature change of the mixed solid that is discharged to the outside of the furnace.

[0018] The quick cooling method is not limited to a particular one, but it is preferred to perform the quick cooling using a liquid and/or inert gas as the coolant. The quick cooling with a liquid is recommended because a liquid can provide a higher cooling rate and hence a higher separation effect than inert gas. The liquid used for the quick cooling is not limited to a particular one, and there is no limitation as to whether any additive is added to the liquid or not. The use of water is preferred from the viewpoints of economy, safety and cooling efficiency. Also, there is no particular limitation in use of inert gas, but the use of a nitrogen gas is preferred from the viewpoints of economy and safety.

[0019] When performing the quick cooling using water, for example, the desired cooling rate may be obtained by spraying water to the mixed solid while regulating the amount of the supplied water with any suitable spraying means. As shown in Fig. 4, by way of example, the mixed solid, etc. discharged out of the moving hearth type furnace are transferred onto a moving means 9, such as a belt conveyor, through a feed duct 8 for movement therewith, and water is sprayed toward the mixed solid, etc. from spraying means 11 that are provided in any desired number with any suitable intervals. The sprayed water quickly cools the mixed solid, etc. and accelerates separation of the slag and the metallic iron because of a difference in shrinkage rate between them, whereby the granular metallic iron and the slag granules are obtained. Alternatively, the mixed solid, etc. may be quickly cooled at the desired cooling rate by pooling water in a cooling tank and controlling the water temperature with selective supply and drain of water. As shown in Fig. 5, by way of example, the mixed solid, etc. discharged out of the moving hearth type furnace 7 are introduced to a cooling tank 13 filled with water 12 through a feeding means 8, such as a feed duct, for dipping in the water. After being quickly cooled down to the predetermined temperature, the mixed solid, etc. are taken out of the cooling tank with any suitable conveying means such as a conveyor. The quick cooling method of dipping the mixed solid, etc. in water is more preferable than the quick cooling method of spraying water because the former method can provide a higher cooling rate, a greater difference in shrinkage rate, and hence a higher separation rate.

[0020] When quickly cooling the mixed solid, etc. by using inert gas such as a nitrogen gas, though not shown, the inert gas may be directly sprayed to the mixed solid, etc., or the mixed solid, etc. may be exposed to an atmosphere of inert gas.

[0021] Additionally, the quick cooling method is not limited to the above-described ones, and those quick cooling methods can be implemented in any desired combination. For example, the mixed solid, etc. may be quickly cooled by spraying water under a nitrogen gas atmosphere, or the mixed solid, etc. may be quickly cooled under a nitrogen gas atmosphere after spraying water.

[0022] Further, the higher the temperature of the mixed solid, etc. at the start of the quick cooling, the greater is the separation effect resulting from the quick cooling. It is therefore preferable to quickly cool the mixed solid, etc. when they are in a high-temperature state immediately after being discharged out of the furnace. Because the temperature of the mixed solid, etc. discharged out of the furnace depends on how far the mixed solid, etc. have been cooled in the furnace, a practical temperature at the start of the quick cooling is not limited to a particular value. However, since the mixed solid, etc. discharged out of the furnace are usually in a solid state, a preferable range for the quick cooling is at least a part of the range from the solidifying point (about 1280 °C) of the metallic iron to 150 °C. If the quick cooling is started from temperature lower than 150 °C, sufficient thermal impacts cannot be applied to the mixed solid, etc. and the separation effect at satisfactory level cannot be obtained in some cases.

[0023] The expression "at least a part" of the range means that the quick cooling does not require to be continued over the entire temperature range. For example, it is meant that when performing the quick cooling at a cooling rate of not less than 250 °C/min in at least a part of the range from the solidifying point of the metallic iron to 150 °C, the mixed solid, etc. may be left to stand for natural cooling in the other temperature range than in a certain part of the range from the solidifying point of the metallic iron to 150 °C in which the mixed solid, etc. are quickly cooled at a cooling rate of not less than 250 °C/min. In other words, it is not meant that the quick cooling of the mixed solid, etc. must be continued over the entire range from the solidifying point of the metallic iron to 150 °C. Further, the quick cooling may be continued beyond the above temperature range, and it is not meant that the quick cooling must be stopped at the time when the temperature reaches 150 °C. For example, after quickly cooling the mixed solid, etc. in the range from the solidifying point of the metallic iron to 150 °C, the quick cooling may be further continued in a temperature range lower than 150 °C. Anyway, the quick cooling requires to be stopped at the time when the desired temperature is reached.

[0024] Because the separation accelerating effect based on quick cooling, which is employed in the present invention, is developed, as described above, by utilizing distortion fracture at the interface between the metallic iron and the slag attributable to thermal impacts caused upon the quick cooling, the quick cooling time may be selected to be very short. For example, even the quick cooling for several seconds is sufficient to fulfill the intended purpose. In particular, when a coolant is employed to perform the quick cooling, the mixed solid is quickly cooled and the separation accelerating effect is obtained at the moment when the mixed solid is brought into contact with the coolant. For example, in the case of dipping the mixed solid in water, the temperature of the mixed solid is abruptly lowered at the moment when the mixed solid is brought into contact with the water, whereupon there occurs distortion fracture at the interface between the metallic iron and the slag, thus resulting in separation of the metallic iron and the slag. As a matter of course, during the period in which the mixed solid is dipped in the water, the quick cooling of the mixed solid is still continued, and the difference in shrinkage rate between the metallic iron and the slag at the interface therebetween is increased in the mixed solid that remains in a non-separated state. Therefore, the separation accelerating effect is further enhanced and a non-separation rate of the slag from the metallic iron is reduced.

[0025] Furthermore, in the present invention, it is also preferable that in addition to the use of water for the quick cooling, the quick cooling of the metallic iron be stopped until reaching 150 °C, and thereafter the metallic iron be left to stand for natural cooling. Stated otherwise, by stopping the quick cooling (stopping contact of the mixed solid, etc.

with water) after cooling the mixed solid, etc. to 150 °C using water, and then leaving the mixed solid, etc. to stand for natural cooling, moisture attached to the metallic iron is evaporated with heat of the metallic iron itself. Accordingly, the metallic iron can be dried with no need of providing any drying means such as a drier.

[0026] In the above, the method of the present invention is described in connection with the case of quickly cooling the mixed solid discharged from the reduction melting furnace together with the granular metallic iron and the slag granules. However, the present invention is also applicable to the case of separating the metallic iron and the slag from each other by any suitable screening means (such as a sieve or a magnetic screening device) at the time when the granular metallic iron, the slag granules and the mixed solid are discharged out of the reduction melting furnace, and then selectively taking out only the mixed solid or both of the mixed solid and the granular metallic iron through selective collection of the granular metallic iron, the slag granules and the mixed solid. Thus, the method of the present invention can be implemented regardless of the presence of the granular metallic iron and/or the slag granules in addition to the mixed solid.

[0027] Also, by separating the metallic iron and the slag contained in the mixed solid from each other as the granular metallic iron and the slag granules according to the method of the present invention, and then selectively collecting the granular metallic iron and the slag granules by any suitable screening means (such as a sieve or a magnetic screening device), metallic iron raw-materials having purity of not less than about 95 %, more preferably of not less than about 98 %, and containing a very small amount of slag components can be finally obtained.

[0028] The method of the present invention will be described below in connection with Example. It is, however, to be noted that the following Example is not purported to limit the present invention, and the present invention can be modified in appropriate ways based on the purports of the present invention mentioned above and below.

Example

[0029] Raw-material agglomerates containing iron ore and coal were supplied to the reduction melting furnace of the moving hearth type shown in Figs. 1 and 3, and then subjected to heating reduction (temperature in the furnace: 1300 °C) with combustion heat and radiation heat generated by combustion burners while the raw-material agglomerates were maintained in a solid state. The raw-material agglomerates were further heated and molten under a reducing atmosphere, thus generating a mixture of metallic iron as an objective product and slag as a by-product. The mixture was cooled down to 1000 °C in the furnace. Granular metallic iron, slag granules and a mixed solid all solidified with the cooling were discharged by a discharging means provided at the downstream side in the moving direction of a hearth. The discharged mixed solid, etc. were introduced through a feed duct to a cooling tank for quick cooling, to which coolants shown in Table 1 were supplied. The cooling tank using nitrogen as the coolant is shown in Fig. 6. The mixed solid, etc. were quickly cooled by supplying a nitrogen gas to the cooling tank at all times (flow rate: 10 Nm^3/hr) while adjusting the flow rate of the nitrogen gas so that the cooling rate was held at 250 °C/min. Additionally, the flow rate of the supplied nitrogen gas was adjusted by exhausting the nitrogen gas through an exhaust duct 14. At the time when the temperature of the metallic iron, etc. was lowered to room temperature, the metallic iron, etc. were taken out of the cooling tank as required, and a total amount of the mixed solid was measured (see "Mass of Mixed Solid" and "Slag Non-Separation Rate" in Table 1). In the case of the nitrogen cooling, the temperature of the metallic iron, etc. was measured by inserting a thermocouple in a mass of the mixed solid accumulated in the cooling tank. The cooling tank using water as the coolant is shown in Fig. 7. Water was pooled in the cooling tank beforehand to cool the mixed solid, etc. introduced to the cooling tank. As a result of separately measuring a cooling rate of the mixed solid, etc. in a water dipped state, the cooling rate was 350 °C/min. At the time when the temperature of the mixed solid, etc. was lowered to room temperature, the mixed solid, etc. were taken out of the cooling tank as required, and a total amount of the mixed solid was measured. Measured results are shown in Table 1.

[0030] Further, in the case of the water cooling, the cooling rate obtained with water dipping was separately measured. More specifically, a thermocouple was inserted in a mass of the mixed solid heated to 1000 °C in the heating furnace, and the cooling rate of the mixed solid was measured in a water dipped state.

Table 1

Test No.	Nitrogen Cooling			Water Cooling			Reduction Ratio
	Total Mass kg	Mass of Mixed Solid kg	Slag Non-Separation Rate %	Total Mass kg	Mass of Mixed Solid kg	Slag Non-Separation Rate %	
1	7.40	0.70	9.5	7.47	0.15	2.0	0.21
2	6.40	0.35	5.5	6.50	0.05	0.8	0.15
3	6.00	0.15	2.5	5.40	0.01	0.2	0.08

* "Total Mass Kg" means the mass of the mixed solid before the start of the cooling.

* "Mass of Mixed Solid kg" means the mass of the mixed solid remaining after the cooling.

* "Slag Non-Separation Rate %" = (Mass of Mixed Solid kg) / (Total Mass kg)

* "Reduction Ratio" = (Slag Non-Separation Rate % with the water cooling) / (Slag Non-Separation Rate % with the nitrogen cooling)

[0031] As seen from Table 1, slag can be separated and removed from the mixed solid by employing nitrogen or water as the coolant. Also, it is seen that the tests employing water as the coolant show lower non-separation rates than the tests employing nitrogen as the coolant, and hence the quick cooling means with water dipping is more preferable quick cooling means.

Comparative Example

[0032] Granular metallic iron was produced using the reduction melting furnace of the moving hearth type under the same conditions as those in Example described above. The mixed solid, etc. discharged out of the furnace were left to stand in the atmosphere for natural cooling to room temperature, but a very high non-separation rate (15 %) was resulted.

Industrial Applicability

[0033] According to the method of the present invention, as described above, metallic iron and slag as components of a mixed solid discharged out of a furnace can be separated from each other with ease. Since the present invention provides metallic iron raw-materials being free from slag and having high iron purity, molten steel having stable quality can be produced with high productivity while reducing electric power consumed by an electric furnace per unit product, by constructing a continuous system that utilizes the thus-provided metallic iron raw-materials as raw materials for steel making.

Claims

1. A method for accelerating separation of granular metallic iron and slag, the method being employed to produce the granular metallic iron with reduction melting of raw-material agglomerates that contain an iron-oxide containing material and a carbonous reducing agent, wherein a mixed solid of the granular metallic iron produced with the reduction melting and the slag produced as a by-product are quickly cooled to accelerate separation of the granular metallic iron and the by-product slag from each other.

2. The method according to Claim 1, wherein the quick cooling is performed using a coolant.

3. The method according to Claim 1 or 2, wherein the quick cooling is performed at a cooling rate of not less than 250 °C/min in at least a part of the range from a solidifying temperature of the granular metallic iron to 150 °C.

4. The method according to Claim 3, wherein the quick cooling is performed at a cooling rate of not less than 350 °C/min.

5. The method according to any one of Claims 1 to 4, wherein water is employed as the coolant, the quick cooling of the granular metallic iron is stopped until reaching 150 °C, and moisture residing on and attached to the granular metallic iron is dried.

FIG. 1

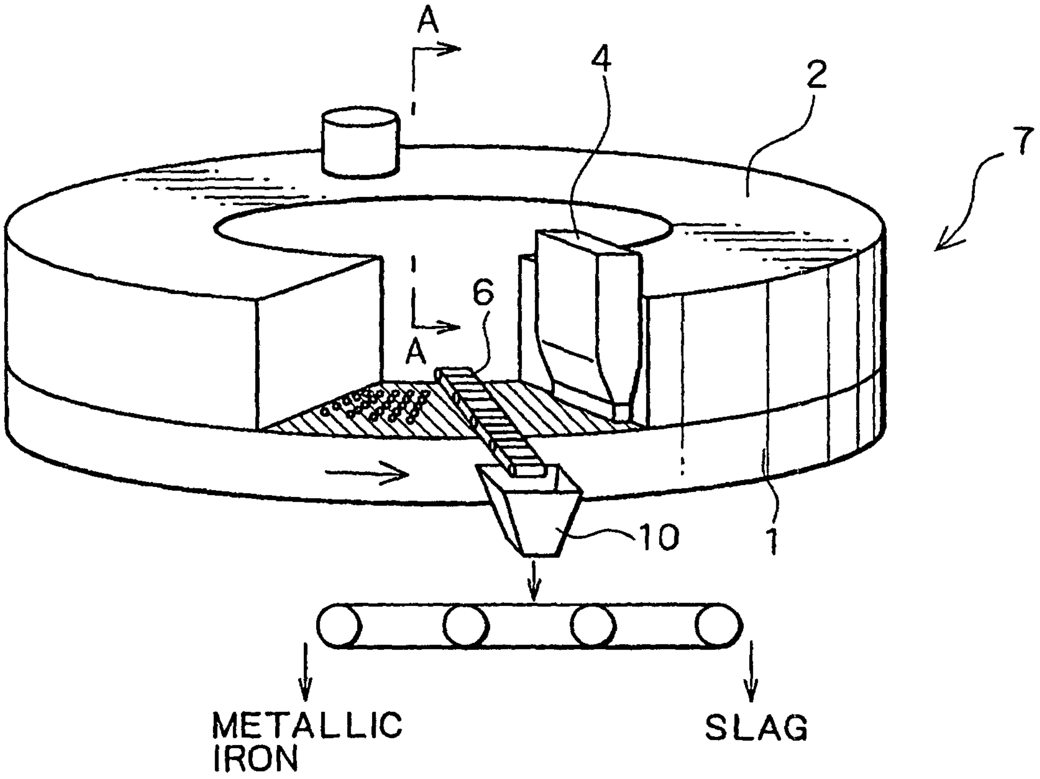

FIG. 2

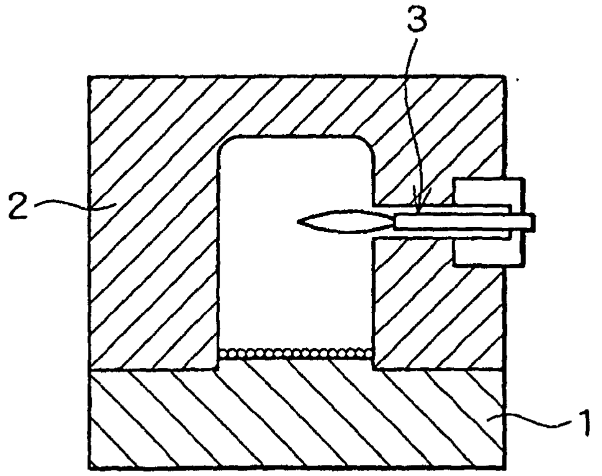

FIG. 3

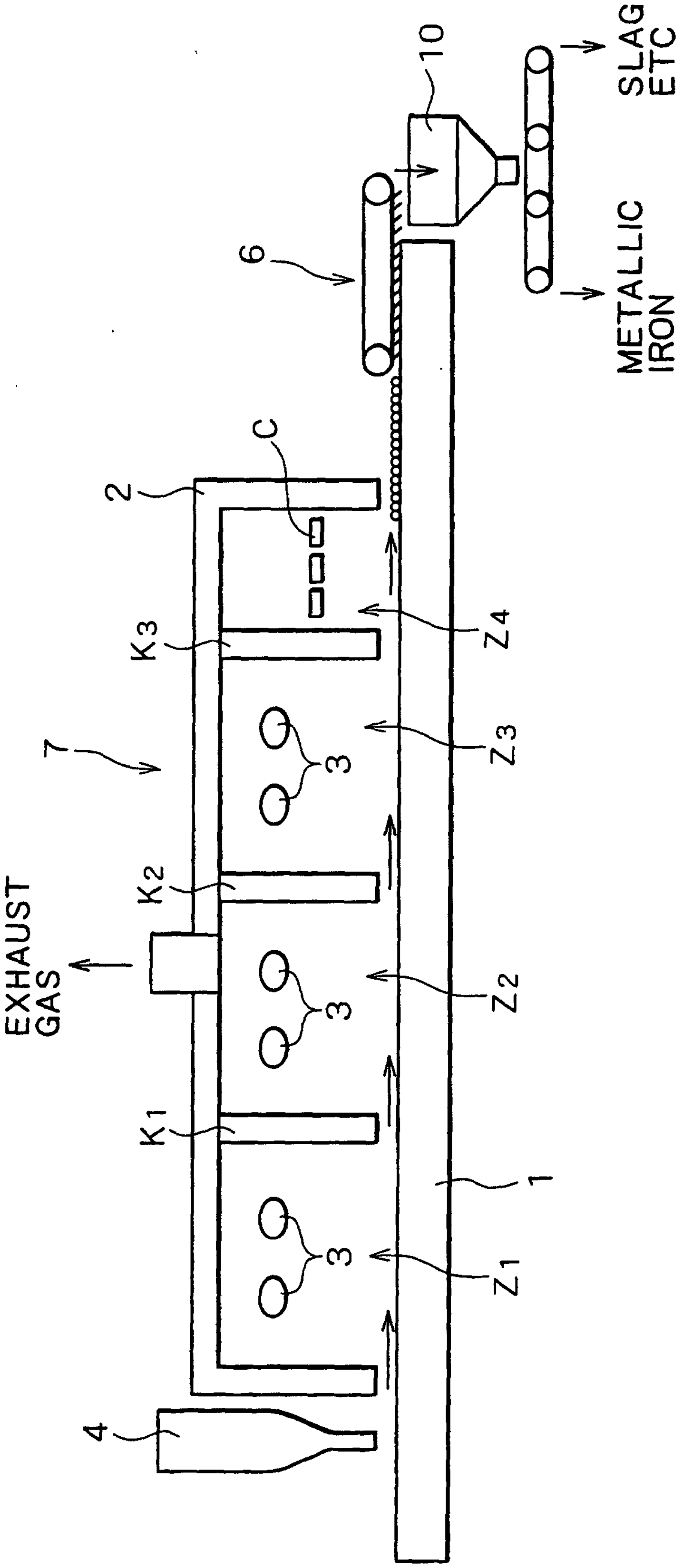
10
SLAG, ETC
METALLIC IRON
6
C
2
K_3
Z_4
7
3
Z_3
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FIG.4

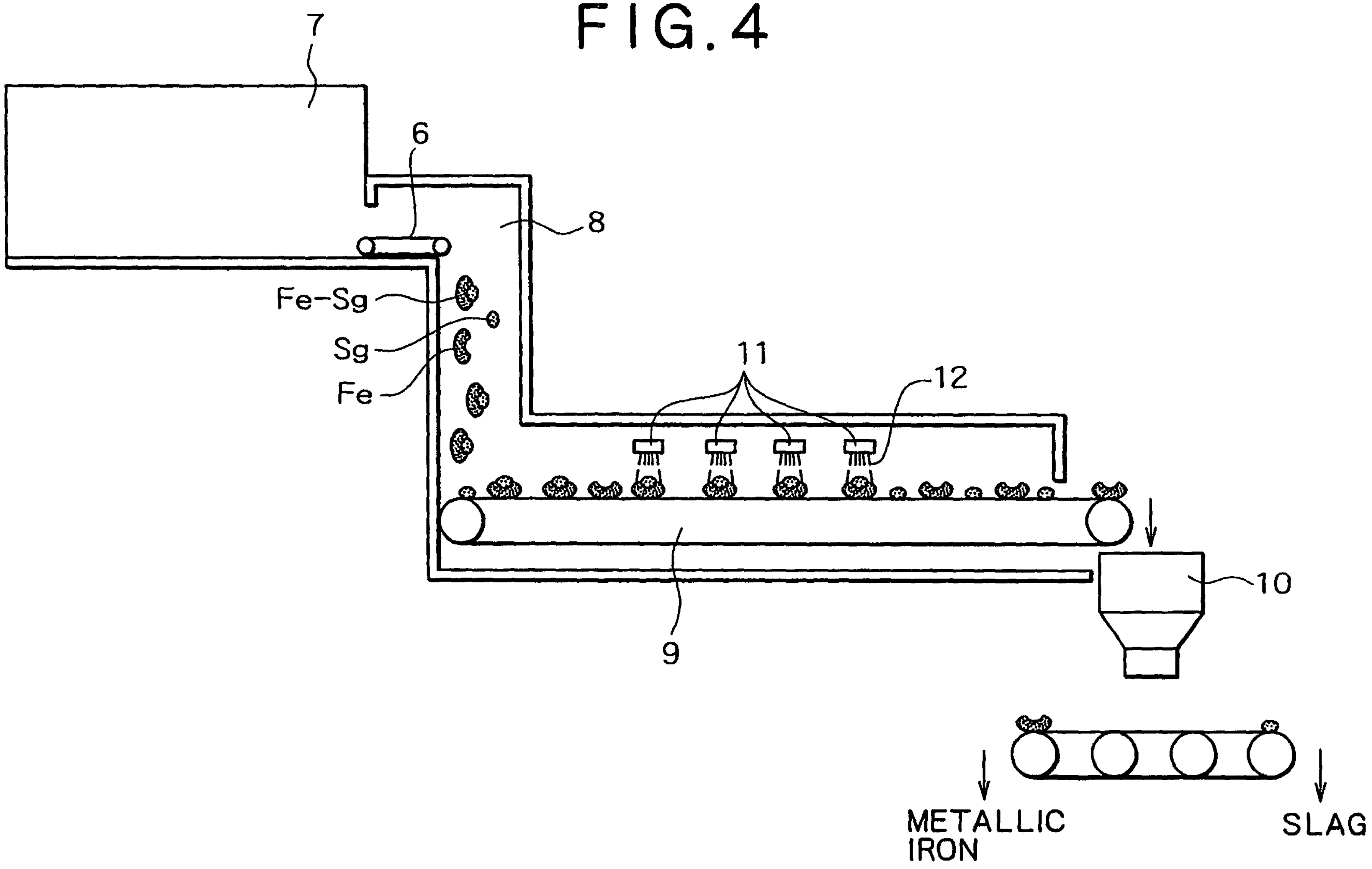


FIG. 5

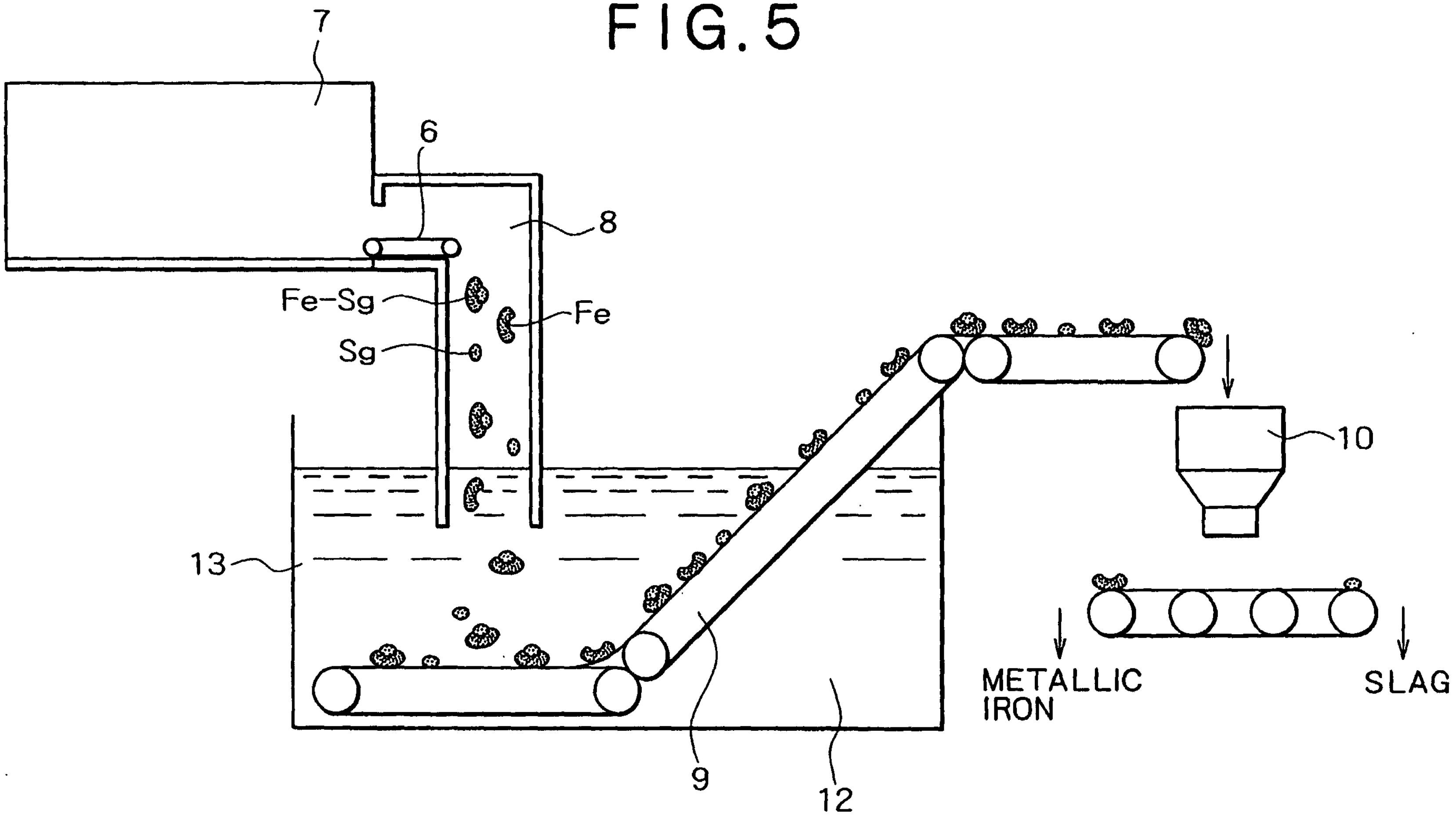
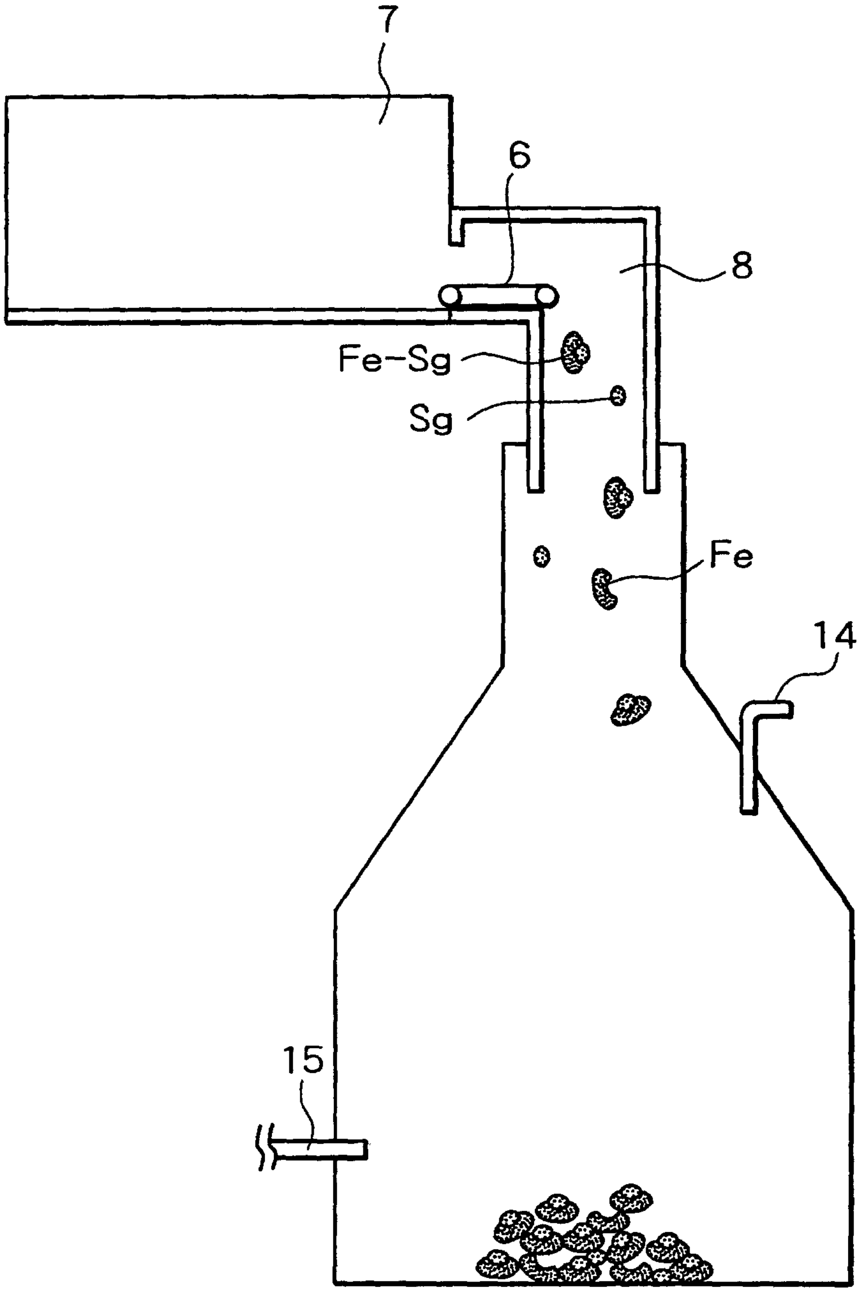
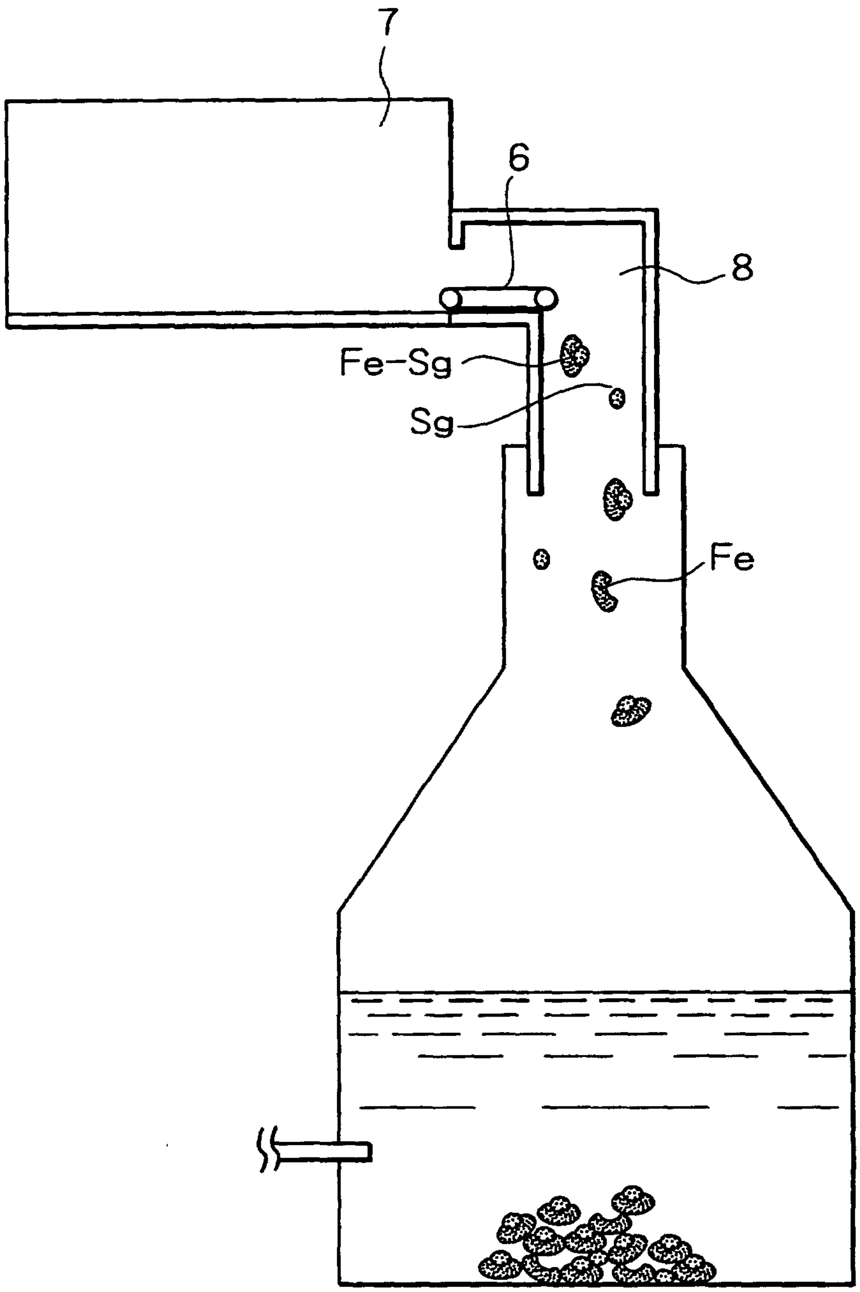


FIG.6



F I G. 7



INTERNATIONAL **SEARCH REPORT**

International application No.
PCT/JP02/05996

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^7 C21B13/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl^7 C21B13/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-2002
Kokai Jitsuyo Shinan Koho	1971-2002	Jitsuyo Shinan Toroku Koho	1996-2002

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E,X	JP 2001-280631 A (Sumitomo Heavy Industries, Ltd.), 10 October, 2001 (10.10.01), (Family: none)	1-5
X	JP 48-014514 A (Kawasaki Steel Corp.), 23 February, 1973 (23.02.73), (Family: none)	1-5
X	JP 10-158710 A (Sumitomo Metal Mining Co., Ltd.), 16 June, 1998 (16.06.98), (Family: none)	1-5
X	JP 2000-212651 A (Kobe Steel, Ltd.), 02 August, 2000 (02.08.00), (Family: none)	1-5

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
02 August, 2002 (02.08.02)

Date of mailing of the international search report
13 August, 2002 (13.08.02)

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Japanese Patent Office

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Form PCT/ISA/210 (second sheet) (July 1998)