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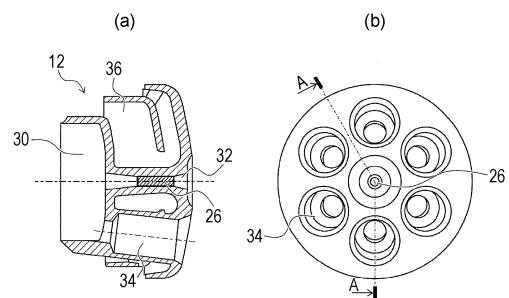
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(54) **LANCE TIP, CONVERTER INTERNAL TEMPERATURE MEASURING EQUIPMENT, AND
CONVERTER INTERNAL TEMPERATURE MEASURING METHOD**

(57) A lance tip that is used in in-converter temperature measurement equipment that is capable of continuously measuring the temperature of molten iron inside a converter is provided.

A lance tip of a lance that is inserted into a converter includes a cylindrical lance tip body and a camera unit. The lance tip body is provided with a containing portion, a peripheral hole through which a gas that is blown against molten iron inside the converter passes, and a water cooling path disposed so as to surround the containing portion. The camera unit has an image sensor that generates image data by photographing the molten iron, a lens, and a radiant-heat shielding filter. The camera unit is provided in the containing portion.

FIG. 2



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Description

Technical Field

5 **[0001]** The present invention relates to a lance tip that is used in measuring the temperature of molten iron that is subjected to blowing inside a converter, in-converter temperature measurement equipment, and an in-converter temperature measurement method using the lance tip and the in-converter temperature measurement equipment.

Background Art

10 **[0002]** In, for example, a blowing process in steelmaking in a converter, a top blowing lance is used, oxygen gas is blown against molten iron to oxidize (burn) phosphorus, carbon, or the like in the molten iron and to adjust the composition of molten iron, and the temperature of molten iron is adjusted so as to become an optimal temperature in a processing operation of a next step. The measurement of the temperature of molten iron during the blowing is important not only
15 with respect to the adjustment of temperature of molten iron but also from the viewpoint of adjusting the composition of molten iron.

[0003] As a technology of measuring the temperature of molten iron, Patent Literature 1 discloses a technology in which an in-converter observation probe provided with a CCD camera is provided at an end of a sub-lance, and the sub-lance is inserted into a converter to measure the temperature inside the converter. Patent Literature 2 discloses a
20 technology in which a CCD camera is provided at an end portion opposite to an end portion of a main lance, and molten iron is photographed from an upper side of the outside of the lance through a hole for ejecting a gas, to thereby measure the temperature of molten iron. Patent Literature 3 discloses a technology in which the luminance of molten iron is measured using a CCD camera from a tuyere of a bottom portion of a converter, to thereby measure the temperature of molten iron. Further, Patent Literature 4 discloses a technology in which a single-core optical fiber that is small enough
25 not to hinder injection of an oxygen jet is installed near an injection nozzle opening of a main lance, and a monochromatic thermometer that is connected to the single-core optical fiber is used to measure the temperature.

Citation List

30 Patent Literature

[0004]

PTL 1: Japanese Unexamined Patent Application Publication No. 10-88221
35 PTL 2: Japanese Unexamined Patent Application Publication No. 2006-126062
PTL 3: Japanese Unexamined Patent Application Publication No. 2007-322382
PTL 4: Japanese Unexamined Patent Application Publication No. 62-226025

Summary of Invention

40 **[0005]** However, in order to increase the hitting accuracy of a blowing end temperature, it is necessary to continuously capture temperature changes in at least a few minutes in the second half of a blowing step. Since the sub-lance disclosed in Patent Literature 1 is a device that intermittently captures the state of the inside of the converter, the temperature changes cannot be continuously captured and it is difficult to increase the hitting accuracy of the blowing end temperature. Further, since probes are worn with each measurement timing, probes need to be frequently replaced, and thus running costs are increased.

[0006] In the device disclosed in Patent Literature 2, since the camera is installed at a position separated by a distance
50 of 10 m or greater from an object to be measured, it is difficult to know which position on a surface of molten iron inside a converter is being observed due to a reduced field of view. In the measurement method disclosed in Patent Literature 3, a high-temperature ladle that is disposed below the converter or the heat of the converter itself heats the CCD camera unit and thus damages this equipment.

[0007] What can be obtained from the device disclosed in Patent Literature 4 is only data regarding temperature, and
55 a temperature measurement position cannot be directly observed. Therefore, the measured temperature may be the temperature of slag instead of the temperature of molten iron, and thus the temperature of molten iron cannot be precisely measured.

[0008] The present invention has been made in view of such problems of the related art, and an object of the present

invention is to provide in-converter temperature measurement equipment that is capable of continuously measuring the temperature of molten iron inside a converter, a lance tip that is used in the in-converter temperature measurement device, and an in-converter temperature measurement method using the in-converter temperature measurement equipment and the lance tip.

Solution to Problem

[0009] Means for solving the problems described above are as follows.

(1) A lance tip of a lance that is inserted into a converter includes a cylindrical lance tip body and a camera unit. The lance tip body is provided with a containing portion, peripheral holes through which a gas that is blown against molten iron inside the converter pass, and a water cooling path disposed so as to surround the containing portion. The camera unit has an image sensor configured to generate image data by photographing the molten iron, a lens, and a radiant-heat shielding filter. The camera unit is provided in the containing portion.

(2) In-converter temperature measurement equipment that measures a temperature of molten iron inside a converter includes a sub-lance on whose end the lance tip according to (1) is provided, an inert gas supply device, and a calculating device configured to convert the image data into temperature data.

(3) In-converter temperature measurement equipment that measures a temperature of molten iron inside a converter includes a top blowing lance on whose end the lance tip according to (1) is provided, an inert gas supply device, a switching device configured to switch between oxygen gas and inert gas, and a calculating device configured to convert the image data into temperature data.

(4) In the in-converter temperature measurement equipment according to (2) or (3), the calculating device is configured to convert spectral radiance data generated from the image data into temperature data.

(5) The in-converter temperature measurement equipment according to any one of (2) to (4), further includes a display device configured to display the image data generated by the image sensor.

(6) An in-converter temperature measurement method using the in-converter temperature measurement equipment according to any one of (2) to (5) includes photographing the molten iron with the camera unit while blowing inert gas against the molten iron, and converting the generated image data into temperature data.

Advantageous Effects of Invention

[0010] It is possible to, by using the in-converter temperature measurement equipment having a lance tip according to the present invention, continuously measure the temperature of molten iron inside the converter while observing the molten iron. Accordingly, it is possible to increase the hitting accuracy of a blowing end temperature in a blowing step and to, thus, reduce the blowing time and the amount of use of auxiliary material.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is a sectional schematic view showing a state in which the temperature of molten iron 102 inside a converter 100 is continuously measured by using in-converter temperature measurement equipment 10 according to a first embodiment.

[Fig. 2] Fig. 2(a) and Fig. 2(b) are a sectional view and a front view of a lance tip 12, respectively.

[Fig. 3] Fig. 3 is a perspective view showing a structure of a camera unit 26.

[Fig. 4] Fig. 4 shows simulation results obtained by a simulation of temperature changes of an image sensor 40 and a lens 42 when a sub-lance 14 is inserted in the converter 100.

[Fig. 5] Fig. 5 is a graph showing a temperature change of molten iron during blowing whose purpose is decarburization.

[Fig. 6] Fig. 6 is a sectional schematic view showing a state in which the temperature of molten iron 102 inside a converter 100 is continuously measured by using in-converter temperature measurement equipment 50 according to a second embodiment.

[Fig. 7] Fig. 7 is a graph showing temperature measurement results of molten stainless steel obtained by the in-converter temperature measurement equipment 50.

[Fig. 8] Fig. 8 is a graph showing ambient temperatures inside a housing.

Description of Embodiments

[0012] Fig. 1 is a sectional schematic view showing a state in which the temperature of molten iron 102 inside a converter 100 is continuously measured by using in-converter temperature measurement equipment 10 according to a first embodiment. The temperature measurement of the molten iron 102 using the in-converter temperature measurement equipment 10 according to the present embodiment can be applied to a blowing step whose purpose is, for example, desiliconization, dephosphorization, or decarburization. In the embodiment below, the in-converter temperature measurement equipment 10 according to the first embodiment is described as being applied to a blowing step whose purpose is decarburization of molten iron.

[0013] Oxygen is supplied from a top blowing lance 104 to the molten iron 102 contained in the converter 100, and a bottom blowing gas, such as nitrogen, is blown from a bottom blowing tuyere 106 and is mixed. Therefore, the decarburization of carbon that is included in the molten iron 102 progresses, and the carbon concentration of the molten iron 102 is reduced. In the decarburization blowing, an end point constituent concentration and a blowing end temperature of the molten iron 102 to be targeted are subjected to static control and dynamic control, and an end point constituent concentration and a blowing end temperature of the molten iron 102 after the blowing are caused to hit the target values. Here, "static control" is control that, from an operation condition before the blowing is started, calculates, for example, the oxygen content that is blown to the molten iron 102. "Dynamic control" is control that, based on a constituent concentration and a temperature measurement value of the molten iron 102 that are measured in the second half of the blowing step, adjusts, for example, the oxygen content that is blown to the molten iron 102.

[0014] The in-converter temperature measurement equipment 10 according to the first embodiment is used in the temperature measurement of the molten iron 102 in the second half of the blowing step, used in the dynamic control. The in-converter temperature measurement equipment 10 according to the first embodiment has a sub-lance 14 on whose end a lance tip 12 is provided, a nitrogen gas supply device 20, a relay unit 22, and a calculating device 24 that converts image data into temperature data. The lance tip 12 has a camera unit 26.

[0015] The sub-lance 14, which is different from the top blowing lance 104, refers to a lance that is a measuring probe which is inserted into the converter, and that includes in the inside thereof a measuring device, such as a thermocouple. The sub-lance 14 may be provided with a gas flow path or a cooling water path as appropriate for protecting the measuring device provided inside the sub-lance 14. In the present embodiment, the sub-lance 14 has a three-pipe structure. Nitrogen gas is supplied from the nitrogen gas supply device 20, and is blown against the molten iron 102 by passing through a central pipe. Cooling water is supplied from a cooling water supply device 110, which is a part of converter equipment, and circulates by passing through two outer pipes. In Fig. 1, reference sign 16 denotes the flow of nitrogen gas, and reference sign 18 denotes the flow of cooling water. With the sub-lance 14 inserted inside the converter 100, the sub-lance 14, while blowing nitrogen gas against the molten iron 102, photographs the molten iron 102 inside the converter 100 with the camera unit 26 provided at an end of the sub-lance 14. Since dust or the like can be removed from a photographing path of the camera unit 26 by blowing nitrogen gas against the molten iron 102 from the sub-lance 14 in this way, the molten iron 102 can be photographed without being blocked by the dust or the like. Nitrogen gas is an example of inert gas, and argon gas may be used as the inert gas.

[0016] The camera unit 26 continuously photographs the molten iron 102, and continuously generates image data. The camera unit 26 may photograph a moving image of the molten iron 102. The image data generated by the camera unit 26 is transmitted to the calculating device 24 via the relay unit 22. The transmission of the image data to the relay unit 22 from the camera unit 26 and the transmission of the image data to the calculating device 24 from the relay unit 22 may be performed through wire or may be wireless.

[0017] The calculating device 24 is, for example, a work station or a general-purpose computer, such as a personal computer. The calculating device 24 converts the image data that is transmitted from the camera unit 26 into temperature data. As a method of converting the image data into temperature data, there are a method of converting luminance data into temperature data by obtaining the luminance data from the image data and a method of converting spectral radiance data into temperature data by obtaining the spectral radiance data from the image data.

[0018] When the luminance data is converted into temperature data, from the obtained image data, the calculating device 24 obtains, as the luminance data, for example, an integral value of luminance within a predetermined sampling time or a maximum luminance value. By using a correspondence relationship, previously measured at a blackbody furnace, between the luminance data and temperature, the calculating device 24 converts the obtained luminance data into temperature data.

[0019] On the other hand, as a method of converting the spectral radiance data into temperature data, a measurement principle based on a two-color radiation thermometer (also called a two-color thermometer or a ratio thermometer) can be applied. In the two-color radiation thermometer, the radiances at two different wavelengths are measured, the ratio between the radiances is calculated, and a comparison is made with a previously measured black-body radiance ratio, to thereby convert it into the temperature of an object. This method can relatively stably measure the temperature even if a change in emissivity occurs. When the spectral radiance data is converted into temperature data based on a principle

that is the same as that of the two-color radiation thermometer, the calculating device 24 obtains, based on three primary colors, which are red (R), green (G), and blue (B), for example, R spectral radiance data and G spectral radiance data, and calculates the radiance ratio from the radiance data, the three primary colors being pieces of image data. The calculating device 24 converts the spectral radiance data into temperature data by using a correspondence relationship, previously examined at, for example, a black-body radiation furnace, between the intensity ratio of the spectral radiance data and temperature.

[0020] When image data captured by an infrared camera is used, the calculating device 24 prepares luminance data corresponding to the infrared wavelength. The calculating device 24 converts the luminance data into temperature data by using a correspondence relationship, previously examined using, for example, a black-body radiation furnace, between the intensity of the luminance data and temperature. As the luminance data that is obtained from the image data, as long as the relationship between a wavelength component intensity thereof and the temperature is previously known, it is possible to use any wavelength component data in an infrared wavelength range.

[0021] When, as the camera unit 26, a device having functions from obtaining image data to converting the image data into temperature data as is the case of an infrared thermography camera is used, the calculating device 24 need not have the function of converting the image data into temperature data. The calculating device 24 displays the temperature data on, for example, a display device 28, such as a display. In this way, the temperature of a liquid surface of the molten iron 102 is continuously measured by using the in-converter temperature measurement equipment 10 according to the first embodiment. The calculating device 24 may display on the display device 28 image data that has been transmitted together with the temperature data. In this way, since, by displaying the image data on the display device 28, the molten iron inside the converter can have its temperature measured while being observed, it is possible to determine whether the temperature data is the temperature of the molten iron 102 or the temperature of slag 114 formed on a surface of the molten iron 102. In addition, by selectively using the temperature data determined as being the temperature of the molten iron 102, it is possible to prevent the measurement of the temperature of the slag 114 and to thereby increase the temperature measurement accuracy of the molten iron 102. When the image data is to be transmitted to another display device by wireless communication, the in-converter temperature measurement equipment 10 need not have the display device 28.

[0022] Fig. 2(a) and Fig. 2(b) are a sectional view and a front view of the lance tip 12, respectively. The sectional view of Fig. 2(a) is a sectional view along A-A in the front view of Fig. 2(b). The lance tip 12 has a cylindrical shape having the same diameter as the sub-lance 14, and is attached to an end of the sub-lance 14. The lance tip 12 has a lance tip body 30 and the camera unit 26. The lance tip body 30 has, for example, a cylindrical shape having a diameter of 300 to 600 mm (400 mm in the example shown in Fig. 2), and is provided with a containing portion 32, peripheral holes 34, and a cooling water path 36.

[0023] The containing portion 32 is a through hole provided at the axial center of the lance tip body 30 and having a diameter of 35 to 70 mm (57 mm in the example shown in Fig. 2). The camera unit 26 is installed in the containing portion 32. Although the containing portion 32 may be a recessed portion that does not open into the sub-lance 14, if the containing portion 32 opens into the sub-lance 14, the camera unit 26 is cooled by nitrogen gas and a temperature rise of the camera unit 26 is suppressed, which is more preferable.

[0024] The peripheral holes 34 are each a hole that passes therethrough nitrogen gas that is blown against the molten iron 102. Each peripheral hole 34 is connected with the central pipe of the sub-lance 14. As shown in Fig. 2(b), six peripheral holes 34 are provided side by side in a ring in an end surface of the lance tip body 30. Although Fig. 2 shows an example in which six peripheral holes 34 are provided, it is not limited thereto, and at least one peripheral hole only needs to be provided. However, the number of peripheral holes 34 is preferably 4 or more and 8 or less. When the number of peripheral holes 34 is 4 or more and 8 or less, the surrounding of the camera unit 26 can be uniformly cooled. In order to remove dust or the slag 114 from the photographing path, a peripheral hole facing the photographing path may be provided.

[0025] The cooling water path 36 is a pipe that passes therethrough cooling water that is supplied from the cooling water supply device 110. The cooling water path 36 is provided so as to surround the containing portion 32. The cooling water path 36 is connected with the two outer pipes on the outer side of the sub-lance 14, and cooling water circulates inside the cooling water path 36. The camera unit 26 installed in the containing portion 32 is cooled due to cooling water of 40°C or lower flowing in the cooling water path 36. Therefore, even if the camera unit 26 is inserted into a high-temperature converter, the temperature of the camera unit 26 can be kept less than or equal to a guaranteed operation temperature of the camera unit 26. For the camera unit 26, for example, a camera unit whose guaranteed operation temperature is 85°C can be used. For example, a CHEETAH series product manufactured by IMPERX applies to such a camera unit. A heat-resistant camera that can endure a temperature of even 200°C manufactured by Integrate Systems Co., Ltd. may be used. Even if a commercial camera whose guaranteed operation temperature is about 60°C is used, as long as the commercial camera is used for a short period of about a few months, the camera can sometimes endure even an ambient temperature of 85 to 100°C. Although the example shown in Fig. 2 is an example in which the containing portion 32 is provided at the axial center of the lance tip body 30, it is not limited thereto. The containing portion 32 only

needs to be provided in a range surrounded by the cooling water path 36.

[0026] Fig. 3 is a perspective view showing a structure of the camera unit 26. Fig. 3(a) is a perspective view of the camera unit 26, and Fig. 3(b) is a perspective view showing each structure of the camera unit 26. The camera unit 26 has a housing 38, an image sensor 40, a lens 42, two radiant-heat shielding filters 44, fixed rings 46, and a battery 48. The housing 38 is made of a metal having a high thermal conductivity, such as Cu, and is a hollow cylindrical container having a photographing hole on one end surface side. The outside diameter of the housing 38 is the same as the inside diameter of the containing portion 32. In the example shown in Fig. 2, the inside diameter of the containing portion 32 is 57 mm.

[0027] The image sensor 40 is a sensor that generates image data by photographing the molten iron 102. The image sensor 40 includes a CCD sensor and a data processing circuit that processes data generated by the CCD sensor and transforms the processed data into image data. The two radiant-heat shielding filters 44 are fixed to corresponding ones of the fixed rings 46 on a side of the lens 42 facing the molten iron 102. A temperature rise of the lens 42 and the image sensor 40 caused by radiant heat from the molten iron is suppressed by providing the radiant-heat shielding filters 44, and, thus, damage to the lens 42 and the image sensor 40 is suppressed. If the two radiant-heat shielding filters 44 can be fixed to the lens 42 by another means, the fixed rings 46 need not be provided. Although, as the image sensor 40, an example in which the image sensor 40 has a CCD sensor is described, the image sensor 40 is not limited thereto, and a CMOS sensor may be used instead of a CCD sensor.

[0028] As the radiant-heat shielding filters 44, one or more types selected from an ND filter (model NDUV10B, model NDUV20B, model NDUV30B) manufactured by Thorlab Inc., a hot mirror (infrared cut filter) (model M254H00) manufactured by Thorlab Inc., and a bandpass filter (model FL532-1) manufactured by Thorlab Inc. can be used. Although Fig. 3 shows an example in which two radiant-heat shielding filters 44 are provided, it is not limited thereto. As long as there is one or more radiant-heat shielding filters 44, it is possible to suppress a temperature rise of the camera unit 26 caused by radiant heat of molten iron and to prevent damage to the camera unit 26. When spectral radiance data is used in the calculating device 24, it is preferable to use a radiant-heat shielding filter that blocks radiant heat having a wavelength different from a wavelength used for converting the spectral radiance data into temperature data.

[0029] The image sensor 40, the lens 42, the two radiant-heat shielding filters 44, and the battery 48 are installed inside the housing 38, and the housing 38 is fixed to the containing portion 32, to thereby mount the camera unit 26 to the lance tip body. The image sensor 40, the lens 42, and the two radiant-heat shielding filters 44 may be directly mounted inside the containing portion 32, and, thus, the camera unit 26 need not have a housing. However, since the workability when replacing the camera unit 26 is better when, for example, the image sensor 40 is previously fixed inside the housing 38 and the housing is fixed to the containing portion 32, it is preferable that the camera unit 26 have the housing 38. The battery 48 is a device that supplies electric power that drives the image sensor 40. As long as the camera unit 26 and an external power source are connected to each other, the camera unit 26 need not have the battery 48.

[0030] Since the temperature of the inside of the converter during blowing is high, when the sub-lance 14 is inserted and the molten iron 102 is photographed, the temperature of the camera unit 26 becomes high, as a result of which the lens 42 and the image sensor 40 may be damaged. Therefore, in the in-converter temperature measurement equipment 10 according to the first embodiment, a temperature rise of the image sensor 40 and the lens 42 is suppressed by disposing the cooling water path 36 around the containing portion 32 to perform cooling, and by providing the radiant-heat shielding filters 44 on the side of the lens 42 facing the molten iron 102.

[0031] Fig. 4 shows simulation results obtained by a simulation of temperature changes of the image sensor 40 and the lens 42 when the sub-lance 14 is inserted in the converter 100. In the simulation, temperature changes of a portion where the image sensor 40 and the lens 42 were contained were simulated by using STAR-CCM+ (manufactured by SIEMENS) and by using cooling water temperatures, a cooling water amount, a thermal conductivity of an outer surface of the lance tip, a thermal conductivity of an inner surface of the lance tip, a lance outer surface temperature, a lance inner surface temperature, and a thermal conductivity of each radiant-heat shielding filter, all of which are shown in Table 1 below. In the simulation, the cooling effect by nitrogen gas is not considered. As a boundary condition, a heat flux from the lance outer surface inside the converter was 800 kW/m². This value is a value that has been set on the assumption that a heat input to cooling water calculated based on an entry-side temperature value and an exit-side temperature value of the cooling water is equal to a heat input from the lance outer surface inside the converter.

[Table 1]

Item		Unit	Value
Cooling Water	Entry-Side Temperature	°C	27
	Exit-Side Temperature	°C	35
	Cooling Water Amount	t/h	500

(continued)

	Item	Unit	Value
5	Thermal Conductivity	Lance-Tip Outer Surface	W/(m ² × K)
		Lance-Tip Inner Surface	W/(m ² × K)
10	Temperature	Lance-Tip Outer Surface	°C
		Lance-Tip Inner Surface	°C
	Thermal Conductivity	Radiant-Heat Shielding Filter	W/(m × K)

[0032] As shown in Fig. 4, the average temperature of a first radiant-heat shielding filter 44(A) became 84°C, and the maximum temperature thereof became 94°C. The average temperature of a second radiant-heat shielding filter 44(B) became 62°C, and the maximum temperature thereof became 66°C. The average temperature of the portion where the image sensor 40 and the lens 42 were contained became 32°C, and the maximum temperature thereof became 61°C. It was confirmed that, since the guaranteed operation temperature of the camera unit 26 used in the first embodiment was less than or equal to 100°C, as long as at least one radiant-heat shielding filter 44 was provided, the temperatures of the image sensor 40 and the lens 42 of the camera unit 26 could be maintained at less than 100°C.

[0033] Fig. 5 is a graph showing a temperature change of molten iron during blowing whose purpose is decarburization. In Fig. 5, the vertical axis indicates molten iron temperature (°C), and the horizontal axis indicates carbon concentration (mass%). Since oxygen is supplied from the top blowing lance 104 and the carbon concentration of the molten iron 102 is reduced, the carbon concentration changes from right to left along the horizontal axis as the blowing progresses. On the other hand, the temperature of the molten iron 102 rises as the blowing progresses.

[0034] In conventional blowing dynamic control, in the second half of a blowing step, the sub-lance is intermittently inserted to measure the temperature of the molten iron 102, and a timing in which a blowing end temperature of the molten iron 102 becomes a target temperature is predicted from the measured value. However, since the timing is only a prediction, the blowing end temperature sometimes does not become the target value due to some reason. In contrast, since, by using the in-converter temperature measurement equipment 10 according to the first embodiment, the molten iron 102 can be subjected to blowing while its temperature is continuously measured in the second half of the blowing step, the blowing end temperature and the target temperature will not differ from each other.

[0035] Although, in the example, described above, an example in which the temperature of the molten iron 102 is measured in the second half of the blowing step has been described, the temperature of the molten iron 102 may be continuously measured in the entire blowing step by using the in-converter temperature measurement equipment 10 according to the first embodiment. In this way, due to continuously measuring the temperature of the molten iron 102 during the blowing, even if a contingency in the blowing step, such as an abnormal temperature rise during the blowing, occurs, it is possible to quickly detect the contingency and to thus quickly deal with the contingency. In this way, by quickly dealing with the contingency, it is possible to suppress an increase in damages caused by the contingency.

[0036] As described above, due to the use of the in-converter temperature measurement equipment 10 according to the first embodiment, it is possible to, while observing the molten iron 102 inside the converter 100, continuously measure the molten iron. Therefore, the accuracy of the blowing end temperature in the blowing step is increased, as a result of which it is possible to reduce blowing time and the amount of use of auxiliary material. Since a consumable-type probe used in a conventional sub-lance is not used, running costs for measuring temperature can also be reduced.

[0037] Next, a second embodiment is described. Fig. 6 is a sectional schematic view showing a state in which the temperature of molten iron 102 inside a converter 100 is continuously measured by using in-converter temperature measurement equipment 50 according to the second embodiment. The in-converter temperature measurement equipment 50 according to the second embodiment has a top blowing lance 52 on whose end the lance tip 12 shown in Fig. 2 is provided, a nitrogen gas supply device 20, a switching device 54 that switches between oxygen gas and nitrogen gas, a relay unit 22, and a calculating device 24 that converts image data into temperature data. The lance tip 12 has a camera unit 26. In the in-converter temperature measurement equipment 50 shown in Fig. 6, structures that are common to those of the in-converter temperature measurement equipment 10 shown in Fig. 1 are given the same reference numerals, and descriptions that are repetitive are not given below.

[0038] The top blowing lance 52 has a three-pipe structure. Nitrogen gas that is supplied from the nitrogen gas supply device 20 or oxygen gas that is supplied from an oxygen gas supply device 112, which is a part of converter equipment, is blown against the molten iron 102 by passing through a central pipe. Cooling water is supplied from a cooling water supply device 110, which is a part of converter equipment, and circulates by passing through two outer pipes. In Fig. 6, reference sign 56 denotes the flow of nitrogen gas or the flow of oxygen gas. When decarburization blowing is to be performed, oxygen gas is supplied to the molten iron 102 from the top blowing lance 52. Therefore, the decarburization

of carbon that is included in the molten iron 102 progresses, and the carbon concentration of the molten iron 102 is reduced.

[0039] On the other hand, when the temperature of the molten iron 102 is to be measured, a gas that is transported is switched from oxygen gas to nitrogen gas by the switching device 54, and, while the nitrogen gas is being blown against the molten iron 102, the molten iron 102 inside the converter 100 is photographed by the camera unit 26 provided at an end. In this way, the temperature of the molten iron 102 inside the converter 100 is continuously measured by using the in-converter temperature measurement equipment 50. The nitrogen gas supply device 20 may be an argon supply device that supplies, for example, argon as an inert gas.

[0040] As the lance tip provided at an end of the top blowing lance 52, the lance tip 12 shown in Fig. 2 can be used. However, when the top blowing lance 52 is used, in order to increase the area of contact of oxygen gas with a molten iron surface, it is preferable to use a lance tip having a plurality of wide peripheral holes 34, and it is more preferable to use a lance tip having four to eight peripheral holes 34. It is preferable that each peripheral hole 34 face slightly outward from the axial center of a lance tip body 30. Therefore, it is possible to suppress mutual interference between gas flows of oxygen gas from the peripheral holes 34 and to suppress scattering of the molten iron 102 caused by the merging of oxygen gas.

[0041] As described above, even due to the use of the in-converter temperature measurement equipment 50 according to the second embodiment, it is possible to, while observing the molten iron 102 inside the converter 100, continuously measure the temperature of the molten iron 102. Therefore, the accuracy of the blowing end temperature in the blowing step is increased, as a result of which it is possible to reduce blowing time and the amount of use of auxiliary material. Since a consumable-type probe used in a conventional sub-lance is not used, running costs for measuring temperature can also be reduced.

EXAMPLES

[0042] Next, an example in which the temperature of a liquid surface of molten stainless steel manufactured by smelting in a converter is continuously measured by using the in-converter temperature measurement equipment 50 shown in Fig. 6 is described. The molten stainless steel to be measured is one whose temperature increased to approximately 1500°C by bottom blowing oxygen, after preliminary treatment of molten pig iron having a weight of 130 tons.

[0043] In the present example, a top blowing lance 52 having a three-pipe structure was installed so that the position of a camera unit 26 was 4.6 m from a slag surface. Nitrogen gas or oxygen gas supplied from the top blowing lance 52 was switched over by a switching device 54. When the molten stainless steel was to be subjected to blowing, oxygen gas was blown from a central pipe of the top blowing lance 52; when the temperature of the molten stainless steel was to be measured, nitrogen gas (flow rate 300 Nm³/min) was blown against the molten stainless steel; and molten iron 102 inside a converter 100 was photographed with the camera unit 26 provided at an end. As the camera unit 26, a camera including a CMOS sensor was used. The guaranteed operation temperature of the camera used is 55°C.

[0044] With a maximum value of luminance within a sampling time of image data generated by the camera unit 26 being defined as luminance data, the luminance data using a correspondence relationship, previously measured in a black-body furnace, between the luminance and temperature was converted into temperature data to thereby continuously measure the temperature of the liquid surface of the molten stainless steel. In order to evaluate the accuracy of temperature measurement results obtained by the present example, conventional batch temperature measurements using a sub-lance were also performed. Further, a temperature sensor was provided inside a housing 38 of the camera unit 26, and the ambient temperature inside the housing 38 during standby above a converter and the ambient temperature inside the housing 38 while inserted inside the converter were also measured.

[0045] Fig. 7 is a graph showing temperature measurement results of stainless molten steel obtained by the in-converter temperature measurement equipment 50. In Fig. 7, the horizontal axis indicates elapsed time (min), and the vertical axis indicates molten stainless steel temperature (°C). The black dots shown in Fig. 7 indicate pieces of temperature data measured by the batch temperature measurements, and the numerical values indicate the temperatures thereof. As shown in Fig. 7, the temperatures measured by the batch temperature measurements and the temperatures measured by the in-converter temperature measurement equipment 50 were the same. From the results, it was confirmed that the temperature of the liquid surface of the molten stainless steel whose temperature was increased to approximately 1500°C by bottom blowing oxygen could be continuously measured by using the in-converter temperature measurement equipment 50.

[0046] Fig. 8 is a graph showing ambient temperatures inside the housing. In Fig. 8, the horizontal axis indicates elapsed time (min:sec), and the vertical axis indicates ambient temperature (°C) inside the housing. As shown in Fig. 8, it was confirmed that the temperature inside the housing 38 was maintained at about ordinary temperature from the time during the standby above the converter to the time while the housing was inserted inside the furnace.

[0047] It was confirmed that when, after the end of the blowing process in the converter, a lance tip 12 was removed from the top blowing lance 52 and the camera unit 26 provided in the containing portion 32 was checked, the camera unit 26 operated normally. From this result, it was confirmed that, in the in-converter temperature measurement equipment

50 according to the present example, even if the temperature of a 1500°C molten stainless steel was measured, the image sensor 40 and the lens 42 could be kept at approximately ordinary temperature, and damage to the camera unit 26 due to heating of the molten stainless steel could be prevented.

5 Reference Signs List

[0048]

10	in-converter temperature measurement equipment
12	lance tip
14	sub-lance
16	flow of nitrogen gas
18	flow of cooling water
20	nitrogen gas supply device
22	relay unit
24	calculating device
26	camera unit
28	display device
30	lance tip body
32	containing portion
34	peripheral hole
36	cooling water path
38	housing
40	image sensor
42	lens
44	radiant-heat shielding filter
46	fixed ring
48	battery
50	in-converter temperature measurement equipment
52	top blowing lance
54	switching device
56	flow of nitrogen gas or flow of oxygen gas
100	converter
102	molten iron
104	top blowing lance
106	bottom blowing tuyere
110	cooling water supply device
112	oxygen gas supply device
114	slag

Claims

1. A lance tip of a lance that is inserted into a converter, the lance tip comprising:

a cylindrical lance tip body and a camera unit,
 wherein the lance tip body is provided with a containing portion, peripheral holes through which a gas that is blown against molten iron inside the converter passes, and a water cooling path disposed so as to surround the containing portion,
 wherein the camera unit has an image sensor configured to generate image data by photographing the molten iron, a lens, and a radiant-heat shielding filter, and
 wherein the camera unit is provided in the containing portion.

2. In-converter temperature measurement equipment that measures a temperature of molten iron inside a converter, the in-converter temperature measurement equipment comprising:

a sub-lance on whose end the lance tip according to Claim 1 is provided;
 an inert gas supply device; and

a calculating device configured to convert the image data into temperature data.

3. In-converter temperature measurement equipment that measures a temperature of molten iron inside a converter, the in-converter temperature measurement equipment comprising:

a top blowing lance on whose end the lance tip according to Claim 1 is provided;
an inert gas supply device;
a switching device configured to switch between oxygen gas and inert gas; and
a calculating device configured to convert the image data into temperature data.

4. The in-converter temperature measurement equipment according to Claim 2 or Claim 3, wherein the calculating device is configured to convert spectral radiance data generated from the image data into temperature data.

5. The in-converter temperature measurement equipment according to any one of Claims 2 to 4, wherein the in-converter temperature measurement equipment further comprises a display device configured to display the image data generated by the image sensor.

6. An in-converter temperature measurement method using the in-converter temperature measurement equipment according to any one of Claims 2 to 5, the in-converter temperature measurement method comprising:
photographing the molten iron with the camera unit while blowing inert gas against the molten iron, and converting the generated image data that has been generated into temperature data.

FIG. 1

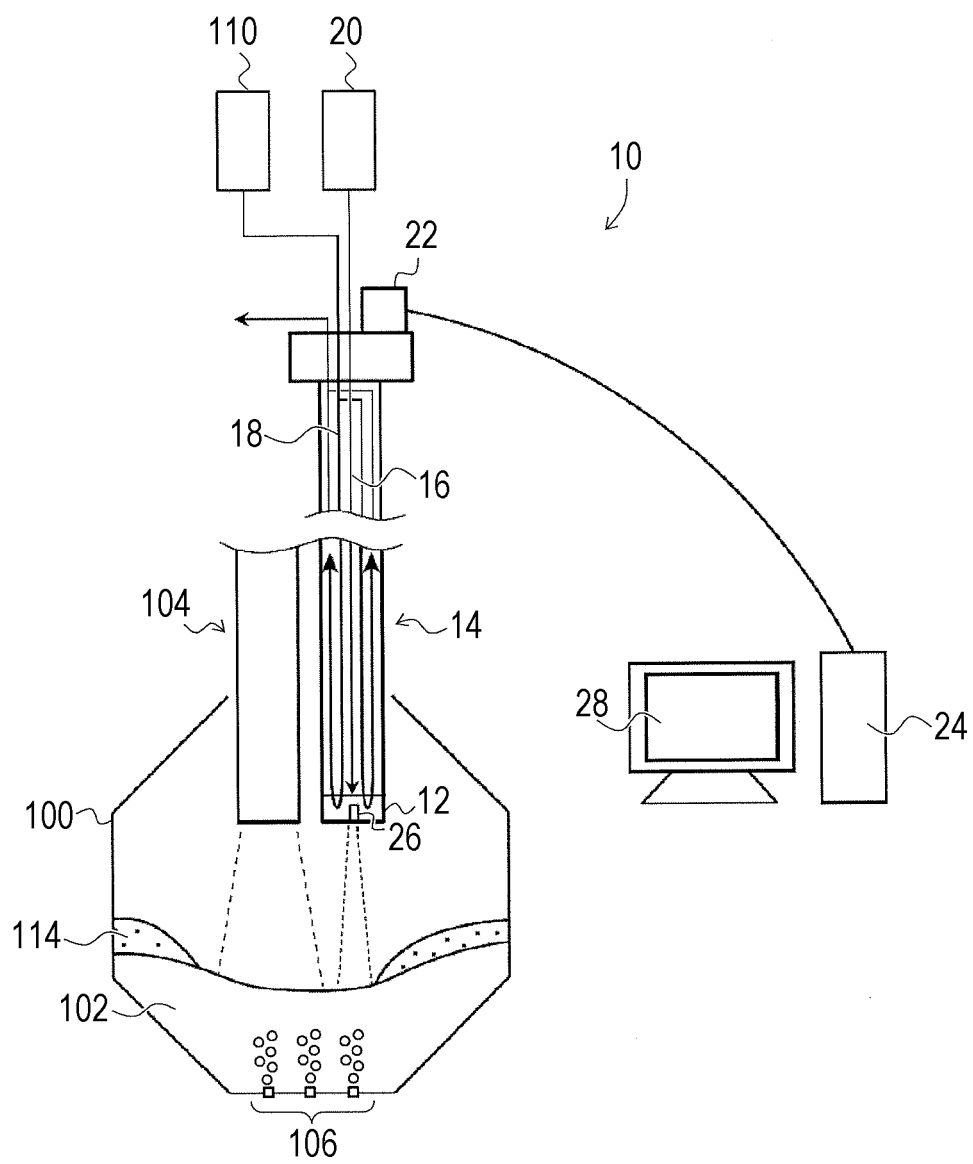


FIG. 2

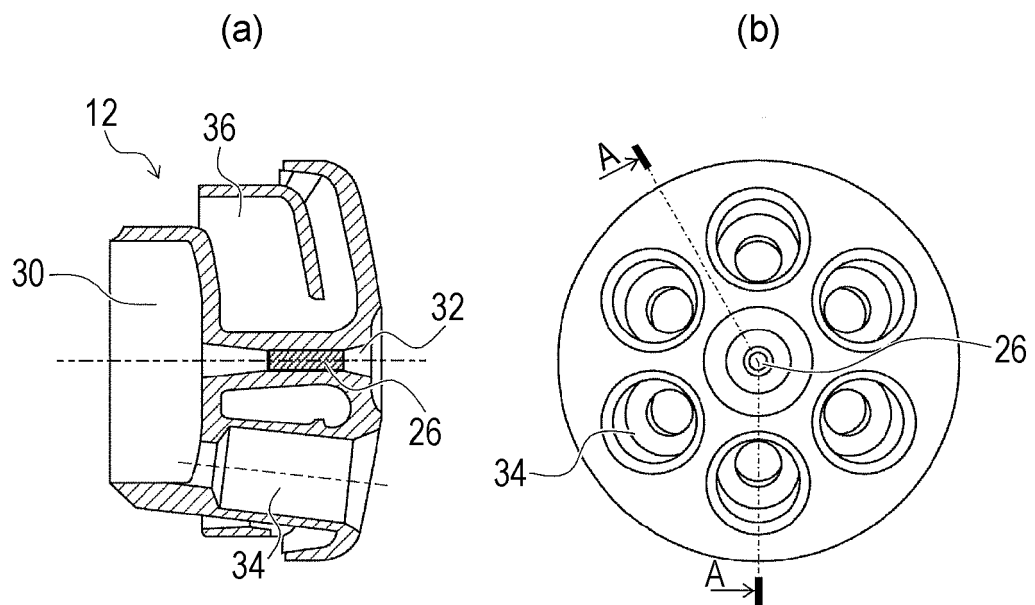
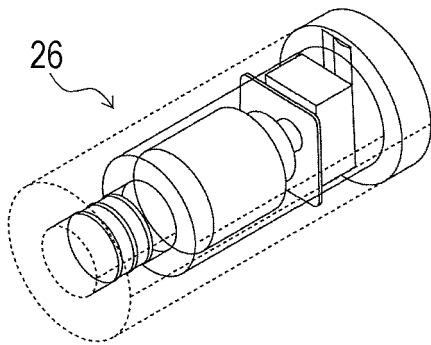


FIG. 3

(a)



(b)

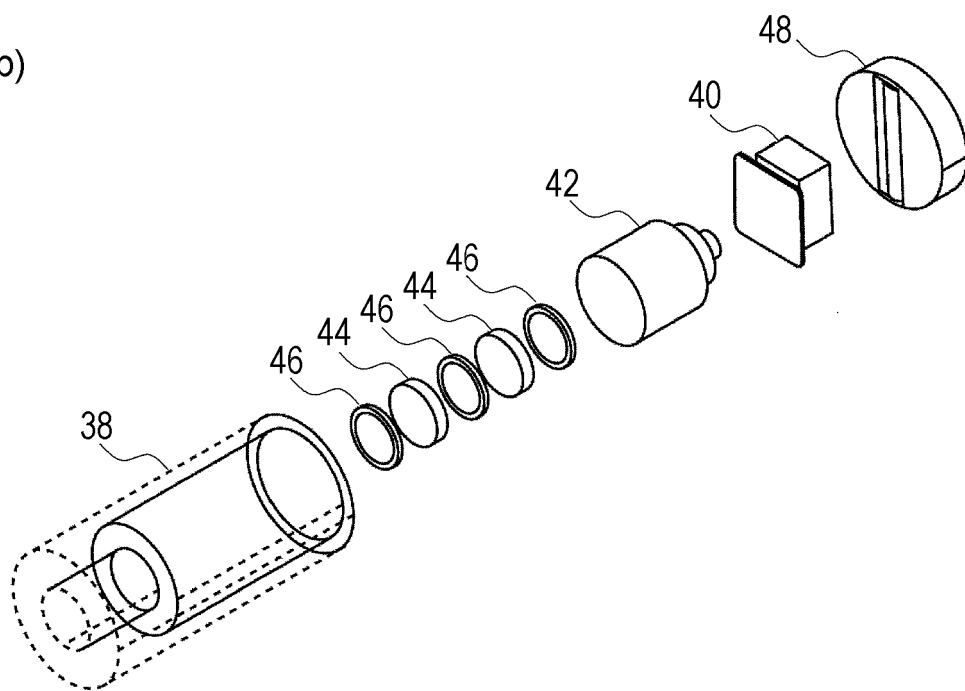
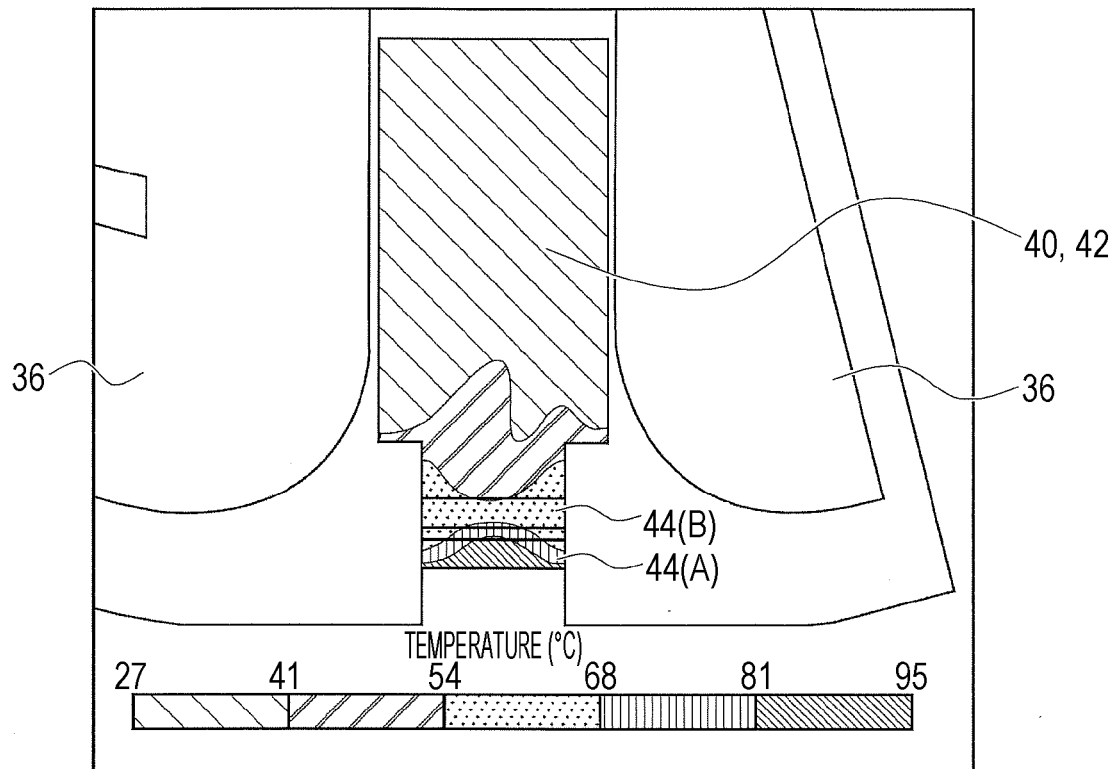


FIG. 4



	AVERAGE TEMPERATURE (°C)	MAXIMUM TEMPERATURE (°C)
RADIANT-HEAT SHIELDING FILTER 44(A)	84	94
RADIANT-HEAT SHIELDING FILTER 44(B)	62	66
IMAGE SENSOR 40 LENS 42	32	61

FIG. 5

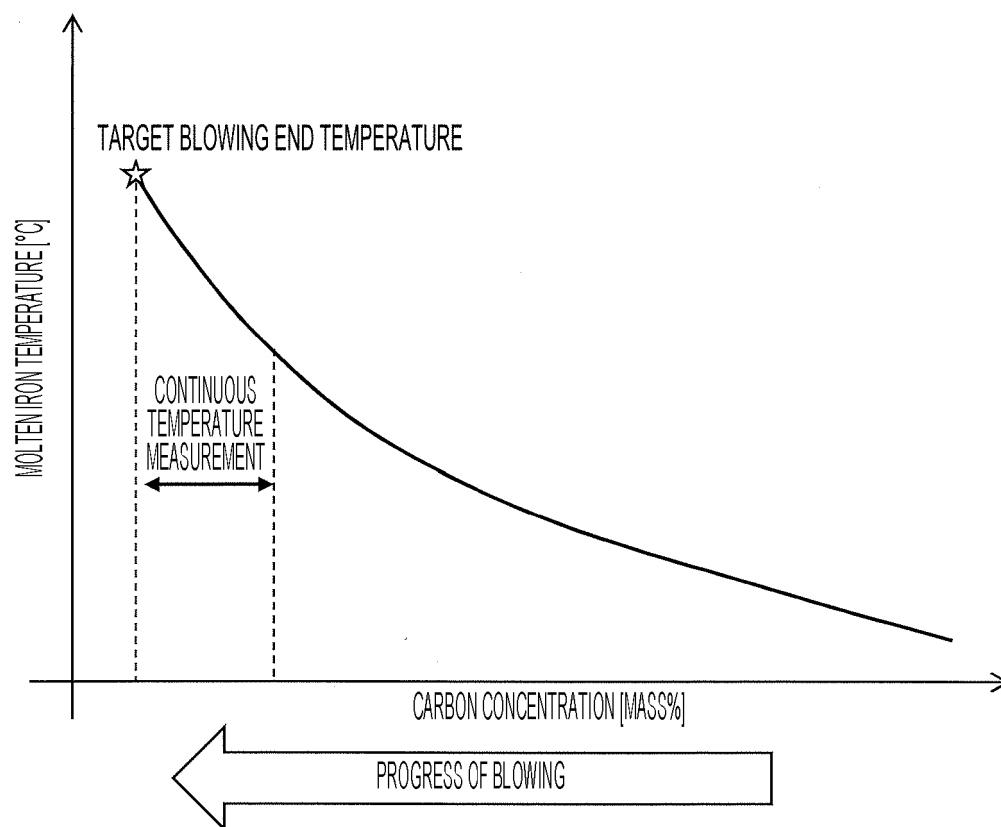


FIG. 6

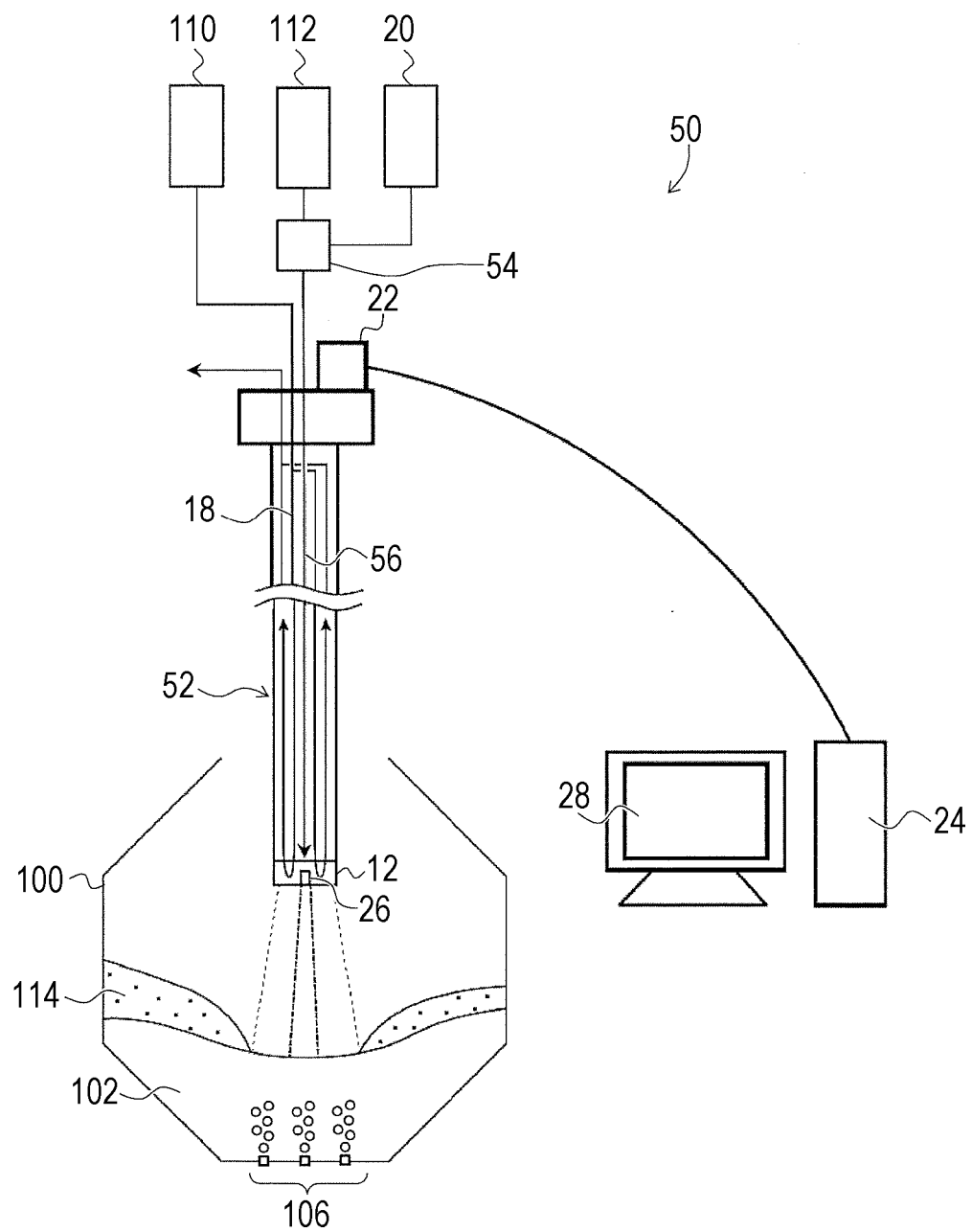


FIG. 7

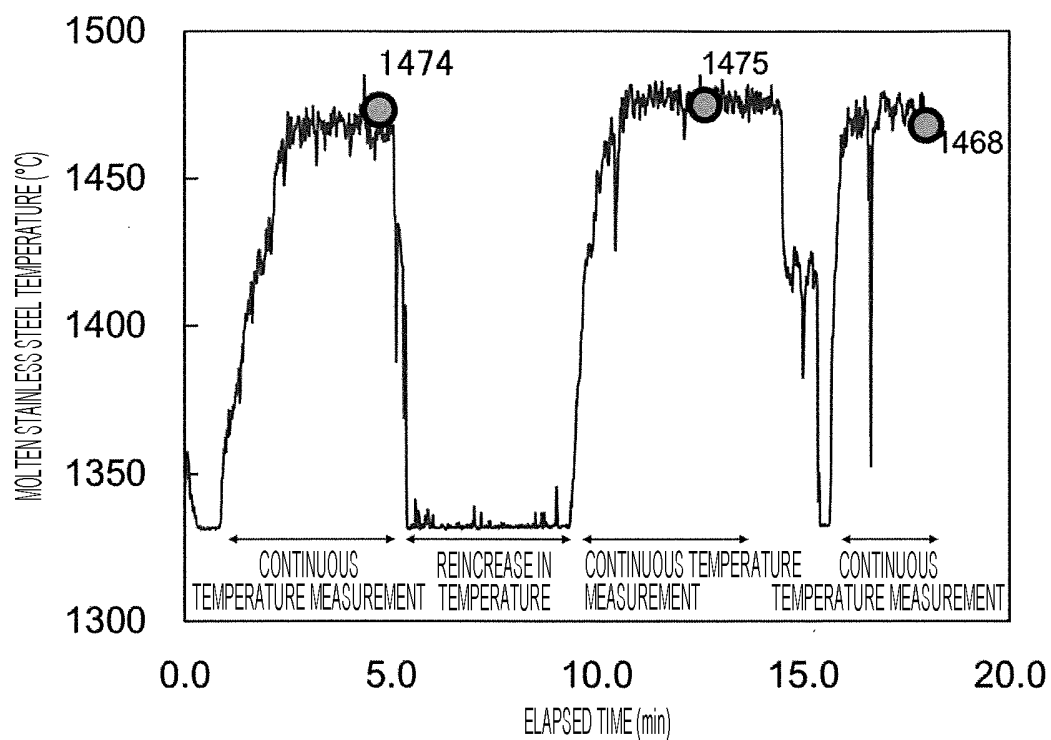
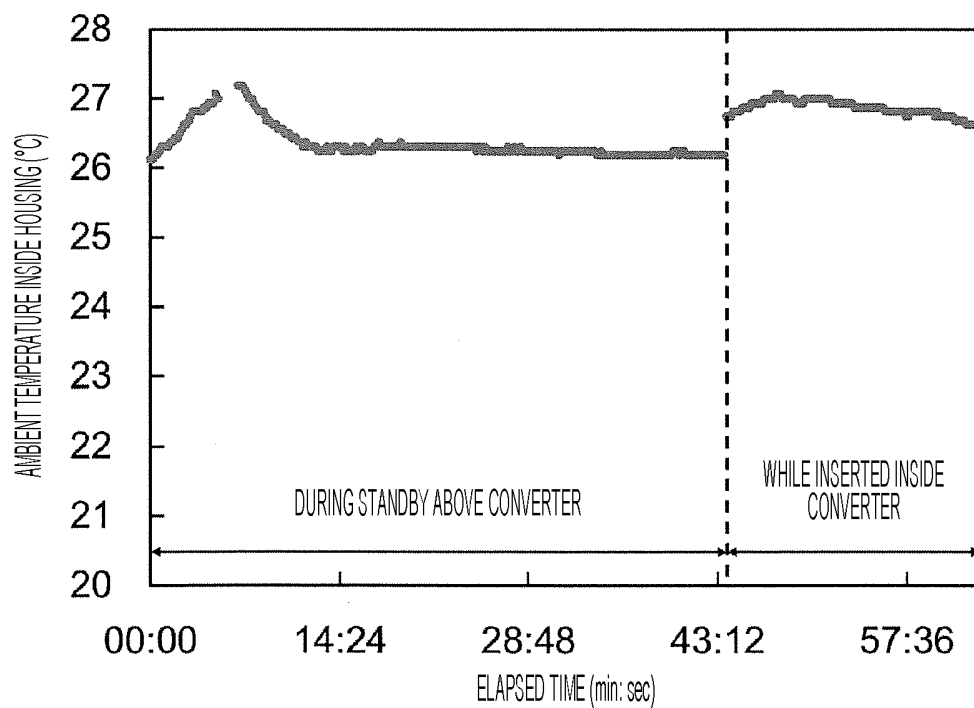


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/000183

A. CLASSIFICATION OF SUBJECT MATTER

C21C 5/46 (2006.01) i

FI: C21C5/46 101; C21C5/46 A

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)

C21C5/46

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2021

Registered utility model specifications of Japan 1996-2021

Published registered utility model applications of Japan 1994-2021

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.
A	JP 63-317614 A (KOBE STEEL, LTD.) 26 December 1988 (1988-12-26) page 1, lower right column, line 7 to page 2, upper left column, line 11, fig. 4-6	1-6
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 162640/1981 (Laid-open No. 68945/1983) (SHINAGAWA REFRACT CO., LTD.) 11 May 1983 (1983-05-11) page 8, line 15 to page 9, line 19, fig. 1, 3	1-6
A	JP 2005-315779 A (JFE STEEL CORPORATION) 10 November 2005 (2005-11-10) paragraphs [0042]-[0045], fig. 1	1-6
A	JP 2015-67875 A (JP STEEL PLANTECH CO.) 13 April 2015 (2015-04-13) paragraphs [0018]-[0026], fig. 1, 2, 5	1-6

☐ 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
10 February 2021 (10.02.2021)Date of mailing of the international search report
22 February 2021 (22.02.2021)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2021/000183

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 63-317614 A	26 Dec. 1988	(Family: none)	
JP 58-68945 U1	11 May 1983	(Family: none)	
JP 2005-315779 A	10 Nov. 2005	(Family: none)	
JP 2015-67875 A	13 Apr. 2015	WO 2015/046027 A1 paragraphs [0017]- [0025], [0041], fig. 1, 2, 5	

REFERENCES CITED IN THE DESCRIPTION

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