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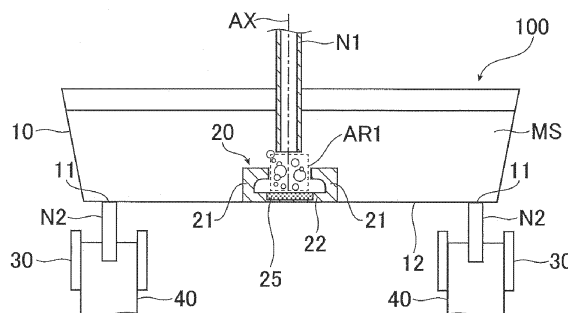
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(54) **TUNDISH FOR CONTINUOUS CASTING, CONTINUOUS CASTING METHOD FOR STEEL, AND WEIR**

(57) A continuous casting tundish capable of increasing the cleanliness of molten steel is provided. A continuous casting tundish includes a reservoir that stores supplied molten steel. The reservoir includes one or more molten steel outlets that allows the molten steel to exit therethrough, and the reservoir also includes a weir having a hollow cylindrical shape and located at upstream of the molten steel from the one or more molten steel outlets. The weir includes a bottom portion; a wall portion rising from the bottom portion; an eave portion provided at an end of the wall portion, the eave portion

covering a periphery of the wall portion and facing the bottom portion of the weir; and a gas supply unit that supplies an inert gas to an interior space enclosed by the wall portion and the bottom portion. The gas supply unit includes a porous portion including pores in an entirety of the porous portion; a support portion that supports the porous portion, the support portion being provided on the wall portion of the weir; and a pipe that allows the inert gas to be delivered therethrough, the pipe being provided in the wall portion of the weir between the support portion and the bottom portion of the weir.

FIG. 1



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Description

Technical Field

5 **[0001]** The present invention relates to a continuous casting tundish, a method for continuously casting steel, and a weir.

Background Art

10 **[0002]** A process for manufacturing steel materials is as follows. Molten steel is supplied from a ladle to a tundish. The molten steel is then supplied to a casting mold and cast to form a cast steel. The cast steel is subjected to processes including rolling and thus formed into a predetermined shape to serve as a steel material.

[0003] Inclusions in molten steel, such as Al_2O_3 , can cause a defect in the steel material, and, therefore, it is preferable to separate and remove inclusions from molten steel prior to casting. Specifically, an approach being used in tundishes is to separate inclusions present in molten steel by causing the inclusions to float.

15 **[0004]** Such a cleaning technique for removing inclusions from molten steel is indispensable for the manufacture of high-quality steel materials, and, accordingly, a need exists to improve the technique. In the related art, an approach being used is to provide a tundish with a weir that separates a steel receiving region, to which molten steel is supplied, from a steel quasi-static region, from which the molten steel is discharged through an outlet provided in a bottom portion.

20 **[0005]** A weir described in Patent Literature 1, for example, has holes formed in a region adjacent to a bottom portion of a tundish, the holes extending from an area of a steel receiving region-side to an area of a steel quasi-static region-side. The weir limits the movement of inclusions that have a lower specific gravity than molten steel. The molten steel flows from the steel receiving region-side to the steel quasi-static region-side by passing through the holes of the weir.

25 **[0006]** Patent Literature 2 discloses that a weir described in Patent Literature 1 is provided in a tundish and also discloses that a rib extending upward from a bottom portion of the tundish is provided on the steel quasi-static region-side. Accordingly, even when inclusions move to the steel quasi-static region-side through the holes of the weir, the direction of their movement can be changed to an upper direction by the rib. Accordingly, the inclusions can be floated even on the steel receiving region-side.

30 **[0007]** Patent Literature 3 discloses that a weir described in Patent Literature 1 is provided in a tundish and also discloses that an inert gas is supplied to the steel quasi-static region-side from a bottom portion of the tundish toward an upper end. Accordingly, even when inclusions move to the steel quasi-static region-side through the holes of the weir, the inclusions are floated by the inert gas.

Citation List

35 Patent Literature

[0008]

PTL 1: Japanese Unexamined Patent Application Publication No. 53-6231

40 PTL 2: Japanese Unexamined Patent Application Publication No. 10-216909

PTL 3: Japanese Unexamined Patent Application Publication No. 2011-143449

Summary of Invention

45 Technical Problem

[0009] Even in the instance where a weir is provided in a tundish as disclosed in Patent Literature 1, inclusions may pass through the holes of the weir. When inclusions are discharged from the molten steel outlet, there is a concern that defects may occur in a steel material.

50 **[0010]** Regarding the floating of inclusions by using a rib as disclosed in Patent Literature 2, a need exists to more effectively float inclusions, and, therefore, there is still room for improvement. Furthermore, a problem arises in that the molten steel between the rib and the weir remains when the casting is completed, which results in an increase in cost associated with the disposal of the remaining steel.

55 **[0011]** In the instance where inclusions are floated by using an inert gas as disclosed in Patent Literature 3, one problem is that a volume fraction of the inert gas in the molten steel needs to be increased so that a sufficient floating effect can be produced. When the flow rate of the inert gas is increased to increase the volume fraction of the inert gas in the molten steel, there is a concern that tundish slag, which is an inclusion present on a surface of molten steel, may be entrained into the molten steel by the inert gas. When tundish slag is entrained into molten steel, the molten steel is contaminated, and,

consequently, there is a concern that defects may occur in a steel material.

[0012] The present invention has been made in view of the problems described above, and objects of the present invention are to provide a continuous casting tundish capable of increasing the cleanliness of molten steel, to provide a method for continuously casting steel, and to provide a weir.

5

Solution to Problem

[0013] The present invention is directed toward solving the problems described above and has the following features.

10 [1] A continuous casting tundish including a reservoir that stores supplied molten steel, wherein the reservoir includes one or more molten steel outlets that allows the molten steel to exit therethrough, and the reservoir also includes a weir having a hollow cylindrical shape and located at upstream side of the molten steel from the one or more molten steel outlets with respect to a direction of the molten steel, the weir including:

15 a bottom portion;
a wall portion rising from the bottom portion;
an eave portion provided at an end of the wall portion, the eave portion covering a periphery of the wall portion and facing the bottom portion of the weir; and
a gas supply unit that supplies an inert gas to an interior space enclosed by the wall portion and the bottom portion,
20 the gas supply unit including:

a porous portion including pores in an entirety of the porous portion;
a support portion that supports the porous portion, the support portion being provided on the wall portion of the weir; and
25 a pipe that allows the inert gas to be delivered therethrough, the pipe being provided in the wall portion of the weir between the support portion and the bottom portion of the weir.

[2] The continuous casting tundish according to [1], wherein

30 the weir further includes a reception chamber enclosed by the porous portion, the support portion, the wall portion of the weir, and the bottom portion of the weir, and
the pipe is provided in the wall portion of the weir, the wall portion enclosing the reception chamber.

35 [3] The continuous casting tundish according to [1] or [2], wherein the gas supply unit further includes an adjustment means that adjusts a flow rate of the inert gas that is supplied from the pipe.

[4] The continuous casting tundish according to any one of [1] to [3], wherein the pipe is disposed along a wall portion of the reservoir and covered with a covering material that is refractory.

[5] A method for continuously casting steel including using the continuous casting tundish according to any one of [1] to [4], wherein the method includes a step of injecting an inert gas at a flow rate that satisfies inequality (1), shown below:

40

$$0.02 \leq R \leq 1.00 \quad (1)$$

where R is the flow rate [NL/(s×m²)] of the inert gas per unit area of the porous portion.

45 [6] A weir provided in a continuous casting tundish and having a hollow cylindrical shape, the weir including:

a bottom portion;
a wall portion rising from the bottom portion;
an eave portion provided at an end of the wall portion, the eave portion covering a periphery of the wall portion and facing the bottom portion of the weir; and
50 a gas supply unit that supplies an inert gas to an interior space enclosed by the wall portion and the bottom portion, the gas supply unit including:

55 a porous portion including pores in an entirety of the porous portion;
a support portion that supports the porous portion, the support portion being provided on the wall portion; and
a pipe that allows the inert gas to be delivered therethrough, the pipe being provided in the wall portion between the support portion and the bottom portion.

[7] The weir according to [6], further including a reception chamber enclosed by the porous portion, the support portion, the wall portion of the weir, and the bottom portion of the weir, wherein the pipe is provided in the wall portion of the weir, the wall portion enclosing the reception chamber.

[8] The weir according to [6] or [7], wherein the gas supply unit further includes an adjustment means that adjusts a flow rate of the inert gas that is supplied from the pipe.

Advantageous Effects of Invention

[0014] The present invention is designed to allow an inert gas to be supplied through a porous portion and, consequently, enables fine bubbles of the inert gas to be supplied to a molten steel pouring region. As a result, a volume fraction of the inert gas in the molten steel can be increased, and, accordingly, inclusions present in the molten steel poured into a tundish from a ladle can be efficiently floated. Hence, the cleanliness of the molten steel can be increased.

Brief Description of Drawings

[0015]

[Fig. 1] Fig. 1 is a diagram illustrating a structure of a continuous casting tundish.

[Fig. 2] Fig. 2 is a diagram illustrating a side view of the continuous casting tundish.

[Fig. 3] Fig. 3 is a diagram illustrating a structure of a weir, illustrated in Fig. 1.

[Fig. 4] Fig. 4 is a top view of the weir, illustrated in Fig. 3.

[Fig. 5] Fig. 5 is a diagram illustrating a state in which a pipe is installed.

[Fig. 6] Fig. 6 is a diagram illustrating another state in which a pipe is installed.

[Fig. 7] Fig. 7 is a graph illustrating a relationship between a gas flow rate per unit area and a number density of inclusions.

[Fig. 8] Fig. 8 is a graph illustrating the number density of inclusions of a Conventional Example and Present Inventions.

Description of Embodiments

[0016] Fig. 1 is a diagram illustrating a structure of a continuous casting tundish. Fig. 2 is a diagram illustrating a side view of the continuous casting tundish. As illustrated in Fig. 1, a continuous casting tundish 100 is disposed between a ladle (not illustrated), in which molten steel MS is stored, and a casting mold 30, in which the molten steel MS is cooled.

[0017] As illustrated in Figs. 1 and 2, the continuous casting tundish (hereinafter simply referred to as a "tundish") 100 includes a reservoir 10, which has a box shape with an open upper portion and a closed bottom. In the present embodiment, the reservoir 10 of the continuous casting tundish 100 has an inverted frustum shape, with the upper base being longer than the lower base.

[0018] The reservoir 10 includes a molten steel pouring region AR1, to which the molten steel MS is poured from a nozzle N1 of the ladle. The molten steel pouring region AR1 is formed along an axis AX of the nozzle N1. In other words, the molten steel pouring region AR1 is formed to extend from an end of the nozzle N1 along the axis AX of the nozzle N1. The molten steel pouring region AR1 is a region expanding in a direction towards a periphery of the axis AX of the nozzle N1.

[0019] The reservoir 10 includes one or more molten steel outlets 11, which allows the molten steel MS to exit therethrough to the casting mold. In the present embodiment, molten steel outlets 11 are formed at one end and another end of a bottom portion 12 of the tundish 100 in a left-and-right direction, as illustrated in Fig. 1.

[0020] The reservoir 10 includes a weir 20, which is disposed between the molten steel pouring region AR1 and the molten steel outlets 11. The weir 20 is located at upstream of the molten steel MS from the molten steel outlets 11. The weir 20 is hollow and has a cylindrical shape with a closed bottom.

[0021] The weir 20 includes a wall portion 21 and a bottom portion 22. The wall portion 21 is formed to enclose the molten steel pouring region AR1. The bottom portion 22 is provided at one end of the wall portion 21, which is a lower end. In other words, the wall portion 21 rises from the bottom portion 22. The bottom portion 22 faces the bottom portion 12 of the tundish 100 and is in contact with the bottom portion 12.

[0022] The weir 20 has a generally U-shaped side-cross-section. The weir 20 has an interior space 20a, which is enclosed by the wall portion 21 and the bottom portion 22. A portion of the molten steel pouring region AR1 is held within the interior space 20a of the weir 20.

[0023] A nozzle N2 is provided at each of the molten steel outlets 11. The nozzle N2 connects the tundish 100 to the casting mold 30. The molten steel MS is supplied to the casting mold 30 from the molten steel outlets 11 via the nozzles N2. The molten steel MS is cooled in the casting mold 30 to form a cast steel 40.

[0024] Fig. 3 is a diagram illustrating a structure of the weir 20. Fig. 4 is a top view of the weir 20. As illustrated in Figs. 3

and 4, the weir 20 includes an eave portion 23 at another end of the wall portion 21, which is an upper end. The eave portion 23 covers a periphery of the wall portion 21 and faces the bottom portion 22.

[0025] The eave portion 23 may have any shape and is preferably formed to project toward the molten steel pouring region AR1. In the present embodiment, the eave portion 23 is formed to extend toward the molten steel pouring portion AR1 in a direction parallel to the bottom portion 22 (e.g., a horizontal direction).

[0026] The weir 20 includes a gas supply unit 24, which supplies an inert gas from above the bottom portion 22 toward the molten steel pouring region AR1. The gas supply unit 24 is provided below the eave portion 23. In other words, the gas supply unit 24 supplies an inert gas to the interior space from above the bottom portion 22. A portion of the inert gas supplied from the gas supply unit 24 comes into contact with the eave portion 23 and travels upward.

[0027] The gas supply unit 24 includes a porous portion 25 and a support portion 26, which supports the porous portion 25. The porous portion 25 has pores 25a in an entirety thereof. The gas supply unit 24 also includes a pipe 27, which allows an inert gas GS to be delivered therethrough. The pipe 27 is provided in the wall portion 21 between the porous portion 25 and the bottom portion 22.

[0028] The porous portion 25 is formed of a refractory material that is a ceramic. The refractory material may be, for example, a material obtained by sintering refractory inorganic particles, which may include one, or a mixture of two or more, selected from alumina, silica, and the like. Particularly preferably, the refractory material is a material formed primarily of alumina.

[0029] The porous portion 25 can be prepared by firing spherical particles formed primarily of alumina, which are used as aggregates, at 1600°C or greater. The porous portion 25 can be produced, for example, by slip-casting a dense castable refractory material.

[0030] The use of spherical particles as aggregates enables the formation of the pores 25a of the porous portion 25. Without limitation, the pores 25a of the porous portion 25 can be formed to have an average pore size of, for example, 10 to 40 μm as measured by mercury intrusion porosimetry. In the instance where the pores 25a are formed as such, the bubbles of the inert gas supplied from the porous portion 25 can be fine bubbles. Specifically, when the inert gas is supplied in a manner of the related art, the size of the bubbles is approximately 100 μm , whereas when the inert gas is supplied in the manner just described, the size of the bubbles can be approximately 1/10 to 1/20 that of the related art. Furthermore, when the pores 25a of the porous portion 25 are 10 to 40 μm , a flow rate of the inert gas can be appropriately controlled.

[0031] The porous portion 25 may have any shape and, in the present embodiment, has a plate shape. Specifically, the shape is a rectangular shape in a top view, as illustrated in Fig. 4.

[0032] The support portion 26 is formed of a refractory material that is a ceramic. The refractory material may be, for example, a material obtained by sintering refractory inorganic particles, which may include one, or a mixture of two or more, selected from alumina, silica, and the like. Particularly preferably, the refractory material is a material formed primarily of alumina.

[0033] The support portion 26 is formed to have a frame shape that can support an edge of a bottom portion of the porous portion 25. The support portion 26 may have any shape and, in the present embodiment, has a rectangular frame shape in a top view. The support portion 26 is provided on the wall portion 21. The support portion 26 is secured, for example, by being fit into a mating recess (not illustrated) formed in the wall portion 21.

[0034] The weir 20 includes a reception chamber 28, which is enclosed by the porous portion 25, the support portion 26, the wall portion 21, and the bottom portion 22. The wall portion 21 enclosing the reception chamber 28 has the pipe 27 provided therein.

[0035] Advantageously, the pipe 27 may be refractory. Fig. 5 illustrates a state in which the pipe 27 is installed. As illustrated in Fig. 5, the pipe 27 is disposed along a wall portion 13 of the reservoir 10. The pipe 27 is covered with a covering material 50, which is refractory. Examples of the covering material 50 include precast refractory materials. The covering material 50 may be a combination of a precast refractory material and a patching material. In the example illustrated in Fig. 5, the covering material 50 located adjacent to the periphery of the reservoir 10 is made of a precast refractory material 51. Another covering material 50 located adjacent to the bottom portion 12 of the tundish 100 is made of a patching material 52.

[0036] Furthermore, the covering material 50 may be a pipe cover. Fig. 6 illustrates another state in which the pipe 27 is installed. In the example illustrated in Fig. 6, a pipe cover 53 is used instead of a precast refractory material, which has been described in the example illustrated in Fig. 5. In addition, the pipe cover 53 may be a plurality of pipe covers. In the example illustrated in Fig. 6, four pipe covers 53 are connected together in an axial direction of the pipe 27.

[0037] With this configuration of the pipe 27, the installation of a refractory material can be facilitated. In addition, the maintainability of the pipe 27 can be improved compared to an instance in which the pipe 27 is inserted through the bottom portion 12 of the tundish 100. Furthermore, processing of the bottom portion 12 of the tundish 100 for inserting the pipe 27 through the bottom portion 12 is unnecessary, and, therefore, leakage of the molten steel from the bottom portion 12 can be inhibited.

[0038] Preferably, the pipe 27 is provided with an adjustment means 29, which adjusts the flow rate of the inert gas. The adjustment means 29 may be a valve. The adjustment means 29 may be manually operated, or a controller (not illustrated) may be used to adjust the opening degree.

[0039] The inert gas supplied from the pipe 27 is introduced to the reception chamber 28. Once the inert gas is introduced to the reception chamber 28, a pressure of the inert gas is uniformly applied to a surface of the porous portion 25 that faces the bottom portion 22. As a result, the inert gas passes from the reception chamber 28 through the pores 25a of the porous portion 25 to be supplied to the molten steel pouring region AR1. By supplying the inert gas in this manner, variations in the state of supply of the inert gas can be inhibited. Examples of the inert gas include, but are not limited to, Ar, N₂, and CO₂.

[0040] In the present embodiment, the inert gas is supplied to the porous portion 25 from the reception chamber 28. Alternatively, the inert gas may be supplied to the porous portion 25 without being passed through the reception chamber 28. For example, an attachment (not illustrated) that can cover the bottom-portion-22-side surface of the porous portion 25 may be attached to the pipe 27 and used for supplying the inert gas.

[0041] A method for continuously casting steel includes a step of supplying the molten steel MS to the tundish 100 through the nozzle N1 connected to the ladle (not illustrated); a step of removing inclusions present in the molten steel MS in the tundish 100; a step of allowing the molten steel MS to exit through the molten steel outlet 11 of the tundish 100 to the casting mold 30; and a step of cooling the molten steel MS in the casting mold 30 to manufacture a cast steel.

[0042] The step of removing inclusions present in the molten steel MS in the tundish 100 includes a step of injecting an inert gas at a flow rate that satisfies inequality (1), shown below.

$$0.02 \leq R \leq 1.0 \quad (1)$$

[0043] R is the flow rate [NL/(s×m²)] of the inert gas per unit area of the porous portion.

[0044] Regarding the gas flow rate (R) per unit area of the porous portion 25, the gas is preferably supplied from the gas supply unit 24 at 0.02 to 1.00 NL/(s×m²) and more preferably at 0.20 to 1.00 NL/(s×m²). The gas flow rate (R) per unit area of the porous portion 25 can be adjusted by the adjustment means 29.

[0045] When the gas flow rate (R) per unit area of the porous portion 25 is 0.02 NL/(s×m²) or greater, the floating of inclusions in the molten steel MS can be promoted.

[0046] When the gas flow rate (R) per unit area of the porous portion 25 is 1.00 NL/(s×m²) or less, the entrainment of tundish slag can be prevented. In the instance where the inert gas is injected under such high flow-speed conditions, the size of the bubbles of the inert gas can be finer. Consequently, the floating of inclusions can be promoted, and the entrainment of the inclusions into the molten steel can be inhibited.

[0047] As described, the tundish 100 of the present invention is designed to allow an inert gas to be supplied through the porous portion 25 and, consequently, enables fine bubbles of the inert gas to be supplied to the molten steel pouring region AR1. As a result, a volume fraction of the inert gas in the molten steel MS can be increased, and, accordingly, inclusions present in the molten steel poured into the tundish 100 from a ladle can be efficiently floated.

[0048] The flow speed of the molten steel MS in the molten steel pouring region AR1 of the weir 20 is higher than in other regions. Accordingly, by supplying the inert gas to the molten steel pouring region AR1, it is possible to increase the frequency at which the bubbles of the inert gas come into contact with one another. As a result, the size of the bubbles of the inert gas can be further reduced. Consequently, the volume fraction of the inert gas in the molten steel MS can be further increased.

[0049] Accordingly, the tundish 100 of the present invention can increase the inclusions-floating effect. Furthermore, since the floating of inclusions can be accomplished with a lower flow rate of the inert gas, the entrainment of slag in the tundish 100 can be inhibited.

[0050] When the molten steel MS supplied from the nozzle N1 reaches the bottom portion 22 of the weir 20, the molten steel MS flows and spreads in a direction towards the periphery of the axis AX of the nozzle N1. When the molten steel MS reaches the wall portion 21 of the weir 20, the molten steel MS is forced upward by a subsequent supply of molten steel MS. When the molten steel MS reaches the eave portion 23, the molten steel MS flows toward a center of the axis AX of the nozzle N1, that is, toward the molten steel pouring region AR1.

[0051] At the center of the axis AX of the nozzle N1, that is, a central portion of the molten steel pouring region AR1, vectors of the molten steel MS, which have various directions, cancel each other. As a result, the flow speed of the molten steel MS decreases.

[0052] Consequently, the occurrence of direct flowing of the molten steel MS from the molten steel pouring region AR1 to the molten steel outlet 11, which is a phenomenon called a "short-circuit flow", can be inhibited. Accordingly, a large amount of the molten steel MS can be caused to flow upward of the weir 20. As a result, the floating of inclusions and separation of the inclusions from the molten steel MS can be facilitated. Consequently, the number of inclusions flowing from the molten steel outlet 11 to the casting mold 30 can be reduced. The tundish 100 of the present invention, in particular, enables the bubbles of the inert gas to be finer than the bubbles of the related art. Fine bubbles make it possible to enhance an inclusions-floating effect. As described, with the tundish 100 of the present invention, inclusions can be floated efficiently, and the entrainment of inclusions into the molten steel can be inhibited; consequently, high-cleanliness steels can be manufactured.

EXAMPLES

(Test Example 1: Test for Counting Inclusions)

(Sample)

[0053] 300 tons of molten steel, which had undergone oxygen blowing in a converter and an RH vacuum degassing process, was used. The molten steel was supplied to a tundish from a ladle.

(Continuous Casting)

[0054] Continuous casting was performed by using Ar as an inert gas that was injected from a weir. Specifically, several tests were performed with the flow rate (R) of the inert gas per unit area of the porous portion being varied (R is the flow rate [NL/(s×m²)] of the inert gas per unit area of the porous portion).

(Measurement of Number of Inclusions)

[0055] The slab prepared by continuous casting was subjected to a measurement of the number of inclusions, which was performed by ultrasonic inspection. Regarding the inclusions, those that had a size of 10 μm or greater were counted. The number of counted inclusions per m² of the slab was calculated and designated as a density.

[0056] Fig. 7 illustrates a relationship between the flow rate (R) of the inert gas per unit area of the porous portion and the density of inclusions in the slab. As illustrated in Fig. 7, when the flow rate (R) of the inert gas was lower than 0.02, the density of inclusions was higher than those obtained under other conditions.

[0057] When the flow rate (R) of the inert gas was 0.02 to 1.00, the density of inclusions was lower than those obtained under other conditions. When the flow rate (R) of the inert gas was greater than 1.00, the density of inclusions was lower than those obtained under the conditions in which no inert gas was supplied. Furthermore, under those conditions, the density of inclusions was higher than those obtained under the conditions in which the flow rate (R) of the inert gas was less than or equal to 1.00.

[0058] Regarding the instance where the flow rate (R) of the inert gas was lower than 0.02, it is believed that under this condition, the effect of floating inclusions in a tundish could not be sufficiently produced. This is believed to be a reason that the density of inclusions was high under this condition.

[0059] Furthermore, it is believed that under the conditions in which the flow rate (R) of the inert gas was greater than 1.00, the inert gas caused tundish slag (inclusions) to be entrained into the molten steel. This is believed to be a reason that under this condition, the density of inclusions was higher than in the instances in which the flow rate (R) of the inert gas was 0.02 to 1.00.

(Test Example 2: Test for Counting Inclusions)

(Sample)

[0060] The same molten steel as that of Test Example 1 was used.

(Continuous Casting)

[0061] Continuous casting was performed using tundishes of a Conventional Example and Invention Examples (Present Inventions 1 to 8). The inert gas that was injected into each of the tundishes was Ar. Specifically, in the Conventional Example, the inert gas was supplied to the molten steel pouring region, with no weir provided in the tundish.

[0062] In the Invention Examples, the weir was provided, and the inert gas was supplied to the molten steel pouring region from the weir. The Invention Examples (Present Inventions 1 to 8) were carried out with the flow rate of the inert gas supplied from the gas supply unit of the weir being varied. The flow rates of the inert gas are shown in Table 1.

[Table 1]

	R
Conventional Example	-
Present Invention 1	0.40
Present Invention 2	0.60

(continued)

	R
Conventional Example	-
Present Invention 3	0.80
Present Invention 4	0.20
Present Invention 5	1.00
Present Invention 6	0.01
Present Invention 7	1.20
Present Invention 8	1.40
R: the flow rate [NL/(s×m ²)] of the inert gas per unit area of the porous portion	

(Measurement of Number of Inclusions)

[0063] The measurement was performed in the same manner as in Test Example 1.

[0064] Fig. 8 illustrates the density of inclusions of the Conventional Example and Invention Examples 1 to 8. As illustrated in Fig. 8, it was found that in Present Inventions 1 to 8, the density of inclusions in the slab was much lower than in the Conventional Example. In particular, in Present Inventions 1 to 5, since the flow rate (R) of the inert gas was 0.02 to 1.00, the obtained results were better than those of Present Inventions 6 to 8.

Reference Signs List

[0065]

100 tundish
 10 reservoir
 11 molten steel outlet
 20 weir
 20a interior space
 21 wall portion
 22 bottom portion
 23 eave portion
 24 gas supply unit
 25 porous portion
 26 support portion
 27 pipe
 28 reception chamber
 29 adjustment means
 AR1 molten steel pouring region
 MS molten steel

Claims

1. A continuous casting tundish comprising a reservoir that stores supplied molten steel, wherein the reservoir comprises one or more molten steel outlets that allows the molten steel to exit therethrough, and the reservoir also comprises a weir having a hollow cylindrical shape located at upstream side of the molten steel from the one or more molten steel outlets, the weir comprising:

a bottom portion;
 a wall portion rising from the bottom portion;
 an eave portion provided at an end of the wall portion, the eave portion covering a periphery of the wall portion and facing the bottom portion of the weir; and
 a gas supply unit that supplies an inert gas to an interior space enclosed by the wall portion and the bottom portion, the gas supply unit comprising:

a porous portion comprising pores in an entirety of the porous portion;
a support portion that supports the porous portion, the support portion being provided on the wall portion of the weir; and
a pipe that allows the inert gas to be delivered therethrough, the pipe being provided in the wall portion of the weir between the support portion and the bottom portion of the weir.

2. The continuous casting tundish according to Claim 1, wherein

the weir further comprises a reception chamber enclosed by the porous portion, the support portion, the wall portion of the weir, and the bottom portion of the weir, and
the pipe is provided in the wall portion of the weir, the wall portion enclosing the reception chamber.

3. The continuous casting tundish according to Claim 1 or 2, wherein the gas supply unit further comprises an adjustment means that adjusts a flow rate of the inert gas that is supplied from the pipe.

4. The continuous casting tundish according to Claim 1 or 2, wherein the pipe is disposed along a wall portion of the reservoir and covered with a covering material that is refractory.

5. The continuous casting tundish according to Claim 3, wherein the pipe is disposed along a wall portion of the reservoir and covered with a covering material that is refractory.

6. A method for continuously casting steel comprising using the continuous casting tundish according to Claim 1 or 2, wherein the method comprises a step of injecting the inert gas at a flow rate that satisfies inequality (1), shown below:

$$0.02 \leq R \leq 1.00 \quad (1)$$

where R is the flow rate [NL/(s×m²)] of the inert gas per unit area of the porous portion.

7. A method for continuously casting steel comprising using the continuous casting tundish according to Claim 3, wherein the method comprises a step of injecting the inert gas at a flow rate that satisfies inequality (1), shown below:

$$0.02 \leq R \leq 1.00 \quad (1)$$

where R is the flow rate [NL/(s×m²)] of the inert gas per unit area of the porous portion.

8. A method for continuously casting steel comprising using the continuous casting tundish according to Claim 4, wherein the method comprises a step of injecting the inert gas at a flow rate that satisfies inequality (1), shown below:

$$0.02 \leq R \leq 1.00 \quad (1)$$

where R is the flow rate [NL/(s×m²)] of the inert gas per unit area of the porous portion.

9. A method for continuously casting steel comprising using the continuous casting tundish according to Claim 5, wherein the method comprises a step of injecting the inert gas at a flow rate that satisfies inequality (1), shown below:

$$0.02 \leq R \leq 1.00 \quad (1)$$

where R is the flow rate [NL/(s×m²)] of the inert gas per unit area of the porous portion.

10. A weir provided in a continuous casting tundish and having a hollow cylindrical shape, the weir comprising:

a bottom portion;
a wall portion rising from the bottom portion;
an eave portion provided at an end of the wall portion, the eave portion covering a periphery of the wall portion and facing the bottom portion of the weir; and
a gas supply unit that supplies an inert gas to an interior space enclosed by the wall portion and the bottom portion,

the gas supply unit comprising:

5 a porous portion comprising pores in an entirety of the porous portion;
a support portion that supports the porous portion, the support portion being provided on the wall portion; and
a pipe that allows the inert gas to be delivered therethrough, the pipe being provided in the wall portion
between the support portion and the bottom portion.

11. The weir according to Claim 10, further comprising a reception chamber enclosed by the porous portion, the support
portion, the wall portion of the weir, and the bottom portion of the weir, wherein
10 the pipe is provided in the wall portion of the weir, the wall portion enclosing the reception chamber.

12. The weir according to Claim 10 or 11, wherein the gas supply unit further comprises an adjustment means that adjusts
a flow rate of the inert gas that is supplied from the pipe.

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FIG. 1

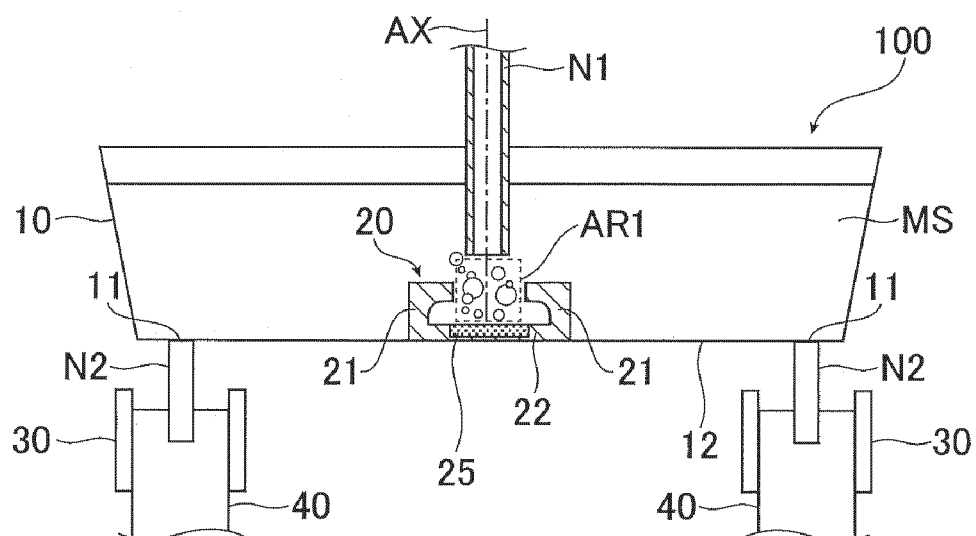


FIG. 2

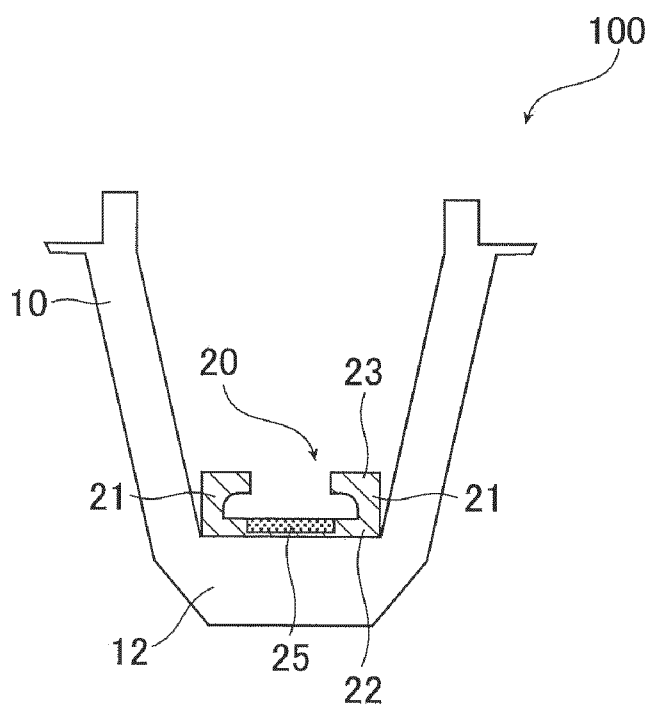


FIG. 3

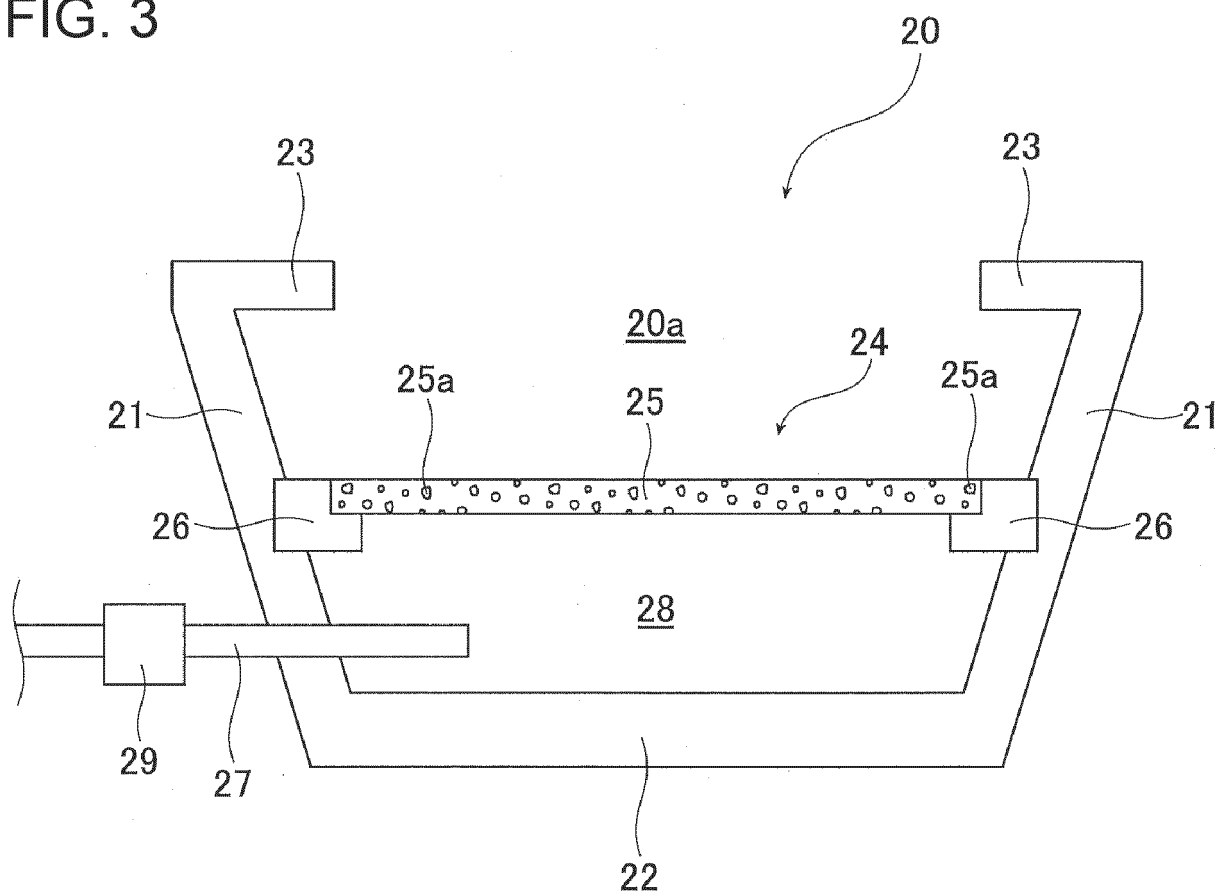


FIG. 4

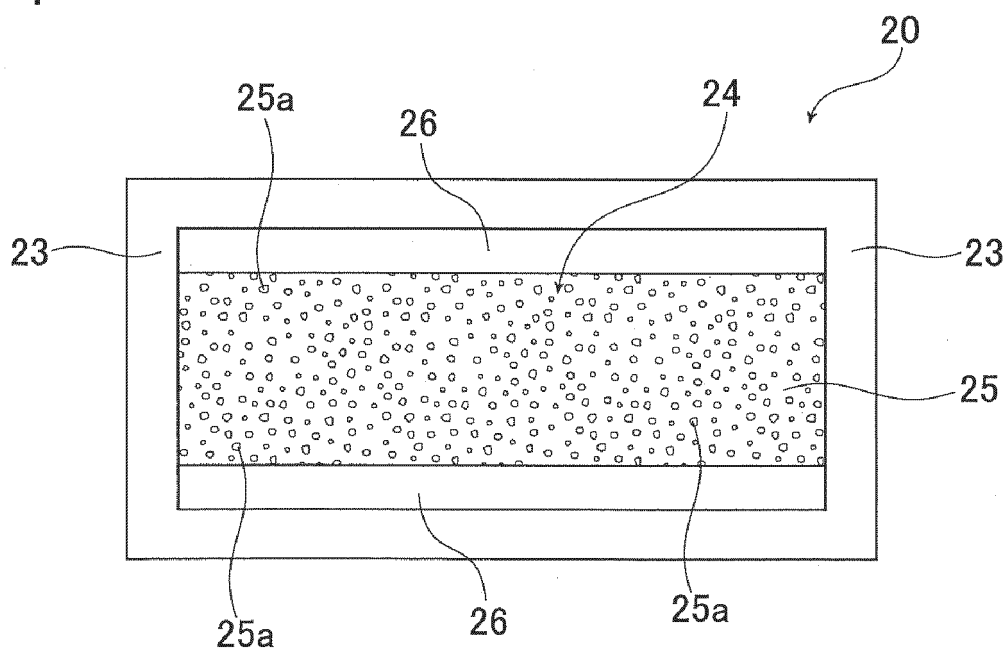


FIG. 5

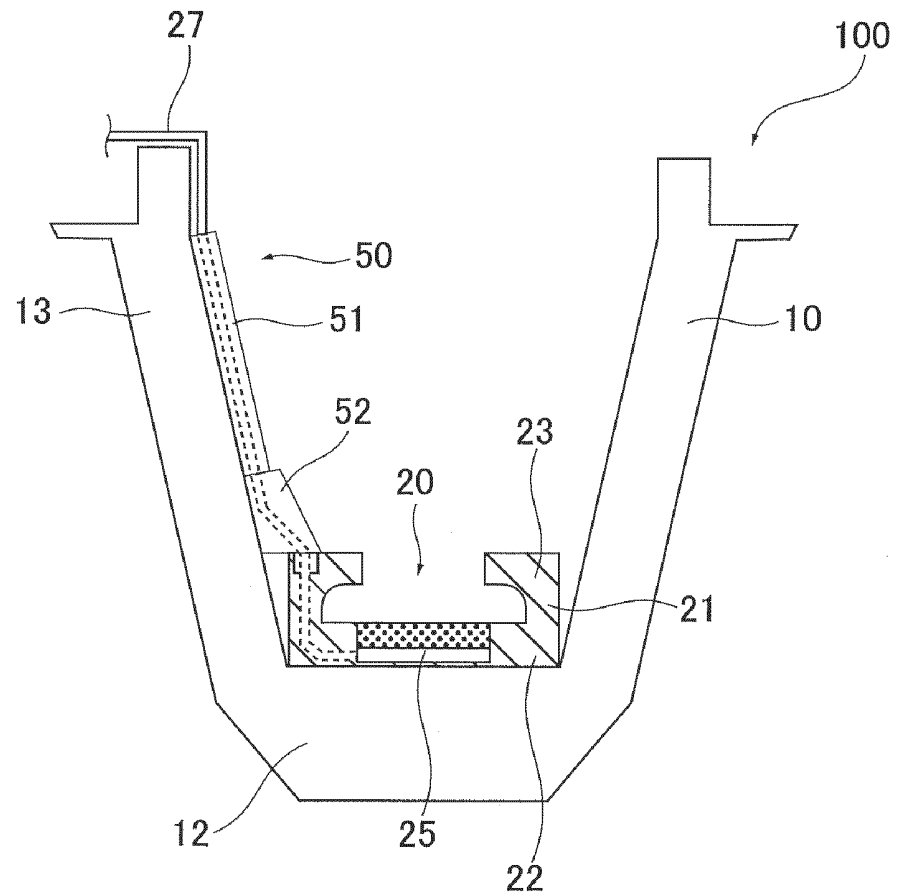


FIG. 6

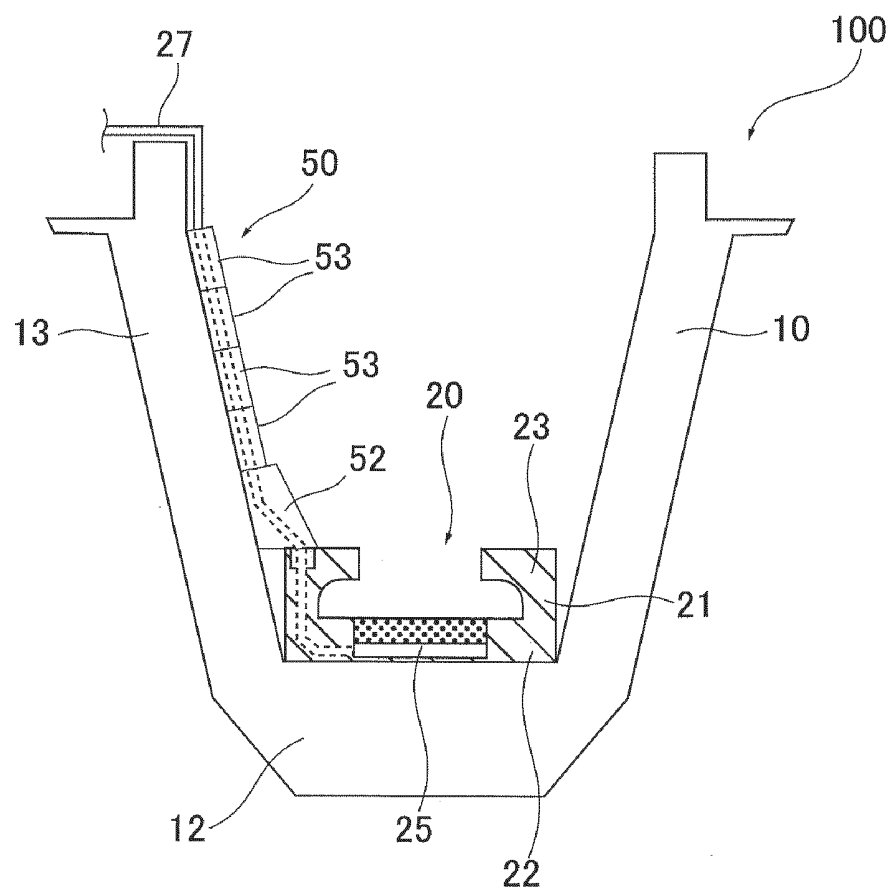


FIG. 7

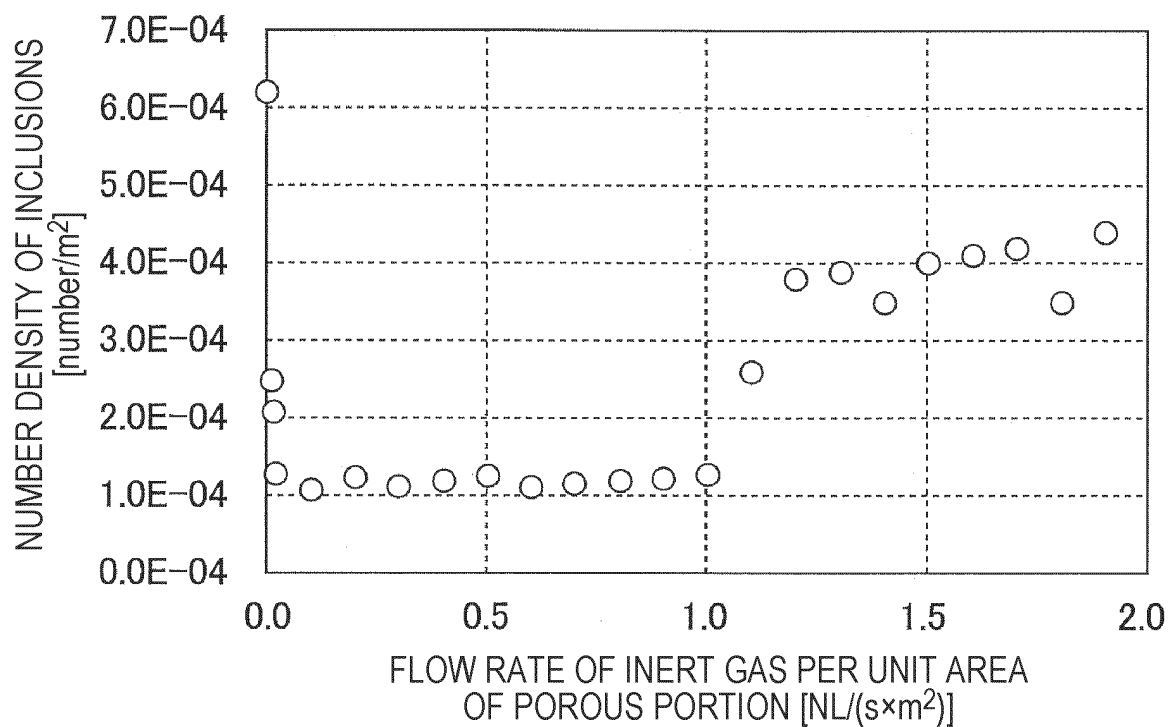
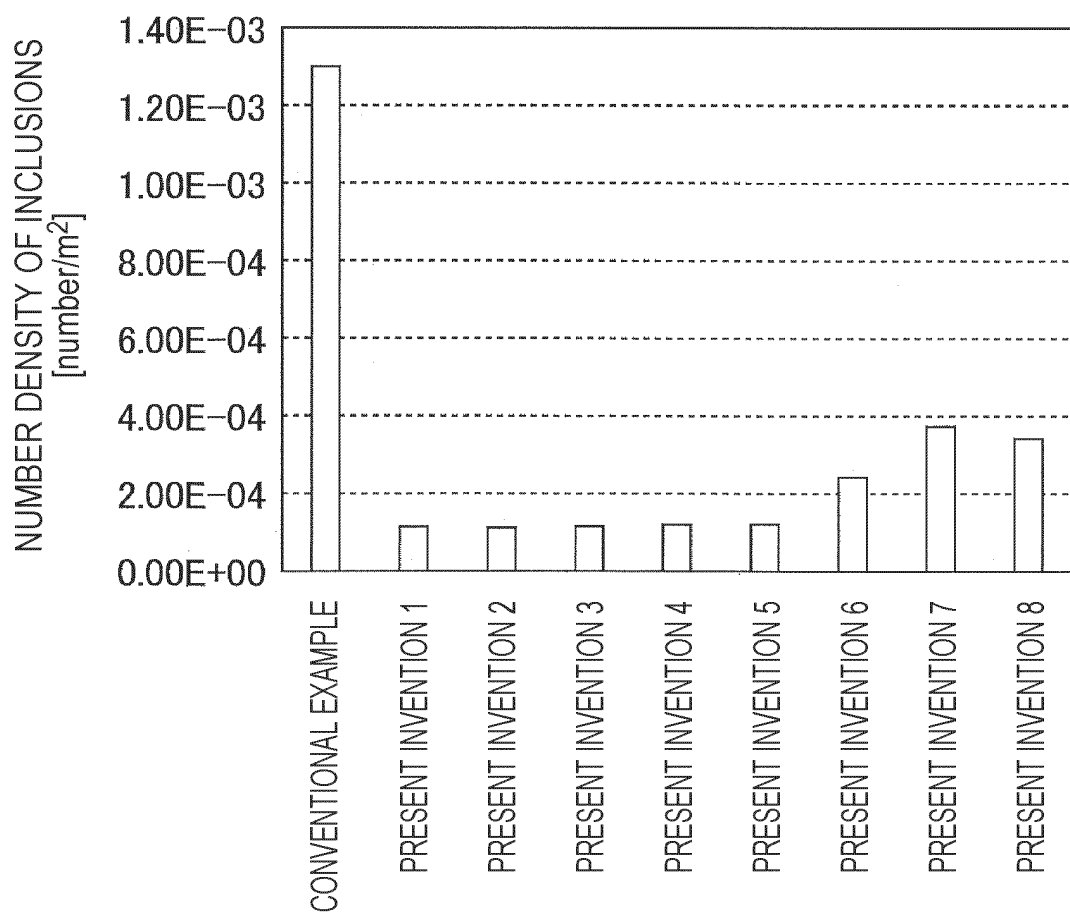


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/028182

A. CLASSIFICATION OF SUBJECT MATTER**B22D 11/10**(2006.01)i; **B22D 11/11**(2006.01)i

FI: B22D11/10 310G; B22D11/10 360Z; B22D11/10 310L; B22D11/11 B

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)

B22D11/10; B22D11/11

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 1971-2023

Registered utility model specifications of Japan 1996-2023

Published registered utility model applications of Japan 1994-2023

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.
X	US 2021/0053111 A1 (HARBISONWALKER INTERNATIONAL, INC.) 25 February 2021 (2021-02-25) paragraphs [0002], [0041]-[0056], fig. 1-3	1-2, 10-11
Y		1-9, 12
Y	JP 9-164455 A (KAWASAKI STEEL CORP) 24 June 1997 (1997-06-24) paragraph [0015]	3-9, 12
X	CN 203109191 U (PUYANG REFRACTORIES GROUP CO., LTD.) 07 August 2013 (2013-08-07) paragraphs [0001], [0015], [0023]-[0027], fig. 1-3	10-11
Y		1-9, 12
A	WO 2013/190799 A1 (JFE STEEL CORPORATION) 27 December 2013 (2013-12-27) paragraphs [0031]-[0038], fig. 4-8	1-12
A	CN 113564309 A (BAOSHAN IRON & STEEL CO., LTD.) 29 October 2021 (2021-10-29) paragraphs [0041]-[0064], fig. 1-7	1-12

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

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Date of the actual completion of the international search

04 October 2023

Date of mailing of the international search report

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Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)

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Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2023/028182

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
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		WO 2021/034559 A1	
		EP 3993920 A1	
		AU 2020334866 A	
		CA 3147522 A	
JP 9-164455 A	24 June 1997	(Family: none)	
CN 203109191 U	07 August 2013	(Family: none)	
WO 2013/190799 A1	27 December 2013	EP 2837441 A1	
		paragraphs [0038]-[0045], fig. 4-8	
		CN 104364032 A	
		KR 10-2015-0006859 A	
		BR 112014030786 A	
		IN 9141DEN2014 A	
CN 113564309 A	29 October 2021	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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- JP 53006231 A [0008]
- JP 10216909 A [0008]
- JP 2011143449 A [0008]