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(54) MOLDING DEVICE FOR CONTINUOUS CASTING EQUIPPED WITH STIRRING DEVICE

(57) There is provided a molding device for continuous casting equipped with an agitator which receives liquid-phase melt of a conductive material and from which a solid-phase cast product is taken out through the cooling of the melt. The molding device includes a casting mold and an agitator. The casting mold receives the liquid-phase melt from an inlet side and discharges the solid-phase cast product from an outlet side by cooling. The agitator is provided outside the casting mold, and includes an electrode unit and a magnetic field generation device. The electrode unit includes first electrodes positioned at the top and a second electrode positioned therebelow, and the magnetic field generation device includes a permanent magnet for applying a magnetic field to the liquid-phase melt. The first electrodes are provided so as to conduct electricity to the liquid-phase melt, and the second electrode is provided so as to conduct electricity to the solid-phase cast product. The first and second electrodes are adapted so as to conduct electricity in the vertical direction through the melt and the cast product provided therebetween. The magnetic field generation device is provided outside the casting mold and generates magnetic lines of force in a lateral direction so that the magnetic lines of force penetrate into the casting mold, reach the inside of the casting mold, and are applied to the melt in the lateral direction crossing the current.

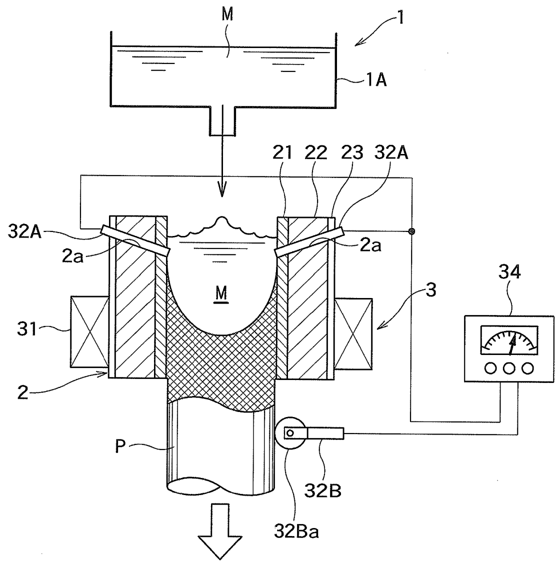

FIG. 1

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Description

Technical Field

[0001] The present invention relates to a molding device for continuous casting, which is equipped with an agitator, of continuous casting equipment that produces a billet, a slab or the like made of non-ferrous metal of a conductor (conductive body), such as Al, Cu, Zn, or an alloy of at least two of them, or an Mg alloy.

Background Art

[0002] In the past, a melt agitating method to be described below has been employed in a casting mold for continuous casting. That is, for the improvement of the quality of a slab, a billet, or the like, in a process for solidifying the melt, that is, when the melt passes through the casting mold, a moving magnetic field, which is generated from the outside of the casting mold by an electromagnetic coil, is applied to the melt present in the casting mold so that agitation occurs in the melt not yet solidified. A main object of this agitation is to degas the melt and to uniformize the structure. However, since the electromagnetic coil is disposed at the position close to high-temperature melt, the cooling of the electromagnetic coil and troublesome maintenance are needed and large power consumption is naturally needed. In addition, the generation of heat from the electromagnetic coil itself caused by the power consumption cannot be avoided, and this heat should be removed. For this reason, there are various problems in that the device itself cannot but become expensive, and the like.

Related Art

Patent Literature

[0003]

Patent Literature 1: JP 09-99344 A

Summary of Invention

Technical Problem

[0004] The invention has been made to solve the above-mentioned problems, and an object of the invention is to provide a molding device for continuous casting equipped with an agitator that reduces the amount of generated heat, is easy to carry out maintenance, is inexpensive, and is easy to use in practice.

[0005] A molding device for continuous casting equipped with an agitator according to an embodiment of the present invention which receives liquid-phase melt of a conductive material and from which a solid-phase cast product is taken out through the cooling of the melt includes a casting mold that receives the liquid-phase melt from an inlet side and discharges the solid-phase cast product from an outlet side by cooling and an agitator that is provided outside the casting mold, and includes an electrode unit that includes first electrodes positioned at the top and a second electrode positioned therebelow, and a magnetic field generation device that includes a permanent magnet for applying a magnetic field to the liquid-phase melt. The first electrodes are provided so as to conduct electricity to the liquid-phase melt, and the second electrode is provided so as to conduct electricity to the solid-phase cast product. The first and second electrodes are adapted so as to conduct electricity in the vertical direction through the melt and the cast product provided therebetween. The magnetic field generation device is provided outside the casting mold and generating magnetic lines of force in a lateral direction so that the magnetic lines of force penetrate into the casting mold, reach the inside of the casting mold, and are applied to the melt in the lateral direction crossing the current.

Brief Description of Drawings

[0006]

Fig. 1 is a diagram illustrating the entire structure of an embodiment of the invention.
Fig. 2 is an explanatory plan view illustrating a state where a melt supply unit of Fig. 1 is removed.
Fig. 3(a) is an explanatory plan view of a magnetic field generation device of an agitator, and Fig. 3(b) is an explanatory plan view of a modified example thereof.
Fig. 4(a) is an explanatory plan view of another modified example of the magnetic field generation device of the agitator, and Fig. 4(b) is an explanatory plan view of a modified example thereof.
Fig. 5 is a diagram illustrating the entire structure of another embodiment of the invention.
Fig. 6 is a diagram illustrating the entire structure of still another embodiment of the invention.
Fig. 7 is a diagram illustrating the entire structure of yet another embodiment of the invention.
Fig. 8 is a diagram illustrating the entire structure of still another embodiment of the invention.

Description of Embodiments

[0007] For deeper understanding of an embodiment of the invention, an electromagnetic agitator of continuous casting equipment in the related art will be described briefly.

[0008] In the related art, a fixed amount of melt M of non-ferrous metal is discharged from a melt receiving box that is called a tundish and is poured into a casting mold that is provided on the lower side. Cooling water for cooling the casting mold is circulated in the casting mold. Accordingly, high-temperature melt starts to solidify from the outer periphery thereof (a portion thereof close to the casting mold) from the moment that the high-temperature melt comes into contact with the casting mold.

[0009] Since the melt, which is positioned at the central portion of the casting mold, is distant from the wall of the casting mold that is being cooled, the solidification of the melt positioned at the central portion of the casting mold is naturally later than that of the melt positioned at the peripheral portion of the casting mold. For this reason, two kinds of melt, that is, liquid (liquid-phase) melt and a solid (solid-phase) casting are simultaneously present in the casting mold. Meanwhile, generally, if melt is solidified too rapidly, gas remains in a cast product (product) having been changed into a solid and causes the quality of the product to deteriorate. For this reason, degassing is facilitated by the agitating of the melt that is not yet solidified. The electromagnetic agitator has been used for the agitating in the related art.

[0010] However, when the electromagnetic agitator is used, there are various difficulties as described above.

[0011] Accordingly, the invention is to provide a molding device for continuous casting equipped with an agitator that does not use the electromagnetic agitator.

[0012] An embodiment of the invention will be described in detail below.

[0013] The entire structure of an embodiment of the invention is illustrated in Fig. 1. Fig. 2 is an explanatory plan view illustrating a state where a melt supply unit of Fig. 1 is removed, and mainly illustrates a part of a casting mold 2 and an agitator 3. Fig. 3(a) is an explanatory plan view of a magnetic field generation device 31 of the agitator 3.

[0014] The device according to the embodiment of the invention broadly includes a melt supply unit 1 that supplies melt M of non-ferrous metal of a conductor (conductive body), such as Al, Cu, Zn, or an alloy of at least two of them, or an Mg alloy; a casting mold 2 that receives the melt from the melt supply unit 1; and an agitator 3 that agitates the melt M present in the casting mold 2.

[0015] The melt supply unit 1 includes a tundish (melt receiving box) 1A that receives melt M from a ladle (not illustrated) or the like. The melt M is stored in the tundish (melt receiving box) 1A, inclusion is removed from the melt, and the melt is supplied to the casting mold 2 from the lower portion of the tundish at a constant supply rate. Only the tundish (melt receiving box) 1A is illustrated in Fig. 1.

[0016] The casting mold 2 is adapted in this embodiment so that a columnar product is taken out from the casting mold.

[0017] For this reason, the casting mold 2 is formed so as to have a substantially cylindrical double structure. That is, the casting mold 2 includes an inner casting mold 21 that is provided on the inside and made of a non-conductive material (non-conductive refractory material), and an outer casting mold 22 that is provided outside and made of a conductive material (conductive refractory material).

[0018] Further, an inner casting mold, which is made of a conductive material such as graphite, may be used as the inner casting mold. For example, when graphite is used, it is possible to make the surface of a product smooth since graphite is a soft material.

[0019] Fig. 8 illustrates an example of an embodiment in which an inner casting mold 21A made of graphite is used. Since the inner casting mold 21A is directly electrically connected to a power supply 34 in the case of this embodiment as understood from Fig. 8, upper electrodes 32A do not need to be provided as understood from the comparison between the embodiment of Fig. 1 and this embodiment.

[0020] The casting mold 2 further includes a water jacket 23 outside the outer casting mold 22.

[0021] The water jacket 23 is to cool the melt M that flows into the inner casting mold 21. That is, cooling water is circulated in the water jacket 23, and the outer portion of the outer casting mold 22 is cooled by the cooling water. The melt M is rapidly cooled by the water jacket 23. Since water jackets having various known structures may be employed as the water jacket 23, the detailed description thereof will not be repeated here.

[0022] In addition, a plurality of electrode insertion holes 2a, 2a, ... into which electrodes 32A to be described below are inserted and pulled out are formed at a predetermined interval on the circumference of the casting mold 2 having the above-mentioned structure. The electrode insertion holes 2a are formed so as to be inclined downward toward the center of the casting mold 2. For this reason, if the surface of the melt M is lower than the upper openings of the electrode insertion holes 2a even though the melt M is contained in the casting mold 2, there is no concern that the melt M will leak to the outside.

[0023] The agitator 3 is provided on the casting mold 2. The agitator 3 includes a permanent magnet type magnetic field generation device 31, and a pair of upper and lower electrode (positive and negative electrodes) 32A and 32B.

[0024] In particular, as understood from Fig. 3(a), the magnetic field generation device 31 is formed in the shape of a ring and is installed so as to be directly or indirectly fitted to the outer periphery of the water jacket 23.

[0025] The ring-shaped magnetic field generation device 31 is adapted so that the position of the magnetic field generation device can be adjusted relative to the water jacket 23(casting mold 2) in the vertical direction. Accordingly, it is possible to select the position where agitating efficiency is best relative to the casting mold 2 by adjusting the position of the magnetic field generation device 31 in the vertical direction. Four portions of the magnetic field generation device 31 are magnetized and form pairs of magnetic poles 31a, 31a, ... That is, a portion of each pair of magnetic poles 31a facing the inside of the ring-shaped magnetic field generation device 31 is magnetized to an N pole, and a portion thereof facing the outside of the ring-shaped magnetic field generation device 31 is magnetized to an S pole. Accordingly, magnetic lines ML of force generated from the N pole horizontally pass through the melt M that is present in the casting mold 2, and enter the S pole.

[0026] Current flows between the pair of electrodes 32A and 32B through the melt M and a cast product (product) P. One electrode 32A may be used, but a plurality of electrodes 32A may be used. In this embodiment, two electrodes 32A are used. The electrodes 32A are formed in the shape of a probe. The respective electrodes 32A are inserted into the above-mentioned electrode insertion holes 2a. That is, the electrodes 32A penetrate into the casting mold 2 (the inner casting mold 21 and the outer casting mold 22) from the water jacket 23. Inner ends of the electrodes 32A are exposed to the inside of the inner casting mold 21, come into contact with the melt M, and conduct electricity to the melt M. Outer ends of the electrodes 32A are exposed to the outside of the water jacket 23. The outer ends are connected to the power supply 34 that can supply variable direct current. The electrodes 32A may be supported above the upper opening of the casting mold 2 without penetrating the side wall of the casting mold 2 so that the inner ends of the electrodes 32A are inserted into the melt M from the surface of the melt M flowing into the casting mold 2.

[0027] The number of electrodes used as the electrodes 32A may be arbitrary, and an arbitrary number of the electrodes 32A may be inserted into arbitrary electrode insertion holes of the electrode insertion holes 2a, 2a, ...

[0028] The lower electrode 32B is provided so that the position of the lower electrode 32B is fixed. The electrode 32B is formed of a roller type electrode. That is, the lower electrode 32B includes a rotatable roller 32Ba at the end thereof. The roller 32Ba comes into press contact with the outer surface of a columnar product P as a cast product (a billet or a slab) that is extruded in a solid phase state. Accordingly, as the product P extends downward, the roller 32Ba is rotated. That is, when the product P is extruded downward, the product P extends downward in Fig. 1 while coming into contact with the roller 32Ba and rotating the roller 32Ba.

[0029] Accordingly, when a voltage is applied between the pair of electrodes 32A and 32B from the power supply 34, current flows between the pair of electrodes 32A and 32B through the melt M and the product P. As described above, the power supply 34 is adapted so as to be capable of controlling the amount of current flowing between the pair of electrodes 32A and 32B. Therefore, it is possible to select current where the liquid-phase melt M can be agitated most efficiently in a relation with the magnetic lines ML of force.

[0030] Next, the operation of the device having the above-mentioned structure will be described.

[0031] A fixed amount of the melt M, which is discharged from the tundish (melt receiving box) 1A, is input to the upper portion of the casting mold 2. The casting mold 2 is cooled through the circulation of water in the water jacket 23, so that the melt M present in the casting mold 2 is rapidly cooled and solidified. However, the melt M present in the casting mold 2 has a two-phase structure where the upper portion of the melt is liquid (liquid phase) and the lower portion thereof is solid (solid phase). When passing through the casting mold 2, the melt M is formed in the shape (a columnar shape in this embodiment) corresponding to the shape of the casting mold. Accordingly, a product P as a slab or billet is continuously formed.

[0032] However, since the permanent magnet type magnetic field generation device 31 is disposed outside the casting mold 2, the magnetic field (magnetic lines of force ML) of the magnetic field generation device reaches the melt M, which is present in the casting mold 2, in the lateral direction. In this state, when direct current is supplied to the lower electrode 32B from the upper electrodes 32A by the power supply 34, the current flows to the lower electrode 32B from the upper electrodes 32A through the melt (liquid phase) M of aluminum or the like and the product (solid phase) P. At this time, the current crosses the magnetic lines of force ML, which are generated from the permanent magnet type magnetic field generation device 31, substantially at right angles to the magnetic lines of force. Accordingly, rotation occurs in the liquid-phase melt M in accordance with Fleming's left-hand rule. The melt M is agitated in this way, so that impurities, gas, and the like contained in the melt M float and so-called degassing is actively performed. Accordingly, the quality of the product (a slab or a billet) P is improved.

[0033] On the contrary, the double structure of the casting mold 2 may be formed so that the inner portion of the casting mold is made of a conductive material and the outer portion thereof is made of a non-conductive material. In this case, at least the electrodes 32A may come into electrically contact with the conductive material that forms the inner portion of the casting mold.

[0034] Further, the casting mold 2 may have not a double structure but a single structure. In this case, the casting mold 2 may be made of only a conductive material, and the electrodes 32A may conduct electricity to the casting mold 2. The structure of the other electrode 32B may be the same as described above.

[0035] On the contrary, the casting mold 2 may be made of only a non-conductive material. In this case, it is necessary to make the electrodes 32A conduct electricity to the melt M present in the casting mold 2 by making the electrodes 32A penetrate into the casting mold 2 etc. as illustrated in Fig. 1.

[0036] A magnetic field generation device 31A of Fig. 3(b) may be used instead of the magnetic field generation device 31 of Fig. 3(a). The magnetization direction of the magnetic field generation device 31A of Fig. 3(b) is opposite to that of the magnetic field generation device 31 of Fig. 3(a). Both the magnetic field generation devices have the same function.

[0037] Further, magnetic field generation devices 31-2 and 31A-2 of Figs. 4(a) and 4(b) may be used instead of the magnetic field generation devices 31 and 31A of Figs.

3(a) and 3(b). The magnetic field generation devices 31-2 and 31A-2 of Figs. 4(a) and 4(b) are adapted so that a plurality of rod-like permanent magnets PM are fixed to the inside of a ring-shaped support (yoke) SP. These have the same function.

[0038] Furthermore, an electrode, which includes the roller 32Ba at the end thereof, has been described as the lower electrode 32B in the above-mentioned embodiment. However, the lower electrode does not need to necessarily include the roller 32Ba. Even though a product P is continuously extruded, the electrode 32B only has to keep conducting electricity to the product P and may employ various structures. For example, an elastic member having a predetermined length is used as the electrode 32B and is bent, for example, so as to be convex upward or downward in Fig. 1, and the end of the elastic member comes into press contact with the cast product P by the force of restitution. In this state, the cast product P may be allowed to extend downward.

[0039] According to the above-mentioned embodiment of the invention, it is possible to obtain the following effect.

[0040] In the invention, melt M that is not yet solidified is agitated to give movement, vibration, and the like to the melt M, so that a degassing effect and the uniformization and refinement of the metallic structure are achieved.

[0041] However, the realization of mass production facilities is currently required in the industry. It is essential to realize a casting mold that is as small as possible when mass production is considered.

[0042] Here, the electromagnetic agitator in the related art can cope with a case where several slabs or billets are produced at one time. However, at present, there is a demand for simultaneous production of billets of which the number exceeds 100. The electromagnetic agitator in the related art cannot cope with this demand.

[0043] However, permanent magnets were used as the magnetic field generation device in the device of the invention. For this reason, it is possible to make the device very compact in comparison with the electromagnetic agitator. Accordingly, it is sufficiently possible to realize a molding device for a mass production facility. Further, since the magnetic field generation device is permanent magnet type, it is possible to obtain a device having effects, such as no heat generation, power saving, energy saving, and less maintenance, as a magnetic field generation device.

[0044] Fig. 5 illustrates another embodiment of the invention.

[0045] More current is supplied to this liquid-phase melt M to generate a larger electromagnetic force so that the melt M is rotationally driven.

[0046] This embodiment is different from the embodiment of Fig. 1 in the structure of a casting mold 2A. Other structures are substantially the same as Fig. 1. Accordingly, the detailed description thereof will not be repeated here.

[0047] That is, the casting mold 2A of this embodiment includes a substantially cylindrical casting mold body 2A1. The casting mold body 2A1 includes a circumferential groove that is formed on the inner peripheral surface thereof. An insulating film 2A2 is formed on the inner surface (the peripheral surface and the bottoms) of this groove, and an embedded layer 2A3 is formed by embedding the same conductive material as the casting mold body 2A1 on the insulating film 2A2. An insulating layer portion is formed of the insulating film 2A2 and the embedded layer 2A3. The insulating layer portion is formed on a part of the inner surface of the casting mold, and functions as a portion that does not allow the flow of current from the casting mold.

[0048] This insulating layer portion is formed on a slightly lower portion of the inner surface of the casting mold body 2A1.

[0049] Accordingly, current is hardly allowed to flow to the cast product P from the insulating layer portion of the casting mold body 2A1, that is, a portion adjacent to the cast product P.

[0050] In addition, a terminal 2A4 is provided on the outer periphery of the casting mold body 2A1. Power can be supplied to the casting mold 2A from the power supply 34 through this terminal 2A4. A water jacket is not illustrated in Fig. 5.

[0051] When a voltage is applied between the terminal 2A4 and the electrode 32B by the power supply 34 in the device having this structure, current flows in the casting mold body 2A1, the melt M, and the cast product P. Since current does not flow in the insulating film 2A2 and the embedded layer 2A3 at this time, larger current flows in the melt M. Accordingly, a larger electromagnetic force, which allows the melt M to be agitated, is obtained.

[0052] Fig. 6 illustrates still another embodiment.

[0053] This embodiment is a modified example of the embodiment of Fig. 1.

[0054] This embodiment is different from the embodiment of Fig. 1 in the disposition of the upper electrodes 32A of Fig. 1. That is, in this embodiment, one or a plurality of electrodes 32A0, 32A0, ... are disposed annularly, these electrodes 32A0 are supported by arbitrary means other than the casting mold 2 and the like (the casting mold 2 and the water jacket 23), and lower end portions of each of the electrodes 32A0 is inserted into the melt M. Accordingly, it is possible to adjust the length of the lower end portion, which is inserted into the melt M, of the electrode 32A0 with large degree of freedom regardless of the casting mold 2 and the like. Moreover, naturally, a normal mold may be used as the casting mold 2 etc., and electrode insertion holes do not need to be formed in the casting mold 2. Therefore, it is also possible to prevent the increase in the manufacturing costs of these.

[0055] Other structures are the same as the embodiment of Fig. 1.

[0056] Fig. 7 illustrates yet another embodiment.

[0057] This embodiment may be regarded as a modified example of the embodiment of Fig. 6.

[0058] The embodiment of Fig. 7 is assumed as a device that can be operated when melt M is poured into a casting mold 2, which is provided on the lower side, from a tundish (melt receiving box) 1A, which is provided on the upper side, as continuous melt with no interruption. That is, it is assumed that the melt M present in the tundish (melt receiving box) 1A and the melt M present in the casting mold 2 are integrally connected to each other.

[0059] In Fig. 6, the electrodes 32A0 are inserted into the melt M present in the casting mold 2. However, in Fig. 7, an electrode 32A1 is supported by arbitrary means so as to be inserted into the melt M present in the tundish (melt receiving box) 1A on the premise of the above-mentioned case. Accordingly, it is possible to obtain the same advantage as the above-mentioned embodiment of Fig. 6. In addition, it is possible to set and adjust a distance between the tundish (melt receiving box) 1A and the casting mold 2 or the like regardless of the electrode 32A1.

[0060] Other structures are substantially the same as Fig. 6.

Claims

1. A molding device for continuous casting equipped with an agitator which receives liquid-phase melt of a conductive material and from which a solid-phase cast product is taken out through the cooling of the melt, the molding device comprising:

a casting mold that receives the liquid-phase melt from an inlet side and discharges the solid-phase cast product from an outlet side by cooling; and

an agitator that is provided outside the casting mold, and includes an electrode unit that includes first electrodes positioned at the top and a second electrode positioned therebelow, and a magnetic field generation device that includes a permanent magnet for applying a magnetic field to the liquid-phase melt, the first electrodes being provided so as to conduct electricity to the liquid-phase melt, and the second electrode is provided so as to conduct electricity to the solid-phase cast product, the first and second electrodes being adapted so as to conduct electricity in the vertical direction through the melt and the cast product provided therebetween, and the magnetic field generation device being provided outside the casting mold and generating magnetic lines of force in a lateral direction so that the magnetic lines of force penetrate into the casting mold, reach the inside of the casting mold, and are applied to the melt in the lateral direction crossing the current.

2. The molding device according to claim 1, wherein the magnetic field generation device includes at least one pair of magnetic poles that are formed of an S pole and an N pole, and sides, which are close to and distant from the casting mold, of each magnetic pole are magnetized as an inner magnetic pole and an outer magnetic pole, respectively.

3. The molding device according to claim 1, wherein the plurality of pairs of magnetic poles are arranged around a vertical axis and on the outer periphery of the casting mold.

4. The molding device according to claim 2, wherein the plurality of inner magnetic poles of the plurality of pairs of magnetic poles are S poles or N poles and the plurality of outer magnetic poles thereof are N poles or S poles.

5. The molding device according to claim 1, wherein the magnetic field generation device is adapted so that the position of the magnetic field generation device is vertically adjustable relative to the casting mold.

6. The molding device according to claim 1, wherein the first electrodes are supported by the casting mold or means other than the casting mold.

7. The molding device according to claim 1, wherein the second electrode includes a roller at the end thereof, and the roller is adapted to be rotated through the contact with the outer surface of the cast product to be taken out.

8. The molding device according to claim 1, wherein a power supply, which supplies direct current between the first and second electrodes, is connected to the first and second electrodes.

9. The molding device according to claim 1, wherein the casting mold is made of a non-conductive material so as to have a single structure, is made of a conductive material so as to have a single structure, or is made of a non-conductive material and a conductive material so as to have a double structure.

10. The molding device according to claim 6, wherein the casting mold is made of a non-conductive material so as to have a single structure, and the first electrodes are provided so as to be exposed to the inside of the casting mold through electrode insertion holes.

11. The molding device according to claim 6, wherein the casting mold is made of a conductive material so as to have a single structure, and the first electrodes are provided so as to conduct electricity to the casting mold through at least the electrode insertion holes.

12. The molding device according to claim 6, wherein the casting mold has a double structure of which an inner portion is made of a non-conductive material and an outer portion is made of a conductive material, and the first electrodes are provided so as to be exposed to the inside of the casting mold through electrode insertion holes.

13. The molding device according to claim 6, wherein the casting mold has a double structure of which an inner portion is made of a conductive material and an outer portion is made of a non-conductive material, and the first electrodes are provided so as to conduct electricity to the conductive material of the inner portion through at least the electrode insertion holes.

14. The molding device according to claim 1, wherein the magnetic field generation device is formed of an annular body.

15. The molding device according to claim 14, wherein one portion a plurality of portions of the annular body of the magnetic field generation device forms or form magnet pole or poles.

16. The molding device according to claim 14, wherein the magnetic field generation device includes a ring-shaped support and one permanent magnet body or a plurality of permanent magnet bodies fixed to the support.

17. A molding device for continuous casting equipped with an agitator which receives liquid-phase melt of a conductive material and from which a solid-phase cast product is taken out through the cooling of the melt, the molding device comprising:

a casting mold that receives the liquid-phase melt from an inlet side and discharges the solid-phase cast product from an outlet side by cooling; and
an agitator that is provided outside the casting mold, and includes a magnetic field generation device that includes a permanent magnet for applying a magnetic field to the liquid-phase melt, and a lower electrode that conducts electricity to the solid-phase cast product, the lower electrode being adapted so as to receive current from the casting mold as an upper electrode through the melt and the cast product, and the magnetic field generation device being provided outside the casting mold and generating magnetic lines of force in a lateral direction so that the magnetic lines of force penetrate into the casting mold, reach the inside of the casting mold, and are applied to the melt in the lateral direction crossing the current.

18. The molding device according to claim 17, wherein the magnetic field generation device includes at least one pair of magnetic poles that are formed of an S pole and an N pole, and sides, which are close to and distant from the casting mold, of each magnetic pole are magnetized as an inner magnetic pole and an outer magnetic pole, respectively.

19. The mold device according to claim 17, wherein the casting mold includes an insulating layer portion, which does not allow the flow of the current from the casting mold, on a part of an inner surface thereof.

20. The mold device according to claim 19, wherein the insulating layer portion is formed on a lower portion of the inner surface.

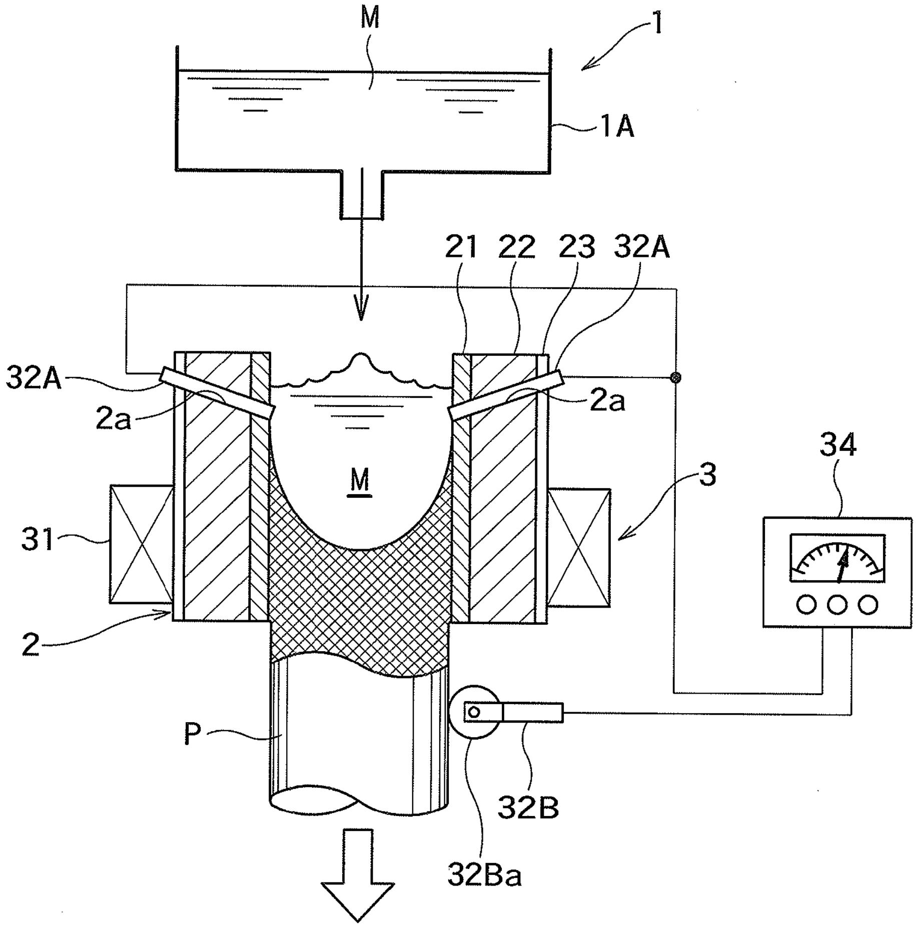
M
1
1A
21 22 23 32A
32A
2a
2a
34
M
3
31
2
P
32B
32Ba

FIG. 1

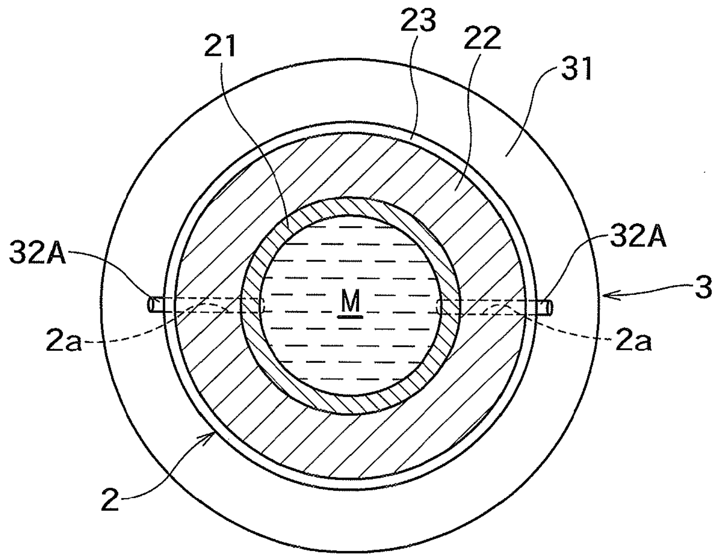
23
21
22
31
32A
32A
3
M
2a
2a
2

FIG. 2

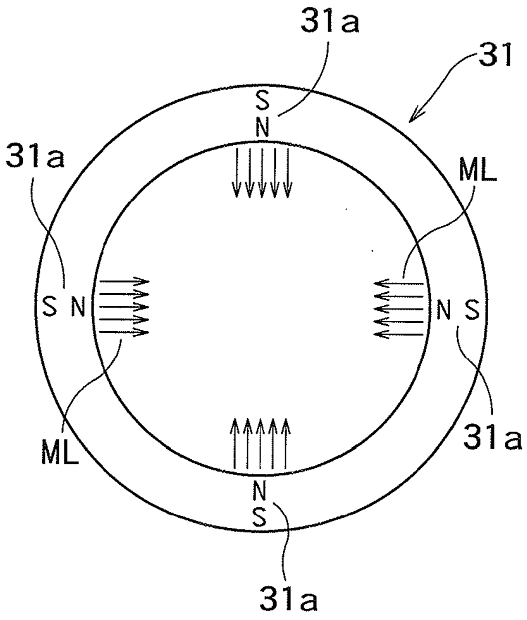

FIG. 3 (a)

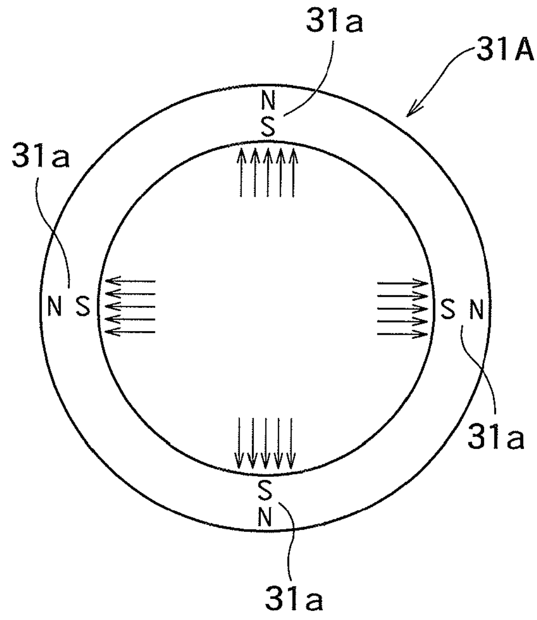

FIG. 3 (b)

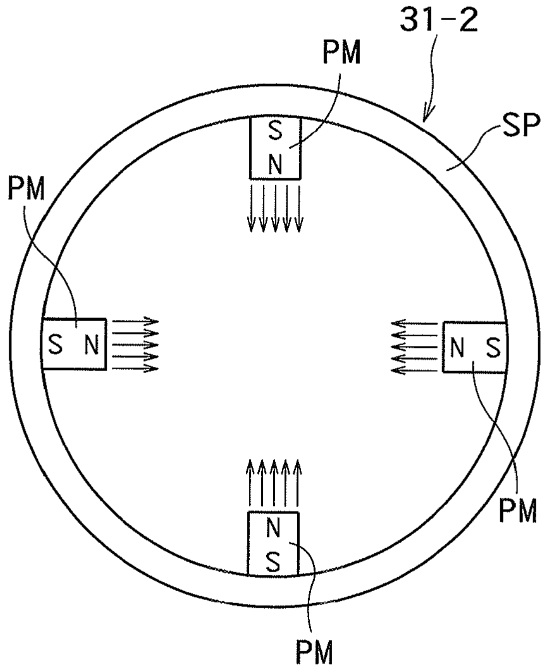

FIG. 4 (a)

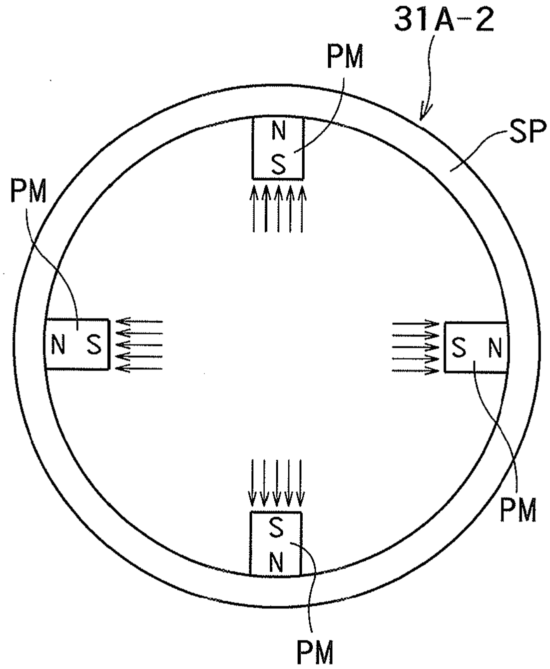

FIG. 4 (b)

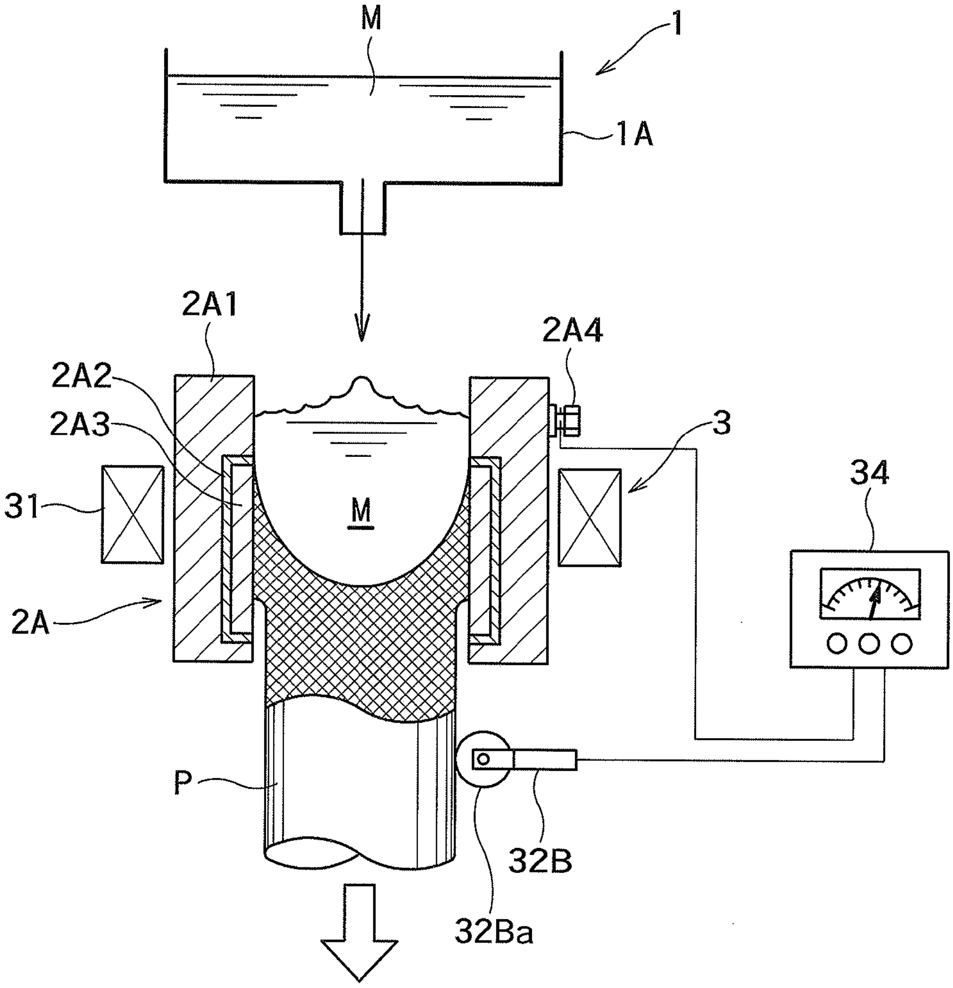

FIG. 5

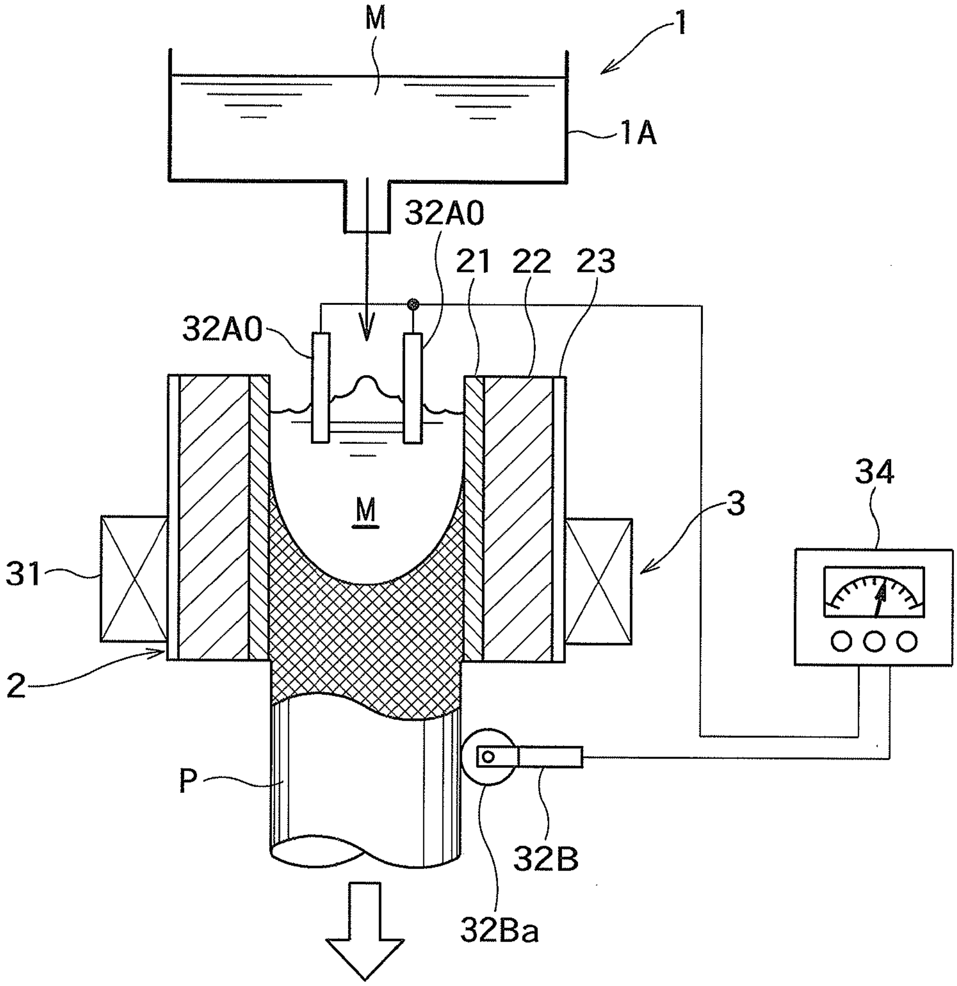

FIG. 6

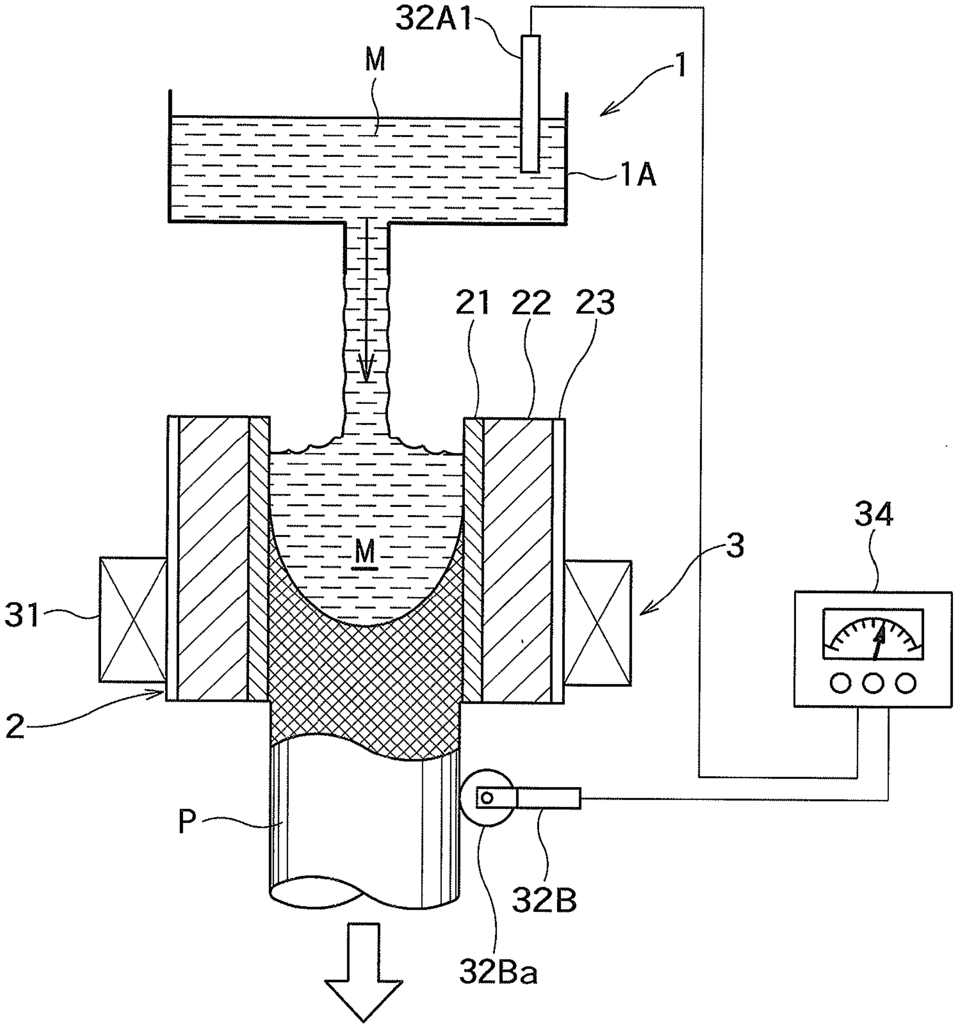

FIG. 7

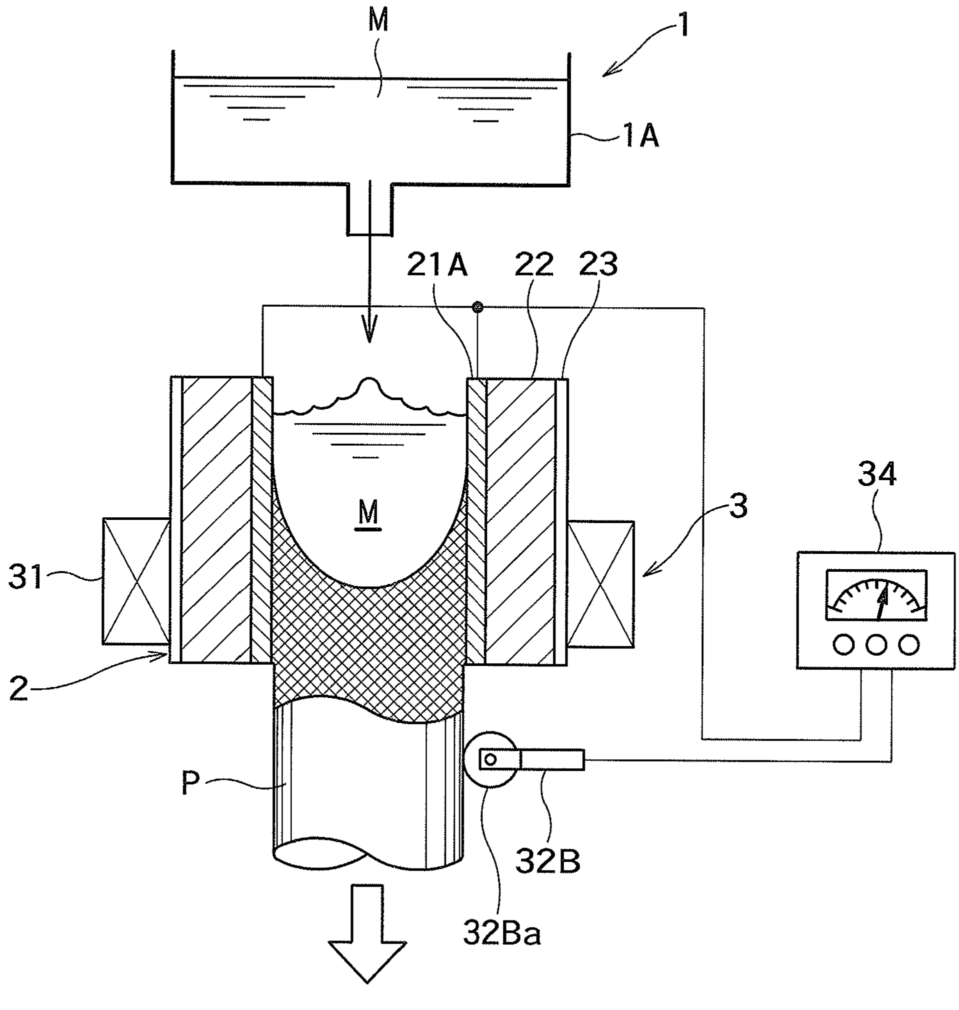

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/066223

A. CLASSIFICATION OF SUBJECT MATTER
B22D11/115(2006.01)i, *B22D11/00*(2006.01)i, *B22D11/04*(2006.01)i

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)
B22D11/115, B22D11/00, B22D11/04

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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.
Y	JP 56-154270 A (Asea AB.), 28 November 1981 (28.11.1981), claims; page 2, upper right column, line 13 to lower left column, line 8; page 2, lower right column, lines 6 to 9; fig. 1 & JP 60-113154 U & US 4478273 A & DE 3101621 A & SE 8000756 A	1-20
Y	JP 58-100956 A (Sumitomo Metal Industries, Ltd.), 15 June 1983 (15.06.1983), page 1, lower right column, lines 2 to 13; fig. 7 (Family: none)	1-20

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

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 September, 2011 (26.09.11)	04 October, 2011 (04.10.11)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/066223

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2-501903 A (Mannesmann AG.), 28 June 1990 (28.06.1990), entire text & EP 345269 A & WO 1988/005353 A1 & DE 3702381 A & BR 8807327 A & ES 2006274 A	1-20
A	WO 2008/010285 A1 (Kenzo TAKAHASHI), 24 January 2008 (24.01.2008), entire text & EP 2045553 A1 & CA 2578691 A1	1-20

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REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 9099344 A **[0003]**