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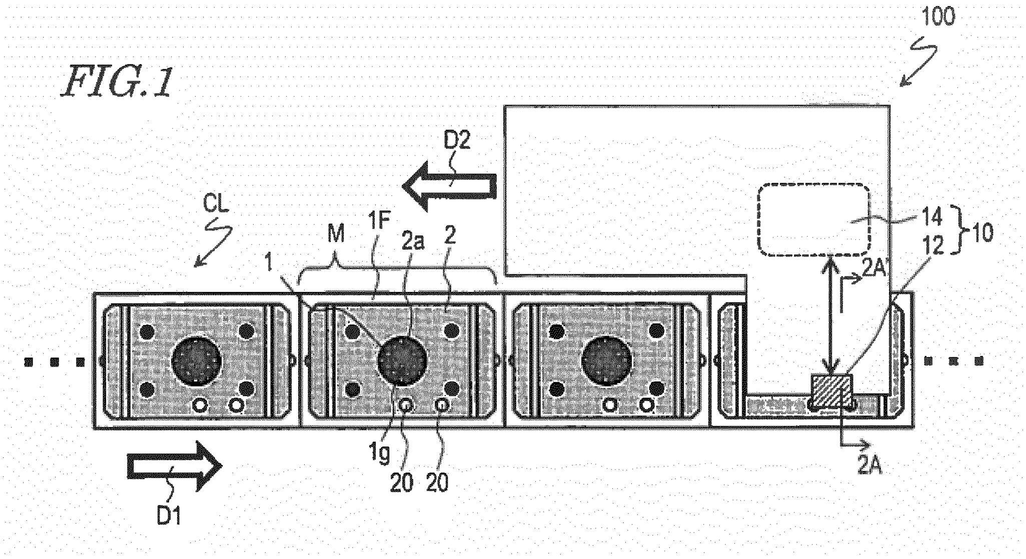
(54) GATE POSITION DETECTION SYSTEM, CASTING DEVICE, GATE POSITION DETECTION METHOD, AND METHOD FOR MANUFACTURING CAST PRODUCT

(57) A pouring cup position detection system (**100**) includes an image processing device (**10**) including an imager (**12**) which moves relative to the mold (**M**); and at least one marker (**20**) provided on the mold and positioned relative to the pouring cup (**1g**). The imager captures an image containing at least one marker. Based on the image captured by the imager, the image processing device generates information concerning the position of the pouring cup.

FIG.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a pouring cup position detection system for detecting the position of a pouring cup of a mold. Moreover, the present invention relates to a casting apparatus, a pouring cup position detection method, and a method of producing castings.

BACKGROUND ART

[0002] Casting techniques are widely used in the manufacture of mass production articles such as automotive vehicle parts. To this day, development efforts have been spent in realizing casting techniques for satisfying various needs.

[0003] Patent Document 1 discloses a technique directed to a cast article releasing apparatus for consecutively releasing cast articles from sand molds which come sequentially conveyed on a casting line. In the technique of Patent Document 1, image processing is performed for sure release of the cast articles. Specifically, an image of a sand mold, including a pouring cup, is captured by a camera (image capture means) which is located near the end of a conveyor; based on this image, the position and dimensions of the pouring cup are calculated by a pouring cup detection/determination means (image processing device); and the releasing apparatus is controlled based on the calculated pouring cup position and the like.

CITATION LIST

PATENT LITERATURE

[0004] [Patent Document 1] Japanese Laid-Open Patent Publication No. 9-225625

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] However, in the technique disclosed in Patent Document 1, spills of melt around the pouring cup may be visible in the image, thus lowering the accuracy of position detection for the pouring cup.

[0006] The present invention has been made in view of the above problem, and an objective thereof is to provide a pouring cup position detection system and a pouring cup position detection method which are capable of accurately detecting the position of a pouring cup of a mold.

SOLUTION TO PROBLEM

[0007] A pouring cup position detection system according to an embodiment of the present invention is a pouring cup position detection system for detecting a position of a pouring cup of a mold, comprising: an image processing device including an imager which moves relative to the mold; and at least one marker provided on the mold and positioned relative to the pouring cup, wherein, the imager captures an image containing the at least one marker; and the image processing device generates information concerning the position of the pouring cup based on the image captured by the imager.

[0008] In one embodiment, the at least one marker comprises a plurality of markers.

[0009] In one embodiment, the plurality of markers comprise three or more markers.

[0010] In one embodiment, the at least one marker is each a marker piece made of a heat-resistant material.

[0011] In one embodiment, the pouring cup position detection system according to the present invention further comprises a protection member surrounding each of the at least one marker.

[0012] In one embodiment, the pouring cup position detection system according to the present invention further comprises a light-shielding cover attached to the imager to restrict light entering the imager.

[0013] In one embodiment, the mold includes a main mold body having the pouring cup formed therein, and a weight to be placed on the main mold body so as to be clear of the pouring cup in planar perspective; and the at least one marker is provided on the weight.

[0014] In one embodiment, the mold includes a flask and a main mold body, the main mold body having the pouring cup formed therein and being situated in the flask; and the at least one marker is provided on the flask.

[0015] A casting apparatus according to an embodiment of the present invention comprises: the above pouring cup position detection system; a pouring machine to pour melt into the mold through the pouring cup; and a pressurizing device to feed at least particulate matter, through the pouring cup, to the mold into which the melt has been poured.

[0016] In one embodiment, the pressurizing device feeds the particulate matter based on the information concerning the position of the pouring cup generated by the image processing device.

[0017] A pouring cup position detection method according to an embodiment of the present invention is a pouring cup position detection method for detecting a position of a pouring cup of a mold, comprising: step (a) of capturing an image containing at least one marker provided on the mold and positioned relative to the pouring cup; and step (b) of generating information concerning the position of the pouring cup based on the image captured at step (a).

[0018] In one embodiment, the pouring cup position detection method according to the present invention further comprises step (c) of positioning the at least one marker relative to the pouring cup by using a positioning jig, the positioning jig having at least one opening formed in a predetermined position or positions.

[0019] A method of producing a casting according to an embodiment of the present invention comprises: step (A) of pouring melt into a mold through a pouring cup; and step (B) of generating information concerning the position of the pouring cup by the above pouring cup position detection method.

[0020] In one embodiment, the method of producing a casting according to the present invention further comprises step (C) of feeding at least particulate matter, through the pouring cup, to the mold into which the melt has been poured, step (C) being executed based on the information concerning the position of the pouring cup generated at step (B).

ADVANTAGEOUS EFFECTS OF INVENTION

[0021] Embodiments of the present invention provide a pouring cup position detection system and a pouring cup position detection method that can accurately detect the position of a pouring cup of a mold.

[0022] A pouring cup position detection system according to an embodiment of the present invention includes an image processing device including an imager, and at least one marker positioned relative to the pouring cup. In the pouring cup position detection system according to an embodiment of the present invention, based on an image containing the marker(s) that is captured by the imager, the image processing device generates information (pouring cup position information) concerning the position of the pouring cup. Since the pouring cup position can be detected as a relative position on the basis of the marker position, the pouring cup position can be accurately detected without being affected by spills of melt around the pouring cup, or the brightness of the melt immediately after being poured.

[0023] From the standpoint of more accurately detecting the pouring cup position, it is more preferable to use a plurality of markers than to use one marker. The reason is that, use of a plurality of markers allows the pouring cup position to be calculated based on a pair consisting of two markers.

[0024] Especially when using three or more markers, a pouring cup position may be calculated from a pair of any two markers, and a mean value may be derived of this value being calculated as many times as there are such pairs, thus attaining a further enhanced detection accuracy. In the case of using three or more markers, so long as a good image is obtained with respect to at least two markers, the pouring cup position can be calculated even if the other marker(s) cannot be imaged well for soiling or other causes.

[0025] When the marker (s) is a marker piece(s) made of a heat-resistant material, soiling of the marker(s) by spills of melt is less likely to occur.

[0026] When a protection member is provided surrounding the marker(s), the protection member can prevent spills of melt from sticking to the marker(s), thus being able to better prevent soiling of the marker(s) by spills of melt.

[0027] When a light-shielding cover is attached to the imager, light entering imager can be restricted by the light-shielding cover, thereby restraining light sources around the imager from exerting unfavorable influences (disturbance) on image capturing.

[0028] The mold may include a main mold body having the pouring cup formed therein, and a weight to be placed on the main mold body, for example. In this case, the marker(s) may be provided on the weight.

[0029] Alternatively, the mold may include a flask and a main mold body situated in the flask. In this case, the marker(s) may be provided on the flask.

[0030] The pouring cup position detection system according to an embodiment of the present invention is suitably used in a casting apparatus. The casting apparatus may include, for example, the pouring cup position detection system according to an embodiment of the present invention and a pouring machine to pour melt into the mold through the pouring cup. When the casting apparatus further includes a pressurizing device to feed particulate matter, through the pouring cup, to the mold into which the melt has been poured, it is possible to reduce the amount of melt to be poured into the mold. This improves the pouring yield, and simplifies the processing work after the casting is released.

[0031] In a construction where the casting apparatus includes a pressurizing device, it is preferable that the pressurizing device feeds particulate matter based on pouring cup position information which is generated by the image processing device. Since the pouring cup position detection system according to an embodiment of the present invention is able to accurately detect the pouring cup position, feeding of the particulate matter can be suitably performed by using the pouring cup position information which is generated by the image processing device in the pouring cup position detection system.

[0032] A pouring cup position detection method according to an embodiment of the present invention includes: step (a) of capturing an image containing at least one marker which is positioned relative to the pouring cup; and step (b) of generating information concerning the position of the pouring cup based on the image captured at step (a). In the pouring cup position detection method according to an embodiment of the present invention, based on the image containing the marker(s) captured at step (a), information (pouring cup position information) concerning the position of the pouring cup is generated at step (b). Since the pouring cup position can be detected as a relative position on the basis of the marker position, the pouring cup position can be accurately detected without being affected by spills of melt around the pouring cup, or by the brightness of the melt immediately after being poured.

[0033] The pouring cup position detection method may further include step (c) of positioning the marker(s) relative to the pouring cup by using a positioning jig, the positioning jig having at least one opening formed in a predetermined position(s). By using the positioning jig, the marker(s) can be easily positioned throughout a plurality of molds.

[0034] The pouring cup position detection method according to an embodiment of the present invention is suitably used in a method of producing a casting. The method of producing a casting may include, for example, step (A) of pouring melt into a mold through a pouring cup, and step (B) of generating information concerning the pouring cup position by the pouring cup position detection method according to an embodiment of the present invention. Since the pouring cup position detection method according to an embodiment of the present invention is able to accurately detect the pouring cup position, the method of producing a casting involving step (B) above is able to suitably perform casting production.

[0035] The method of producing a casting may further include step (C) of feeding particulate matter, through the pouring cup, to the mold into which the melt has been poured. Inclusion of step (C) makes it possible to reduce the amount of melt to be poured into the mold. This improves the pouring yield, and simplifies the processing work after the casting is released. This step (C) is preferably performed based on the pouring cup position information generated at step (B). Since the pouring cup position detection method according to an embodiment of the present invention is able to accurately detect the pouring cup position, executing step (C) based on the pouring cup position information generated at step (B) allows feeding of the particulate matter to be suitably performed.

BRIEF DESCRIPTION OF DRAWINGS

[0036]

[FIG. **1**] An upper plan view schematically showing a pouring cup position detection system 100 according to an embodiment of the present invention.

[FIG. **2**] A cross-sectional view taken along line **2A-2A'** in FIG. **1**.

[FIG. **3**] A diagram schematically showing how image capturing may be conducted by an imager **12**.

[FIG. **4**] An upper plan view, in the case where two markers **20** (a first marker **20A** and a second marker **20B**) are used, showing relative positioning of an opening **2a** of a weight **2** and the two markers **20**.

[FIG. **5**] An upper plan view, in the case where three markers **20** (a first marker **20A**, a second marker **20B**, and a third marker **20C**) are used, showing relative positioning of an opening **2a** of a weight **2** and the three markers **20**.

[FIG. **6**] A perspective view schematically showing a specific example of markers **20**.

[FIG. **7**] A perspective view schematically showing a specific example of markers **20**.

[FIG. **8**] **(a)** and **(b)** are an upper plan view and a perspective view showing an example of more detailed construction of a marker **20** in the form of a marker piece.

[FIG. **9**] A perspective view schematically showing an example where a protection member **22** is provided so as to surround each marker **20**.

[FIG. **10**] **(a)** and **(b)** are an upper plan view and a side view showing an example of more detailed construction of the protection member **22**.

[FIG. **11**] A perspective view schematically showing a specific example of markers **20**.

[FIG. **12**] An upper plan view showing a specific example of positions of markers **20** on the weight **2**.

[FIG. **13**] An upper plan view schematically showing a positioning jig **24**.

[FIG. **14**] **(a)** and **(b)** are diagrams illustrating a positioning method using a positioning jig **24**.

[FIG. **15**] **(a)** and **(b)** are diagrams illustrating a positioning method using a positioning jig **24**.

[FIG. **16**] An upper plan view showing a specific example of positions of markers **20** on a metal flask (flask) **1F**.

[FIG. **17**] **(a)** and **(b)** are a side view and a lower plan view schematically showing an example of the imager **12**.

[FIG. **18**] A block diagram schematically showing a casting apparatus **200** according to an embodiment of the present invention.

[FIG. **19**] A diagram showing a pressurizing device **120** included in the casting apparatus **200**.

[FIG. **20**] A diagram showing a state immediately after melt **m** has been poured into a mold **M** (main mold body **1**) through a pouring cup **1g**.

[FIG. **21**] A diagram showing a state in which a gas **G** is being blown into the cavity of the main mold body **1** from a nozzle portion **121** of the pressurizing device **120**.

[FIG. **22**] A diagram showing a state in which particulate matter **129** is being sent (blown) from the nozzle portion **121** of the pressurizing device **120** into the cavity of the main mold body **1**.

[FIG. **23**] A diagram showing a state in which blowing of particulate matter **129** into the cavity of the main mold body **1** has been completed.

[FIG. **24**] A flowchart showing an exemplary pouring cup position detection method according to an embodiment of the present invention.

[FIG. **25**] A flowchart showing another exemplary pouring cup position detection method according to an embodiment of the present invention.

[FIG. **26**] A flowchart showing an exemplary method of producing a casting according to an embodiment of the present invention.

[FIG. **27**] A flowchart showing a more detailed example of position detection for the pouring cup **1g**.

DESCRIPTION OF EMBODIMENTS

[0037] Hereinafter, embodiments of the present invention will be described with reference to the drawings. Note that the present invention is not to be limited to the following embodiments.

[0038] First, with reference to FIG. **1** and FIG. **2**, a pouring cup position detection system **100** according to an embodiment of the present invention will be described. FIG. **1** is an upper plan view schematically showing the pouring cup position detection system **100** being installed in a casting line **CL**, and FIG. **2** is a cross-sectional view taken along line **2A**-**2A'** in FIG. **1**.

[0039] As shown in FIG. **1**, on the casting line **CL**, a plurality of molds **M** are conveyed in a predetermined direction D1. Each mold **M** includes a main mold body **1** having a pouring cup **1g** formed therein, a flask (which herein is a metal flask) **1F**, and a weight **2**. The main mold body **1** is a sand mold, with a cavity formed therein. The main mold body **1** is located within the metal flask **1F**. Note that the main mold body **1** is not limited to a sand mold, but may be any of various molds for casting methods which perform gravity pouring. For example, it may be a mold made of ceramic particles, or a mold made of metal particles.

[0040] As shown in FIG. **2**, the cavity of the main mold body **1** is composed of a sprue **1a**, runners **1b**, risers **1c**, and a product portion **1d**. In the example shown in FIG. **1** and FIG. **2**, a weight **2** is placed on the main mold body **1**. The weight **2** has an opening **2a**, and is disposed so that the pouring cup **1g** of the main mold body **1** is exposed through the opening **2a** (i.e., so that the pouring cup **1g** overlaps the opening **2a**). In other words, the weight **2** is placed on the main mold body 1 so as to be clear of the pouring cup **1g** in planar perspective.

[0041] The pouring cup position detection system **100** detects the position of the pouring cup **1g** (which typically is the center position of the pouring cup **1g**) of a mold **M**. As shown in FIG. **1** and FIG. **2**, the pouring cup position detection system **100** includes: an image processing device **10**, which in turn includes an imager (digital camera) **12**; and at least one marker **20** that is provided on the mold **M** and positioned relative to the pouring cup **1g**. The pouring cup position detection system **100** (i.e., the part thereof excluding the marker (s) **20**) is able to move in a direction **D2**, which is opposite to the direction **D1** of conveyance of the mold **M**. Therefore, the imager **12** is able to move relatively to the mold **M**.

[0042] In the present embodiment, a plurality of (or more specifically, two) markers **20** are provided for one mold **M**. The markers **20** are situated on the weight **2**.

[0043] In addition to the aforementioned imager **12**, the image processing device **10** includes a calculation section **14**. The calculation section **14** is typically a computer (e.g., a panel computer). The image processing device **10** may further include an illuminator which is not shown.

[0044] As shown in FIG. **2** and further in FIG. **3**, the imager **12** captures an image containing the markers **20**. Based on the image which has been captured by the imager **12** (i.e., an image containing the markers **20**), the image processing device **10** generates information concerning the position of the pouring cup **1g** (hereinafter referred to also as "pouring cup position information"). Generation of the pouring cup position information occurs as predetermined image processing is applied to the image containing the markers **20**.

[0045] As described earlier, in the pouring cup position detection system **100** of the present embodiment, pouring cup position information is generated based on the image containing the markers **20**, whereby the position of the pouring cup **1g** of the mold **M** can be accurately detected. In detecting the position of the pouring cup through image processing, one possible technique might be to capture an image containing the pouring cup **1g**, and directly detect the position of the pouring cup **1g** from that image. However, such a technique may not be able to accurately detect the position of the pouring cup **1g**. For example, spills of melt around the pouring cup **1g** may be visible in the image, thus lowering the accuracy of detecting the position of the pouring cup **1g**. On the other hand, in the pouring cup position detection system **100** of the present embodiment, pouring cup position information is generated based on an image containing the markers

20, which are positioned relative to the pouring cup **1g**; therefore, the position of the pouring cup **1g** is detectable as a relative position based on the positions of the markers **20**. As a result, the position of the pouring cup **1g** can be detected more accurately than by a technique of imaging the pouring cup **1g**.

[0046] While the present embodiment illustrates an example where there are two markers **20**, the number of markers **20** is not limited thereto. There may be one marker **20**, or three or more markers **20**. However, a plurality of markers **20** will enable more accurate detection of the position of the pouring cup **1g** than does one marker **20**. Moreover, three or more markers **20** will enable more accurate detection of the position of the pouring cup **1g** than do two markers **20**.

[0047] Now, an exemplary method of calculating the position of the pouring cup **1g** in the case of using a plurality of markers **20** will be described. In the following example, calculation is conducted by assuming that the center of the circular opening **2a** which is made in the weight **2** coincides with the center of the pouring cup **1g**.

[0048] FIG. **4** is an upper plan view, in the case where two markers **20** are used, showing relative positioning between the opening **2a** of the weight **2** and the two markers **20**. Herein, between the two markers **20** shown in FIG. **4**, the marker **20A** that is located relatively to the right is referred to as the first marker, and the marker **20B** that is located relatively to the left is referred to as the second marker.

[0049] In FIG. **4** (i.e. in the captured image), a coordinate system is envisaged where, given a certain point as an origin, an x axis is defined by an axis extending along the right-left direction from the origin (the right side of the origin being positive, the left side negative), and a y axis is defined by an axis extending along the top-bottom direction from the origin (the upper side of the origin being positive, the lower side negative).

[0050] The center of the opening **2a** is designated as **P0**(x_0, y_0); the center of the first marker **20A** as **P1**(x_1, y_1); and the center of the second marker **20B** as **P2**(x_2, y_2). Moreover, there is a distance **R** between the center **P0** of the opening **2a** and the center **P1** of the first marker **20A**; and an angle α (counterclockwise being positive) is constituted by a line connecting the center **P1** of the first marker **20A** and the center **P2** of the second marker **20B** and a line connecting the center **P1** of the first marker **20A** and the center **P0** of the opening **2a**. Furthermore, an angle θ (counterclockwise being positive) is constituted by a line connecting the center **P1** of the first marker **20A** and the center **P2** of the second marker **20B** and the negative direction of the x axis.

[0051] The angle θ is expressed by eq. (1) below, and the coordinates (x_0, y_0) of the center **P0** of the opening 2a are expressed by eqs. (2) and (3) below. The distance **R** and the angle α can be determined in advance by using a positioning jig **24** described later, for example. Therefore, by applying image processing to an image containing the first marker **20A** and the second marker **20B** to determine the coordinates (x_1, y_1) of **P1** and the coordinates (x_1, y_2) of **P2**, it is possible to calculate the coordinates (x_0, y_0) of the center **P0** of the opening **2a**, i.e., the position of the center of the pouring cup **1g**.

[eq. 1]

$$\theta = \sin^{-1}\left((y_1 - y_2)/\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}\right) \quad \cdots (1)$$

[eq. 2]

$$x_0 = x_1 - R\cos(\alpha - \theta) \quad \cdots (2)$$

[eq. 3]

$$y_0 = y_1 + R\sin(\alpha - \theta) \quad \cdots (3)$$

[0052] FIG. **5** is an upper plan view, in the case where three markers **20** (a first marker **20A**, a second marker **20B**, and a third marker **20C**) are used, showing relative positioning of the opening **2a** of the weight **2** and the three markers **20**.

[0053] In the case where three or more markers **20** are used, any two markers **20** may be selected from among the three or more markers **20**, and similarly to the method which has been described with reference to FIG. **4**, coordinates (x_0, y_0) of the center **P0** of the opening **2a** may be calculated with respect to that pair (i.e., two markers **20**). By calculating the coordinates (x_0, y_0) of the center **P0** of the opening **2a** as many times as there are pairs (combinations) of two such markers **20** (e.g., three in the case of using three markers **20**), and taking a mean value of the calculated values, the detection accuracy can be enhanced.

[0054] Moreover, in the case of using three or more markers **20**, so long as a good image is obtained with respect to at least two markers **20**, the coordinates (x_0, y_0) of the center **P0** of the opening **2a** can still be calculated even if the other marker(s) **20** cannot be imaged well for soiling or other causes.

[0055] As has already been described, there may only be one marker **20**. In the case of using one marker **20**, the position of the pouring cup **1g** can be calculated in the following manner, for example.

[0056] Herein, it is assumed that all molds **M** are arranged parallel to the direction of conveyance **D**, and that any clockwise (or counterclockwise) shift in planar perspective would be negligible.

[0057] Assuming that there is a difference (Δx, Δy) between the coordinates (x0, y0) of the center **P0** of the opening **2a** and the coordinates (x_1, y_1) of the center **P1** of the marker **20**, then, the coordinates (x0, y0) of the center **P0** of the opening **2a** are expressed by eqs. (4) and (5) below.

$$x_0 = x_1 - \Delta x \quad \cdots (4)$$

$$y_0 = y_1 - \Delta y \quad \cdots (5)$$

[0058] Δx and Δy can be determined in advance by using a positioning jig **24** described below, for example. Therefore, by applying image processing to an image containing one marker **20** to determine the coordinates (x_1, y_1) of the center **P1** thereof, it is possible to calculate the coordinates (x_0, y_0) of the center **P0** of the opening **2a**, i.e., the position of the center of the pouring cup **1g**.

[0059] Next, with reference to FIG. **6** to FIG. **11**, a specific construction of the marker(s) **20** will be described.

[0060] In an example shown in FIG. **6**, planar markers **20** are formed through application of a heat-resistant paint, or attaching sheets of heat-resistant material. In order to suitably recognize the markers **20**, the markers **20** are preferably white. The example shown in FIG. **6** has an advantage of being able to form the markers **20** easily. However, since the markers **20** are planar (i.e., having substantially zero thickness), the markers **20** are likely to be soiled by spills of melt in the example shown in FIG. **6**.

[0061] In an example shown in FIG. **7**, the markers **20** are cylindrical marker pieces which are made of a heat-resistant material (e.g. iron). The example shown in FIG. **7** has an advantage in the markers **20** are less likely to be soiled by spills of melt. Although the height (thickness) of the markers **20** in the form of marker pieces is not particularly limited, it is preferably 25 mm or more from the standpoint of unlikeliness of soiling.

[0062] FIGS. **8(a)** and **(b)** are an upper plan view and a perspective view showing an example of more detailed construction of a marker **20** in the form of a marker piece. In order to enable suitable recognition of the marker **20**, it is preferable that the marker **20** has a white upper face 20u, and that the marker **20** has a matte-black side face **20s**. The marker **20** has a diameter **d1** of e.g. 30 mm. The marker **20** has a height **h1** of e.g. 30 mm. As shown in FIGS. **8(a)** and **(b)**, the marker **20** is attached to the weight **2** with a bolt 21, for example.

[0063] In the example shown in FIG. **9**, a protection member **22** is provided so as to surround each marker **20**. Herein, a cylindrical protection member **22** is disposed on the outside of each cylindrical marker **20**. The protection member **22** is made of a heat-resistant material (e.g. iron). In the example shown in FIG. **8**, the protection member **22** prevents spills of melt from sticking to the markers **20**, thus better preventing soiling of the marker **20** by spills of melt.

[0064] FIGS. **10(a)** and **(b)** are an upper plan view and a side view showing an example of more detailed construction of the protection member **22**. In order to enable suitable recognition of the marker **20**, it is preferable that the entire protection member **22** is matte black. In the example shown in FIGS. **10(a)** and **(b)**, the protection member **22** includes a cylindrical base portion **22a** and a semicylindrical collar portion **22b** provided on the base portion **22a**. The protection member **22** is to be disposed so that the collar portion **22b** is located on the side of the marker **20** facing the pouring cup **1g** (i.e., facing the opening **2a**). The base portion **22a** has an outer diameter **d2** of e.g. 70 mm, and the collar portion **22b** has an inner diameter **d3** of e.g. 48 mm. The base portion **22a** has a height **h2** of e.g. 25 mm, and the collar portion **22b** has a height **h3** of e.g. 10 mm.

[0065] Although the coloration of the marker **20** and the protection member **22a** is not limited to the above example, the coloration is preferably one that maximizes the contrast between the marker **20** (or the upper face **20u** of the marker **20**) and its surroundings.

[0066] FIG. **6** to FIG. **10** show cases where the shape of each marker **20** (i.e., a planar shape of the marker 20) appears circular when viewed in the direction of image capturing (i.e., parallel to the center axis of the opening **2**); however, the planar shape of the marker **20** is not limited to circular, but may be any arbitrary shape. For example, as shown in FIG. **11**, the planar shape of the marker **20** may be rectangular. FIG. **11** shows an example where marker pieces which are shaped in quadrangular prisms are provided as markers **20**. Even if the markers **20** have a planar shape other than a circular shape, the center position of the opening **2a** can be calculated by extracting the centroid point, or an edge, of the marker **20**.

[0067] Moreover, the positions of the markers **20** on the weight **2** are not limited to those shown in the figures above. The markers **20** may be disposed at arbitrary positions **20P** on the weight **2** as shown in FIG. **12**, for example. However, preferably all disposed markers **20** are capable of being imaged through a single capturing.

[0068] Now, an exemplary method of positioning the markers **20** relative to the pouring cup **1g** will be described. The markers **20** can be positioned relative to the pouring cup **1g** by using a positioning jig **24** shown in FIG. **13**, for example. The positioning jig **24** has at least one (e.g., plural as shown herein) opening formed in a predetermined position(s). In the example shown in FIG. **13**, the positioning jig **24** has a first opening **24a** corresponding to the opening **2a** of the weight **2** and a second opening **24b** corresponding to a marker **20**.

[0069] FIGS. **14(a)** and **(b)**and FIGS. **15(a)** and **(b)** are diagrams showing a positioning method using the positioning jig **24**. First, as shown in FIG. **14(a)**, a plug (lid) **26** made of resin is fitted in the opening **2a** of the weight **2**. Herein, since the opening **2a** is circular, the plug **26** has a disk shape. Next, as shown in FIG. **14(b)**, the positioning jig **24** is placed on the weight **2** so that the first opening **24a** fits around the plug **26**.

[0070] Then, as shown in FIG. **15(a)**, the marker **20** is fitted in the second opening **24b** of the positioning jig **24**, and fixed with the bolt **21**. This produces a weight **2**, as shown in FIG. **15(b)**, having a marker **20** attached thereon which is positioned relative to the opening **2a** (i.e., relative to the pouring cup **1g**).

[0071] Use of the positioning jig **24** facilitates positioning of the marker **20** with respect to a plurality of molds **1** (i.e., a plurality of weights **2**). Note that the plug **26** can also be used for calibrating the position of the opening **2a** of the weight **2**. From an image which is captured with the imager **12** while the positioning jig **24** is placed on the weight **2** (i.e., on the mold **M**), coordinates (x_0, y_0) of the center **P0** of the opening **2a** can be determined, and by using these resultant (x_0, y_0), the aforementioned R, α, Δx, Δy can be obtained.

[0072] In the illustrated construction, the positioning jig **24** itself is positioned relative to the weight **2** by the plug **26**; however, the positioning jig **24** may be positioned relative to the weight **2** (or the mold **M**) by means of any structure, including constructions other than the illustrated construction. Therefore, the positioning jig **24** does not need to have an opening formed corresponding to the opening **2a** of the weight **2**, and may at least have an opening(s) which is formed corresponding to the marker(s) **20**. Therefore, in the case where there is one marker **20**, only one opening may be formed.

[0073] The markers **20** does not need to be provided on the weight **2** so long as they are positioned relative to the pouring cup **1g**. For example, as shown in FIG. **16**, the markers **20** may be provided at arbitrary positions **20P** on the metal flask (flask) **1F** of the mold **M**.

[0074] FIGS. **17(a)** and **(b)** show an example of specific construction of the imager **12**. FIGS. **17(a)** and **(b)** are a side view and a lower plan view schematically showing the imager **12**.

[0075] As shown in FIG. **17(a)**, the imager **12** is connected to a communication cable **13**, so that an image which is captured by the imager **12** is output to the calculation section **14** via the communication cable **13**. Moreover, a dust cover **15** and a light-shielding cover **16** are attached on the imager **12**. The dust cover **15** prevents dust from attaching to a lens **12a** of the imager **12**.

[0076] The light-shielding cover **16** restricts light that enters the imager **12**. Herein, as shown in FIG. **17(b)**, the light-shielding cover **16** is disposed so as to partially cover the lens **12a** when the imager **12** is viewed from below. The light-shielding cover **16** restrains light sources around the imager **12** from exerting unfavorable influences (disturbance) on image capturing.

[0077] As described above, with the pouring cup position detection system **100** of the present embodiment, the position of the pouring cup **1g** of the mold **M** can be detected accurately. The pouring cup position detection system **100** can be suitably used for a casting apparatus.

[0078] FIG. **18** shows a casting apparatus **200** including the pouring cup position detection system **100**. FIG. **18** is a block diagram schematically showing the casting apparatus **200**.

[0079] As shown in FIG. **18**, the casting apparatus **200** includes the pouring cup position detection system **100**, a pouring machine **110**, and a pressurizing device **120**. The casting apparatus **200** further includes a control device **130**.

[0080] The pouring machine **110** pours melt into the mold **M** through the pouring cup **1g**. There is no particular limitation as to the construction of the pouring machine **110**. Various types of pouring machines can be used as the pouring machine **110**, e.g., an automatic pouring machine of the type that tilts a ladle. A ladle-tilting type automatic pouring machine includes a ladle, a ladle tilting mechanism for tilting the ladle, and the like.

[0081] To the mold **M** into which the melt has been poured, the pressurizing device **120** feeds at least particulate matter through the pouring cup **1g**. The pressurizing device **120** includes a nozzle portion which sends out particulate matter, a moving mechanism which moves the nozzle portion, and a particulate matter supplier which supplies the particulate matter to the nozzle portion. The particulate matter is made of a heat-resistant material, and may be sand or steel balls, for example. Typically, the pressurizing device **120** blows the particulate matter into the mold **M** through the pouring cup **1g** together with a gas (e.g., compressed air).

[0082] The control device **130** controls the operating timing, amount of motion, and the like of the pouring machine **110** and the pressurizing device **120**. The control device **130** is able to perform the aforementioned control based on information which is output from the image processing device **10**. The control device **130** is, for example, a programmable logic controller (PLC).

[0083] Because of having the pressurizing device **120**, the casting apparatus **200** is able to reduce the amount of melt to be poured into the mold **M**. This improves the pouring yield, and simplifies the processing work after the casting is released.

[0084] Note that the feeding of particulate matter by the pressurizing device **120** is to take place promptly after the melt is poured into the mold **M**. However, if the pouring cup **1g** is imaged immediately after the melt has been poured, the very bright melt may make it difficult to precisely recognize the shape of the pouring cup **1g**. However, in the casting apparatus **200**, the pressurizing device **120** carries out feeding of the particulate matter (i.e., blowing of the gas and particulate matter) based on the information concerning the position of the pouring cup **1g** which is generated by the image processing device **10** (i.e., the position of the pouring cup **1g** which is detected as relative position based on the position(s) of the marker(s) **20**). Therefore, the nozzle portion can be accurately located above the pouring cup **1g**, thus to suitably perform feeding of the particulate matter. It also prevents the nozzle portion from breaking by interfering with the metal flask (flask) **1F** or the weight **2** of the mold **M**.

[0085] Now, with reference to FIG. **19**, an example of specific construction of the pressurizing device **120** will be described. In the example shown in FIG. **19**, the pressurizing device **120** includes a nozzle portion **121**, a moving mechanism **122**, and a particulate matter supplier **123**.

[0086] The nozzle portion **121** is a portion which blows out (sends out) the gas and particulate matter **129** into the pouring cup **1g** of the mold **M**.

[0087] The moving mechanism **122** is able to move the nozzle portion **121**. Specifically, the moving mechanism **122** is able to move the nozzle portion **121** along the right-left direction (i.e., a parallel direction to the direction of conveyance **D1** of the mold **M**), the front-rear direction (i.e., an orthogonal direction to the direction of conveyance **D1**) and the top-bottom direction. There is no particular limitation as to the specific construction of the moving mechanism **122** so long as it is capable of moving the nozzle portion **121** in the aforementioned manners; for example, servo motors for enabling movement along each of the right-left direction, the front-rear direction, and the top-bottom direction are encompassed.

[0088] The particulate matter supplier **123** supplies the particulate matter **129** to the nozzle portion **121**. The particulate matter supplier **123** includes a particulate matter tank **124** which holds the particulate matter **129**, a particulate matter feed pipe **125** through which the particulate matter tank **124** and the nozzle portion **121** are allowed to communicate, and an open-close slide member **126** which is provided between the particulate matter tank **124** and the particulate matter feed pipe **125**. The particulate matter supplier **123** further includes a gas feed pipe **127** which is connected to the particulate matter feed pipe **125**, and an open-close valve **128** which is attached to the gas feed pipe **127**.

[0089] As already described, because of having the pressurizing device **120**, the casting apparatus **200** is able to reduce the amount of melt to be poured into the mold **M**.

[0090] Generally speaking, the cavity of a mold is composed of a sprue, runners, risers, and a product portion (see FIG. **2**). When producing a casting, the melt is poured not only into the product portion, but also into the sprue, runners, and risers. Once the melt completes its solidification as the mold is cooled after melt pouring, the mold is broken apart in order to release the casting. At this time, the portion corresponding to the product portion is isolated and subjected to finishing, thus becoming a final product. The portions corresponding to the sprue, runners, and risers are redissolved as return material. Thus, pouring of the melt elsewhere other than the product portion (i.e., the region of the cavity that corresponds to the actual product) has been a cause for a low pouring yield. Moreover, such excess pouring has also been a cause for increased processing work after the casting is released from the mold.

[0091] In contrast to this, since the pressurizing device **120** feeds at least the particulate matter **129** into the mold **M** through the pouring cup **1g** after the melt has been poured, the amount of melt to be poured into the sprue **1a** and the runners **1b** can be reduced. This improves the pouring yield, and simplifies the processing work after the casting is released.

[0092] Hereinafter, with reference to FIG. **20** to FIG. **23**, an operation of the pressurizing device **120** will be described.

[0093] FIG. **20** shows a state immediately after melt **m** has been poured into the mold **M** (main mold body **1**) through the pouring cup **1g**. The volume of the poured melt **m** is smaller than the total volume of the cavity of the main mold body **1**, and substantially equal to the volume of the product portion **1d** and the risers **1c** (or, slightly greater than the volume of the product portion **1d** and the risers **1c**).

[0094] As shown in FIG. **21**, the nozzle portion **121** of the pressurizing device **120** is moved by the moving mechanism **122** (not shown in FIG. **21**) to over the pouring cup **1g** of the mold **M** which has finished pouring, and a gas **G** is blown from the nozzle portion **121** into the cavity of the main mold body **1**. Blowing of the gas **G** is performed by placing the open-close valve **128**, which is attached to the gas feed pipe **127**, in an open state. This pushes in the melt m so as to fill the product portion **1d** and the risers **1c**.

[0095] Next, as shown in FIG. **22**, the particulate matter **129** is fed into the cavity from the nozzle portion **121**. Feeding of the particulate matter **129** is performed by placing the open-close slide member **126**, which is provided between the particulate matter tank **124** and the particulate matter feed pipe **125**, in an open state. At this point, the open-close valve

128 also remains in an open state, so that the particulate matter **129** is blown in together with the gas **G**.

[0096] FIG. **23** shows a state where blowing of the particulate matter **129** has been completed. As shown in FIG. **23**, at this point, the uppermost portion of the melt **m** is at a higher position than is its rearmost portion; therefore, a flowing force acts on the melt **m** to restore the state shown in FIG. **20**, but its flow is restrained by the frictional force due to the particulate matter **129** that has been blown in (i.e., a frictional force within particulate matter **129** and a frictional force between the particulate matter **129** and the inner surface of the cavity).

[0097] Thus, by feeding the particulate matter **129** into the cavity with the pressurizing device **120**, the amount of melt to be poured into the sprue **1a** and runners **1b** can be reduced (substantially eliminated).

[0098] The above example illustrates that the feeding of the particulate matter **129** is performed after blowing the gas **G**; however, the gas **G** may be blown at the same time as feeding the particulate matter **129**, or after feeding the particulate matter **129**.

[0099] Instead of the construction involving blowing the particulate matter **129** into the cavity together with the gas **G**, a construction may be adopted such that the particulate matter **129** is pushed into the cavity by a pushing member (e.g., a rod of a pneumatic cylinder).

[0100] Next, a pouring cup position detection method and a method of producing a casting, as performed by the aforementioned pouring cup position detection system **100** and the casting apparatus **200**, will be described with reference to flowcharts.

[0101] FIG. **24** is a flowchart showing an exemplary pouring cup position detection method according to the present embodiment.

[0102] In the pouring cup position detection method according to the present embodiment, first, an image containing at least one marker **20** that is positioned relative to the pouring cup **1g** is captured (step **S1**). As will be seen from what has been described above, a more accurate detection of the position of the pouring cup **1g** at this step **S1** will be enabled by capturing an image containing a plurality of markers **20** (preferably three or more markers **20**).

[0103] Next, image processing is applied to the image which was acquired at step **S1** to generate information concerning the position of the pouring cup **1g** (step **S2**). In this manner, the position of the pouring cup **1g** of the mold M can be detected.

[0104] In the pouring cup position detection method according to the present embodiment, pouring cup position information is generated based on an image containing a marker(s) **20** that is positioned relative to the pouring cup **1g**; therefore, the position of the pouring cup **1g** can be detected as relative position with respect to the position(s) of the marker(s) **20**. This allows the position of the pouring cup **1g** to be accurately detected.

[0105] FIG. **25** is a flowchart showing another exemplary pouring cup position detection method according to the present embodiment.

[0106] In the example shown in FIG. **25**, before step **S1**, the positioning jig **24** is used to position at least one marker **20** relative to the pouring cup **1g** (step **S0**). As has been described with reference to FIG. **13**, at least one (e.g., plural, in the example shown in FIG. **13**) opening is formed at a predetermined position(s) of the positioning jig **24**. By using the positioning jig **24**, the marker(s) **20** can be easily positioned throughout a plurality of molds **M**.

[0107] FIG. **26** is a flowchart showing an exemplary method of producing a casting according to the present embodiment.

[0108] In the method of producing a casting according to the present embodiment, first, melt is poured into the mold **M** through the pouring cup **1g** (step **S11**). Next, information concerning the position of the pouring cup **1g** is generated (step **S12**). This step **S12** is executed by the aforementioned pouring cup position detection method.

[0109] Then, to the mold **M** into which the melt has been poured, at least particulate matter **129** is fed through the pouring cup **1g** (step **S13**). This step **S13** is executed based on the pouring cup position information generated at step **S12**. Thereafter, when the melt completes its solidification, mold breaking and finishing are carried out (step **S14**). Thus, a casting is produced.

[0110] The method of producing a casting according to the present embodiment includes step **S13** of feeding particulate matter **129** to the mold **M**, into which the melt has been poured, through the pouring cup **1g**. As a result, the amount of melt to be poured into the mold **M** can be reduced. Thus, the pouring yield is improved, and the processing work after the casting is released can be simplified. Moreover, since this step **S13** is performed based on information concerning the position of the pouring cup **1g** which is generated by the image processing device, feeding of the particulate matter **129** can be suitably performed.

[0111] Although the above description illustrates an example where feeding of the particulate matter **129** is performed based on pouring cup position information which is generated by the image processing device **10**, this is not the only example of control that is based on pouring cup position information. For example, melt pouring may be performed based on the pouring cup position information. Performing the melt pouring based on the pouring cup position information makes for more efficient or automated pouring work.

[0112] FIG. **27** is a flowchart showing a more detailed example of position detection for the pouring cup **1g**.

[0113] When the casting apparatus **200** moves to the position of a mold, the imager **12** captures an image containing the markers **20**, with an instruction from the control device **130** (step **S21**).

[0114] Next, markers **20** are extracted from within the captured image (step **S22**). Extraction of the marker **20** is performed by, for example, determining the color (brightness), shape, and size. At this time, any spills of melt (i.e., regions of largest brightness) within the image are excluded.

[0115] Then, from a pair of markers **20** (i.e., two markers **20**), the position of the pouring cup **1g** (or the center position of the opening **2a** of the weight **2**) is calculated (step **S23**). In doing this, an amount of translational motion of the position of the pouring cup **1g** is calculated from one marker **20** in the pair, whereas an amount of rotational motion of the position of the pouring cup **1g** is calculated from the other marker **20** (which is the technique described with reference to FIG. **4**). In the case where three or more markers **20** are provided, any two arbitrary markers **20** are selected, calculation is provided for each such pair, and a mean value and variance are determined.

[0116] Next, plausibility of the calculated position of the pouring cup **1g** (or the center position of the opening **2a** of the weight **2**) is determined (step **S24**). If the calculated position is not within the expected range, then it is deemed as a result of failure in the extraction of the markers **20** or movement of the casting apparatus **200**, and an error signal is output. In the case of three or more markers **20**, if the variance exceeds the expected range, an error signal may be output, or a mistake in the extraction of the markers **20** due to soiling of the markers **20** or the like may be recognized and only the calculation results for the pair(s) that can be deemed as having been correctly extracted may be used.

[0117] Then, a difference between the calculated position of the pouring cup **1g** (or the center position of the opening **2a** of the weight **2**) and the expected position is calculated (step **S25**). The result of calculation is output as a correction value to the control device **130**.

[0118] Next, the casting apparatus **200** moves based on the correction value, and a casting operation is performed (step **S26**).

[0119] Then, the value of the calculation result and the image are stored in computer file form (step **S27**). Thereafter, the casting apparatus **200** is moved to the position of a next mold. In this manner, detection of the position of the pouring cup **1g** and the subsequent casting operation can be executed.

INDUSTRIAL APPLICABILITY

[0120] According to embodiments of the present invention, a pouring cup position detection system and a pouring cup position detection method that can accurately detect the position of a pouring cup of a mold are provided. The pouring cup position detection system and pouring cup position detection method according to embodiments of the present invention can be broadly used in casting methods which perform gravity pouring.

REFERENCE SIGNS LIST

[0121]

M	mold
1	main mold body
1a	sprue
1b	runner
1c	riser
1d	product portion
1g	pouring cup
1F	flask (metal flask)
2	weight
2a	opening
10	image processing device
12	imager
13	communication cable
14	calculation section
15	dust cover
16	light-shielding cover
20	marker
20u	upper face of marker
20s	side face of marker
21	bolt
22	protection member
22a	base portion
22b	collar portion

24 positioning jig
24a first opening
24b second opening
26 plug
100 pouring cup position detection system
110 pouring machine
120 pressurizing device
121 nozzle portion
122 moving mechanism
123 particulate matter supplier
124 particulate matter tank
125 particulate matter feed pipe
126 open-close slide member
127 gas feed pipe
128 open-close valve
129 particulate matter
130 control device
200 casting apparatus

Claims

1. A pouring cup position detection system for detecting a position of a pouring cup of a mold, the pouring cup position detection system comprising:

   an image processing device including an imager which moves relative to the mold; and
   at least one marker provided on the mold and positioned relative to the pouring cup, wherein,
   the imager captures an image containing the at least one marker; and
   the image processing device generates information concerning the position of the pouring cup based on the image captured by the imager.

2. The pouring cup position detection system of claim 1, wherein the at least one marker comprises a plurality of markers.

3. The pouring cup position detection system of claim 2, wherein the plurality of markers comprise three or more markers.

4. The pouring cup position detection system of any of claims 1 to 3, wherein the at least one marker is each a marker piece made of a heat-resistant material.

5. The pouring cup position detection system of any of claims 1 to 4, further comprising a protection member surrounding each of the at least one marker.

6. The pouring cup position detection system of any of claims 1 to 5, further comprising a light-shielding cover attached to the imager to restrict light entering the imager.

7. The pouring cup position detection system of any of claims 1 to 6, wherein,
   the mold includes a main mold body having the pouring cup formed therein, and a weight to be placed on the main mold body so as to be clear of the pouring cup in planar perspective; and
   the at least one marker is provided on the weight.

8. The pouring cup position detection system of any of claims 1 to 6, wherein,
   the mold includes a flask and a main mold body, the main mold body having the pouring cup formed therein and being situated in the flask; and
   the at least one marker is provided on the flask.

9. A casting apparatus comprising:

   the pouring cup position detection system of any of claims 1 to 8;
   a pouring machine to pour melt into the mold through the pouring cup; and

a pressurizing device to feed at least particulate matter, through the pouring cup, to the mold into which the melt has been poured.

10. The casting apparatus of claim 9, wherein the pressurizing device feeds the particulate matter based on the information concerning the position of the pouring cup generated by the image processing device.

11. A pouring cup position detection method for detecting a position of a pouring cup of a mold, comprising:

step (a) of capturing an image containing at least one marker provided on the mold and positioned relative to the pouring cup; and
step (b) of generating information concerning the position of the pouring cup based on the image captured at step (a).

12. The pouring cup position detection method of claim 11, further comprising step (c) of positioning the at least one marker relative to the pouring cup by using a positioning jig, the positioning jig having at least one opening formed in a predetermined position or positions.

13. A method of producing a casting, comprising:

step (A) of pouring melt into a mold through a pouring cup; and
and step (B) of generating information concerning the position of the pouring cup by the pouring cup position detection method of claim 11 or 12.

14. The method of producing a casting of claim 13, further comprising step (C) of feeding at least particulate matter, through the pouring cup, to the mold into which the melt has been poured, step (C) being executed based on the information concerning the position of the pouring cup generated at step (B).

FIG.1

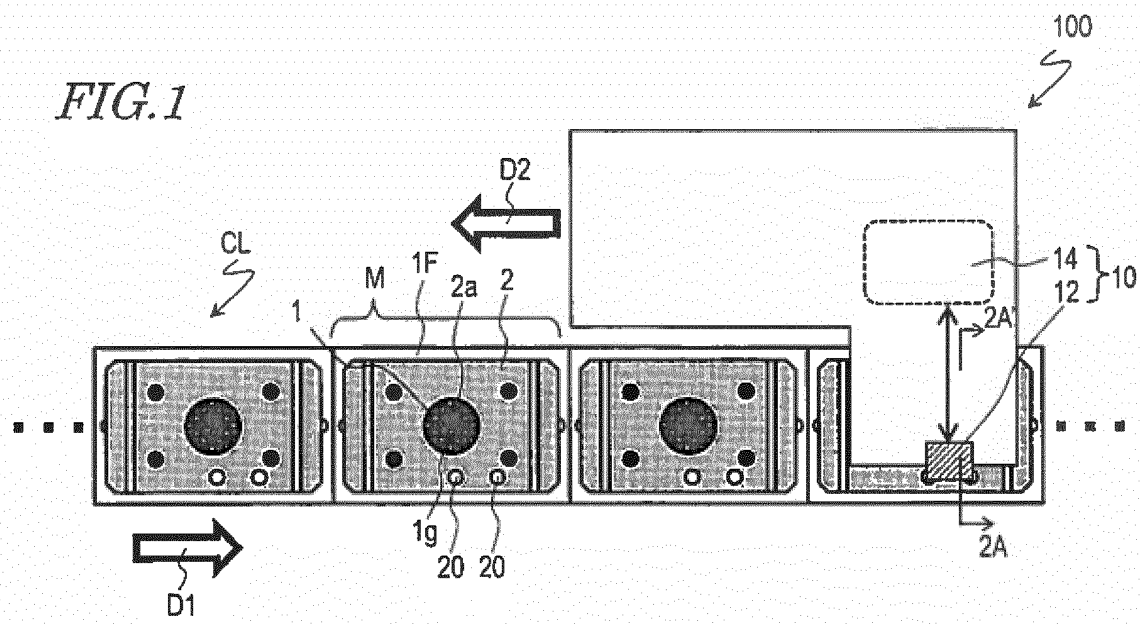


FIG.2

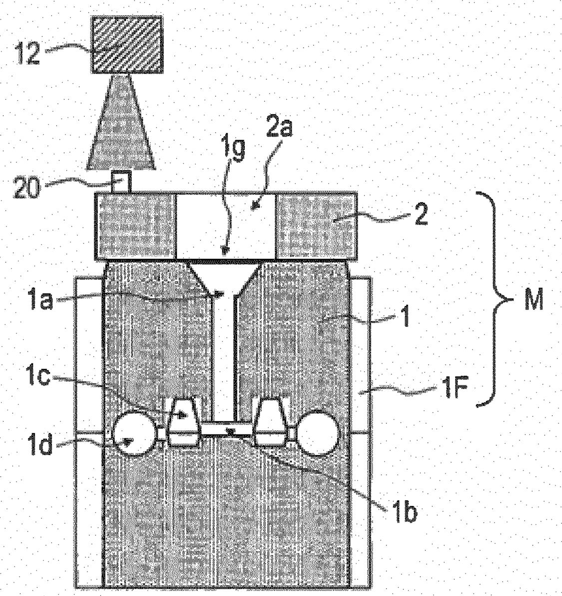


FIG.3

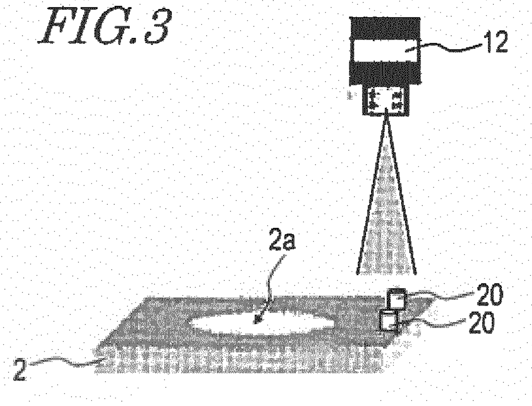


FIG.4

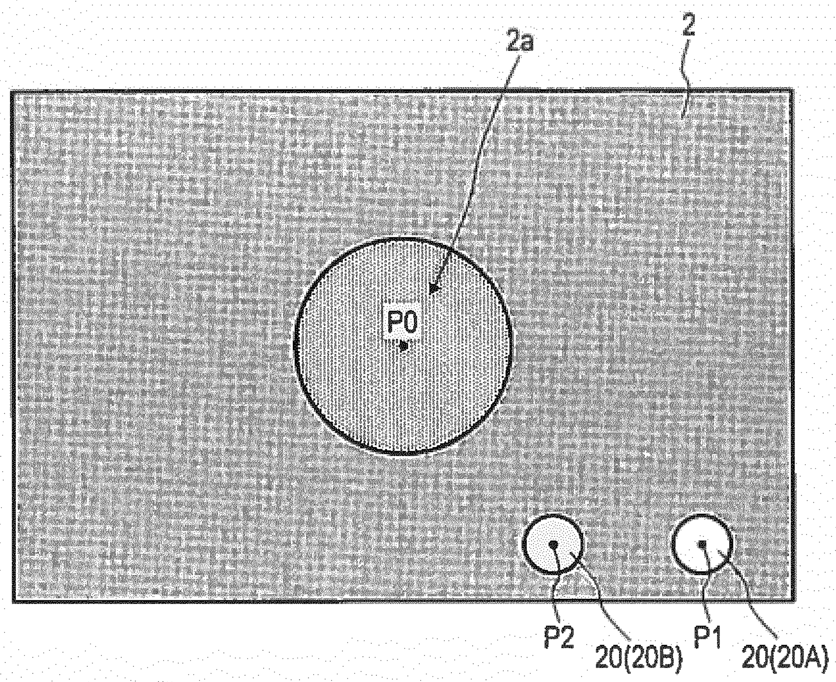


FIG.5

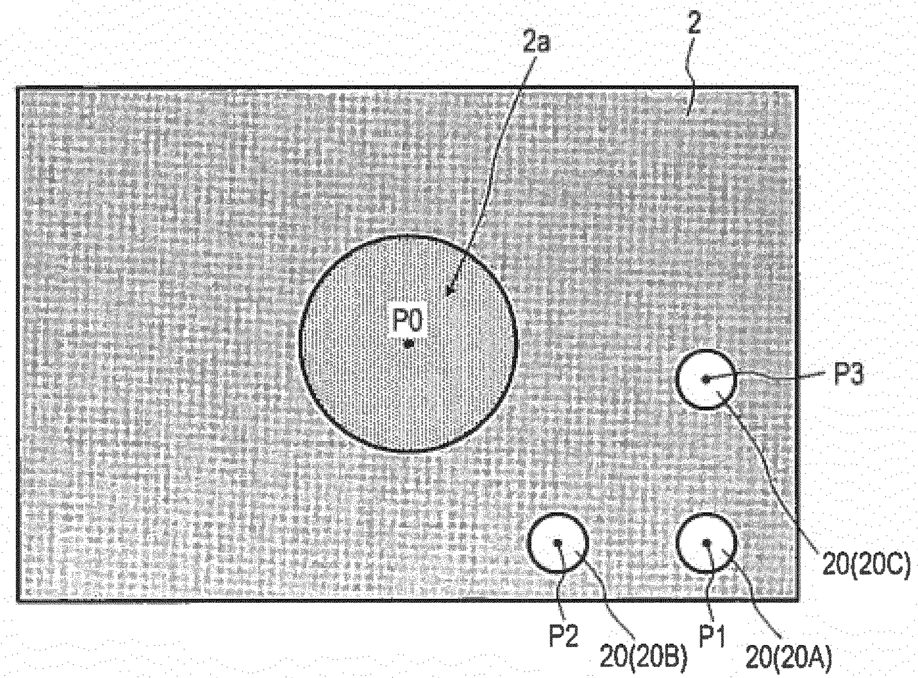


FIG.6

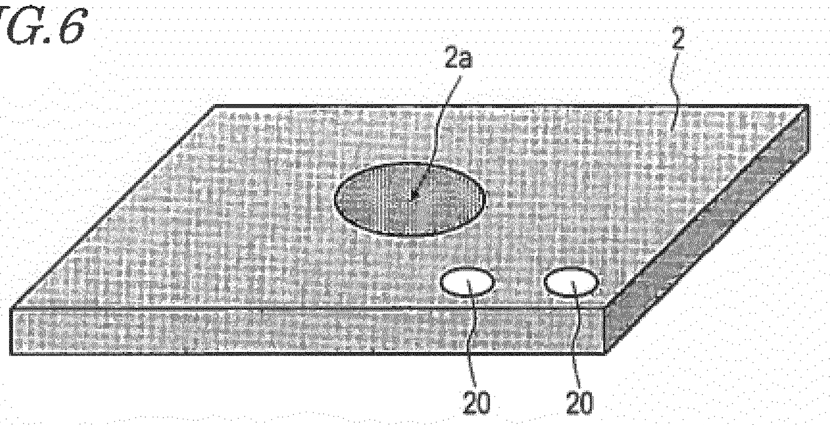


FIG.7

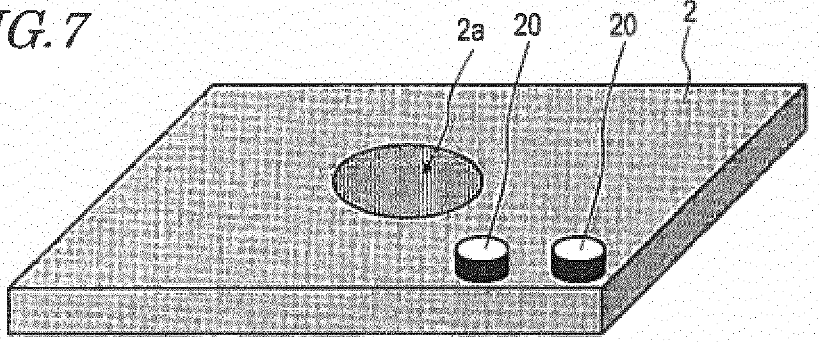


FIG.8

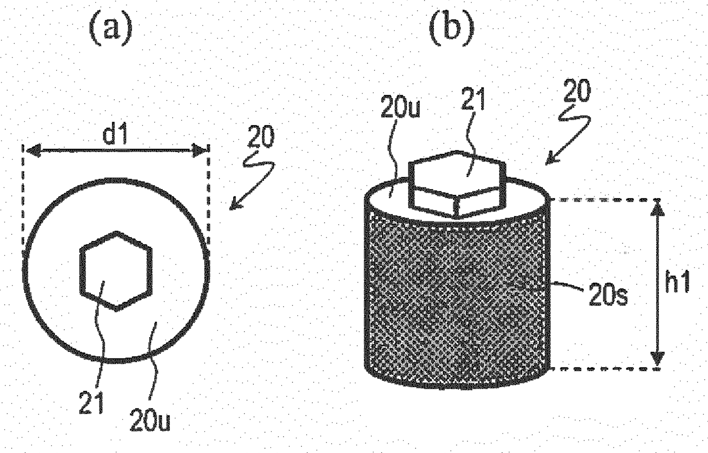


FIG.9

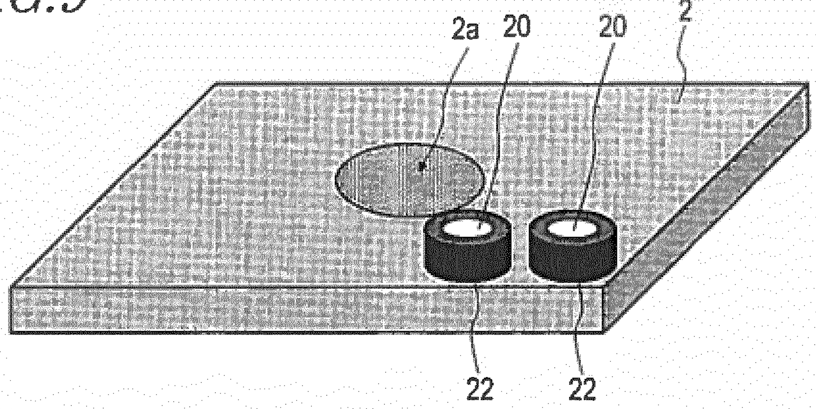


FIG.10

(a)

(b)

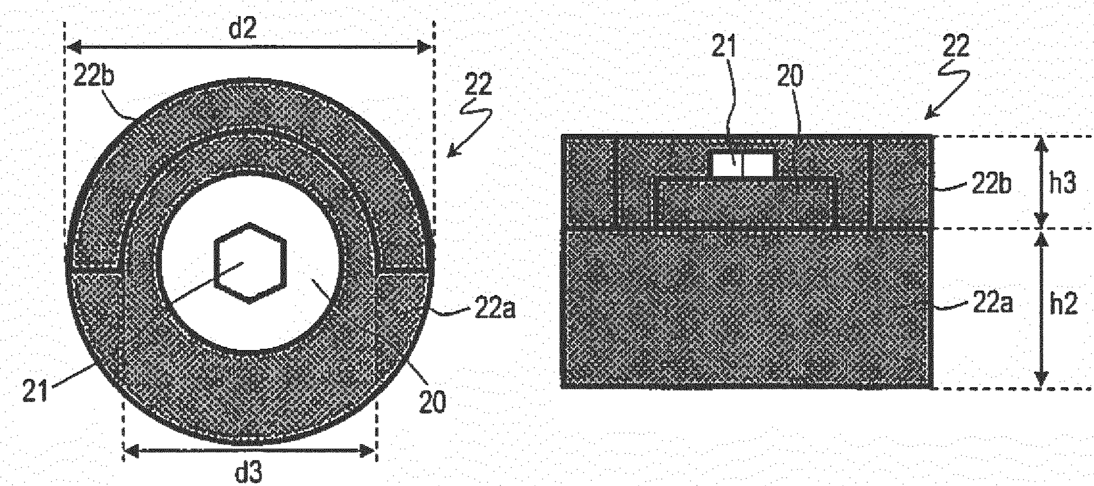


FIG.11

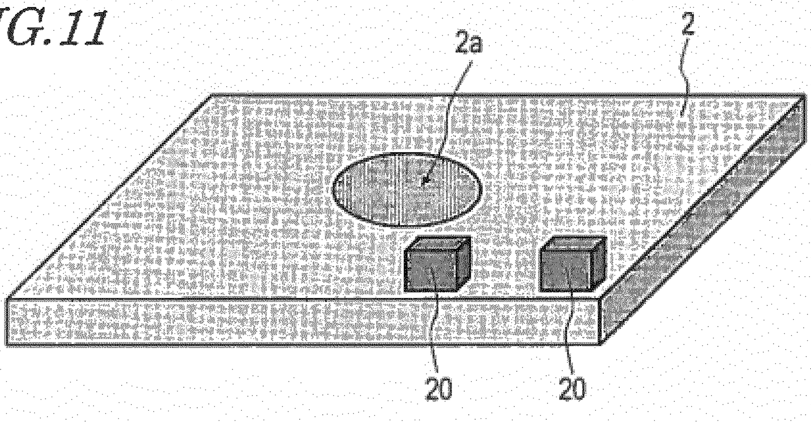


FIG.12

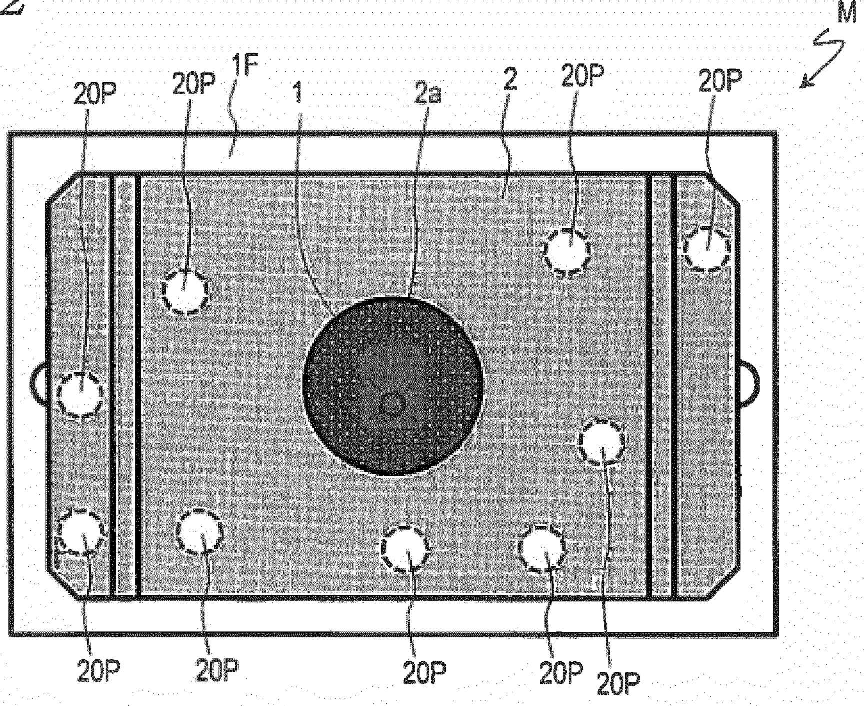

M
20P
20P
1F
1
2a
2
20P
20P
20P
20P
20P
20P
20P
20P
20P

FIG.13

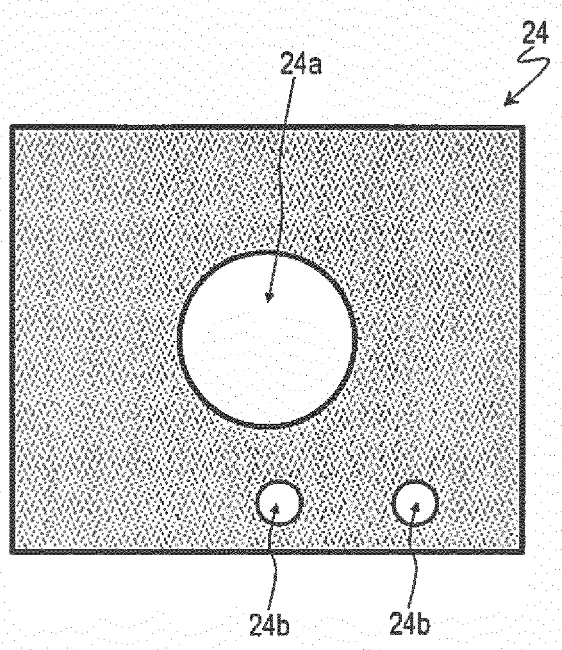
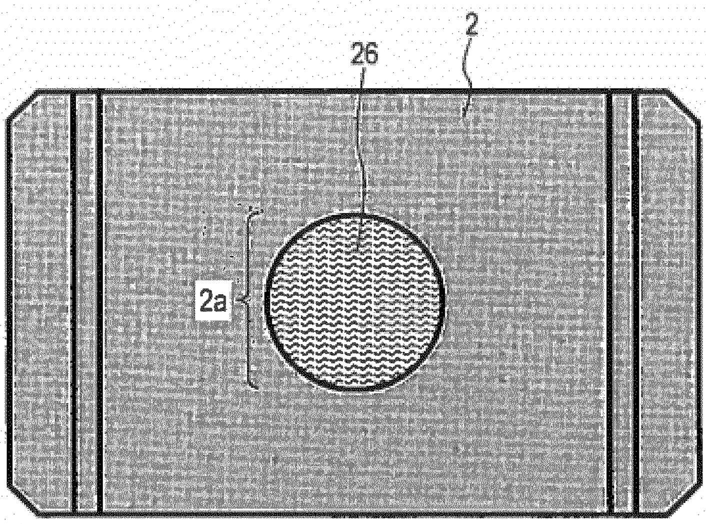

24
24a
24b
24b

FIG.14

(a)



(b)

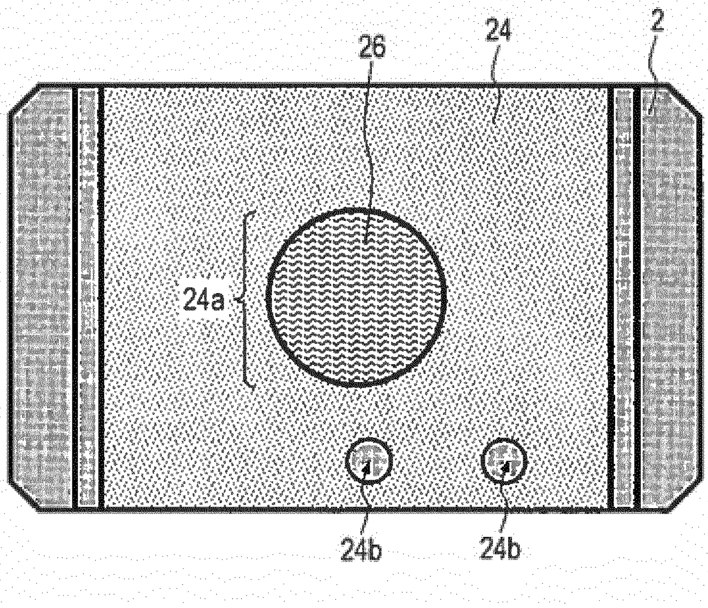
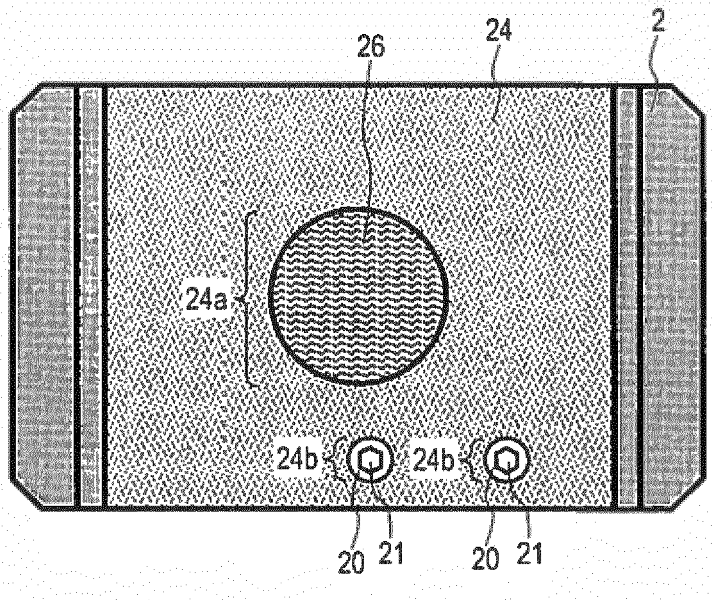


FIG.15

(a)



(b)

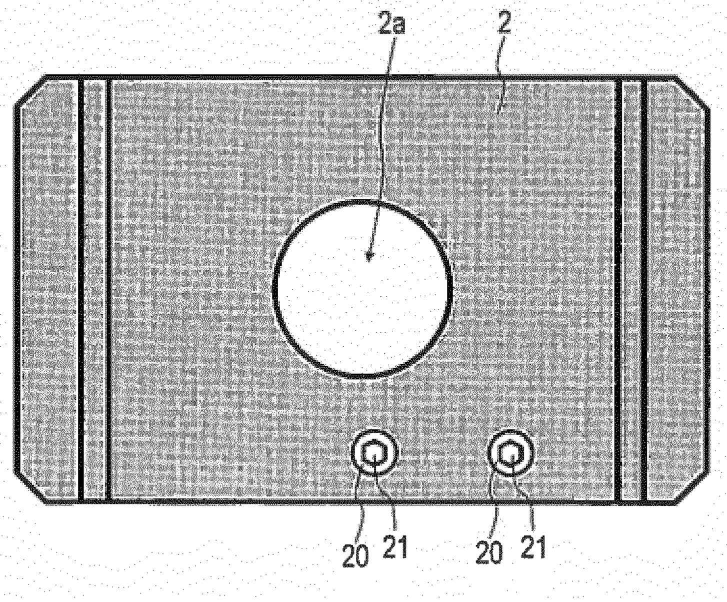


FIG.16

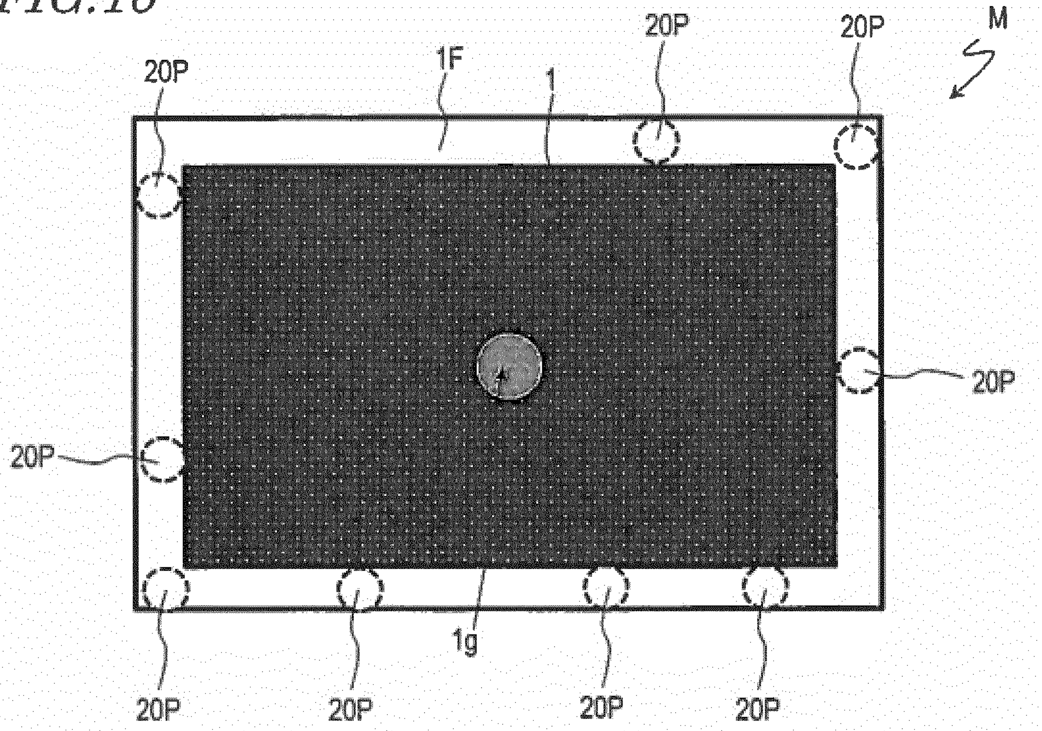

20P
20P
20P
M
1F
1
20P
20P
1g
20P
20P
20P
20P

FIG.17

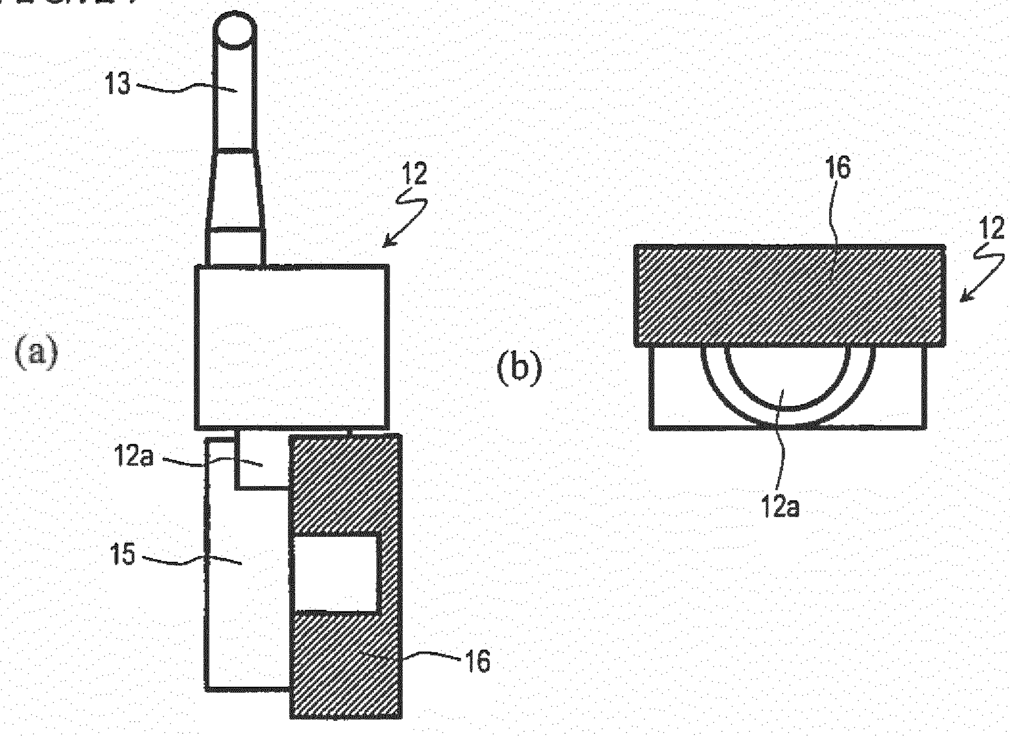

13
12
(a)
12a
15
16
(b)
16
12
12a

FIG.18

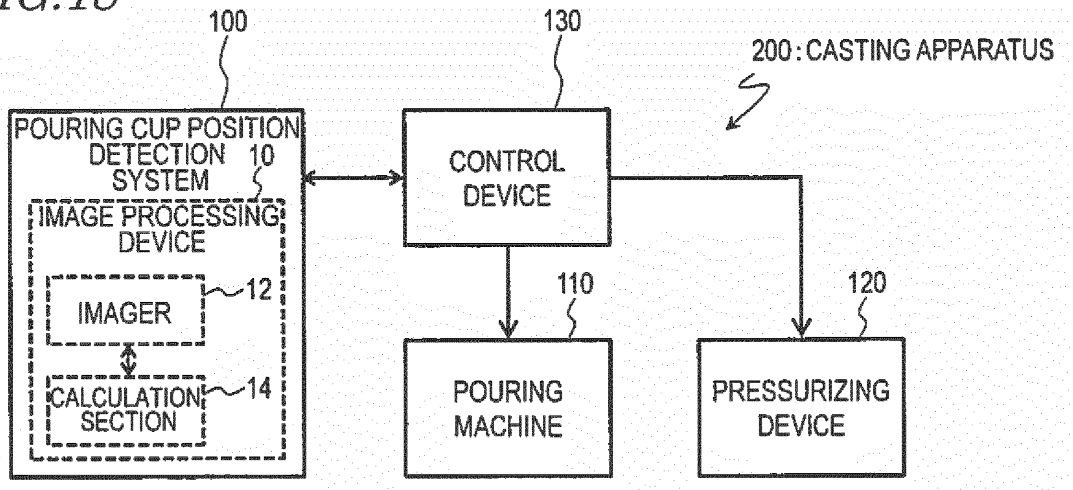


FIG.19

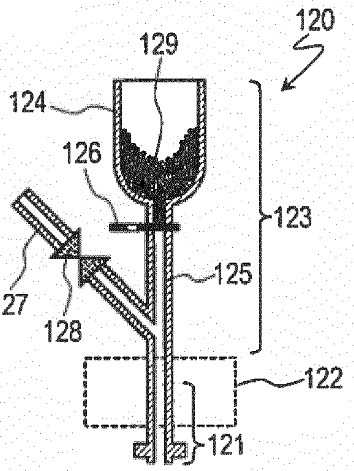


FIG.20

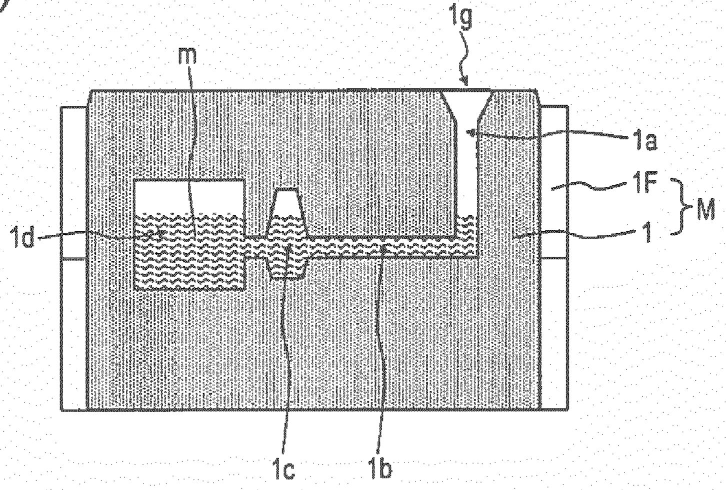


FIG.21

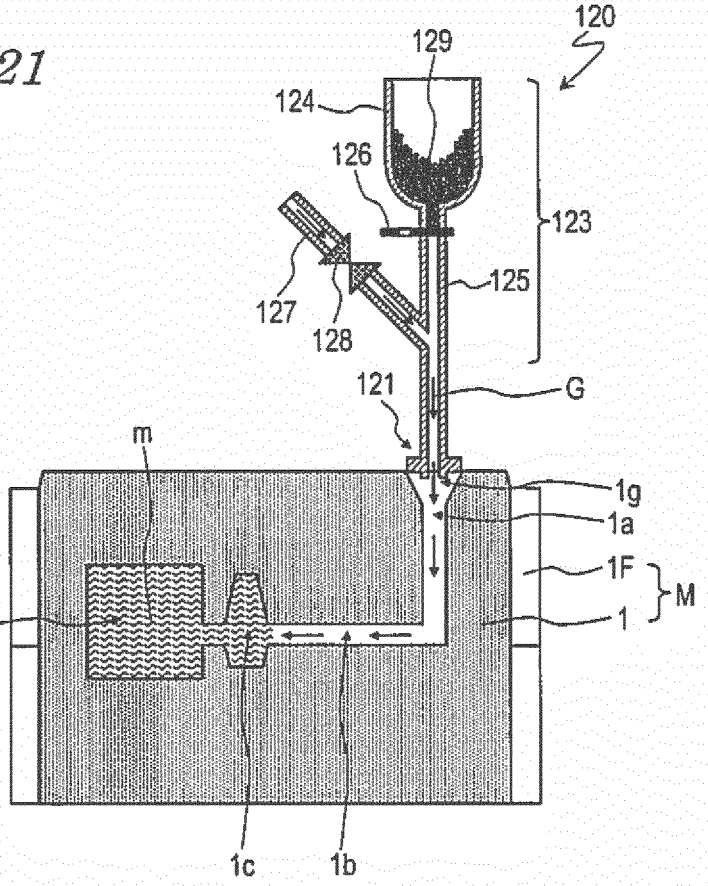


FIG.22

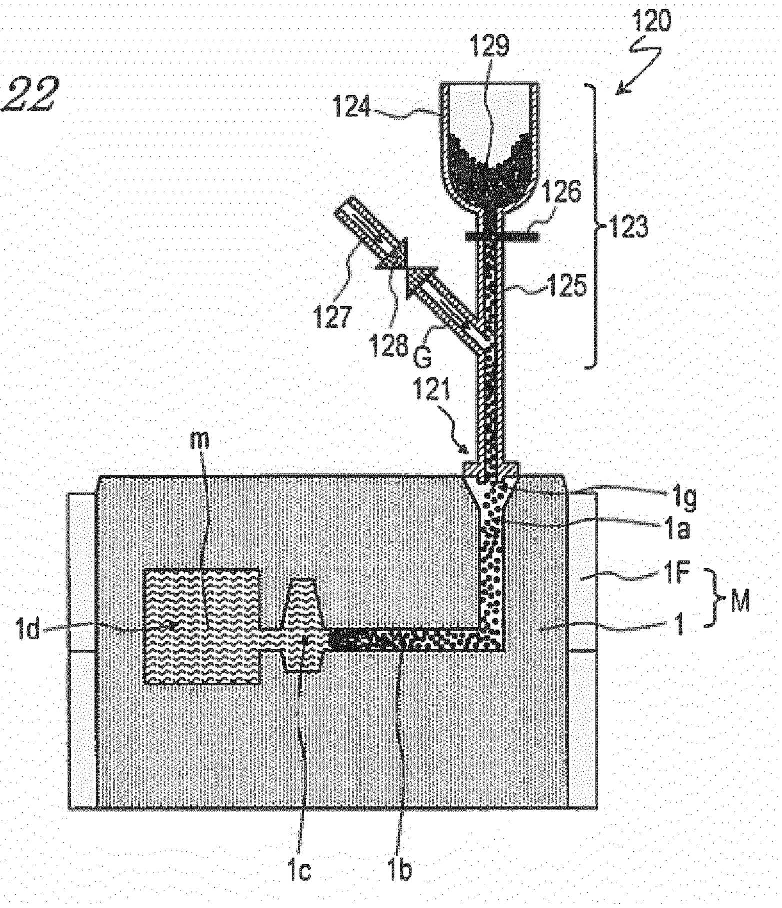


FIG.23

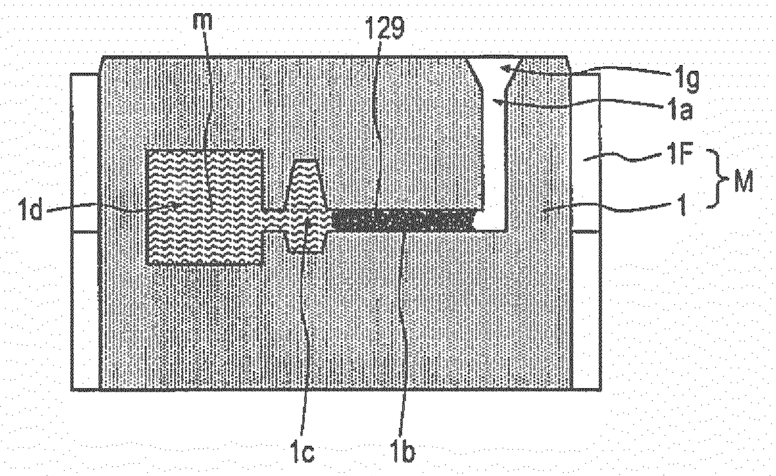

m
129
1g
1a
1F
M
1
1d
1c
1b

FIG.24

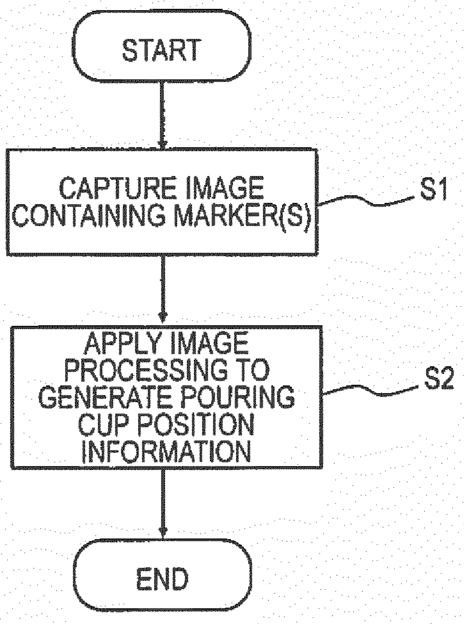

START
CAPTURE IMAGE CONTAINING MARKER(S)
S1
APPLY IMAGE PROCESSING TO GENERATE POURING CUP POSITION INFORMATION
S2
END

FIG.25

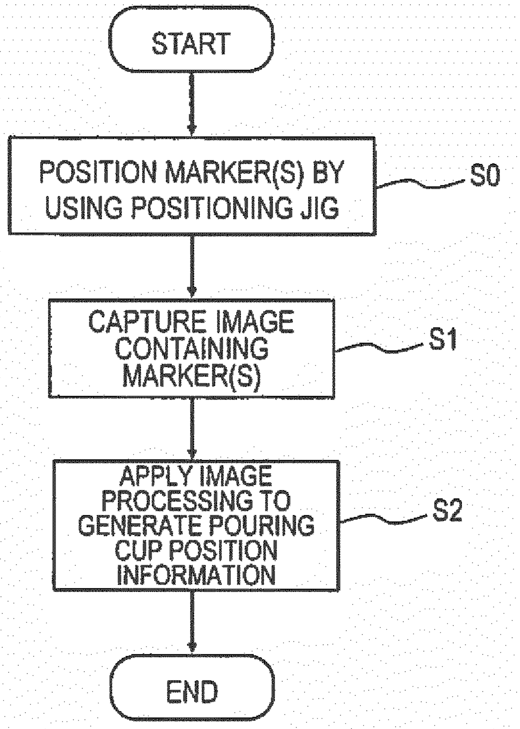

START
POSITION MARKER(S) BY USING POSITIONING JIG
S0
CAPTURE IMAGE CONTAINING MARKER(S)
S1
APPLY IMAGE PROCESSING TO GENERATE POURING CUP POSITION INFORMATION
S2
END

FIG.26

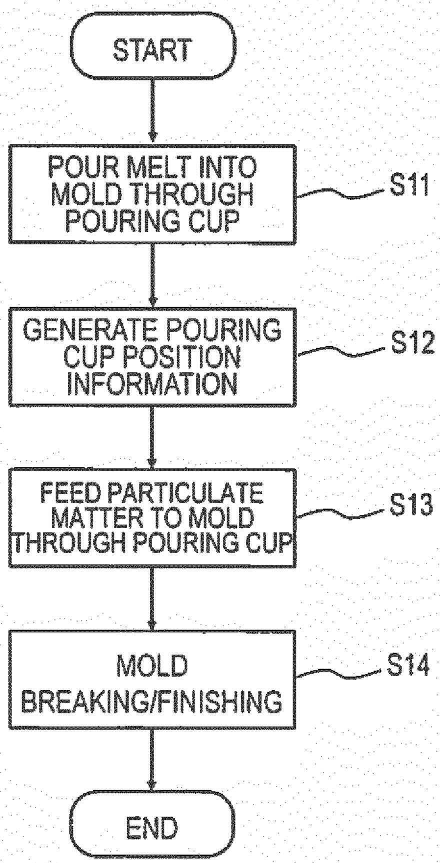
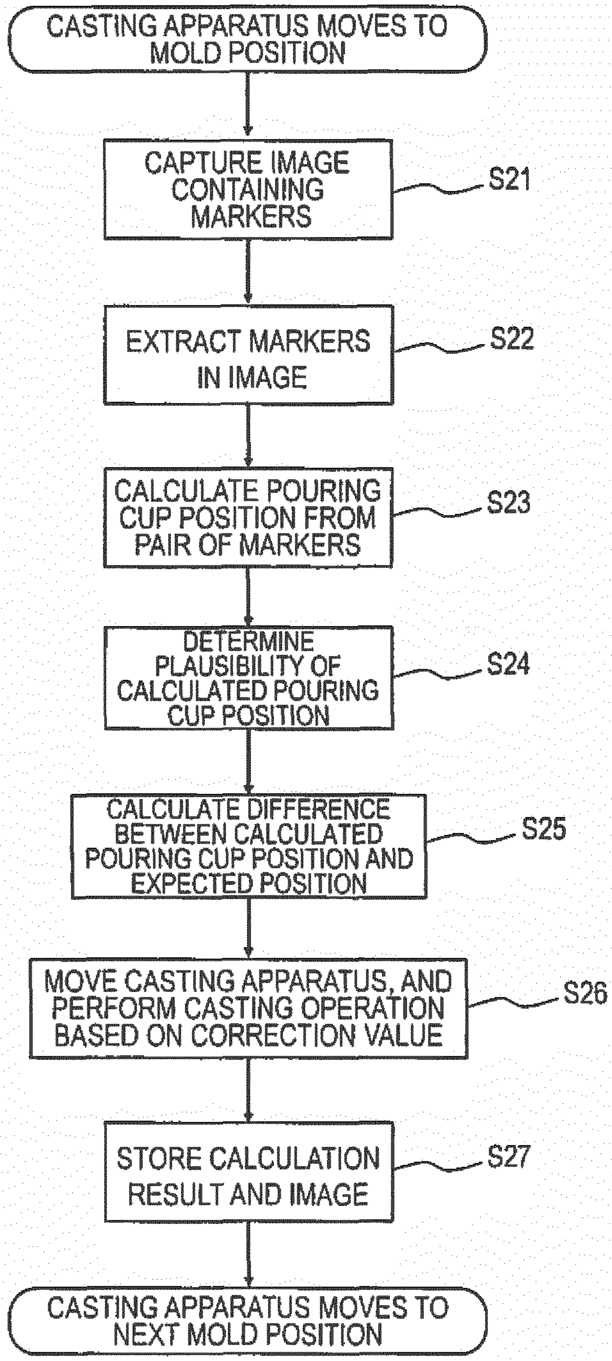

START
POUR MELT INTO MOLD THROUGH POURING CUP
S11
GENERATE POURING CUP POSITION INFORMATION
S12
FEED PARTICULATE MATTER TO MOLD THROUGH POURING CUP
S13
MOLD BREAKING/FINISHING
S14
END

FIG.27


CASTING APPARATUS MOVES TO MOLD POSITION
CAPTURE IMAGE CONTAINING MARKERS
S21
EXTRACT MARKERS IN IMAGE
S22
CALCULATE POURING CUP POSITION FROM PAIR OF MARKERS
S23
DETERMINE PLAUSIBILITY OF CALCULATED POURING CUP POSITION
S24
CALCULATE DIFFERENCE BETWEEN CALCULATED POURING CUP POSITION AND EXPECTED POSITION
S25
MOVE CASTING APPARATUS, AND PERFORM CASTING OPERATION BASED ON CORRECTION VALUE
S26
STORE CALCULATION RESULT AND IMAGE
S27
CASTING APPARATUS MOVES TO NEXT MOLD POSITION

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2015/069905

A. CLASSIFICATION OF SUBJECT MATTER

B22D35/04(2006.01)i, *B22C9/08*(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)

B22D35/04, B22C9/08

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	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

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 4-305358 A (Hitachi Metals, Ltd.), 28 October 1992 (28.10.1992), (Family: none)	1-14
A	JP 54-096434 A (Kobe Steel, Ltd.), 30 July 1979 (30.07.1979), (Family: none)	1-14

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

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 July 2015 (23.07.15)	04 August 2015 (04.08.15)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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

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Patent documents cited in the description

- JP 9225625 A **[0004]**