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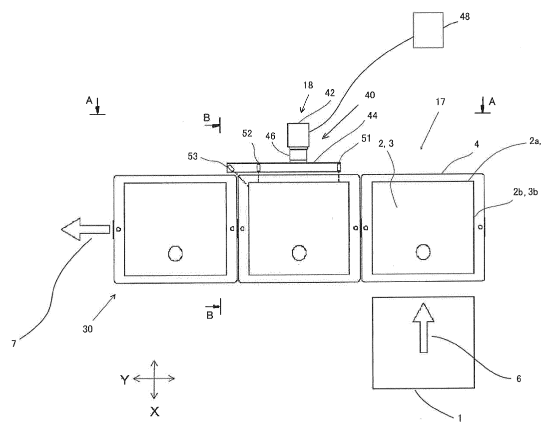
(54) **MOLD DISPLACEMENT DETECTING DEVICE AND MOLD DISPLACEMENT DETECTING METHOD FOR UPPER AND LOWER MOLDS**

(57) To provide a device and a method for detecting, before pouring starts, any misalignment between a cope and a drag that have been molded by a flaskless molding machine and then assembled. The device (40) that can detect any misalignment between the cope (2) and the drag (3) that have been molded by the flaskless molding machine (1) and then assembled and that are being transported to the position for pouring comprises a plurality of means (51), (52), (53) for measuring distances to the cope and the drag that measures the distances (S11), (S12), (S13), (S21), (S22), (S23) to the cope and the drag, and a means (48) for calculating a degree of a misalignment between the cope and the drag on a basis of the distances to the cope and the drag that have been measured by the means for measuring distances to the cope and the drag.

Fig. 1



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Description

Technical Field

[0001] The present invention relates to a device and a method that can detect any misalignment between a cope and a drag that have been manufactured by means of a flaskless molding machine and that have then been assembled.

Background Art

[0002] Conventionally, a method has been known by which a cope and a drag that have been manufactured by means of a flaskless molding machine and that have then been assembled are transported and are covered with a jacket to have a weight put on them (for example, see Japanese Utility Model Publication No. H6-61363).

[0003] However, in the cope and the drag that have been manufactured by means of a flaskless molding machine and that have then been assembled, a misalignment between the cope and the drag may occur while being transported or covered with the jacket. If molten metal is poured into the cope and the drag in which a misalignment occurs, a product will have a defect. This is a problem.

[0004] The present invention has been developed to solve this problem. The objective of it is to provide a device and a method that can detect, before pouring starts, any misalignment between a cope and a drag that have been manufactured by means of a flaskless molding machine and that have then been assembled.

Disclosure of Invention

[0005] To achieve the above-mentioned objective, a device that can detect any misalignment between a cope and a drag of a first aspect of the present invention is, as shown in Figs. 1, 2, and 3, for example, a device 40 that can detect any misalignment between a cope 2 and a drag 3 that have been manufactured by means of a flaskless molding machine 1 and assembled and that are being transported to a position for pouring. The device 40 comprises a plurality of means 51, 52, and 53 for measuring distances to the cope and the drag that measure distances to the cope 2 and the drag 3. It also comprises a means 48 for calculating a degree of a misalignment between the cope and the drag that calculates a degree of a misalignment between the cope 2 and the drag 3 on a basis of the distances to the cope 2 and the drag 3 as measured by the means 51, 52, and 53 for measuring distances to the cope and the drag. By this configuration, since the distances to the cope and the drag are measured by a plurality of the means for measuring distances to the cope and the drag and any degree of misalignment is calculated on the basis of the measured distances, any misalignment can be reliably detected.

[0006] The device that can detect any misalignment between the cope and the drag of a second aspect of the present invention, as in Figs. 1, 2, and 3, for example, in the device 40 of the first aspect, further comprises a means 46 for moving up and down that moves up and down the plurality of the means 51, 52, 53 for measuring distances to the cope and the drag. It has three means 51, 52, 53 for measuring distances to the cope and the drag. The three means 51, 52, 53 for measuring distances to the cope and the drag measure distances to points 2i, 2j, 2k, 3i, 3j, 3k, which are on same levels of the cope 2 and the drag 3. The three means 51, 52, 53 for measuring distances to the cope and the drag are caused by the means 46 for moving up and down to move to a level for measuring the cope 2 and to a level for measuring the drag 3. By this configuration, since three means for measuring distances to the cope and the drag measure the distances to the points that are on the same level as the cope and the drag, the position of the cope and drag are determined to reliably detect any degree of misalignment.

[0007] The device that can detect any misalignment between the cope and the drag of a third aspect of the present invention, as in Figs. 4 and 5, for example, is the device 40 of the second aspect, wherein the cope 2 and the drag 3 are rectangular in each horizontal section. The three means 51, 52, 53 for measuring distances to the cope and the drag are a first means 51 for measuring distances to the cope and the drag, a second means 52 for measuring distances to the cope and the drag, and a third means 53 for measuring distances to the cope and the drag. The first means 51 for measuring distances to the cope and the drag measures the distances to the points 2i, 3i, which are on first sides 2a, 3a of the cope and drag, which sides are parallel to a conveying direction 7, respectively. The second means 52 for measuring distances to the cope and the drag measures the distances to the points 2j, 3j, which are spaced apart from the points 2i, 3i on the first sides 2a, 3a by a predetermined distance in the horizontal direction, respectively. The third means 53 for measuring distances to the cope and the drag measures the distances to the points 2k, 3k, which are on second sides 2b, 3b of the cope and drag, which sides are perpendicular to the conveying direction 7, respectively. By this configuration, since three points on two sides of a rectangular section are measured by the three means for measuring distances to the cope and the drag, the position of the cope and drag are determined to reliably detect the degree of any misalignment.

[0008] The device that can detect any misalignment between the cope and the drag of a fourth aspect of the present invention, as in Figs. 1, 2, and 3, for example, is the device 40 of the third aspect, wherein the first means 51 for measuring distances to the cope and the drag, the second means 52 for measuring distances to the cope and the drag, and the third means 53 for measuring distances to the cope and the drag, are laser-type displacement sensors. By this configuration, since the first, second, and third means for measuring distances to the cope and the drag are laser-type displacement sensors, the distances to the points of the cope and drag are reliably measured by means of non-contact sensors.

[0009] A method that can detect any misalignment between the cope and the drag of a fifth aspect of the present invention, as in Figs. 1 - 5, for example, is a method to use the device 40 of the third aspect. The method comprises a step of moving the first means 51 for measuring distances to the cope and the drag, the second means 52 for measuring distances to the cope and the drag, and the third means 53 for measuring distances to the cope and the drag to a level to measure the cope 2 by the means 46 for moving up and down. It also comprises a step of measuring a distance S11 to the point 2i on the first side 2a of the cope by the first means 51 for measuring distances to the cope and the drag. It also comprises a step of measuring a distance S12 to the point 2j on the first side 2a of the cope by the second means 52 for measuring distances to the cope and the drag. It also comprises a step of measuring a distance S13 to the point 2k on the second side 2b of the cope by the third means 53 for measuring distances to the cope and the drag. It also comprises a step of calculating a position in a horizontal plane and an angle of rotation in a horizontal direction of the cope 2 by the means 48 for calculating a degree of a misalignment between the cope and the drag based on the distance S11 to the point 2i on the first side 2a of the cope measured by the first means 51 for measuring distances to the cope and the drag, the distance S12 to the point 2j on the first side 2a of the cope measured by the second means 52 for measuring distances to the cope and the drag, and the distance S13 to the point 2k on the second side 2b of the cope measured by the third means 53 for measuring distances to the cope and the drag. It also comprises a step of moving the first means 51 for measuring distances to the cope and the drag, the second means 52 for measuring distances to the cope and the drag, and the third means 53 for measuring distances to the cope and the drag to a level to measure the drag 3 by the means 46 for moving up and down. It also comprises a step of measuring a distance S21 to the point 3i on the first side 3a of the drag by the first means 51 for measuring distances to the cope and the drag. It also comprises a step of measuring a distance S22 to the point 3j on the first side 3a of the drag by the second means 52 for measuring distances to the cope and the drag. It also comprises a step of measuring a distance S23 to the point 3k on the second side 3b of the drag by the third means 53 for measuring distances to the cope and the drag. It also comprises a step of calculating a position in a horizontal plane and an angle of rotation in a horizontal direction of the drag 3 by the means 48 for calculating a degree of a misalignment between the cope and the drag based on the distance S21 to the point 3i on the first side 3a of the drag measured by the first means 51 for measuring distances to the cope and the drag, the distance S22 to the point 3j on the first side 3a of the drag measured by the second means 52 for measuring distances to the cope and the drag, and the distance S23 to the point 3k on the second side 3b of the drag measured by the third means 53 for measuring distances to the cope and the drag. It also comprises a step of calculating a degree of a misalignment based on the positions in the horizontal plane and the angles of rotation in the horizontal direction of the cope 2 and the drag 3 that have been calculated. It also comprises a step of determining that a misalignment has occurred if the degree of misalignment is outside of a predetermined allowable range. By this configuration a misalignment can be determined based on the correct degree of misalignment that has been detected.

[0010] The method that can detect any misalignment between the cope and the drag of a sixth aspect of the present invention is the method of the fifth aspect, wherein no molten metal is poured into the cope and the drag that have been determined to have a misalignment. By this configuration, since no molten metal is poured into the cope and drag where it has been determined that a misalignment has occurred, consumption of molten metal due to useless pouring can be prevented.

[0011] The method that can detect any misalignment between the cope and the drag of a seventh aspect of the present invention is the method of the fifth aspect, wherein if a misalignment is determined to have occurred, then a molding operation by the flaskless molding machine 1 is stopped. By this configuration, since a molding operation by the flaskless molding machine can be stopped until the causes of any misalignment are resolved, consumption of molding sand due to useless molding can be prevented.

[0012] The method that can detect any misalignment between the cope and the drag of an eighth aspect of the present invention is the method of the fifth aspect, wherein if a misalignment is determined to have occurred, then a cause of the misalignment is identified and displayed based on an appearance of the misalignment. By this configuration, since a cause of the misalignment is identified and displayed based on the appearance of the misalignment, resolving the cause of a misalignment is easy.

[0013] The method that can detect any misalignment between the cope and the drag of a ninth aspect of the present invention is the method of the fifth aspect, wherein if a misalignment is determined to have occurred then a cause of the misalignment is identified based on an appearance of the misalignment, so that conditions for operating the device that is the cause of the misalignment are adjusted. By this configuration, since the cause of the misalignment is identified based on the appearance of the misalignment, so that the conditions for operating the device that is the cause of the misalignment are adjusted, the cause of the misalignment can be resolved. Thus no substantial misalignment occurs.

[0014] The method that can detect any misalignment between the cope and the drag of a tenth aspect of the present invention is the method of the fifth aspect, wherein if no misalignment is determined to have occurred, then data are stored that show that no misalignment has occurred in the flaskless molding machine 1 or a molding line 30 that conveys the cope 2 and the drag 3 from the flaskless molding machine 1 to a position for pouring. By this configuration, since the data that show that no misalignment has occurred in the flaskless molding machine or the molding line are stored it can be confirmed that no problem due to a misalignment has occurred during molding.

[0015] The method that can detect any misalignment between the cope and the drag of an eleventh aspect of the present invention is the method of the fifth aspect, wherein data on the positions in the horizontal plane and the angle of rotation in the horizontal direction of the cope and the drag that have been calculated and data on the degree of misalignment that has been calculated are stored. By this configuration, since the data on the degree of misalignment are stored, valuable data for analyzing a cause of a misalignment and for operating and maintaining the flaskless molding machine or the molding line can be accumulated.

[0016] The method that can detect any misalignment between the cope and the drag of a twelfth aspect of the present invention is the method of the fifth aspect, wherein if the degree of misalignment is within the allowable range, but not within a warning range, which is smaller than an allowable range, a predictor of a misalignment is displayed. By this configuration, since the predictor of a misalignment is known, the operation of the device that produces a defective product can be adjusted before a misalignment occurs. Thus waste due to a misalignment can be prevented.

[0017] The device that can detect any misalignment between the cope and the drag of a thirteenth aspect of the present invention, as in Figs. 4, 5, and 6, for example, is the device 60 of the first aspect, wherein the cope 2 and the drag 3 are rectangular in each horizontal section. The plurality of means 71, 72, 73, 74, 75, 76 for measuring distances to the cope and the drag are a first means 71 for measuring distances to the cope, a second means 72 for measuring distances to the cope, a third means 73 for measuring distances to the cope, a first means 74 for measuring distances to the drag, a second means 75 for measuring distances to the drag, and a third means 76 for measuring distances to the drag. The first means 71 for measuring distances to the cope measures the distance S11 to the point 2i, which is on a first side 2a of the cope, which side is parallel to a direction for conveying the cope 2 and the drag 3. The second means 72 for measuring distances to the cope measures the distance S12 to the point 2j, which is spaced apart from the point 2i on the first side 2a of the cope by a predetermined distance in the horizontal direction. The third means 73 for measuring distances to the cope measures the distance S13 to the point 2k, which is on a second side 2b of the cope, which side is perpendicular to the direction for conveying the cope 2 and the drag 3. The first means 74 for measuring distances to the drag measures the distance S21 to the point 3i, which is on a first side 3a of the drag, which side is parallel to the direction for conveying the cope 2 and the drag 3. The second means 75 for measuring distances to the drag measures the distance S22 to the point 3j, which is spaced apart from the point 3i on the first side 3a of the drag by a predetermined distance in the horizontal direction. The third means 76 for measuring distances to the drag measures the distance S23 to the point 3k, which is on a second side 3b of the drag, which side is perpendicular to the direction for conveying the cope 2 and the drag 3. By this configuration, since the three points of the cope and three points of the drag are measured by the six means for measuring distances to the cope or the drag, the positions of the cope and drag are determined without moving the means for measuring distances up and down, to reliably and quickly detect the degree of any misalignment.

[0018] The device that can detect any misalignment between the cope and the drag of a fourteenth aspect of the present invention, as in Figs. 7 and 8, for example, is the device 5 of the first aspect, wherein the cope 2 and the drag 3 are rectangular in each horizontal section. The plurality of means 8, 9, 11, 12 for measuring distances to the cope and the drag are a first means 8 for measuring distances to the cope, a first means 9 for measuring distances to the drag, a second means 11 for measuring distances to the cope, and a second means 12 for measuring distances to the drag. The first means 8 for measuring distances to the cope measures a distance to a first side 2a of the cope, which side is parallel to the direction for conveying the cope 2. The first means 9 for measuring distances to the drag measures a distance to a first side 3a of the drag, which side is parallel to the direction for conveying the drag 3. The second means 11 for measuring distances to the cope measures a distance to a second side 2b of the cope, which side is perpendicular to the direction for conveying the cope 2. The second means 12 for measuring distances to the drag measures a distance to a second side 3b of the drag, which side is perpendicular to the direction for conveying the drag 3. By this configuration, since the points of the cope on the sides that are parallel to and perpendicular to the direction for conveying the cope and the points of the drag on the sides that are parallel to and perpendicular to the direction for conveying the drag are measured by the four means for measuring distances to the cope or the drag, the positions of the cope and the drag are reliably identified so that any misalignment can be reliably detected.

[0019] The device that can detect any misalignment between the cope and the drag of a fifteenth aspect of the present invention, as in Figs. 7 and 8, for example, is the device 5 of the fourteenth aspect, wherein the first means 8 for measuring distances to the cope and the first means 9 for measuring distances to the drag are configured to be moved by means of an actuator 10 in the direction for conveying the cope 2 and the drag 3.

The second means 11 for measuring distances to the cope and the second means 12 for measuring distances to the drag are configured to be moved by means of an actuator 13 in a direction perpendicular to the direction for conveying the cope 2 and the drag 3. By this configuration, since the first means for measuring the distance to the cope and the first means for measuring the distance to the drag, and the second means for measuring the distance to the cope and the second means for measuring the distance to the drag, move by the actuators in the directions that are parallel to the sides to be measured, the distances can be continually measured at any interval along the sides of the cope and the drag. Thus, a lot of data for determining any alignment can be obtained so that any misalignment can be reliably detected.

[0020] The device that can detect any misalignment between the cope and the drag of a sixteenth aspect of the present invention, as in Figs. 7 and 8, for example, is the device 5 of the fourteenth aspect, wherein the first means 8 for measuring distances to the cope, the first means 9 for measuring distances to the drag, the second means 11 for measuring distances to the cope, and the second means 12 for measuring distances to the drag, are configured to be able to be simultaneously moved up and down by an actuator 15. By this configuration, a vertical adjustment of the means for measuring distances can be achieved within a short period of time.

[0021] The device that can detect any misalignment between the cope and the drag of a seventeenth aspect of the present invention, as in Figs. 7 and 8, for example, is the device 5 of the fourteenth aspect, wherein the first means 8 for measuring distances to the cope, the first means 9 for measuring distances to the drag, the second means 11 for measuring distances to the cope, and the second means 12 for measuring distances to the drag, are laser-type displacement sensors. By this configuration, since the first means for measuring distances to the cope, the first means for measuring distances to the drag, the second means for measuring distances to the cope, and the second means for measuring distances to the drag, are laser-type displacement sensors, the distances are reliably measured by means of non-contact sensors.

[0022] A method that can detect any misalignment between the cope and the drag of an eighteenth aspect of the present invention, as in Figs. 7 - 11, for example, is a method to use the device 5 of the fourteenth aspect. The method comprises a step of measuring a distance S1 to a first side 2a of the cope by the first means 8 for measuring distances to the cope. It also comprises a step of measuring a distance S2 to a first side 3a of the drag by the first means 9 for measuring distances to the drag. It also comprises a step of measuring a distance S3 to a second side 2b of the cope by the second means 11 for measuring distances to the cope. It also comprises a step of measuring a distance S4 to a second side 3b of the drag by the second means 12 for measuring distances to the drag. It also comprises a step of determining a misalignment that has occurred if a difference between the distance S1 to the first side 2a of the cope that is measured by the first means 8 for measuring distances to the cope and the distance S2 to the first side 3a of the drag that is measured by the first means 9 for measuring distances to the drag or a difference between the distance S3 to the second side 2b of the cope that is measured by the second means 11 for measuring distances to the cope and the distance S4 to the second side 3b of the drag that is measured by the second means 12 for measuring distances to the drag, is outside of an allowable range. By this configuration, since an alignment is determined based on the difference in the distances to the first sides of the cope and the drag, which distances are measured by the first means for measuring distances to the cope and the first means for measuring distances to the drag, respectively, or the difference in the distances to the second sides of the cope and the drag, which distances are measured by the second means for measuring distances to the cope and the second means for measuring distances to the drag, respectively, any misalignment can be reliably determined.

[0023] The method that can detect any misalignment between the cope and the drag of a nineteenth aspect of the present invention, as in Figs. 7 - 11, for example, is the method of the eighteenth aspect, wherein the first means 8 for measuring distances to the cope and the first means 9 for measuring distances to the drag are configured to be moved by means of an actuator 10 in the direction for conveying the cope 2 and the drag 3. The second means 11 for measuring distances to the cope and the second means 12 for measuring distances to the drag are configured to be moved by means of an actuator 13 in a direction perpendicular to the direction for conveying the cope 2 and the drag 3. The first means 8 for measuring distances to the cope, the first means 9 for measuring distances to the drag, the second means 11 for measuring distances to the cope, and the second means 12 for measuring distances to the drag, continually measure distances S1, S2, S3, S4 to the respective sides 2a, 3a, 2b, 3b of the cope and drag at intervals along at least parts of the sides 2a, 3a, 2b, 3b. By this configuration, since each of the means for measuring distances to the cope and to the drag can move by means of the actuators in the direction that is parallel to the sides to be measured, the distances can be continually measured at any intervals along the sides of the cope and the drag. Thus, a lot of data for determining any alignment can be obtained so that any misalignment can be reliably detected.

[0024] The method that can detect any misalignment between the cope and the drag of a twelfth aspect of the present invention, as in Figs. 7 - 11, for example, is the method of the eighteenth aspect, wherein no molten metal is poured into the cope 2 and the drag 3 that have been determined to have a misalignment. By this configuration, since no molten metal is poured into the cope and drag that have been determined to have a misalignment, consumption of molten metal due to useless pouring can be prevented.

[0025] The basic Japanese patent application, No. 2016-003646, filed January 12, 2016, is hereby incorporated by reference in its entirety in the present application.

[0026] The present invention will become more fully understood from the detailed description given below. However, that description and the specific embodiments are only illustrations of the desired embodiments of the present invention, and so are given only for an explanation. Various possible changes and modifications will be apparent to those of ordinary skill in the art on the basis of the detailed description.

[0027] The applicant has no intention to dedicate to the public any disclosed embodiment. Among the disclosed changes and modifications, those which may not literally fall within the scope of the present claims constitute, therefore, under the doctrine of equivalents, a part of the present invention.

[0028] The use of the articles "a," "an," and "the" and similar referents in the specification and claims are to be construed to cover both the singular and the plural form of a noun, unless otherwise indicated herein or clearly contradicted by the context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein is intended merely to better illuminate the invention, and so does not limit the scope of the invention, unless otherwise stated.

Brief Description of Drawings

[0029]

[Fig. 1]
Fig. 1 is a schematic drawing that shows a plan view of the device that can detect any misalignment between a cope and a drag. The device is an embodiment of the present invention.
[Fig. 2]
Fig. 2 is a view taken along the arrow A-A in Fig. 1.
[Fig. 3]
Fig. 3 is a view taken along the arrow B-B in Fig. 1.
[Fig. 4]
Fig. 4 is a schematic drawing that illustrates a measurement of a distance to a side of a cope.
[Fig. 5]
Fig. 5 is a schematic drawing that illustrates a measurement of a distance to a side of a drag.
[Fig. 6]
Fig. 6 is a side view of the device that can detect any misalignment between a cope and a drag. The device is a modification of the device as in Fig. 1.
[Fig. 7]
Fig. 7 is a schematic drawing that shows a plan view of the device that can detect any misalignment between a cope and a drag. The device is another embodiment of the present invention.
[Fig. 8]
Fig. 8 is a view taken along the arrow A-A in Fig. 7.
[Fig. 9]
Fig. 9 is a view taken along the arrow B-B in Fig. 7.
[Fig. 10]
Fig. 10 is a schematic drawing that illustrates a measurement of a distance to a side of a cope and a drag. The side is perpendicular to a direction to convey the cope and the drag.
[Fig. 11]
Fig. 11 is a schematic drawing that illustrates a measurement of a distance to a side of a cope and a drag. The side is parallel to a direction to convey the cope and the drag.

Mode for Carrying Out the Invention

[0030] Below, with reference to the drawings, embodiments of the present invention are discussed in detail. In Figs. 1, 2, and 3 the reference number "1" denotes a flaskless molding machine. In this invention, the flaskless molding machine 1 is a following molding machine. After molding a cope and a drag by using molding sand (green sand in this embodiment), the cope and the drag are assembled. Then the cope and the drag are extracted from upper and lower flasks to be carried out of the molding machine.

[0031] At a position adjacent to the flaskless molding machine 1, the cope 2 and the drag 3 that have been carried out of the flaskless molding machine 1 in the direction shown by the arrow 6 are mounted on a bogie 4 with a molding board. The cope 2 and the drag 3 that have been mounted on the bogie 4 with a molding board are intermittently conveyed in the direction shown by the arrow 7 (the conveying direction of the cope 2 and the drag 3) by a distance that equals the length of a mold, i.e., a pitch, by a means for conveying (a pusher and a cushion), which is not shown. The bogie 4 with a molding board travels on a rail 20 that is supported by a frame 22.

[0032] At a position adjacent to the cope 2 and the drag 3 that are intermittently conveyed, a device 40 that can detect any misalignment between the cope 2 and the drag 3 is provided. Now, the details of the device 40 that can detect any misalignment between the cope and the drag (hereafter, "device 40"), which is a first embodiment of the present invention, are discussed. Incidentally, the direction for conveying the cope 2 and the drag 3 is called a Y-direction, the direction perpendicular to the direction for conveying the cope 2 and the drag 3 is called an X-direction, and the vertical direction is called a Z-direction.

[0033] The device 40 has three means 51, 52, 53 for measuring distances to the cope and the drag (hereafter, "means 51, 52, 53") that are arranged along the direction (the Y-direction) for conveying the cope 2 and the drag 3. The three means 51, 52, 53 are mounted on a frame 44 for moving up and down that extends along the Y-direction. The frame 44 for moving up and down moves up and down by means of a cylinder 46, i.e., an actuator. The cylinder 46 is supported by a supporting frame 42 that stands on a base. Incidentally, the cylinder 46, i.e., the actuator, can be any type, such as an electric type, an oil-pressure type, a water-pressure type, or an air-pressure type. Furthermore, the actuator is not limited to the cylinder 46, but may be any known means, such as trapezoidal thread forms or a pantograph. The supporting frame 42 does not need to stand on the base, but may be fixed to the frame 22.

[0034] The frame 44 for moving up and down is a beam that is nearly as long as the cope 2 and the drag 3 in the Y-direction. The first means 51 is mounted on the part of the frame 44 for moving up and down that is near the back end in the direction for conveying the cope 2 and the drag 3. It measures distances to the points 2i, 3i on the first sides 2a, 3a, which are parallel (the Y-direction) to the direction for conveying the cope 2 and the drag 3. The second means 52 is mounted on the front part of the frame 44 for moving up and down in the direction for conveying the cope 2 and the drag 3. It measures distances to the points 2j, 3j on the first sides 2a, 3a. The points 2j, 3j are located on the same level as the points 2i, 3i and spaced apart from them by a predetermined distance. Here, the predetermined distance is the horizontal distance by which the locations of the centers and the angles of rotations of the cope 2 and the drag 3 can be appropriately calculated based on the positions of the three points, as discussed below. The third means 53 is mounted on the part of the frame 44 for moving up and down that is near the front end in the direction for conveying the cope 2 and the drag 3. It measures distances to the points 2k, 3k on the second sides 2b, 3b, which are perpendicular (the X-direction) to the direction for conveying the cope 2 and the drag 3. The points 2k, 3k are located on the same level as the points 2i, 3i and the points 2j, 3j.

[0035] The first means 51 and the second means 52 preferably face the direction (the X-direction) that is perpendicular to the direction of the frame 44 for moving up and down (the Y-direction), to measure the distances to the points 2i, 3i, 2j, 3j on the first sides 2a, 3a, which sides are parallel to the frame 44 for moving up and down. The third means 53 faces diagonally to measure the distances to the points 2k, 3k on the second sides of 2b, 3b. These sides are perpendicular to the frame 44 for moving up and down. By placing the first means 51, the second means 52, and the third means 53 in this way, the distances to three points, i.e., the positions, can be measured. These points are positioned on a horizontal plane (not on a line). These means are arranged along what is almost a line on the frame 44 for moving up and down. Further, the device 40 does not obstruct the cope 2 or the drag 3 that are being transported.

[0036] Since the cylinder 46 moves up and down the frame 44 for moving up and down, the first, second, and third means 51, 52, 53 move up and down. The first, second, and third means 51, 52, 53 are moved up and down to a set height to measure the points 2i, 2j, 2k of the cope 2 and to a set height to measure the points 3i, 3j, 3k of the drag 3. Thus the positions of a total of six points, i.e., three points on the cope 2 and three points on the drag 3, can be measured by three means 51, 52, 53.

[0037] The points 2i, 2j, 2k of the cope 2 and the points 3i, 3j, 3k of the drag 3 are positioned at a predetermined distance from a parting plane 19 between the cope 2 and the drag 3. The predetermined distance for the points 2i, 2j, 2k of the cope 2 may be the same as, or different from, that for the points 3i, 3j, 3k of the drag 3. For example, the points 2i, 2j, 2k are positioned at a level that is 100 mm higher than the parting plane 19. And the points 3i, 3j, 3k are positioned at a level that is 100 mm lower than the parting plane 19. Incidentally, the distance from the upper surface of the bogie 4 with a molding board to the parting plane 19 equals the height of the drag 3. The height of the drag 3 is measured for each drag 3 that has been molded by the flaskless molding machine 1. When the device 40 measures the distances, the height is then known.

[0038] The shapes of the cope 2 and the drag 3 that are molded by the flaskless molding machine 1 are known. Once the positions of the points 2i, 2j, 2k are known, then the location of the center of, and the angle of the horizontal rotation of, the cope 2, can be calculated. Thus, if the cross-section of it is rectangular, then the coordinates of the four corners can be calculated. In the same way, once the positions of the points 3i, 3j, 3k are known, the location of the center of, and the angle of the horizontal rotation of, the drag 3, can be calculated. Thus, if the cross-section of it is rectangular, the coordinates of the four corners can be calculated. Incidentally, the cope 2 and the drag 3 are horizontally mounted on the bogie 4 with a molding board. Any misalignment between the cope 2 and the drag 3 can be determined based on the locations of the centers and the angles of the horizontal rotations, or the coordinates of the four corners, which are discussed above. The locations of the centers and the angles of the horizontal rotations, or the coordinates of the four corners, are calculated by the means 48 for calculating the degree of a misalignment between the cope and the drag (hereafter, "the means 48 for calculating"). The means 48 for calculating may be provided in the device 40 as a dedicated means for calculating the degree of a misalignment between the cope and the drag. Alternatively, it may be installed in a controller for another device such as the flaskless molding machine 1, the molding line 30 for conveying the cope 2 and the drag 3, and a pouring machine (not shown) that pours molten metal into the cope 2 and the drag 3. Namely, the means 48 for calculating may be a controller.

[0039] Preferably, laser-type displacement sensors are used for the first, second, and third means 51, 52, 53. Since they are laser-type displacement sensors, the measurements are accurate, without any contact being made with the cope 2 or the drag 3. Further, they are compact. However, these means are not limited to the laser-type displacement sensors, but may be any known displacement sensors, such as ultrasonic displacement sensors and contact displacement sensors.

[0040] Next, with further reference to Figs. 4 and 5, a method that can detect any misalignment between the cope and the drag by using the device 40 is discussed. The cope 2 and the drag 3 that have been molded by the flaskless molding machine 1 are mounted on the bogie 4 with a molding board at a station 17 for carrying a mold in. The cope 2 and the drag 3 that have been mounted on the bogie 4 with a molding board are intermittently conveyed on the molding line 30. When the cope 2 and the drag 3 that are intermittently conveyed are carried into a station 18 for detecting a misalignment, namely, they stop at a position that is predetermined in relation to the device 40, the device 40 operates to detect any misalignment. Here, the words "stop at a position that is predetermined in relation to the device 40" mean to stop at a position where the first, second, and third means 51, 52, 53 of the device 40 can easily measure the distances to the three points 2i, 2j, 2k of the cope 2 and to the three points 3i, 3j, 3k of the drag 3. That is, the position where the cope 2 and the drag 3 that are intermittently conveyed temporarily stop is not just beside the device 40, but slightly shifts forward or backward. Because of this the third means 53 can measure the distances to the points 2k, 3k on the second sides 2b, 3b. The bogie 4 with a molding board that is carried into the station 18 for detecting a misalignment is preferably fixed by a clamp (not shown) so as not to move. Any error in measuring the distances by means of the device 40, that is caused by a shake of the bogie 4 with a molding board can be prevented.

[0041] While the cope 2 and the drag 3 stop while being intermittently conveyed, the device 40 first adjusts, by means of the cylinder 46, the level of the frame 44 for moving up and down to a level for measuring the distances to the three points 2i, 2j, 2k of the cope 2. Namely, it adjusts the level to the predetermined level above the parting plane 19. Then the first means 51 measures the distance S11 to the point 2i, the second means 52 measures the distance S12 to the point 2j, and the third means 53 measures the distance S13 to the point 2k. The measured distances S11, S12, S13 are sent to the means 48 for calculating. The means 48 for calculating calculates the horizontal location of the center and the angle of rotation of the cope 2.

[0042] After the first, second, and third means 51, 52, 53 have measured the distances to the three points 2i, 2j, 2k, the level of the frame 44 for moving up and down is adjusted by means of the cylinder 46 to a level for measuring the distances to the three points 3i, 3j, 3k of the drag 3. Then the first means 51 measures the distance S21 to the point 3i, the second means 52 measures the distance S22 to the point 3j, and the third means 53 measures the distance S23 to the point 3k. The operations up to these measurements are carried out while the cope 2 and the drag 3 stop while being intermittently conveyed. The measured distances S21, S22, S23 are sent to the means 48 for calculating. The means 48 for calculating calculates the horizontal location of the center and the angle of rotation of the drag 3.

[0043] Incidentally, after the first, second, and third means 51, 52, 53 have measured the distances to the three points 3i, 3j, 3k, the level of the frame 44 for moving up and down may be adjusted to a level for measuring the distances to the three points 2i, 2j, 2k of the cope 2, so that the first, second, and third means 51, 52, 53 measure the distances S11, S12, S13 to the points 2i, 2j, 2k, respectively. Further, the first, second, and third means 51, 52, 53 can measure in any order or at the same time. In the present application documents, the order of steps is arbitrary. So the steps may be carried out in any order or at the same time, except for any step that is discussed by using a word that defines a sequence, e.g., "after," or except when the sequence is obvious from the context.

[0044] The means 48 for calculating calculates the coordinates of the respective four corners of rectangles based on the locations of the centers and the angles of rotations of the cope 2 and the drag 3. It calculates the horizontal distances between corresponding corners of the cope 2 and the drag 3.

[0045] A misalignment is determined based on the horizontal distances between corresponding corners of the cope 2 and the drag 3 that have been calculated by the means 48 for calculating. For example, when an allowable range for horizontal distances is 0.5 mm or less, the allowable range is 0 to 0.5 mm. The misalignment is determined by seeing if the horizontal distances of the four corners are within the allowable range. This operation for determining may be carried out by a dedicated means for calculating a degree of a misalignment between the cope and the drag of the device 40 or by a controller for another device. If the distance at any of the four corners exceeds the allowable range, then a misalignment may be determined to have occurred. Alternatively, if the distances at two or three or all four corners exceed the allowable range, then a misalignment may be determined to have occurred. Alternatively, if the average or the root-mean-square of the four distances exceeds the allowable range, then a misalignment may be determined to have occurred. Alternatively, the misalignment may be determined to have occurred on the basis of the differences in the locations of the centers and the angles of rotations. The result of determining a misalignment is sent to the controller of the molding line 30, the pouring machine (not shown), or the like.

[0046] After the operation for determining a misalignment by the device 40 is finished, the clamp on the bogie 4 with a molding board is released and the cope 2 and the drag 3 are again intermittently conveyed. Then a jacket (not shown) is capped on the cope 2 and the drag 3 and a weight is placed on them before pouring starts. Then molten metal is poured into the cope 2 and the drag 3 by the pouring machine (not shown). Incidentally, the operation for determining a misalignment by the device 40 may be carried out after the jacket is capped or after the weight is placed on it. The misalignment is determined to have occurred by measuring the distances to the respective three points 2i, 2j, 2k, and 3i, 3j, 3k of the cope 2 and the drag 3 from the first, second, and third means 51, 52, 53 of the device 40. The first, second, and third means 51, 52, 53 are mounted on the frame 44 for moving up and down that is spaced apart from the cope 2 and the drag 3 by a predetermined distance. Thus unless measuring the distances to the points 2i, 2j, 2k, 3i, 3j, 3k is disturbed by the jacket, the measurement can be performed after the jacket is capped.

[0047] If a misalignment is determined to have occurred as a result of detecting a misalignment, preferably no molten metal is poured into the cope 2 and the drag 3 that have a misalignment. Namely, the controller of the pouring machine is set not to pour molten metal into the cope 2 and the drag 3 that have the misalignment. Since no molten metal is poured into the cope 2 and the drag 3 that have the misalignment, consuming molten metal by useless pouring can be prevented.

[0048] If a misalignment is determined to have occurred as a result of detecting a misalignment, molding by the flaskless molding machine 1 is preferably stopped. Namely, until the causes of the misalignment are resolved, molding by the flaskless molding machine 1 is stopped. Since molding the cope 2 and the drag 3 that may have a misalignment can be avoided, consuming the molding sand by useless molding can be prevented. Here the wording "molding by the flaskless molding machine 1 is stopped" just means that no mold is molded. The flaskless molding machine 1 may operate so that no mold is molded. Or the flaskless molding machine 1 may be deactivated so that only the molding line 30 may operate.

[0049] If the misalignment is determined to have occurred as a result of detecting a misalignment, the cause of the misalignment, to be displayed, is preferably identified based on the appearance of the misalignment. For example, if the cope 2 is displaced backwards relative to the drag 3, namely, in the direction that the flaskless molding machine 1 pushes a mold out (the arrow 6 in Fig. 1), the initial velocity for pushing the drag 3 out by means of a device for pushing a mold out (not shown) may be too fast. If the cope 2 is displaced backwards relative to the drag 3, namely, in the direction that the molding line 30 conveys the cope 2 and drag 3 (the arrow 7 in Fig. 1), the initial velocity for pushing the bogie 4 with a molding board by means of a pusher (not shown) may be too fast. In this way, the causes of the misalignment can be predicted based on the direction of the misalignment between the cope 2 and the drag 3. By displaying the causes of the misalignment that have been identified, the operator can easily learn what devices are to be repaired, and so can easily resolve the causes of the misalignment. The causes of the misalignment may be displayed on a display panel of the device 40, a dedicated display panel, or a controller for another device.

[0050] If a misalignment is determined to have occurred as a result of detecting a misalignment, the cause of the misalignment is preferably identified based on the appearances of the misalignment, so that the operating condition of the device that causes the misalignment is preferably modified. For example, if the cope 2 is displaced backwards relative to the drag 3, namely, in the direction toward which the flaskless molding machine 1 pushes a mold out (the arrow 6 in Fig. 1), the initial velocity for pushing the drag 3 out by means of a device for pushing a mold out (not shown) may be too fast. In this case the initial velocity of the device for pushing a mold out, which is the operating condition that causes the misalignment, is modified. Specifically, the initial velocity of the device for pushing a mold out is automatically or manually modified to be decreased. In this way the misalignment is prevented from occurring in the following cycles. If the cope 2 is displaced backwards relative to the drag 3, namely, in the direction toward which the molding line 30 conveys the cope 2 and drag 3 (the arrow 7 in Fig. 1), the initial velocity for pushing the bogie 4 with a molding board by means of a pusher (not shown) may be too fast. In this case the initial velocity of the pusher, which is the operating condition that causes the misalignment, is modified. Specifically, the initial velocity of the pusher is automatically or manually modified, to be decreased. In this way the misalignment is prevented from occurring in the following cycles.

[0051] If no misalignment is determined to have occurred as a result of detecting a misalignment, data are preferably stored that show that no misalignment has been caused by the flaskless molding machine 1 or the molding line 30, which conveys the cope 2 and the drag 3 from the flaskless molding machine 1 to the position for pouring. By storing the data in this way, if a defect is found in a product, and as it can be confirmed that no misalignment has occurred during molding, the cause of the defect is easily investigated. Incidentally, the data may be stored in the means 48 for calculating or in a controller for another device.

[0052] Further, the data on the positions in the horizontal plane and the angle of rotation in the horizontal direction of the cope 2 and the drag 3 that have been calculated by the means 48 for calculating and the data on the calculated degree of misalignment are preferably stored. Since the data on the positions in the horizontal plane and the angle of rotation in the horizontal direction of the cope 2 and the drag 3 and the data on the calculated degree of misalignment are stored in this way, any change in the degree of misalignment can be found. Thus data that are useful to investigate the cause of a misalignment and to maintain the flaskless molding machine 1 and the molding line 30 can be accumulated. The data may be stored in the means 48 for calculating or in a controller for another device.

[0053] Even when the degree of misalignment between the cope 2 and the drag 3 that has been calculated by the means 48 for calculating is within the preset allowable range, it may not be within a warning range, which is set to be smaller than the allowable range. In this case a predictor of a misalignment is preferably displayed. If a predictor is displayed, the operating condition that can cause the misalignment between the cope 2 and the drag 3 can be modified before a defect occurs. Thus any possible waste caused by a defect can be prevented. Incidentally, the predictor of a misalignment may be displayed on a display panel of the device 40, a dedicated display panel, or a controller for another device.

[0054] Next, with reference to Fig. 6, a device 60 that can detect any misalignment between the cope and the drag (hereafter, "the device 60"), which is a second embodiment, is discussed in detail. About the device 60, only the points that differ from the device 40 are discussed. The device 60 has a first means 71 for measuring distances to the cope, a second means 72 for measuring distances to the cope, a third means 73 for measuring distances to the cope, a first means 74 for measuring distances to the drag, a second means 75 for measuring distances to the drag, and a third means 76 for measuring distances to the drag, to measure the distances to the points 2i, 2j on the first side 2a of the cope 2, the distance to the point 2k on the second side 2b of the cope 2, the distances to the points 3i, 3j on the first side 3a of the drag 3, and the distance to the point 3k on the second side 3b of the drag 3. The first means 71 for measuring distances to the cope, the second means 72 for measuring distances to the cope, and the third means 73 for measuring distances to the cope, are mounted on a horizontal frame 64 at positions that are suitable to measure the distances to the points 2i, 2j, 2k of the cope 2. The first means 74 for measuring distances to the drag, the second means 75 for measuring distances to the drag, and the third means 76 for measuring distances to the drag, are mounted on a horizontal frame 66 at positions that are suitable to measure the distances to the points 3i, 3j, 3k of the drag 3. The two horizontal frames 64, 66 are fixed to the supporting frame 62. Namely, they are not moved up and down by an actuator.

[0055] By the device 60, since three points of the cope 2 and three points of the drag 3, namely, a total of six points, are measured by the six means 71 - 76 for measuring distances to the cope and the drag, the locations of the centers and the angles of rotations of the cope 2 and the drag 3 are determined without vertically moving the means for measuring distances to the cope and the drag. Thus the degree of misalignment can be quickly and accurately detected. Further, as no actuator vertically moves a frame for moving up and down, the six means 71 - 76 for measuring distances to the cope and the drag can measure the distances to the points 2i, 2j, 2k, 3i, 3j, 3k of the cope 2 and the drag 3 at the same time. Thus the period of time for operating the device 60 can be shortened.

[0056] Next, with reference to Figs. 7 - 11, a device 5 that can detect any misalignment between the cope and drag (hereafter, "the device 5"), which is a third embodiment, is discussed. The device 5 has a first means 8 for measuring distances to the cope (hereafter, "the first means 8 for measuring") that measures the distances to the first side 2a of the cope, which side is parallel to the Y-direction. It also has a first means 9 for measuring distances to the drag (hereafter, "the first means 9 for measuring") that measures the distances to the first side 3a of the drag, which side is parallel to the Y-direction. The first means 8 for measuring and the first means 9 for measuring are configured to move in the Y-direction by means of a first cylinder 10, i.e., an actuator.

[0057] The device 5 also has a second means 11 for measuring distances to the drag (hereafter, "the second means 11 for measuring") that measures the distances to the second side 2b of the drag, which side is parallel to the X-direction. It also has a second means 12 for measuring distances to the drag (hereafter, "the second means 12 for measuring") that measures the distances to the second side 3b of the drag, which side is parallel to the X-direction. The second means 11 for measuring and the second means 12 for measuring are configured to move in the X-direction by means of a second cylinder 13, i.e., an actuator.

[0058] The first cylinder 10 and the second cylinder 13 are attached to a common frame 14 for moving up and down (see Fig. 8). The frame 14 for moving up and down is configured to move in the Z-direction by means of a third cylinder 15, i.e., an actuator. Namely, it can be moved up and down. The third cylinder 15 is attached to a supporting frame 16. The supporting frame 16 stands on a base 21.

[0059] By this embodiment, the laser-type displacement sensors are used for the first means 8 for measuring, the first means 9 for measuring, the second means 11 for measuring, and the second means 12 for measuring. By the embodiment the electric cylinders are used for the first cylinder 10, the second cylinder 13, and the third cylinder 15.

[0060] Below, the operations of the device that is constructed as discussed above are discussed. By a means for carrying in, which means is not shown, the bogie 4 with a molding board has been carried in the station 17 for carrying a mold in. Next, the cope 2 and the drag 3 are carried in the direction of the arrow 6 from the flaskless molding machine 1 to be mounted on the bogie 4 with a molding board. Next, the cope 2 and the drag 3 that have been mounted on the bogie 4 with a molding board are intermittently conveyed by the means for conveying in the direction of the arrow 7 by a pitch to be sent to the station 18 for detecting a misalignment.

[0061] A misalignment between the cope 2 and the drag 3 is detected at the station 18 for detecting a misalignment. Now, detecting a misalignment between the cope 2 and the drag 3 is discussed in detail. First, the means for clamping the bogie with a molding board, which means is not shown, clamps the bogie 4 with a molding board that is positioned at the station 18 for detecting a misalignment to fix the position of the bogie 4 with a molding board.

[0062] Next, by activating the third cylinder 15 the frame 14 for moving up and down is moved up or down so that the position in the Z-direction is adjusted. By this embodiment the respective means for measuring distances to the cope and the drag are located so that the midpoint between the projecting centers of the first means 8 for measuring and the first means 9 for measuring is at the same height as the midpoint between the projecting centers of the second means 11 for measuring and the second means 12 for measuring. Thus, the frame 14 for moving up and down is moved up or down so that the midpoints between the projecting centers are at the same height as the height of the parting plane 19 between the cope 2 and the drag 3.

[0063] The height from the upper surface of the bogie 4 with a molding board to the parting plane 19 is the same as the height of the drag 3. The height of the drag 3 is measured for every mold by a means for measuring, e.g., an encoder, of the flaskless molding machine 1, which means is not shown. Thus the height of the parting plane 19 can be known for every mold.

[0064] Next, by activating the first cylinder 10, the first means 8 for measuring and the first means 9 for measuring are moved back and forth in the Y-direction. In this embodiment the stroke L1 of the movement (see Fig. 7) is set to be 300 mm, which is about a half of the length of the cope 2 and the drag 3. While moving forward in that movement, the distances in the X-direction to the sides of the cope 2 and the drag 3 are measured. Specifically, as in Fig. 11, the distance S1 from the tip of the first means 8 for measuring to the first side 2a of the cope is measured by the first means 8 for measuring. The distance S2 from the tip of the first means 9 for measuring to the first side 3a of the drag is measured by the first means 9 for measuring.

[0065] In measuring the distances S1, S2, the distances to at least parts of the sides of the cope and the drag (within the range of the stroke L1 in this embodiment) are continually measured at predetermined intervals along the sides of the cope and the drag. By this embodiment, the distances are measured at every 1 mm interval along the sides. Incidentally, while moving backward in that movement the distances S1, S2 are not measured. The first means 8 for measuring and the first means 9 for measuring are moved back to the original positions.

[0066] Next, by activating the second cylinder 13, the second means 11 for measuring and the second means 12 for measuring are moved back and forth in the X-direction. In this embodiment the stroke L2 of the movement (see Fig. 7) is set to be 200 mm, which is less than the length of the cope 2 and the drag 3. While moving forward in that movement the distances in the Y-direction to the sides of the cope 2 and the drag 3 are measured. Specifically, as in Fig. 10, the distance S3 from the tip of the second means 11 for measuring to the second side 2b of the cope is measured by the second means 11 for measuring. The distance S4 from the tip of the second means 12 for measuring to the second side 3b of the drag is measured by the second means 12 for measuring.

[0067] In measuring the distances S3, S4, the distances to at least parts of the sides of the cope and the drag (within the range of the stroke L2 in this embodiment) are continually measured at predetermined intervals along the sides of the cope and the drag. By this embodiment, the distances are measured at every 1 mm interval along the sides. Incidentally, while moving backward in the reciprocating movement the distances S3, S4 are not measured. The second means 11 for measuring and the second means 12 for measuring are moved back to the original positions.

[0068] Next, the clamp is released by the means for clamping the bogie with a molding board from the bogie 4 with a molding board that is positioned at the station 18 for detecting a misalignment. Then the cope 2 and the drag 3 and the bogie 4 with a molding board, which are positioned at the station 18 for detecting a misalignment, are intermittently conveyed by the means for conveying in the direction of the arrow 7 by a pitch to be sent out from the station 18 for detecting a misalignment. On the cope 2 and the drag 3, which are sent out from the station 18 for detecting a misalignment, a jacket (not shown) is capped in a following process and a weight (not shown) is mounted on the upper surface of the cope 2. Thereafter molten metal is poured into the cope 2 and the drag 3.

[0069] Now, a method for detecting a misalignment from the measured distances S1, S2, S3, S4 is discussed in detail. First, the difference S5 between the distance S1 and the distance S2 is obtained to be compared with a predetermined range (an allowable range). The predetermined range is determined by adding the allowable range to a reference value, which is a dimension determined by the design. As an example in this embodiment, the reference value is 7 mm and the allowable range is ±0.5 mm. Thus the predetermined range is 6.5 - 7.5 mm. If the difference S5 is outside of this range, then a misalignment is determined to have occurred. Also, the difference S6 between the distance S3 and the distance S4 is obtained. If the difference S6 is outside of the predetermined range, then a misalignment is determined to have occurred. As an example in this embodiment, the reference value is 2 mm and the allowable range is ±0.5 mm. Thus the predetermined range is 1.5 - 2.5 mm. If the difference S6 is outside of this range, then a misalignment is determined to have occurred. Incidentally, these operations for calculating, comparing, determining, etc., are automatically carried out by the means for calculating a degree of a misalignment between the cope and the drag, a controller, etc., which are not shown.

[0070] By this embodiment, as discussed above, the distances S1, S2, S3, S4 are measured at every 1 mm interval along the sides of the cope and the drag. Thus the differences S5, S6 are obtained multiple times. The difference that is used for determining a misalignment can be arbitrarily selected from the differences S5, S6 that are continually obtained multiple times. For example, if one of the differences S5, S6 is outside of the predetermined range, then a misalignment is determined to have occurred. For another example, if both differences S5, S6 that are continually obtained multiple times are outside of the predetermined range, then a misalignment is determined to have occurred. As discussed above, by the device 5, since a misalignment is determined to have occurred by using differences at multiple points along the sides 2a, 2b, 3a, 3b of the cope 2 and the drag 3, a misalignment can be reliably determined to have occurred.

[0071] An instruction is sent by a controller to the pouring machine, which is not shown, so that no molten metal will be poured into the cope 2 and the drag 3 that have been determined to have a misalignment as discussed above.

[0072] Incidentally, by the present invention, the first means 8 for measuring and the first means 9 for measuring are movable by the first cylinder 10, i.e., an actuator, in the direction for conveying the cope 2 and the drag 3. Further, the second means 11 for measuring and the second means 12 for measuring are movable in the direction that is perpendicular to the direction for conveying the cope 2 and the drag 3. By this configuration, since the distances to the sides of the cope and the drag can be continually measured at predetermined intervals along the sides, a lot of data that are measured and that are used for determining a misalignment can be obtained. Thus any trend in misalignments can be advantageously found.

[0073] By the present invention, the first means 8 for measuring, the first means 9 for measuring, the second means 11 for measuring, and the second means 12 for measuring, can be simultaneously moved up and down by the third cylinder 15, i.e., an actuator. By this configuration, the positions in the Z-direction can be advantageously adjusted within a short period of time.

[0074] Further, by the present invention, the laser-type displacement sensors are used for the first means 8 for measuring, the first means 9 for measuring, the second means 11 for measuring, and the second means 12 for measuring. By this configuration, the distances to the sides of the cope and drag can be correctly measured. Further, the device can be made to be compact.

[0075] Further, by the present invention, if the difference S5 between the distance S1 to the first side 2a of the cope as measured by the first means 8 for measuring and the distance S2 to the first side 3a of the drag as measured by the first means 9 for measuring or the difference S6 between the distance S3 to the second side 2b of the cope as measured by the second means 11 for measuring and the distance S4 to the second side 3b of the drag as measured by the second means 12 for measuring is outside of the predetermined allowable range, then a misalignment is determined to have occurred. By this configuration, a misalignment in the assembled cope 2 and drag 3 that have been molded by the flaskless molding machine 1, which misalignment is not visible, can be advantageously detected.

[0076] Further, by the present invention, the distances are continually measured at predetermined intervals along at least parts of the sides of the cope and the drag by the first means 8 for measuring, the first means 9 for measuring, the second means 11 for measuring, and the second means 12 for measuring. By this configuration, a lot of data that are measured and that are used for determining a misalignment can be obtained along the sides of the cope and the drag. Thus any trend in misalignments can be advantageously found.

[0077] Further, by the present invention, no molten metal is poured into the cope 2 and the drag 3 that have been determined to have a misalignment. By this configuration, advantageously the amount of molten metal can be reduced and a useless product with a defect can be prevented.

[0078] By the embodiment of the present invention, after the first means 8 for measuring and the first means 9 for measuring are moved back and forth in the Y-direction by means of the first cylinder 10, the second means 11 for measuring and the second means 12 for measuring are moved back and forth in the X-direction, by means of the second cylinder 13. However, the order of the movements is not limited to the above. They may be moved in the reverse order or at the same time.

[0079] By the embodiment of the present invention, the distances S1, S2, S3, S4 are continually measured at the predetermined intervals along at least parts of the sides of the cope and the drag. However, the measurements are not limited to the above. The distances may be continually measured at the predetermined intervals along the entire sides of the cope and the drag.

[0080] Further, by the embodiment of the present invention, if either of the differences S5, S6 is outside of the predetermined allowable range, a misalignment is determined to have occurred. However, the determination is not limited to the above. Only if both of the differences S5, S6 are outside of the predetermined allowable range may a misalignment be determined to have occurred.

[0081] Further, by the embodiment of the present invention, the device 5 is located downstream of the station 17 for carrying a mold in by a pitch. However, the location of it is not limited to the above. The device 5 may be located anywhere, including at the station 17 for carrying a mold in, but upstream of the position where molten metal is poured into the cope 2 and the drag 3.

[0082] Further, by the embodiment of the present invention, the actuators are not limited to the first cylinder 10, the second cylinder 13, or the third cylinder 15. They may be another type. For example, they may be motors.

[0083] By the above discussion, data on the location of the center of, the angle of rotation of, and the degree of misalignment of, the cope 2 and the drag 3, are sent from the device 5, 40, 60 to the dedicated means 48 for calculating or to a controller for another device, to be processed. However, the data may be sent to a personal computer, a main frame (a general-purpose computer), a server, a cloud server, etc., that are positioned outside the foundry, through the internet, to be processed. Further, the data that have been processed by such a computer, such as the data for operating the device, may be sent back to the device in the foundry, including the device 5, 40, 60, through the internet. The connection with the internet may be made through a controller for another device, not directly through the device 5, 40, 60.

[0084] Below, the main reference numerals and symbols that are used in the detailed description and drawings are listed.

1 the flaskless molding machine
2 the cope
2a the first side of the cope
2b the second side of the cope
2i, 2j, 2k the points for measuring the distances to the cope
3 the drag
3a the first side of the drag
3b the second side of the drag
3i, 3j, 3k the points for measuring the distances to the drag
4 the bogie with a molding board
5 the device that can detect any misalignment between the cope and the drag
6 the direction for carrying out (the cope and the drag from the flaskless molding machine)
7 the conveying direction of (the cope and the drag)
8 the first means for measuring distances to the cope
9 the first means for measuring distances to the drag
10 the first cylinder (the actuator)
11 the second means for measuring distances to the cope
12 the second means for measuring distances to the drag
13 the second cylinder (the actuator)
14 the frame for moving up and down
15 the third cylinder (the actuator)
16 the supporting frame
17 the station for carrying a mold in
18 the station for detecting a misalignment
19 the parting plane
20 the rail
21 the base
22 the frame
30 the molding line
40 the device that can detect any misalignment between the cope and the drag
42 the supporting frame
44 the frame for moving up and down
46 the cylinder (the actuator)
48 the controller (the means for calculating the degree of a misalignment between the cope and the drag)
51 the first means for measuring distances to the cope and the drag
52 the second means for measuring distances to the cope and the drag
53 the third means for measuring distances to the cope and the drag
60 the device that can detect any misalignment between the cope and the drag
62 the supporting frame
64, 66 the horizontal frame
71 the first means for measuring distances to the cope
72 the second means for measuring distances to the cope
73 the third means for measuring distances to the cope
74 the first means for measuring distances to the drag
75 the second means for measuring distances to the drag
76 the third means for measuring distances to the drag
S1 the distance to the first side of the cope
S2 the distance to the first side of the drag
S3 the distance to the second side of the cope
S4 the distance to the second side of the drag
S5 the difference between the distance to the first side of the cope and the distance to the first side of the drag
S6 the difference between the distance to the second side of the cope and the distance to the second side of the drag
S11 the distance from the first means for measuring distances to the cope and the drag to the point on the first side of the cope
S12 the distance from the second means for measuring distances to the cope and the drag to the point on the first side of the cope
S13 the distance from the third means for measuring distances to the cope and the drag to the point on the second side of the cope
S21 the distance from the first means for measuring distances to the cope and the drag to the point on the first side of the drag
S22 the distance from the second means for measuring distances to the cope and the drag to the point on the first side of the drag
S23 the distance from the third means for measuring distances to the cope and the drag to the point on the second side of the drag

Claims

1. A device that can detect any misalignment between a cope and a drag that have been manufactured by means of a flaskless molding machine and assembled and that are being transported to a position for pouring, the device comprising:

a plurality of means for measuring distances to the cope and the drag that measure distances

to the cope and the drag; and
a means for calculating a degree of a misalignment between the cope and the drag that calculates a degree of a misalignment between the cope and the drag on a basis of the distances to the cope and the drag as measured by the means for measuring distances to the cope and the drag.

2. The device that can detect any misalignment between the cope and the drag of claim 1, further comprising:

a means for moving up and down that moves up and down the plurality of the means for measuring distances to the cope and the drag;
wherein the device has three means for measuring distances to the cope and the drag, the three means for measuring distances to the cope and the drag measuring distances to points, which are on same levels of the cope and the drag, and
wherein the three means for measuring distances to the cope and the drag are caused by the means for moving up and down to move to a level for measuring the cope and to a level for measuring the drag.

3. The device that can detect any misalignment between the cope and the drag of claim 2,
wherein the cope and the drag are rectangular in each horizontal section, and
wherein the three means for measuring distances to the cope and the drag are a first means for measuring distances to the cope and the drag, a second means for measuring distances to the cope and the drag, and a third means for measuring distances to the cope and the drag, wherein the first means for measuring distances to the cope and the drag measures the distances to the points, which are on first sides of the cope and drag, which sides are parallel to a conveying direction, respectively, wherein the second means for measuring distances to the cope and the drag measures the distances to the points, which are spaced apart from the points on the first sides by a predetermined distance in the horizontal direction, respectively, wherein the third means for measuring distances to the cope and the drag measures the distances to the points, which are on second sides of the cope and drag, which sides are perpendicular to the conveying direction, respectively.

4. The device that can detect any misalignment between the cope and the drag of claim 3,
wherein the first means for measuring distances to the cope and the drag, the second means for measuring distances to the cope and the drag, and the third means for measuring distances to the cope and the drag, are laser-type displacement sensors.

5. A method that can detect any misalignment between the cope and the drag is a method to use the device of claim 3, the method comprising the steps of:

moving the first means for measuring distances to the cope and the drag, the second means for measuring distances to the cope and the drag, and the third means for measuring distances to the cope and the drag to a level to measure the cope by the means for moving up and down;
measuring a distance to the point on the first side of the cope by the first means for measuring distances to the cope and the drag;
measuring a distance to the point on the first side of the cope by the second means for measuring distances to the cope and the drag;
measuring a distance to the point on the second side of the cope by the third means for measuring distances to the cope and the drag;
calculating a position in a horizontal plane and an angle of rotation in a horizontal direction of the cope by the means for calculating a degree of a misalignment between the cope and the drag based on the distance to the point on the first side of the cope measured by the first means for measuring distances to the cope and the drag, the distance to the point on the first side of the cope measured by the second means for measuring distances to the cope and the drag, and the distance to the point on the second side of the cope measured by the third means for measuring distances to the cope and the drag;
moving the first means for measuring distances to the cope and the drag, the second means for measuring distances to the cope and the drag, and the third means for measuring distances to the cope and the drag to a level to measure the drag by the means for moving up and down;
measuring a distance to the point on the first side of the drag by the first means for measuring distances to the cope and the drag;
measuring a distance to the point on the first side of the drag by the second means for measuring distances to the cope and the drag;
measuring a distance to the point on the second side of the drag by the third means for measuring distances to the cope and the drag;
calculating a position in a horizontal plane and an angle of rotation in a horizontal direction of the drag by the means for calculating a degree of a misalignment between the cope and the drag based on the distance to the point on the first side of the drag measured by the first means for measuring distances to the cope and the drag, the distance to the point on the first side of the drag measured by the second means for

measuring distances to the cope and the drag, and the distance to the point on the second side of the drag measured by the third means for measuring distances to the cope and the drag; calculating a degree of a misalignment based on the positions in the horizontal plane and the angles of rotation in the horizontal direction of the cope and the drag that have been calculated; and

determining that a misalignment has occurred if the degree of misalignment is outside of a predetermined allowable range.

6. The method that can detect any misalignment between the cope and the drag of claim 5, wherein no molten metal is poured into the cope and the drag that have been determined to have a misalignment.

7. The method that can detect any misalignment between the cope and the drag of claim 5, wherein if a misalignment is determined to have occurred, then a molding operation by the flaskless molding machine is stopped.

8. The method that can detect any misalignment between the cope and the drag of claim 5, wherein if a misalignment is determined to have occurred, then a cause of the misalignment is identified and displayed based on an appearance of the misalignment.

9. The method that can detect any misalignment between the cope and the drag of claim 5, wherein if a misalignment is determined to have occurred then a cause of the misalignment is identified based on an appearance of the misalignment, so that conditions for operating the device that is the cause of the misalignment is adjusted.

10. The method that can detect any misalignment between the cope and the drag of claim 5, wherein if no misalignment is determined to have occurred, then data are stored that show that no misalignment has occurred in the flaskless molding machine or a molding line that conveys the cope and the drag from the flaskless molding machine to a position for pouring.

11. The method that can detect any misalignment between the cope and the drag of claim 5, wherein data on the positions in the horizontal plane and the angle of rotation in the horizontal direction of the cope and the drag that have been calculated and data on the degree of misalignment that has been calculated are stored.

12. The method that can detect any misalignment between the cope and the drag of claim 5, wherein if the degree of misalignment is within the allowable range, but not within a warning range, which is smaller than the allowable range, a predictor of a misalignment is displayed.

13. The device that can detect any misalignment between the cope and the drag of claim 1, wherein the cope and the drag are rectangular in each horizontal section, wherein the plurality of means for measuring distances to the cope and the drag are a first means for measuring distances to the cope, a second means for measuring distances to the cope, a third means for measuring distances to the cope, a first means for measuring distances to the drag, a second means for measuring distances to the drag, and a third means for measuring distances to the drag, wherein the first means for measuring distances to the cope measures the distance to the point, which is on a first side of the cope, which side is parallel to a direction for conveying the cope and the drag, wherein the second means for measuring distances to the cope measures the distance to the point, which is spaced apart from the point on the first side of the cope by a predetermined distance in the horizontal direction, wherein the third means for measuring distances to the cope measures the distance to the point, which is on a second side of the cope, which side is perpendicular to the direction for conveying the cope and the drag, wherein the first means for measuring distances to the drag measures the distance to the point, which is on a first side of the drag, which side is parallel to the direction for conveying the cope and the drag, wherein the second means for measuring distances to the drag measures the distance to the point, which is spaced apart from the point on the first side of the drag by a predetermined distance in the horizontal direction, wherein the third means for measuring distances to the drag measures the distance to the point, which is on a second side of the drag, which side is perpendicular to the direction for conveying the cope and the drag.

14. The device that can detect any misalignment between the cope and the drag of claim 1, wherein the cope and the drag are rectangular in each horizontal section, wherein the plurality of means for measuring distances to the cope and the drag are a first means for measuring distances to the cope, a first means for measuring distances to the drag, a second means for measuring distances to the cope, and a second means for measuring distances to the drag, wherein the first means for measuring distances to the cope measures a distance to a first side of the cope, which side is parallel to the direction for conveying the cope, wherein the first means for measuring distances to

the drag measures a distance to a first side of the drag, which side is parallel to the direction for conveying the drag, wherein the second means for measuring distances to the cope measures a distance to a second side of the cope, which side is perpendicular to the direction for conveying the cope, wherein the second means for measuring distances to the drag measures a distance to a second side of the drag, which side is perpendicular to the direction for conveying the drag.

15. The device that can detect any misalignment between the cope and the drag of claim 14,
wherein the first means for measuring distances to the cope and the first means for measuring distances to the drag are configured to be moved by means of an actuator in the direction for conveying the cope and the drag, and
wherein the second means for measuring distances to the cope and the second means for measuring distances to the drag are configured to be moved by means of an actuator in a direction perpendicular to the direction for conveying the cope and the drag.

16. The device that can detect any misalignment between the cope and the drag of claim 14,
wherein the first means for measuring distances to the cope, the first means for measuring distances to the drag, the second means for measuring distances to the cope, and the second means for measuring distances to the drag, are configured to be able to be simultaneously moved up and down by an actuator.

17. The device that can detect any misalignment between the cope and the drag of claim 14,
wherein the first means for measuring distances to the cope, the first means for measuring distances to the drag, the second means for measuring distances to the cope, and the second means for measuring distances to the drag, are laser-type displacement sensors.

18. A method that can detect any misalignment between the cope and the drag is a method to use the device of claim 14, the method comprising the steps of:

measuring a distance to a first side of the cope by the first means for measuring distances to the cope;
measuring a distance to a first side of the drag by the first means for measuring distances to the drag;
measuring a distance to a second side of the cope by the second means for measuring distances to the cope;
measuring a distance to a second side of the drag by the second means for measuring distances to the drag; and
determining a misalignment that has occurred if a difference between the distance to the first side of the cope that is measured by the first means for measuring distances to the cope and the distance to the first side of the drag that is measured by the first means for measuring distances to the drag or a difference between the distance to the second side of the cope that is measured by the second means for measuring distances to the cope and the distance to the second side of the drag that is measured by the second means for measuring distances to the drag, is outside of an allowable range.

19. The method that can detect any misalignment between the cope and the drag of claim 18,
wherein the first means for measuring distances to the cope and the first means for measuring distances to the drag are configured to be moved by means of an actuator in the direction for conveying the cope and the drag,
wherein the second means for measuring distances to the cope and the second means for measuring distances to the drag are configured to be moved by means of an actuator in a direction perpendicular to the direction for conveying the cope and the drag, and
wherein the first means for measuring distances to the cope, the first means for measuring distances to the drag, the second means for measuring distances to the cope, and the second means for measuring distances to the drag, continually measure distances to the respective sides of the cope and drag at intervals along at least parts of the sides.

20. The method that can detect any misalignment between the cope and the drag of claim 18,
wherein no molten metal is poured into the cope and the drag that have been determined to have a misalignment.

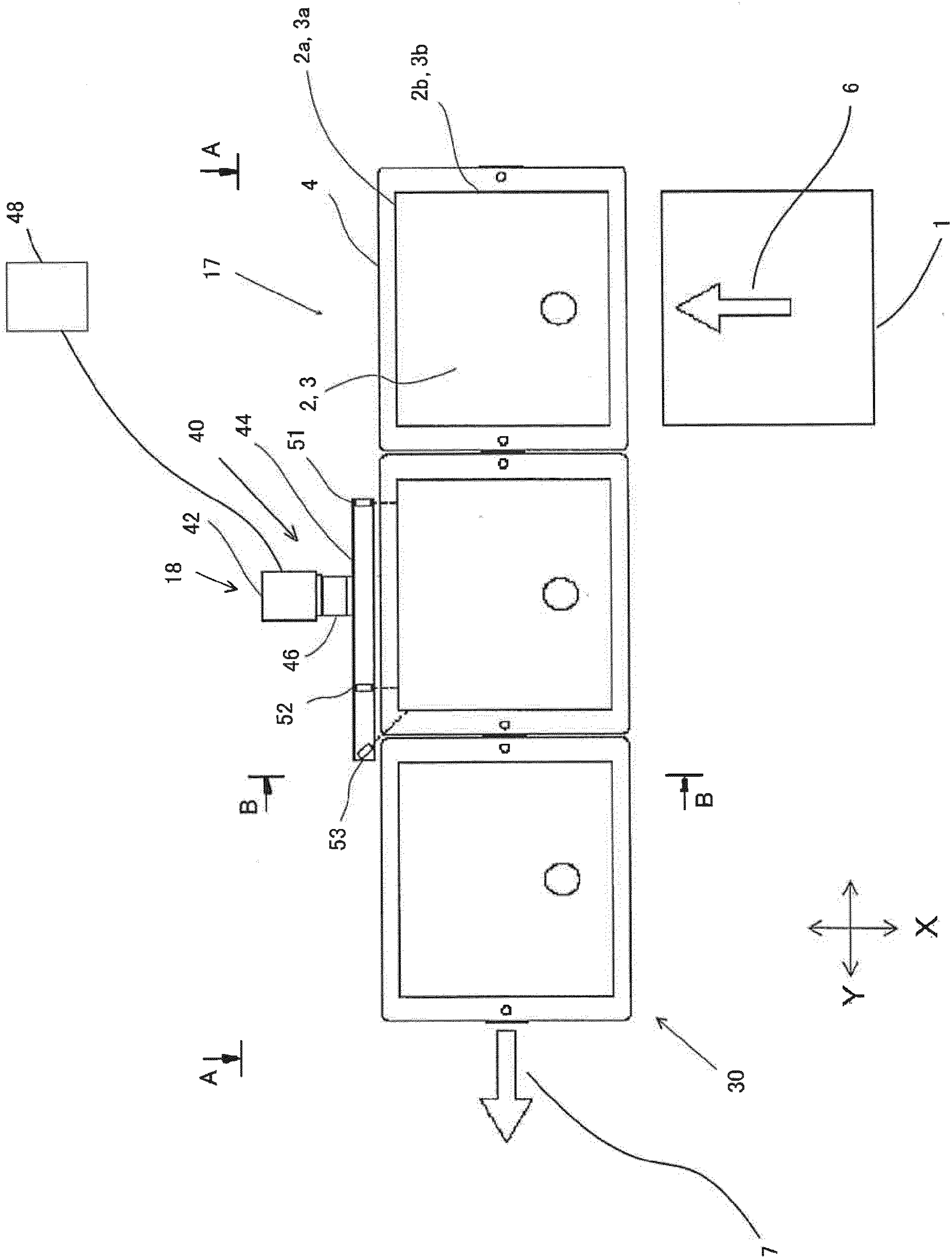


Fig. 1

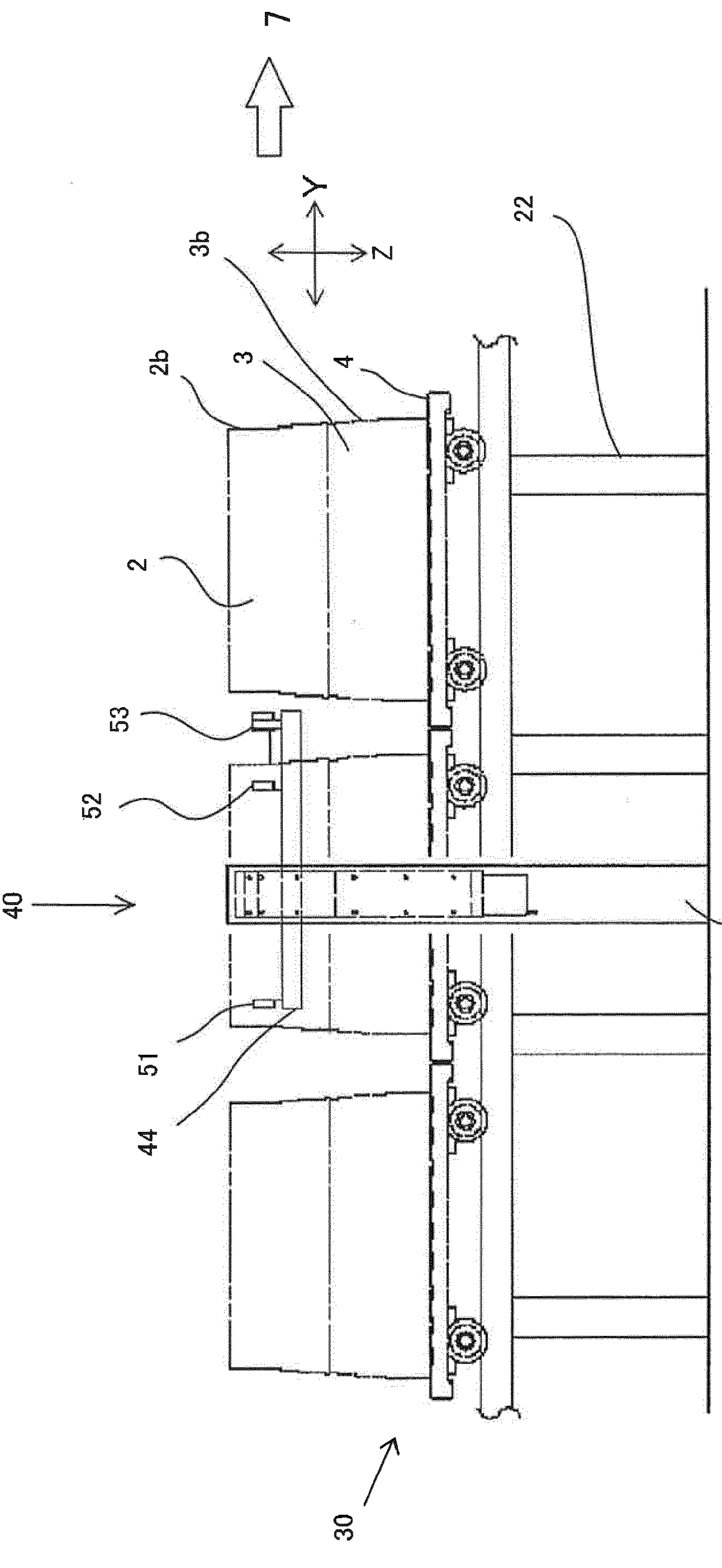


Fig. 2

Fig. 3

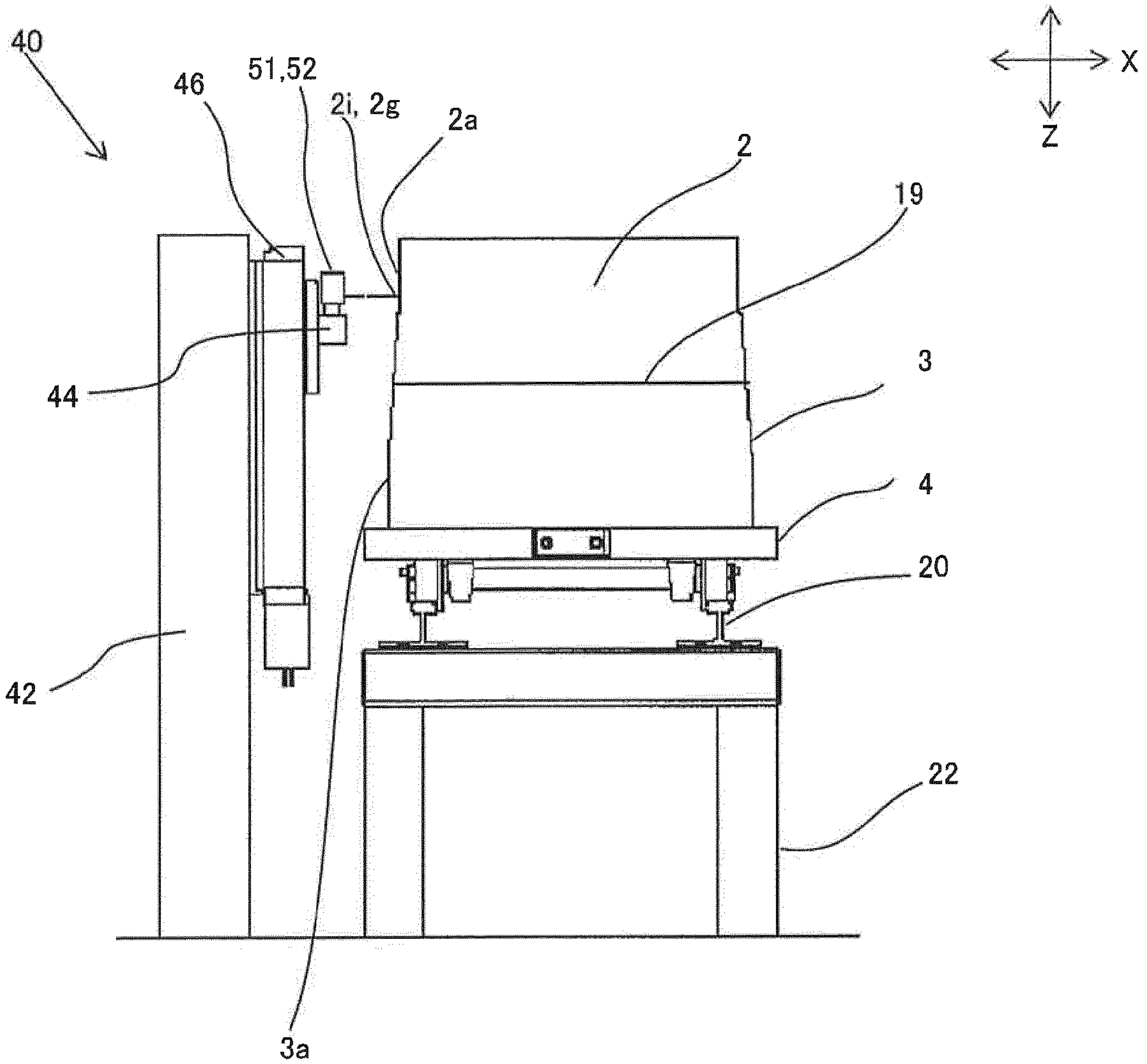


Fig. 4

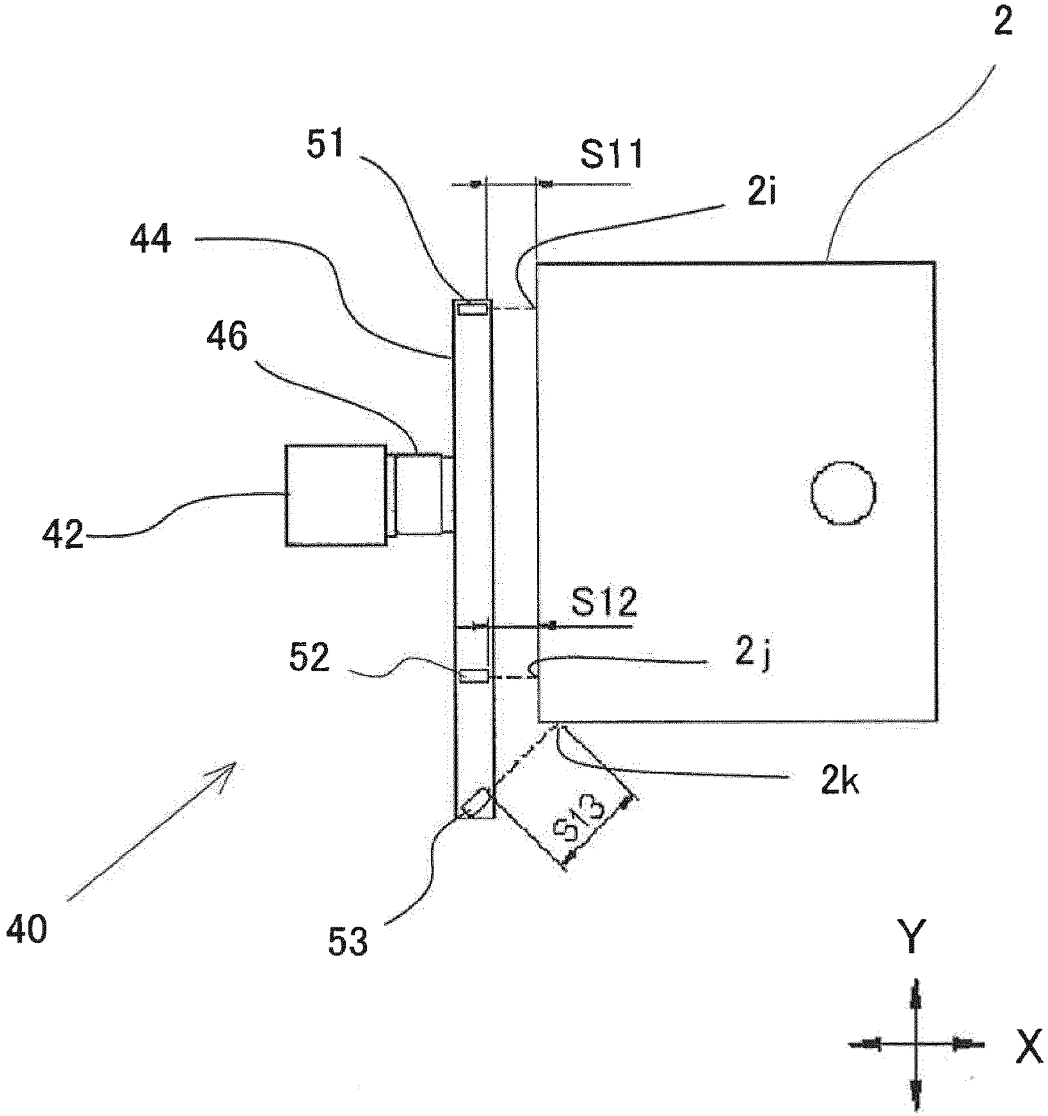


Fig. 5

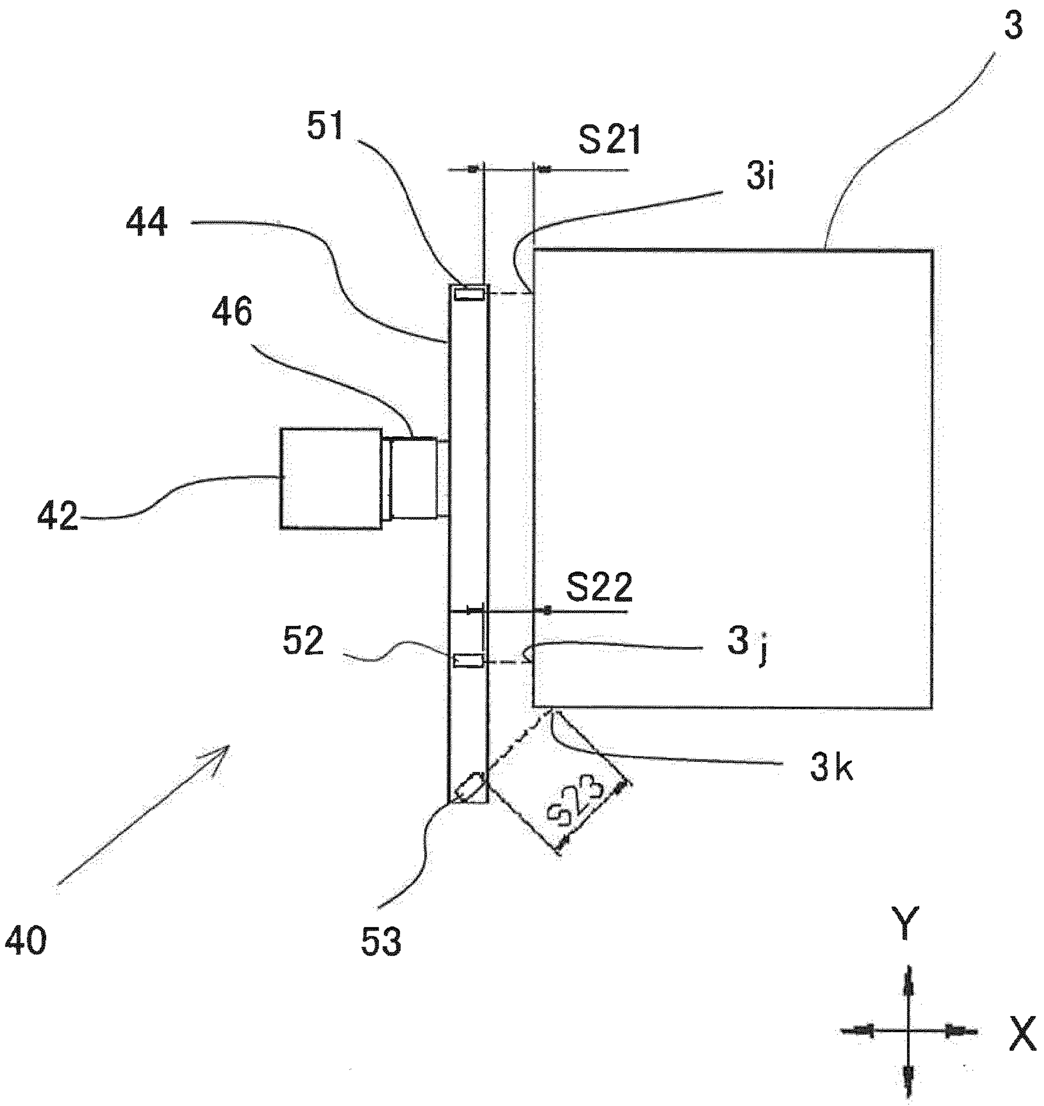
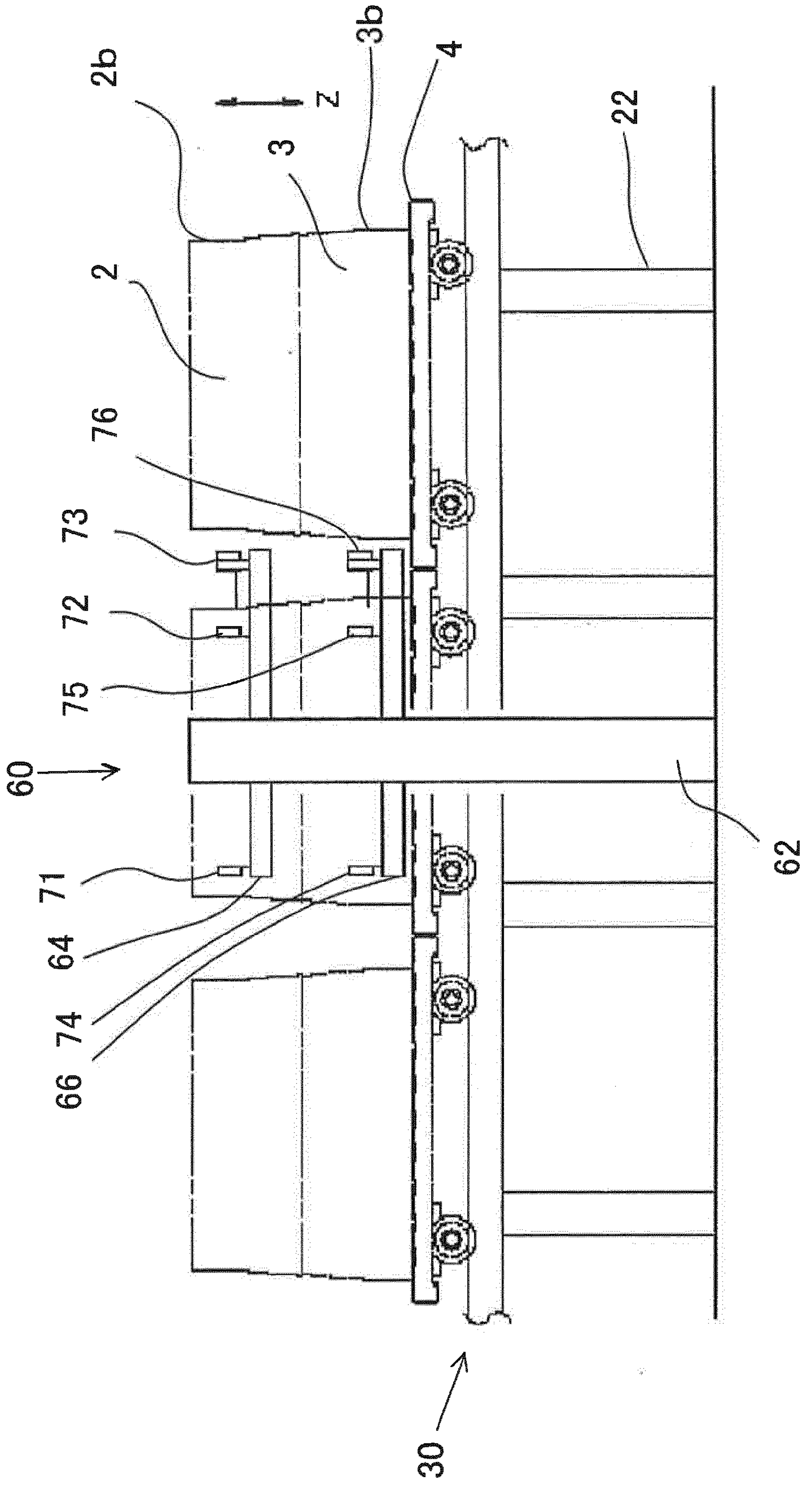


Fig. 6



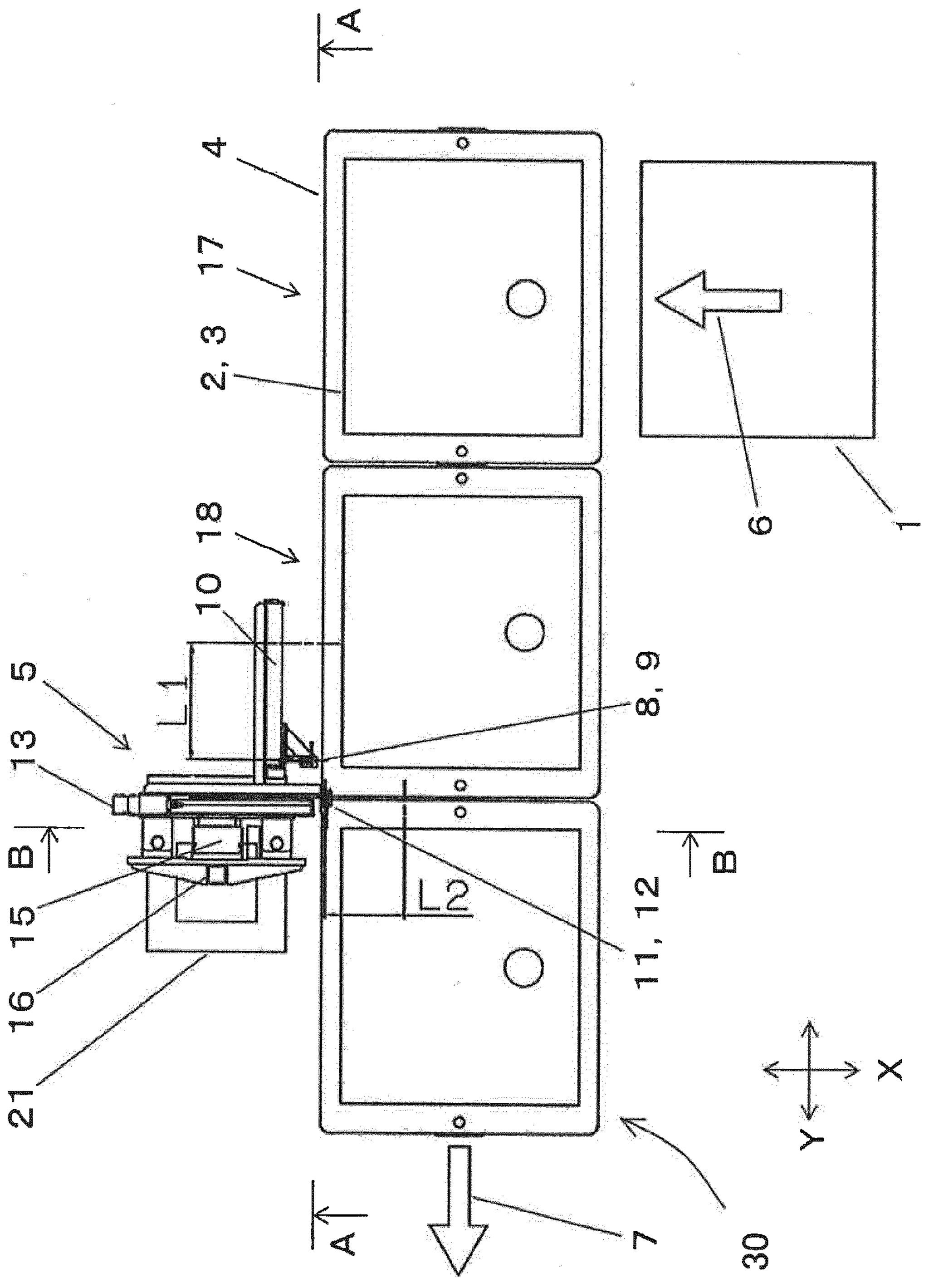


Fig. 7

Fig. 8

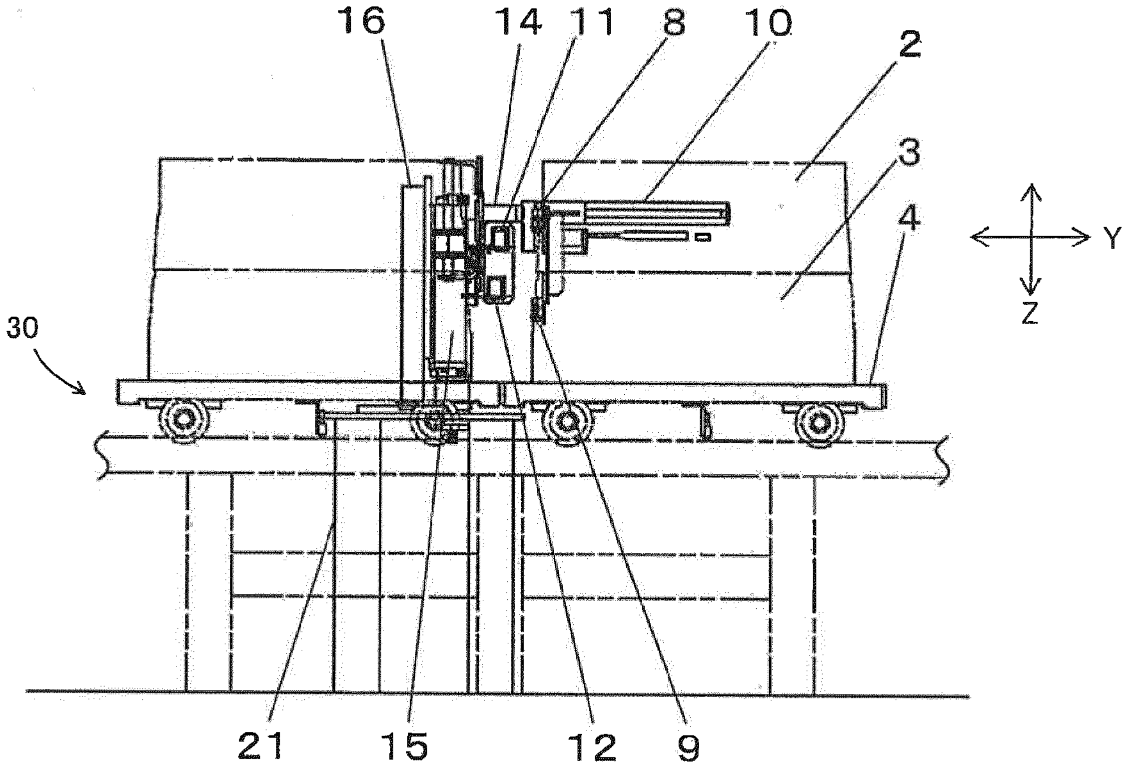


Fig. 9

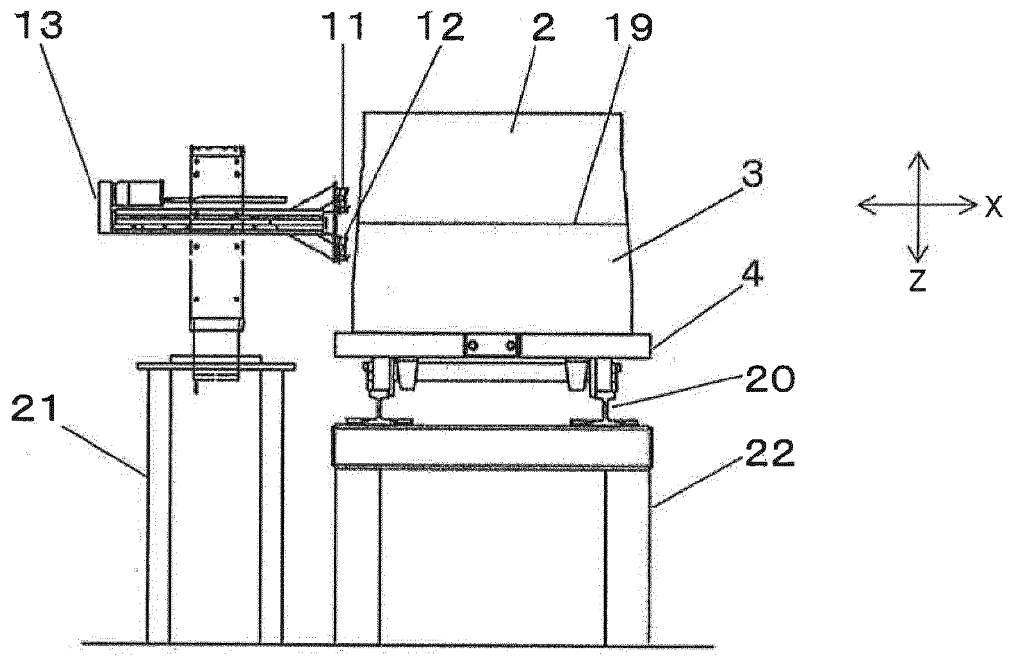
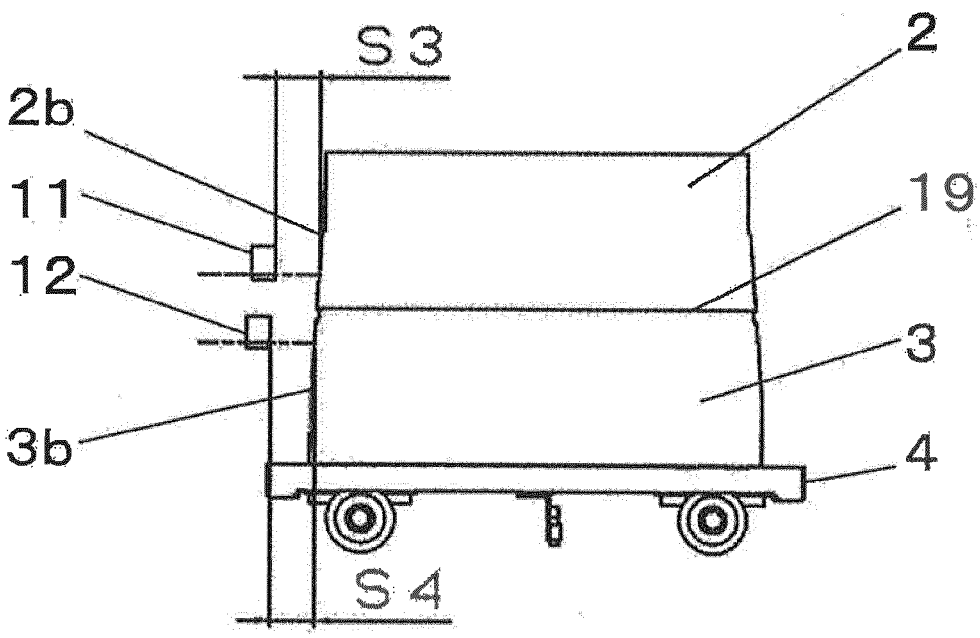
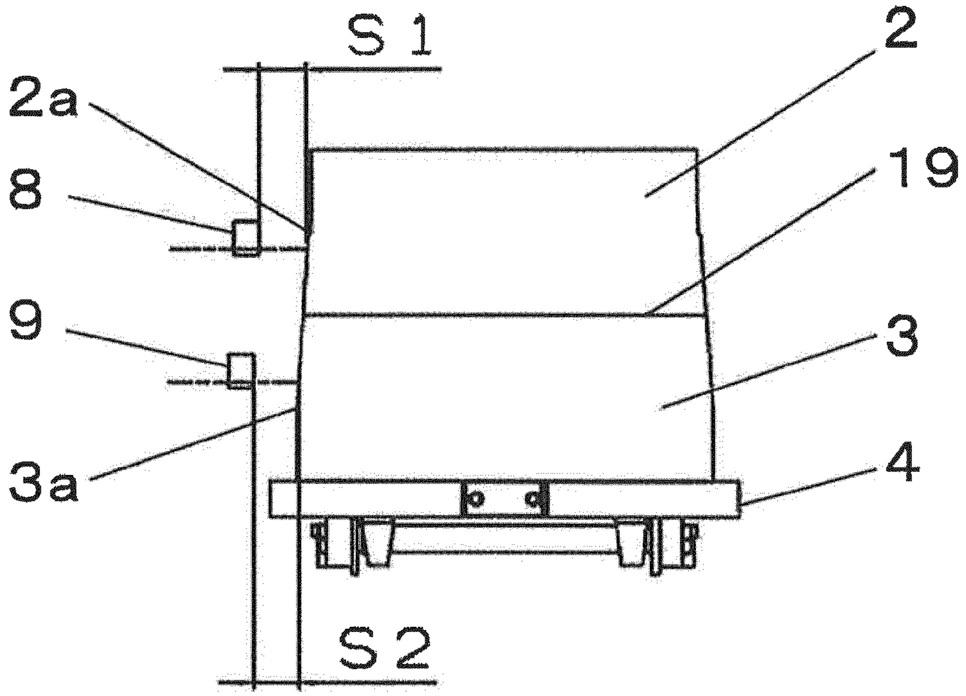


Fig. 10



S3−S4=S6

Fig. 11



S1−S2=S5

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2016/088068

A. CLASSIFICATION OF SUBJECT MATTER

B22C9/00(2006.01)i, *B22C11/00*(2006.01)i, *B22D45/00*(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)

B22C9/00, B22C11/00, B22D45/00

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	1996-2017
Kokai Jitsuyo Shinan Koho	1971-2017	Toroku Jitsuyo Shinan Koho	1994-2017

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 57-168747 A (Komatsu Ltd.), 18 October 1982 (18.10.1982), Detailed Explanation of the Invention; fig. 1 to 11 (Family: none)	1-20
Y	JP 57-79041 A (Kawai Musical Instruments Mfg. Co., Ltd.), 18 May 1982 (18.05.1982), Detailed Explanation of the Invention; fig. 1 to 8 (Family: none)	1-20
Y	JP 10-120172 A (Mecs Corp.), 12 May 1998 (12.05.1998), paragraphs [0005] to [0035]; fig. 1 to 6 (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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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 January 2017 (31.01.17)	07 February 2017 (07.02.17)

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

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/088068

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 10-249487 A (Toyota Motor Corp.), 22 September 1998 (22.09.1998), paragraphs [0012] to [0020]; fig. 1 to 3 (Family: none)	4,17
Y	JP 7-229712 A (Hitachi Metals, Ltd.), 29 August 1995 (29.08.1995), paragraphs [0005] to [0010]; fig. 1 to 3 (Family: none)	4,17

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H661363 B **[0002]**
- JP 2016003646 A **[0025]**