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(54) **PRINTING DEVICE, PRINTING METHOD, AND DETECTION METHOD**

(57) The present invention more appropriately irradiates a medium with ultraviolet rays. A printing device 10 uses an ultraviolet curable ink to perform printing on a three-dimensional medium 50 held by a holding jig 40 which is a holding member. The printing device 10 includes an inkjet head 102, a sub-scanning drive part 18, and a control part 30. The holding jig 40 includes a rotation mechanism, an ultraviolet irradiator, and a cover. The control part 30 causes the inkjet head 102 to perform a main scanning operation by causing the inkjet head 102 to discharge the ink while causing the rotation mechanism to rotate the medium 50 and causes the inkjet head to perform a sub-scanning operation within a range such that the position of a nozzle row in the sub-scanning direction remains within an opposing position medium range when the range from one end to the other end of the medium 50 in the sub-scanning direction at a position opposing the nozzle row is defined as the opposing position medium range.

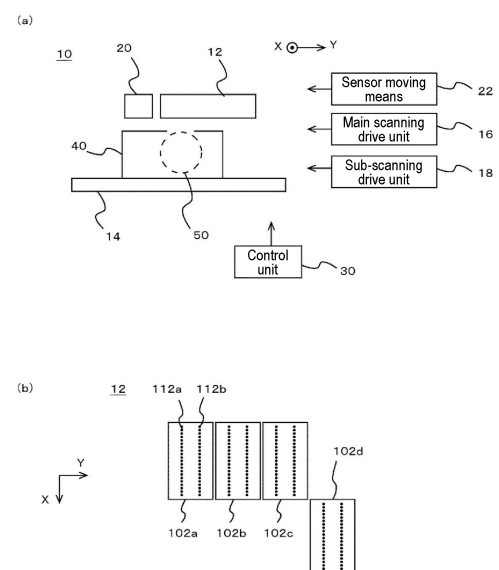


FIG. 1

Description

Technical Field

[0001] The present invention relates to a printing apparatus, a printing method, and a detection method.

Related Art

[0002] Conventionally, a printing apparatus performing printing on an outer surface of a cylindrical body according to an inkjet technique is known (for example, see Patent Document 1). In the printing apparatus disclosed in Patent Document 1, a cylindrical body without ink absorbency is mounted on a mandrel that is rotatable on a central axis and movable in both the axial direction and a direction orthogonal to the axial direction, then desired decorative printing is applied by discharging ultraviolet-curable inks of respective colors from respective inkjet heads of an inkjet head group constituted by a plurality of nozzles that respectively discharge ink of respective colors onto the outer surface of the cylindrical body, and the decorative printing is irradiated with ultraviolet rays for curing.

Related Art Documents

Patent Documents

[0003] Patent Document 1: Japanese Patent Application Laid-Open No. 2010-143200

SUMMARY OF INVENTION

Problem to Be Solved by Invention

[0004] In the case of performing printing according to the inkjet technique using an ultraviolet-curable ink, when ultraviolet rays irradiated for curing the ink hit the inkjet head, the ink may cure at positions of the nozzles of the inkjet head, which may cause nozzle clogging. Further, in the case of performing printing while rotating a medium (workpiece) serving as a printing target, it is contemplated to irradiate ultraviolet rays to the side surface of the medium at a position (a position where the medium has rotated) advanced in the rotation direction from an ink landing position. In such a case, it is contemplated that ultraviolet rays leaking from around the medium become more likely to reach the inkjet head. Therefore, in the case of performing printing in such a configuration, it is desired to more appropriately perform ultraviolet ray irradiation to the medium. Accordingly, an objective of the present invention is to provide a printing apparatus, a printing method, and a detection method capable of solving the above problem.

[0005] Further, in the case of performing printing on a medium serving as a printing target according to the inkjet technique, normally, the inkjet head is caused to dis-

charge ink while moving the inkjet head relatively with respect to a position over the medium opposed to the inkjet head. Further, droplets of ink (ink drops) discharged from the inkjet head reach the medium upon flight between the inkjet head and the medium. To perform printing with high quality, it is desired to cause the inkjet head to discharge ink at a timing matching a distance (head gap) between the inkjet head and the medium.

[0006] Further, regarding this point, for example, in the case of performing printing on a medium (three-dimensional medium) in a three-dimensional shape according to the inkjet technique, if there is deviation in a relative position of the inkjet head with respect to the medium, it may become difficult to perform printing with high quality. For example, in the case of performing printing on a flat medium such as paper or a film, even if deviation occurs in the relative position of the inkjet head with respect to the medium, no change occurs in the head gap. However, in the case of a three-dimensional medium, the head gap varies depending on the position of the medium. Therefore, if deviation occurs in the relative position of the inkjet head with respect to the medium, deviation also occurs in the head gap. As a result, in the case of performing color printing using a plurality of inks of colors different from each other, differences may occur in the deviation manner of the ink landing position according to the ink color, and printing quality may deteriorate. Therefore, conventionally, it has been desired to more appropriately perform printing on a three-dimensional medium. Accordingly, an objective of the present invention is to provide a printing apparatus and an adjustment method capable of solving the above problem.

Means for Solving Problem

[0007] The inventors of the present application have conducted intensive research on a configuration that performs printing according to the inkjet technique while rotating a three-dimensional medium and irradiates ultraviolet rays to an outer surface of the medium. The inventors have conceived of disposing a cover between an ultraviolet irradiator irradiating ultraviolet rays and an inkjet head to cover at least the ultraviolet irradiator. With such a configuration, a configuration in which ultraviolet rays hardly hit the inkjet head can be realized. In the case of using such a cover, for example, it is contemplated to use a cover having an opening matching a shape of the medium. However, even in such a case, it is contemplated that, for example, gaps may be formed between ends of the medium and the cover in an axial direction of rotation, and ultraviolet rays may leak from the gaps. In the case of performing printing on the outer surface of the medium, the inkjet head is caused to discharge ink to respective positions on the outer surface by causing the inkjet head to perform a main scanning operation (scan) and a sub-scanning operation (feed). Here, the sub-scanning operation refers to an operation of moving

relatively with respect to the medium in a predetermined sub-scanning direction. In such a case, for example, if printing is to be performed on a wide range on the outer surface of the medium, it is contemplated that the inkjet head would pass a position of a gap between the cover and the medium in any of the sub-scanning operation performed for a plurality of times. As a result, it is contemplated that ultraviolet rays leaking from the gap hit the inkjet head, causing ink to cure in the vicinity of the nozzles and resulting in nozzle clogging.

[0008] In this regard, the inventors of the present application have conceived of configuring the manner of relative movement of the inkjet head in at least a part of the plurality of times of the sub-scanning operation to be different from the general sub-scanning operation, to create a configuration in which the inkjet head does not pass positions of gaps between the cover and the medium. With such a configuration, ultraviolet rays can be prevented from hitting the inkjet head at positions of gaps between the cover and the medium. Accordingly, nozzle clogging in the inkjet head becomes less likely to occur.

[0009] Further, through additional intensive research, the inventors of the present application have found features necessary to obtain such effects and arrived at the present invention. To solve the above problems, the present invention is a printing apparatus performing printing using an ultraviolet-curable ink on a three-dimensional medium held by a holding member, which holds the medium serving as a printing target. The printing apparatus includes: an inkjet head having a nozzle row in which a plurality of nozzles are arranged with positions different from each other in a predetermined nozzle row direction; a sub-scanning drive unit causing the inkjet head to perform a sub-scanning operation of moving the inkjet head relatively with respect to the medium in a sub-scanning direction parallel to the nozzle row direction; and a control unit configured to control operations of the inkjet head and the sub-scanning drive unit. The holding member includes: a rotation mechanism rotating the medium while holding the medium at a position opposed to the nozzle row; an ultraviolet irradiator irradiating ultraviolet rays to an outer surface of the medium; and a cover that is a member covering at least the ultraviolet irradiator from a side of an upper surface of the holding member, which is a surface on a side opposed to the inkjet head, the cover having an opening at a position opposed to the nozzle row and covering the upper surface of the holding member while allowing the nozzle row and the medium to be opposed to each other at the position of the opening. The rotation mechanism rotates the medium such that a direction of movement of the outer surface of the medium at the position opposed to the nozzle row is a main scanning direction orthogonal to the sub-scanning direction. The control unit is configured to: further perform control on a rotation operation of rotating the medium by the rotation mechanism, and cause the inkjet head to perform a main scanning opera-

tion of discharging ink to the rotating medium by causing the inkjet head to discharge ink while rotating the medium with the rotation mechanism; cause the inkjet head to discharge ink to a printing range having a wider range in the sub-scanning direction than a nozzle row length, which is a length of the nozzle row in the sub-scanning direction, by causing the inkjet head to perform the main scanning operation for a plurality of times while causing the inkjet head to perform the sub-scanning operation in an interval between at least a part of the plurality of times of the main scanning operation; and cause the inkjet head to perform the sub-scanning operation within a range that does not move a position of the nozzle row in the sub-scanning direction to outside an opposed position medium range, the opposed position medium range being defined as a range from one end to another end in the sub-scanning direction of the medium disposed at the position opposed to the nozzle row.

[0010] With such a configuration, in the sub-scanning operation, the inkjet head can be prevented from passing the positions of the gaps between the cover and the medium, and ultraviolet rays can be prevented from hitting the inkjet head at the positions of the gaps between the cover and the medium. Accordingly, clogging of the nozzles of the inkjet head becomes less likely to occur. In such a configuration, the control unit causes the inkjet head to perform all of the plurality of times of the main scanning operation in a state where the position of the nozzle row in the sub-scanning direction is within the opposed position medium range. In such a case, the control unit causes the inkjet head to perform printing on the entire side surface of the medium at maximum, by causing the inkjet head to perform the sub-scanning operation in an interval between at least a part of the plurality of times of the main scanning operation.

[0011] Further, in such a configuration, the ultraviolet irradiator irradiates the medium with ultraviolet rays from a position farther from the inkjet head than a position (uppermost portion of the medium) of the medium closest to the inkjet head. With such a configuration, the ultraviolet irradiator can be easily and appropriately covered by the cover. In such a case, it is desirable that the ultraviolet irradiator irradiates ultraviolet rays toward a position at a rotation angle of 90 degrees to 180 degrees from an ink landing position, at which the ink lands on the medium, in the rotation direction of the medium, downstream in the rotation direction with respect to the ink landing position.

[0012] Further, in such a configuration, the printing apparatus may perform printing according to a multi-pass technique in which a number of times of the main scanning operation performed with one position of the medium being opposed to the nozzle row is a plurality of times. In such a case, the control unit is configured to cause the inkjet head to perform the main scanning operation for a number of times corresponding to a preset number of passes, in a state where one end (front end) of the medium in the sub-scanning direction and one end (front

end) of the nozzle row are aligned with each other in the sub-scanning direction. After causing the inkjet head to perform the main scanning operation for the number of times corresponding to the number of passes, before causing the inkjet head to perform the main scanning operation for a next time, the control unit is configured to cause the inkjet head to perform the sub-scanning operation of moving in the sub-scanning direction relatively with respect to the medium by a pass number corresponding distance, which is a movement distance corresponding to a distance obtained by dividing the nozzle row length by the number of passes. With such a configuration, the main scanning operations corresponding to the number of passes to be performed initially can be appropriately executed without performing a sub-scanning operation in which the inkjet head passes the position of the gap between the cover and the medium on the one end side of the medium. Accordingly, ultraviolet rays can be prevented from hitting the inkjet head at the position of the gap between the cover and the medium. Such an operation may also be regarded as starting the initial main scanning operation (main scanning operation of the first scan) with one end of the medium and one end of the inkjet head aligned with each other. Further, the pass number corresponding distance is an example of a standard movement distance (feed amount) in the sub-scanning operation.

[0013] Further, in such a case, it is also contemplated to perform the sub-scanning operation by a distance shorter than the pass number corresponding distance during the main scanning operations corresponding to the number of passes to be performed initially. For example, it is contemplated that the printing resolution of the printing apparatus in the sub-scanning direction is made higher than a resolution corresponding to a nozzle pitch in the nozzle row. The nozzle pitch refers to a pitch in the sub-scanning direction of the nozzles in the nozzle row. By performing printing according to the multi-pass technique, the printing resolution in the sub-scanning direction can be made higher than the resolution corresponding to a nozzle pitch. For example, it is contemplated that, in an interval between at least a part of the number of times of the main scanning operation corresponding to the number of passes performed with the one end of the medium and the one end of the nozzle row aligned with each other, the sub-scanning drive unit moves the inkjet head relatively with respect to the medium in the sub-scanning direction by a distance less than the nozzle pitch. With such a configuration, high-resolution printing can be performed while preventing ultraviolet rays from hitting the inkjet head at the position of the gap between the cover and the medium.

[0014] Further, in such a configuration, the control unit causes the inkjet head to perform the main scanning operation and the sub-scanning operation such that a sub-scanning operation in which the inkjet head is disposed at the position of the gap between the cover and the medium is not performed on another end (rear end)

side of the medium and the inkjet head, either. More specifically, in the sub-scanning operation performed for a time in which a position of the another end of the nozzle row is to exceed a position of the another end of the medium in the sub-scanning direction upon setting a movement distance of the inkjet head relative to the medium to the pass number corresponding distance, the control unit is configured to cause the inkjet head to perform the sub-scanning operation such that the inkjet head moves relatively with respect to the medium by a movement distance by which the another end of the nozzle row moves until reaching the position of the another end of the medium. With such a configuration, a sub-scanning operation in which the another end of the nozzle row exceeds the position of the another end of the medium can be prevented. Accordingly, ultraviolet rays can be prevented more appropriately from hitting the inkjet head at the position of the gap between the cover and the medium. Further, after causing the inkjet head to perform the sub-scanning operation in which the another end of the nozzle row reaches the position of the another end of the medium in the sub-scanning direction, the control unit is configured to cause the inkjet head to perform the main scanning operation for a plurality of times with the another end of the medium and the another end of the nozzle row aligned with each other. With such a configuration, the main scanning operation can be performed for a required number of times on a range including the another end of the medium. Further, the control unit causes the inkjet head to perform the main scanning operations corresponding to the number of passes with the another end of the medium and the another end of the nozzle row aligned with each other. The another end of the medium and the another end of the nozzle row being aligned with each other may be a state where the distance between the another end of the medium and the another end of the nozzle row is equal to or less than the nozzle pitch. In such a case, the control unit may cause the inkjet head to perform a sub-scanning operation of performing relative movement by a distance less than the nozzle pitch in an interval between the plurality of times of the main scanning operation performed in such a state.

[0015] Further, in the control on printing operations, it is also contemplated to take a range (printing target region) to be printed on the medium as the range of the medium. In such a case, one end (front end) of the medium refers to a position corresponding to one end of the printing range in the sub-scanning direction. Further, the another end (rear end) of the medium is a position corresponding to another end of the printing range in the sub-scanning direction. Aligning the one end of the medium and the one end of the nozzle row corresponds to aligning a position corresponding to one end of the printing data in the sub-scanning direction with the position of the one end of the nozzle row in the sub-scanning direction. Further, aligning the another end of the medium and the another end of the nozzle row corresponds to aligning a position corresponding to another end of the printing data in the sub-

scanning direction with the position of the another end of the nozzle row in the sub-scanning direction.

[0016] Further, in such a configuration, for example, if a gap is formed between the cover and the medium due to displacement of the cover or the like, unintended ultraviolet leakage may occur and ultraviolet rays may hit the inkjet head. Therefore, it is preferable to be capable of confirming whether the cover appropriately covers the ultraviolet irradiator in a predetermined state. In such a case, for example, it is contemplated to detect the status of the gap using a sensor. More specifically, it is contemplated that the printing apparatus further includes: a sensor used for detecting a position of the upper surface of the holding member; and a sensor moving means moving the sensor relatively with respect to the holding member. Here, the holding member may further include a cover moving means moving the cover in a direction in which a distance between the inkjet head and the cover varies. The control unit is further configured to control the sensor and the sensor moving means, and detect a status of a gap formed between the cover and the medium based on an output of the sensor acquired while moving the sensor by the sensor moving means along a path passing an edge of the opening of the cover. With such a configuration, the status of the gap formed between the cover and the medium can be detected. Accordingly, unintended ultraviolet leakage can be appropriately prevented from occurring due to displacement of the cover or the like. In such a case, the control unit is configured to move the sensor along a plurality of paths in a direction intersecting the nozzle row direction. The plurality of paths include: a one-end side path passing a vicinity of one end of the medium in the sub-scanning direction; an other-end side path passing a vicinity of another end of the medium; and an intermediate position path passing over the medium between the one-end side path and the other-end side path. With such a configuration, the status of a gap formed between the cover and the medium can be detected more appropriately.

[0017] As such a sensor, for example, a photosensor detecting light may be suitably used. In such a case, for example, it is contemplated that a light reflective member is attached to at least a part of at least one of the medium and the cover. In such a case, the control unit is configured to move the sensor along a path where the sensor is capable of detecting reflected light from the light reflective member on at least one of the medium and the cover. With such a configuration, the status of the gap formed between the cover and the medium can be detected more appropriately. As the light reflective member, for example, a tape of a light reflective color such as white may be suitably used. Further, in the case of using a photosensor as the sensor, it is also contemplated to directly detect ultraviolet rays leaking from the gap by the sensor. In such a case, in a state where ultraviolet rays are irradiated to the outer surface of the medium by the ultraviolet irradiator, the control unit is further configured to detect ultraviolet rays leaking from a gap between the

edge of the opening of the cover and the medium based on the output of the sensor. With such a configuration, unintended ultraviolet leakage due to displacement of the cover or the like can be detected more appropriately. Further, as a configuration of the present invention, it is also contemplated to use a printing method or the like having similar features as described above. In such a case as well, similar effects as described above can be obtained.

[0018] Further, the features of the present invention may also be considered focusing on a configuration using such a sensor. In such a case, the present invention is a printing apparatus performing printing using an ultraviolet-curable ink on a three-dimensional medium held by a holding member, which holds the medium serving as a printing target. The printing apparatus includes: an inkjet head having a nozzle row in which a plurality of nozzles are arranged with positions different from each other in a predetermined nozzle row direction; a sensor used for detecting a position of an upper surface of the holding member, which is a surface of the holding member opposed to the inkjet head; a sensor moving means moving the sensor relatively with respect to the holding member; and a control unit configured to control operations of the inkjet head, the sensor, and the sensor moving means. The holding member includes: a rotation mechanism rotating the medium while holding the medium at a position opposed to the nozzle row; an ultraviolet irradiator irradiating ultraviolet rays to an outer surface of the medium; a cover that is a member covering at least the ultraviolet irradiator from a side of the upper surface of the holding member, has an opening at a position opposed to the nozzle row, and covers the upper surface of the holding member while allowing the nozzle row and the medium to be opposed to each other at the position of the opening; and a cover moving means moving the cover in a direction in which a distance between the inkjet head and the cover varies. The control unit is configured to detect a status of a gap formed between the cover and the medium based on an output of the sensor acquired while moving the sensor by the sensor moving means along a path passing an edge of the opening of the cover.

[0019] With such a configuration, the status of a gap formed between the cover and the medium can be appropriately detected. Accordingly, unintended ultraviolet leakage due to displacement of the cover or the like can be appropriately prevented. Therefore, with such a configuration, irradiation of ultraviolet rays to the medium can be performed more appropriately. Further, as a configuration of the present invention, it is also contemplated to use a detection method or the like having similar features as described above. In such a case as well, similar effects as described above can be obtained.

[0020] Further, the inventors of the present application have conceived of detecting a relative position of an inkjet head with respect to a medium in the case of performing printing on a three-dimensional medium according to the inkjet technique, to perform adjustment as necessary.

Further, as such a method, the inventors of the present application have conceived of causing the inkjet head to draw a pattern that overlaps on the medium in the case where the relative position of the inkjet head is correct, and does not overlap in the case where the relative position of the inkjet head deviates from the correct position. Further, through intensive research, the inventors of the present application have conceived of using, as such a pattern, a first pattern drawn by a nozzle row (nozzle row in the inkjet head) having a relative position at a first position with respect to the medium, and a second pattern drawn by the nozzles having a relative position at a second position. With such a configuration, the relative position of the inkjet head with respect to the medium can be detected, and the position of the inkjet head can be appropriately adjusted as necessary.

[0021] Further, through additional intensive research, the inventors of the present application have found features necessary for obtaining such effects and arrived at the present invention. To solve the above problems, the present invention is a printing apparatus performing printing on a three-dimensional medium. The printing apparatus includes: an inkjet head having a nozzle row in which a plurality of nozzles are arranged in a predetermined nozzle row direction; a main scanning drive unit causing the inkjet head to perform a main scanning operation of discharging ink while moving relatively along a preset main scanning direction over a printing surface of the medium; and a control unit configured to control operations of the inkjet head and the main scanning drive unit. The control unit is configured to cause the inkjet head to draw a first pattern and a second pattern in adjusting a position of the inkjet head. With a relative position of the inkjet head with respect to the medium being at a predetermined reference position, the first pattern and the second pattern are drawn at a same position in the main scanning direction on the medium. The inkjet head draws the first pattern with ink discharged from the nozzles of the nozzle row in a state where a relative position of the nozzle row with respect to the medium is at a first position, and draws the second pattern with ink discharged from the nozzles of the nozzle row in a state where the relative position of the nozzle row with respect to the medium is at a second position different from the first position.

[0022] With such a configuration, in the case where the relative position of the inkjet head having the nozzle row is aligned with the reference position, the first pattern and the second pattern are drawn at the same position in the main scanning direction on the medium. Further, in the case where the relative position of the inkjet head deviates from the reference position, a shift occurs in positions (positions in the main scanning direction) where the first pattern and the second pattern are drawn on the medium. Accordingly, whether the relative position of the inkjet head is aligned with the reference position can be appropriately detected. Accordingly, the relative position of the inkjet head can be appropriately adjusted as ne-

cessary. Therefore, with such a configuration, printing can be performed more appropriately on a three-dimensional medium.

[0023] In such a configuration, the relative position of the nozzle row with respect to the medium (relative position of the nozzle row) may be regarded as corresponding to the relative position of the inkjet head with respect to the medium. Regarding the relative position of the inkjet head, the reference position may be regarded as a predetermined correct position. Further, the first pattern and the second pattern being drawn at the same position in the main scanning direction may be regarded as being drawn at substantially the same position at a precision corresponding to the quality or the like required for printing. The first pattern and the second pattern being drawn at the same position in the main scanning direction may also be regarded as the first pattern and the second pattern overlapping in the main scanning direction.

[0024] Further, in such a configuration, the medium is held by a holding member disposed at a position opposed to the inkjet head. The holding member includes a rotation mechanism rotating the medium while holding the medium at a position opposed to the nozzle row. The main scanning drive unit moves the inkjet head relatively in the main scanning direction with respect to the position of the medium opposed to the nozzle row by rotating the medium with the rotation mechanism. With such a configuration, in the case of using a three-dimensional medium, the inkjet head can be caused to appropriately perform the main scanning operation. Accordingly, printing can be appropriately performed on a three-dimensional medium. As the medium held by the holding member, for example, a cylindrical (tubular) medium may be suitably used. The cylindrical medium is an example of a medium in a rotating body shape. Further, it is also contemplated that the holding member holds a medium having a rotating body shape other than a cylindrical shape, such as a conical or truncated conical medium. Further, in the case of rotating the medium with the holding member, the first pattern and the second pattern being drawn at the same position in the main scanning direction may also be regarded as the first pattern and the second pattern being drawn at the same position in the rotation direction.

[0025] Further, in such a configuration, it is contemplated to draw the first pattern and the second pattern using a plurality of nozzle rows included in one inkjet head. In such a case, the inkjet head has a plurality of nozzle rows having positions different from each other in the main scanning direction. The plurality of nozzle rows are an example of a plurality of nozzle rows in which the relative position of one with respect to the other is known. Regarding the plurality of nozzle rows, the positions in the main scanning direction being different from each other means that, in a state where the inkjet head is at a position for discharging ink to the medium, the positions of the plurality of nozzle rows in the inkjet head in the main scanning direction are different from each other. Further, in such a case, for example, it is contemplated to draw the

first pattern by discharging ink from the nozzles in a first nozzle row among the plurality of nozzle rows in one inkjet head, and to draw the second pattern by discharging ink from the nozzles in a second nozzle row different from the first nozzle row. Accordingly, it is possible to appropriately detect whether the position of the inkjet head having the nozzle rows is aligned with the reference position.

[0026] Further, in the case of using an inkjet head having a plurality of nozzle rows and using the above-described holding member, it is contemplated that the inkjet head is fixed such that the first nozzle row and the second nozzle row are disposed on sides opposite to each other, with the position of the rotation center of the medium in the main scanning direction as a boundary, and the first nozzle row and the second nozzle row are caused to draw the first pattern and the second pattern. In such a case, regarding the position in the main scanning direction, it is contemplated to align the center position between the first nozzle row and the second nozzle row in the inkjet head with the position of the rotation axis of the medium. Further, the control unit of the printing apparatus causes the inkjet head to draw the first pattern and the second pattern by causing the nozzles of the first nozzle row and the nozzles of the second nozzle row to discharge ink in such a state.

[0027] Further, as the first pattern and the second pattern in such a configuration, it is contemplated to use patterns having an overlapping manner that varies depending on the manner of positional deviation in the case where the relative position of the inkjet head with respect to the medium deviates from the reference position. With such a configuration, the relative position of the inkjet head can be adjusted more easily and appropriately. Further, in such a configuration, the printing apparatus may include a plurality of inkjet heads. In such a case, for example, in addition to the first pattern and the second pattern described above, it is also contemplated to cause the inkjet heads to draw a pattern for detecting deviation in the distance between the inkjet heads. As such a pattern, it is contemplated to use a pattern having a state that varies depending on the distance between the plurality of inkjet heads. In such a case, the control unit of the printing apparatus further causes the plurality of inkjet heads to draw a pattern having a state that varies depending on the distance between the plurality of inkjet heads. Further, the first pattern and the second pattern described above are patterns for adjusting deviation in ink landing positions that occurs between a plurality of nozzle rows with known relative positions, such as a plurality of nozzle rows in one inkjet head. In contrast, the above-described pattern for detecting deviation in the distance between the inkjet heads is a pattern for adjusting deviation in ink landing positions that occurs between the inkjet heads.

[0028] Further, in the case of holding the medium by the holding member and performing printing while rotating the medium, it is also contemplated to draw the first

pattern and the second pattern with different rotation directions of the medium. In such a case, the features of the present invention may also be considered focusing on the configuration of a printing apparatus performing printing on a three-dimensional medium held by a holding member. Regarding the present invention, it is also contemplated that a printing apparatus performs printing on a three-dimensional medium held by a holding member, which holds the medium serving as a printing target. The printing apparatus includes: an inkjet head having a nozzle row in which a plurality of nozzles are arranged in a predetermined nozzle row direction; a main scanning drive unit causing the inkjet head to perform a main scanning operation of discharging ink while moving relatively along a preset main scanning direction over a printing surface of the medium; and a control unit configured to control operations of the inkjet head and the main scanning drive unit. The holding member includes a rotation mechanism rotating the medium while holding the medium at a position opposed to the nozzle row. The main scanning drive unit moves the inkjet head relatively in the main scanning direction with respect to the printing surface of the medium by rotating the medium with the rotation mechanism. The control unit is configured to cause the inkjet head to draw a first pattern and a second pattern in adjusting a position of the inkjet head. With a relative position of the inkjet head with respect to the medium being at a predetermined reference position, the first pattern and the second pattern are drawn at a same position in the main scanning direction on the medium. The inkjet head draws the first pattern in a state where the medium is rotated in a first rotation direction by the rotation mechanism, and draws the second pattern in a state where the medium is rotated in a second rotation direction opposite to the first rotation direction. With such a configuration as well, it is possible to appropriately detect whether the relative position of the inkjet head is aligned with the reference position. Accordingly, printing can be performed more appropriately on a three-dimensional medium. Further, as a configuration of the present invention, it is also contemplated to use an adjustment method having similar features as described above. In such a case as well, similar effects as described above can be obtained.

Effects of Invention

[0029] According to the present invention, ultraviolet irradiation to a medium can be performed more appropriately. Further, according to the present invention, printing can be performed more appropriately on a three-dimensional medium.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

[FIG. 1] is a diagram illustrating a printing apparatus

10 according to an embodiment of the present invention. FIG. 1(a) shows an example configuration of essential components of the printing apparatus 10. FIG. 1(b) shows an example configuration of a head unit 12.

[FIG. 2] is a diagram showing an example configuration of a holding jig 40. FIG. 2(a) and (b) are a cross-sectional view and a top view schematically showing an example configuration of the holding jig 40.

[FIG. 3] is a diagram showing an example configuration of the holding jig 40. FIG. 3(a) is a cross-sectional view showing a more specific example configuration of the holding jig 40. FIG. 3(b) is a perspective view showing an example configuration of an ultraviolet irradiator 208 in the holding jig 40.

[FIG. 4] is a diagram illustrating a magnet sheet 224 in the holding jig 40.

[FIG. 5] is a diagram showing an example of a main scanning operation and a sub-scanning operation that are the same as or similar to conventional methods.

[FIG. 6] is a diagram showing an example of a main scanning operation and a sub-scanning operation in the present embodiment.

[FIG. 7] is a diagram showing another example of the main scanning operation and the sub-scanning operation in the present embodiment. FIG. 7(a) shows an example of a position of an inkjet head 102 during the main scanning operation of an Nth scan and an (N+1)th scan performed on a medium 50 of a predetermined size. FIG. 7(b) shows an example of the position of the inkjet head 102 during the main scanning operation of an (N-1)th scan and an Nth scan performed on a medium 50 of a predetermined size different from FIG. 7(a).

[FIG. 8] is a diagram showing an example operation for detecting a status of a gap using a sensor 20.

[FIG. 9] is a flowchart representing an example operation for detecting a status of a gap in the printing apparatus 10.

[FIG. 10] is a diagram illustrating a method for printing on a side surface of the medium 50. FIG. 10(a) and (b) show example methods of printing on a side surface of the medium 50.

[FIG. 11] is a diagram illustrating a target of adjustment performed on the printing apparatus 10. FIG. 11(a) shows an example of a correct state that does not require adjustment. FIG. 11(b) shows an example of a state that requires adjustment.

[FIG. 12] is a diagram illustrating patterns drawn by the printing apparatus 10 during adjustment. FIG. 12(a) is a diagram illustrating patterns 302a and 302b drawn by the inkjet head 102. FIG. 12(b) shows an example of states of the patterns 302a and 302b drawn in the case where no deviation occurs in a relative position of the inkjet head 102 with respect to the medium 50.

[FIG. 13] is a diagram illustrating patterns drawn by the printing apparatus 10 during adjustment. FIG. 13(a) and (b) show examples of states of patterns 302a and 302b drawn in the case where deviation occurs in the relative position of the inkjet head 102 with respect to the medium 50.

[FIG. 14] is a diagram illustrating adjustment related to a distance between inkjet heads 102. FIG. 14(a) and (b) are diagrams illustrating a problem that occurs in the case where there is deviation in the distance between the inkjet heads 102. FIG. 14(c) shows an example of patterns 304a and 304b used during adjustment related to the distance between the inkjet heads 102.

[FIG. 15] is a diagram showing a modified example of an adjustment operation for the printing apparatus 10. FIG. 15(a) and (b) show examples of the adjustment operation.

EMBODIMENTS FOR IMPLEMENTING INVENTION

[0031] Hereinafter, embodiments according to the present invention will be described with reference to the drawings. FIG. 1 is a diagram illustrating a printing apparatus 10 according to an embodiment of the present invention. FIG. 1(a) shows an example configuration of essential components of the printing apparatus 10. Except for the aspects described below, the printing apparatus 10 and components of the printing apparatus 10 may have the same or similar features as conventional printing apparatuses and components thereof.

[0032] In the present embodiment, the printing apparatus 10 is an inkjet printer that performs printing using an ultraviolet-curable ink (UV ink) on a three-dimensional medium 50 held by a holding jig 40. The ultraviolet-curable ink refers to an ink that is fixed to the medium 50 upon curing with ultraviolet irradiation. The medium 50 may also be regarded as a processing target (workpiece) that is a target of printing processing in the printing apparatus 10. Further, in the present embodiment, the holding jig 40 is an example of a holding member that holds the medium 50, and rotatably holds the medium 50 around a predetermined rotation axis at a position opposed to an inkjet head 102, and rotates the medium 50 in accordance with control of the printing apparatus 10. The position opposed to the inkjet head 102 refers to a position opposed to nozzle rows of the inkjet head 102. Holding the medium 50 at the position opposed to the inkjet head 102 means holding the medium 50 at the position opposed to the inkjet head 102 during ink discharge in which ink is discharged from the inkjet head 102 to the medium 50. Further, in the present embodiment, the holding jig 40 includes an ultraviolet irradiator and irradiates ultraviolet rays to an outer surface of the medium 50. The configuration of the holding jig 40 will be described in more detail later.

[0033] Further, in the present embodiment, the printing apparatus 10 includes a head unit 12, a platform unit 14, a

main scanning drive unit 16, a sub-scanning drive unit 18, a sensor 20, a sensor moving means 22, and a control unit 30. The head unit 12 is configured to include an inkjet head that discharges ink to the medium 50. The configuration of the head unit 12 will be described in more detail later. The platform unit 14 is a platform-shaped member that holds the holding jig 40 at a position opposed to the head unit 12. In the present embodiment, with the holding jig 40 placed on an upper surface, the platform unit 14 holds the holding jig 40 such that the medium 50 held by the holding jig 40 and the inkjet head of the head unit 12 are opposed to each other. The main scanning drive unit 16 is a drive unit that causes the inkjet head of the head unit 12 to perform a main scanning operation. The main scanning operation is an operation of discharging ink while moving relatively with respect to the medium 50 in a preset main scanning direction (Y direction in the figure). Further, in the present embodiment, by causing the holding jig 40 to rotate the medium 50 in accordance with control of the control unit 30, the main scanning drive unit 16 moves the opposed position between the medium 50 and the nozzle rows in a circumferential direction. This may also be regarded as the inkjet head moving relatively in the main scanning direction with respect to the medium 50 due to rotation of the medium 50. The main scanning operation in the present embodiment may also be regarded as an operation of discharging ink to a rotating medium. Further, the main scanning operation may also be regarded as an operation of discharging ink to the medium 50 while fixing the position of the inkjet head with respect to the medium 50 in a sub-scanning direction.

[0034] The sub-scanning drive unit 18 is a drive unit that causes the inkjet head of the head unit 12 to perform a sub-scanning operation. The sub-scanning operation refers to an operation of moving relatively with respect to the medium 50 in a sub-scanning direction (X direction in the figure) orthogonal to the main scanning direction. The sub-scanning operation may also be regarded as a feed operation that changes a range of the medium opposed to the inkjet head by relative movement in the sub-scanning direction. Further, in the present embodiment, the main scanning direction is an example of a predetermined first direction. The sub-scanning direction is an example of a second direction orthogonal to the first direction. Further, the main scanning operation is an example of a first scanning of discharging ink while moving relatively in the first direction with respect to each position of the medium 50. The sub-scanning operation is an example of a second scanning of moving relatively with respect to the medium 50 in the second direction.

[0035] The sensor 20 is detection means used for detecting a state of the holding jig 40. In the present embodiment, the sensor 20 is a photosensor and detects ultraviolet rays leaking from an opening of the holding jig 40. The sensor 20 enables detection of whether the medium 50 is appropriately disposed with respect to the holding jig 40. More specifically, with the sensor 20 detecting leakage of ultraviolet rays that occurs due to

displacement of a cover of the holding jig 40 or the medium 50, displacement of the cover or the medium 50 can be detected. Further, it is also contemplated that, based on the detection result of the sensor 20, the status of a gap formed between the cover of the holding jig 40 and the medium 50 may be detected. The sensor moving means 22 is means for moving the sensor 20 relatively with respect to the holding jig 40, and moves the sensor 20 according to a spot to be detected by the sensor 20. Further, the control unit 30 is a portion including, for example, a CPU of the printing apparatus 10, and controls operations of respective units of the printing apparatus 10 in accordance with a program such as firmware (FW) of the printing apparatus 10 or the like.

[0036] Next, the configuration of the head unit 12 will be described in more detail. FIG. 1(b) shows an example configuration of the head unit 12. In the present embodiment, the head unit 12 has a plurality of inkjet heads 102 that discharge ultraviolet-curable ink. In the present embodiment, the head unit 12 has four inkjet heads 102, as distinguished and shown as reference signs 102a to 102d in the figure. Among them, the inkjet heads 102a to 102c are arranged side by side in the main scanning direction, with their positions aligned in the sub-scanning direction. Further, the inkjet head 102d is arranged with its position shifted in the sub-scanning direction from the inkjet heads 102a to 102c. This may also be regarded as arranging at least a part of the inkjet heads 102 of the head unit 12 side by side in the main scanning direction, with their positions aligned in the sub-scanning direction, and may also be regarded as arranging a part of the inkjet heads 102 with their positions shifted in the sub-scanning direction from the other inkjet heads 102.

[0037] Further, for example, as distinguished and shown by reference signs 112a and 112b on the inkjet head 102 labeled as reference sign 102a in the figure, in the present embodiment, the inkjet head 102 has a plurality of nozzle rows 112 (two nozzle rows 112). The nozzle row 112 is a row in which a plurality of nozzles are arranged with their positions differing from each other in a predetermined nozzle row direction. In the present embodiment, the nozzle row direction is a direction parallel to the sub-scanning direction. Further, the positions of the plurality of nozzle rows 112 in the main scanning direction are different from each other. Further, in the present embodiment, the plurality of nozzle rows 112 in the same inkjet head 102 are an example of a plurality of nozzle rows 112 in which the relative position of one with respect to the other is known. The inkjet head 102 discharges inks of a plurality of colors by the plurality of nozzle rows 112. The inkjet head 102 discharges an ink of a first color from a first nozzle row 112, and discharges an ink of a second color different from the first color from a second nozzle row 112 different from the first nozzle row 112. Further, according to the content of printing required, the inkjet head 102 may also discharge ink of the same color from the plurality of nozzle rows 112.

[0038] Here, in the present embodiment, the printing

apparatus 10 performs printing using a multi-pass technique. The multi-pass technique is a technique in which a main scanning operation is performed for a plurality of times on one position of the medium 50. Further, in the present embodiment, during execution of printing by the printing apparatus 10, by moving the head unit 12 relatively with respect to the medium 50, the control unit 30 moves the inkjet heads 102 of the head unit 12 sequentially to directly above the rotating medium 50 to oppose the inkjet heads 102 to the medium 50. Then, the control unit 30 causes the plurality of inkjet heads 102 to sequentially discharge ink to the medium 50. With the first inkjet head 102 and the medium 50 opposed to each other, the control unit 30 causes the inkjet head 102 to discharge ink to an entire printing range on a side surface of the medium 50. Then, after causing the first inkjet head 102 to discharge ink to the medium 50, the control unit 30 causes the second inkjet head 102 different from the first inkjet head 102 to oppose to the medium 50, and in such a state, in a manner similar to the above, causes the inkjet head 102 to discharge ink to the side surface of the medium 50. By repeating similar operations thereafter, the control unit 30 causes the plurality of inkjet heads 102 of the head unit 12 to discharge ink to the medium 50.

[0039] Next, the configuration of the holding jig 40 used in the printing apparatus 10 in the present embodiment will be described in more detail. FIG. 2 and FIG. 3 show an example configuration of the holding jig 40. FIG. 2(a) and (b) are a cross-sectional view and a top view schematically showing an example configuration of the holding jig 40. FIG. 3(a) is a cross-sectional view showing an example of a more specific configuration of the holding jig 40. FIG. 3(b) is a perspective view showing an example configuration of the ultraviolet irradiator 208 in the holding jig 40. As described above, in the present embodiment, the holding jig 40 rotatably holds the medium 50. Further, the holding jig 40 irradiates ultraviolet rays to the outer surface of the medium 50. To perform these operations, in the present embodiment, the holding jig 40 includes a housing unit 202, a cover 204, a rotation mechanism 206, an ultraviolet irradiator 208, a light source holding unit 210, and a cover moving means 212.

[0040] The housing unit 202 is a housing portion of the holding jig 40 that constitutes a bottom surface and side surfaces of the holding jig 40, and the rotation mechanism 206, the ultraviolet irradiator 208, the light source holding unit 210, and the like are accommodated between the housing unit 202 and the cover 204. The cover 204 is a member that covers the upper surface of the holding jig 40. The upper surface of the holding jig 40 is a surface of the holding jig 40 on a side opposed to the inkjet head 102 (see FIG. 1). Further, the cover 204 may also be regarded as a member that covers at least the ultraviolet irradiator 208 from the upper surface side of the holding jig 40. Further, in the present embodiment, the cover 204 includes an opening 220 at a position opposed to the nozzle rows of the inkjet head 102, and covers the upper surface of the holding jig 40 while the nozzle rows and the

medium 50 are opposed each other at the position of the opening 220. Having the opening 220 at a position opposed to the nozzle rows means having the opening 220 at a position opposed to the nozzle rows of any of the inkjet heads 102 in a state where such inkjet heads 102 are opposed to the medium 50 during printing. Further, the opening 220 may also be regarded as being opened on the upper surface of the holding jig 40 such that ink discharged from the nozzle rows by the inkjet head 102 reaches the medium 50.

[0041] Further, in the present embodiment, the cover 204 includes a base unit 222 and a magnet sheet 224. The base unit 222 is a plate-shaped portion that constitutes a base portion of the cover 204, and holds the magnet sheet 224 at a position between the inkjet head 102 and the medium 50. The magnet sheet 224 is a removable portion of the cover 204, and is processed into a shape that matches the shape of the medium 50. As described above, in the present embodiment, the cover 204 includes the opening 220. The opening 220 is preferably shaped to match the shape of the medium 50 such that an unnecessary gap is not formed with respect to the medium 50 at the opening 220. Therefore, in the present embodiment, by forming the opening 220 at the magnet sheet 224 and holding the magnet sheet 224 by the base unit 222, the opening 220 of the cover 204 is formed in a shape that matches the shape of the medium 50. Further, as shown in the figure, the base unit 222 includes an opening that is larger than the opening 220 of the cover 204, and holds the magnet sheet 224 to cover a part of such a large opening. With such a configuration, an opening 220 that matches the shape of the medium 50 can be appropriately formed at the cover 204. The magnet sheet 224 of the cover 204 may also be regarded as a member having a shape that matches the medium 50. The base unit 222 may be regarded as a portion having a constant shape that does not depend on the shape of the medium 50.

[0042] The rotation mechanism 206 is a mechanism that rotates the medium 50 while holding the medium 50 at the position opposed to the nozzle rows of the inkjet head 102. Further, in the present embodiment, the rotation mechanism 206 includes a shaft unit 226 and a rotation drive unit 228. The shaft unit 226 is a portion that rotatably holds the medium 50, and is configured to rotatably hold the medium 50 at one end side and another end side in the axial direction of the rotation axis of the medium 50. As the shaft unit 226, a chuck or the like that matches the medium 50 may be suitably used. The rotation drive unit 228 is a drive unit that rotates the shaft unit 226, and is configured to rotate the medium 50 together with the shaft unit 226 by rotating the shaft unit 226. Further, as described above, in the printing apparatus 10 in the present embodiment (see FIG. 1), during the main scanning operation, by rotating the medium 50, the inkjet head 102 is moved relatively with respect to the outer surface of the medium 50. By controlling the operation of the rotation drive unit 228, the control unit 30 (see

FIG. 1) of the printing apparatus 10 controls a rotation operation in which the rotation mechanism 206 rotates the medium 50. Further, by controlling the operations of the inkjet head 102 and the rotation mechanism 206 via the main scanning drive unit 16 (see FIG. 1), the control unit 30 causes the inkjet head 102 to discharge ink while causing the rotation mechanism 206 to rotate the medium 50. Accordingly, the control unit 30 causes the inkjet head 102 to perform the main scanning operation. Further, in the present embodiment, the rotation mechanism 206 rotates the medium 50 such that a direction of movement of the outer surface of the medium 50 at the position opposed to the nozzle rows of the inkjet head 102 becomes the main scanning direction.

[0043] The ultraviolet irradiator 208 is an ultraviolet light source (UV light source) that irradiates ultraviolet rays to the outer surface (side surface) of the medium 50, and is disposed at a position adjacent to the medium 50 in the housing unit 202 of the holding jig 40 to thereby irradiate ultraviolet rays to the outer surface of the rotating medium 50. Accordingly, the ultraviolet irradiator 208 cures the ink (ultraviolet-curable ink) adhered to the medium 50. Further, in the present embodiment, the ultraviolet irradiator 208 includes a lighting unit 242 and an eave 244, for example, as shown in FIG. 3(b). The lighting unit 242 is a portion that generates ultraviolet rays in the ultraviolet irradiator 208, and includes, for example, a plurality of UV LEDs. The UV LED is a light-emitting diode that emits ultraviolet rays. Further, the lighting unit 242 lights up in accordance with control of the control unit 30. The eave 244 is a light-shielding member (light-shielding unit) for blocking a part of the ultraviolet rays generated by the lighting unit 242. In the present embodiment, with the eave 244 disposed between the inkjet head 102 and the lighting unit 242, the eave 244 blocks ultraviolet rays traveling in a direction toward the inkjet head 102. By using such an eave 244, stray light traveling toward the inkjet head 102 can be appropriately reduced.

[0044] Further, in the present embodiment, the ultraviolet irradiator 208 irradiates ultraviolet rays to the medium 50 from a position farther from the inkjet head 102 than an uppermost portion of the medium 50. The uppermost portion of the medium 50 refers to a position of the medium 50 closest to the inkjet head 102. With such a configuration, the ultraviolet irradiator 208 can be easily and appropriately covered by the cover 204. Accordingly, stray light traveling from the ultraviolet irradiator 208 toward the inkjet head 102 can be more appropriately reduced. Further, in the present embodiment, the ultraviolet irradiator 208 irradiates ultraviolet rays toward a position at a rotation angle of 90 degrees to 180 degrees from an ink landing position, at which the ink lands on the medium 50, in the rotation direction of the medium 50, downstream in the rotation direction with respect to the ink landing position. Further, the position at which the ultraviolet irradiator 208 is disposed is preferably such a position that reflected light from the medium 50 is directed

away (for example, downward) from the inkjet head 102.

[0045] The light source holding unit 210 is a platform-shaped member that holds the ultraviolet irradiator 208. In the present embodiment, with the ultraviolet irradiator 208 held on an upper surface, the light source holding unit 210 holds the ultraviolet irradiator 208 at such a position that ultraviolet rays can be irradiated toward the outer surface of the medium 50. The cover moving means 212 is a means for moving the cover 204 in the vertical direction. The vertical direction referred to here is a direction in which the distance between the inkjet head 102 and the cover 204 varies. Further, in the present embodiment, the cover moving means 212 is a means for moving the cover 204 by a manual operation of a user, and moves the base unit 222 of the cover 204 in the vertical direction in response to rotation of a handle for manual operation, for example, to thereby move the magnet sheet 224 together with the base unit 222. With the cover moving means 212, the cover 204 can be moved according to the size of the medium 50 or the like. To appropriately reduce stray light traveling from the ultraviolet irradiator 208 toward the inkjet head 102, it is important not to form a large gap between the cover 204 and the medium 50. In order not to form such a gap, it is preferable to bring an edge of the opening 220 of the cover 204 sufficiently close to the medium 50. For this purpose, it is preferable to appropriately move the cover 204 in the vertical direction according to the size of the medium 50 or the like. In the present embodiment, by moving the cover 204 using the cover moving means 212, the gap between the cover 204 and the medium 50 can be made sufficiently small. Making the gap between the cover 204 and the medium 50 sufficiently small can be regarded as substantially eliminating the gap in the lateral direction of the medium 50. The gap in the lateral direction of the medium 50 refers to a gap in a direction orthogonal to the rotation axis of the medium 50. Substantially eliminating the gap in the lateral direction means reducing the gap to such an extent that stray light, which would otherwise become a problem, does not occur, within a range that does not affect the rotation of the medium 50.

[0046] Next, countermeasures against stray light executed in the printing apparatus 10 in the present embodiment will be described in more detail. As described above, in the present embodiment, the cover 204 includes the base unit 222 and the magnet sheet 224. Further, the magnet sheet 224 is processed into a shape that matches the shape of the medium 50 or the like. By using such a magnet sheet 224, for example, as shown in FIG. 4, the gap in the lateral direction of the medium 50 can be appropriately and sufficiently reduced. FIG. 4 is a diagram illustrating the magnet sheet 224 in the holding jig 40. The upper-left view in FIG. 4 shows an example of a state where the magnet sheet 224 is disposed. Further, the lower-right view shows an example of a state where the magnet sheet 224 is removed. As can be understood from the states and the like illustrated in FIG. 4, in the

present embodiment, by using the magnet sheet 224, the gap in the lateral direction of the medium 50 can be appropriately and sufficiently reduced as described above.

[0047] However, even in the case of using the magnet sheet 224 having a shape that matches the shape of the medium 50 or the like, if the position of the cover 204 in the vertical direction is inappropriate, an unintended gap may be formed between the cover 204 and the medium 50, and stray light, which would become a problem, may reach the inkjet head 102. Therefore, in the printing apparatus 10 in the present embodiment, the status of a gap formed between the cover 204 and the medium 50 is detected using the sensor 20 (see FIG. 1). The sensor 20 may be regarded as being used for detection at positions on the upper surface of the holding jig 40. Further, in the present embodiment, to facilitate detection by the sensor 20, a white tape 232 is attached to predetermined positions on the magnet sheet 224. The tape 232 is an example of a light reflective member that is attached to at least a part of at least one of the medium 50 and the cover 204. As the tape 232, a tape of a light reflective color other than white may also be used. Further, as the light reflective member, a member other than the tape 232 may also be used. Further, in the present embodiment, the tape 232 may also be regarded as indicating a spot to be detected by the sensor 20. The operation of detecting the status of the gap using the sensor 20 will be described in more detail later.

[0048] Further, as described above, in the present embodiment, by using the magnet sheet 224 and adjusting the position of the cover 204 in the vertical direction, the gap in the lateral direction (main scanning direction, left-right direction) of the medium 50 can be made sufficiently small. In such a case, in the lateral direction, by overlapping the edge of the cover 204 with the medium 50 in the vertical direction at the position of the edge of the cover 204, stray light can be appropriately prevented. However, in such a case as well, in the lateral direction and on the one end side and the another end side (close side and far side) in the front-rear direction (sub-scanning direction), if the gap is eliminated, the medium 50 rotates with the cover 204 and the medium 50 in contact with each other, and scratches and the like are likely to occur on the medium 50. Therefore, at these positions, gaps that are not blocked by either the cover 204 or the medium 50 are likely to be formed. As a result, for example, upon causing the inkjet head 102 to perform the main scanning operation and the sub-scanning operation according to the conventional method, stray light leaking from the ends in the front-rear direction reaches the inkjet head 102, and problems such as nozzle clogging are likely to occur. In contrast, in the present embodiment, by causing the inkjet head 102 to perform the main scanning operation and the sub-scanning operation such that the inkjet head 102 does not pass the positions at the gaps between the cover 204 and the medium 50 in the front-rear direction, such influence of stray light is less likely to

occur. Hereinafter, the main scanning operation and the sub-scanning operation performed by the inkjet head 102 in the present embodiment will be described in more detail. Further, for convenience of illustration, first, an example of the main scanning operation and the sub-scanning operation that are the same as or similar to the conventional method will be described.

[0049] FIG. 5 is a diagram showing an example of the main scanning operation and the sub-scanning operation that are the same as or similar to the conventional method, and shows an example of the main scanning operation and the sub-scanning operation in which ink is discharged to respective positions on the medium 50 by one inkjet head 102. The illustrated operation is an example of a 2-pass operation in which the main scanning operation is performed twice on respective positions on the medium 50. Further, in FIG. 5, regions labeled with letters A to D are regions having a width in the sub-scanning direction that corresponds to the number of passes. These regions may also be regarded as band regions corresponding to one pass. Hereinafter, these regions will be referred to as regions A to D. Further, the operation will be described with the lower side in the figure as the close side and the upper side as the far side.

[0050] In a first main scanning operation (first scan) in the illustrated operation, the inkjet head 102 performs a first-pass ink discharge on the region A. In such a case, with the inkjet head 102 moved to the close side beyond a position corresponding to the close-side end of the printing data, ink is discharged to the medium 50 using only a part (half) of the inkjet head 102 on the far side. Further, in a second main scanning operation (second scan), the inkjet head 102 performs a second-pass ink discharge on the region A and performs a first-pass ink discharge on the region B. In such a case, for example, as shown in the figure, ink is discharged to the medium 50 using the entire inkjet head 102. At the time the second scan is completed, an image drawn by the inkjet head 102 is completed on the close-side end portion (front end portion) of the medium 50 corresponding to the region A.

[0051] Thereafter, by performing the main scanning operation while performing the sub-scanning operation in the interval between the main scanning operations, the inkjet head 102 discharges ink to respective positions on the medium 50. In a fourth main scanning operation (fourth scan), which is one operation before a final main scanning operation (final scan) in the illustrated operation, the inkjet head 102 performs a second-pass ink discharge on the region C and performs a first-pass ink discharge on the region D. In such a case as well, for example, as shown in the figure, ink is discharged to the medium 50 using the entire inkjet head 102. In contrast, in a fifth main scanning operation (fifth scan), which is the final scan, by performing the main scanning operation with the inkjet head 102 moved further to the far side by sub-scanning operation, second-pass ink is discharged to the region D. In such a case, ink is discharged to the medium 50 using only a part (half) of the inkjet head 102

on the close side. Therefore, in a part of the plurality of times of the main scanning operation such as the first scan and the fifth scan, the inkjet head 102 passes over the gaps between the cover 204 and the medium 50 in the front-rear direction. At the positions of such gaps, stray light are likely to hit the inkjet head 102. As a result, nozzle clogging is likely to occur in the inkjet head 102. In contrast, in the present embodiment, by causing the inkjet head 102 to perform the main scanning operation and the sub-scanning operation as shown in FIG. 6, for example, such problems are less likely to occur.

[0052] FIG. 6 is a diagram showing an example of the main scanning operation and the sub-scanning operation in the present embodiment, and shows an example of the main scanning operation and the sub-scanning operation in which ink is discharged to respective positions on the medium 50 by one inkjet head 102. As shown in the figure, in the present embodiment, regarding at least a part of the plurality of times of the main scanning operation and the sub-scanning operation, the operation is configured to be different from the operation shown in FIG. 5 in terms of the way of moving the inkjet head 102 in the sub-scanning operation and which portion of the inkjet head 102 is caused to discharge ink in the main scanning operation. Accordingly, the main scanning operation and the sub-scanning operation in which the inkjet head 102 passes over the gaps between the cover 204 and the medium 50 in the front-rear direction are eliminated. Such an operation may also be regarded as an operation in which the nozzle rows of the inkjet head 102 are not extended to the outer side beyond the close-side and far-side end portions of the printing data.

[0053] The operation shown in FIG. 6 is also an example of a 2-pass operation similar to the operation shown in FIG. 5. Further, the regions A to D are regions having a width in the sub-scanning direction corresponding to the number of passes. In the present embodiment, in the first scan, regarding the positions of front ends, which are close-side end portions, in the sub-scanning direction, the inkjet head 102 is moved to a position at which the front end of the medium 50 and the front end of the inkjet head 102 overlap with each other, to cause the inkjet head 102 to perform the main scanning operation. Further, in the control on the printing operation, it may also be contemplated to take a printing range (printing target region) to be printed on the medium 50 as the range of the medium 50. In such a case, the front end of the medium 50 may be regarded as a position corresponding to the front end of the printing range on the medium 50. Further, aligning the positions of the front end of the medium 50 and the front end of the inkjet head 102 may also be regarded as aligning the position corresponding to the front end of the printing data with the position of the front end of the inkjet head 102. Further, in the first scan, as shown in the figure, ink is discharged to the medium 50 using only a part (half) of the inkjet head 102 on the close side. Accordingly, in the first scan, the inkjet head 102 performs a first-pass ink discharge on the

region A.

[0054] Further, after performing the main scanning operation of the first scan, as shown in the figure, the main scanning operation of the second scan is performed without substantially changing the position of the inkjet head 102 in the sub-scanning direction. Not substantially changing the position of the inkjet head 102 in the sub-scanning direction means not changing the position of the inkjet head 102 by more than a narrow movement distance for enhancing the resolution in the sub-scanning direction. It is contemplated that the printing apparatus 10 makes the printing resolution in the sub-scanning direction higher than the resolution corresponding to the nozzle pitch of the nozzle row by performing printing using the multi-pass technique. The nozzle pitch refers to a pitch of nozzles in the nozzle row in the sub-scanning direction. For example, it is contemplated to move the inkjet head 102 relatively with respect to the medium 50 by a distance less than the nozzle pitch between the first scan and the second scan. Even in the case of moving the inkjet head 102 relatively with respect to the medium 50 by such a short distance, it may be contemplated that the position of the inkjet head 102 in the sub-scanning direction is not substantially changed.

[0055] Further, in the second scan, as shown in the figure, ink is discharged to the medium 50 using the entire inkjet head 102. Accordingly, in the second scan, the inkjet head 102 performs a second-pass ink discharge on the region A and performs a first-pass ink discharge on the region B. At the time the second scan is completed, an image drawn by the inkjet head 102 is completed on the front end portion of the medium 50 corresponding to the region A.

[0056] Thereafter, until the far-side end portion (rear end) of the inkjet head 102 reaches the position of the far-side end portion (rear end) of the medium 50, the inkjet head 102 discharges ink to respectively positions of the medium 50 by performing the main scanning operation while performing the sub-scanning operation in the interval between the main scanning operations. The far-side end portion of the inkjet head 102 reaching the position of the far-side end portion of the medium 50 may be regarded as the position of the far-side end portion of the inkjet head 102 reaching the position of the far-side end portion of the medium 50 upon performing a sub-scanning operation with a standard movement distance (feed amount) in any of the sub-scanning operations. The position of the far-side end portion of the inkjet head 102 reaching the position of the far-side end portion of the medium 50 in the sub-scanning operation may also be regarded as the position of the far-side end portion of the inkjet head 102 and the position of the far-side end portion of the medium 50 overlapping with each other during or at the end of the sub-scanning operation. Further, the standard movement distance in the sub-scanning operation refers to a movement distance determined according to the number of passes. The movement distance determined according to the number of

passes is a movement distance corresponding to a distance obtained by dividing the nozzle row length by the number of passes. The nozzle row length refers to a length of the nozzle row in the sub-scanning direction. In the present embodiment, the standard movement distance in the sub-scanning operation is a movement distance (pass number corresponding distance) corresponding to a distance obtained by dividing the nozzle row length by the number of passes. As described above, in the control on the printing operation, it is contemplated to take the printing range as the range of the medium 50. In such a case, the far-side end portion of the medium 50 is a position corresponding to the another end of the printing range in the sub-scanning direction.

[0057] In the example illustrated in FIG. 6, in the sub-scanning operation performed immediately before performing the fourth scan, the far-side end portion of the inkjet head 102 comes to the position of the far-side end portion of the medium 50. In the present embodiment, after performing the main scanning operation of the second scan, the sub-scanning operation is performed with the standard movement distance each time the main scanning operation is performed, until the main scanning operation of the fourth scan is performed. In the main scanning operations from the second scan to the fourth scan, ink is discharged to the medium 50 using the entire inkjet head 102. In such a case, in the third scan, the inkjet head 102 performs a second-pass ink discharge on the region B and performs a first-pass ink discharge on the region C. In the fourth scan, a second-pass ink discharge is performed on the region C, and a first-pass ink discharge is performed on the region D.

[0058] Here, after the main scanning operation of the fourth scan is performed, if a sub-scanning operation is performed with the standard movement distance, the far-side end portion of the inkjet head 102 would exceed the position of the far-side end portion of the medium 50. If such a sub-scanning operation is performed, in this sub-scanning operation and a next main scanning operation to be performed, the inkjet head 102 would pass over the gap between the cover 204 and the medium 50 in the front-rear direction. Then, stray light hits the inkjet head 102 at the position of the gap, and nozzle clogging is likely to occur. Therefore, in the present embodiment, a subsequent main scanning operation is performed without performing a sub-scanning operation in which the far-side end portion of the inkjet head 102 exceeds the position of the far-side end portion of the medium 50. More specifically, after the main scanning operation of the fourth scan is performed, the main scanning operation of the fifth scan is performed without substantially changing the position of the inkjet head 102 in the sub-scanning direction. In this main scanning operation, as shown in the figure, ink is discharged to the medium 50 using only a part (half) of the inkjet head 102 on the far side. Accordingly, the inkjet head 102 can be prevented from passing the position of the gap (gap in the front-rear direction) between the cover 204 and the medium 50. Accordingly,

the printing operation can be appropriately performed on the medium 50 according to the multi-pass technique without performing the main scanning operation in a state where the inkjet head 102 is disposed over the gap in the front-rear direction between the cover 204 and the medium 50. Therefore, according to the present embodiment, stray light (ultraviolet rays) can be prevented from hitting the inkjet head 102 at the positions of the gaps between the cover 204 and the medium 50. Accordingly, it is possible to make nozzle clogging of the inkjet head 102 less likely to occur.

[0059] Here, as can be understood from the illustrated operations and the like, in the present embodiment, printing is performed on a printing range having a width in the sub-scanning direction that is wider than the nozzle row length. Further, regarding such a printing operation, if focusing on the control performed by the control unit 30 in the printing apparatus 10, it may be contemplated that the control unit 30 causes the inkjet head 102 to discharge ink to a printing range having a range in the sub-scanning direction that is wider than the nozzle row length, by causing the inkjet head to perform the main scanning operation for a plurality of times while causing the inkjet head to perform a sub-scanning operation in an interval between at least a part of the plurality of times of the main scanning operation.

[0060] Further, the printing operation described above with reference to FIG. 6 is an example operation in which the inkjet head 102 is always over the medium 50. The inkjet head 102 being always over the medium 50 means that the inkjet head 102 is not disposed over the gaps between the cover 204 and the medium 50 at any timing of the main scanning operation and the sub-scanning operation performed with the ultraviolet irradiator 208 turned on in the series of printing operations. The function of the printing apparatus 10 that performs such printing operations may also be regarded as a function that completes printing without causing the inkjet head 102 to protrude from over the medium 50. Further, in the case where a range from one end to another end of the medium 50 in the sub-scanning direction at a position opposed to the nozzle rows of the inkjet head 102 is defined as an opposed position medium range, it may also be contemplated that the printing apparatus 10 causes the inkjet head 102 to perform the sub-scanning operation within a range that does not move the position of the nozzle rows in the sub-scanning direction to outside the opposed position medium range. Further, regarding such an operation, if focusing on the control of the control unit 30, in the present embodiment, the control unit 30 causes the inkjet head 102 to perform all of the plurality of times of the main scanning operation with the position of the nozzle rows in the sub-scanning direction being within the opposed position medium range. Further, the control unit 30 causes the inkjet head 102 to perform printing on the entire side surface of the medium 50 at maximum, by causing the inkjet head 102 to perform the sub-scanning operation in an interval between at least a part of the

plurality of times of the main scanning operation. Performing printing on the entire side surface of the medium 50 by the inkjet head 102 may be regarded as discharging ink from the inkjet head 102 to positions where ink needs to be discharged by the inkjet head 102 among the entire side surface of the medium 50, according to an image to be printed or the like. Further, performing printing on the entire side surface of the medium 50 may also be regarded as the entire side surface of the medium 50 becoming a substantial printing range. The entire side surface becoming a substantial printing range means that a range that an observer can recognize as the entirety becomes the printing range according to the purpose of printing or the like.

[0061] Further, the printing range in the present embodiment is a range of printing indicated by the printing data. Further, if considering by focusing on the relationship between the printing data and the printing operation, as can be understood from the matters described above and the like, the printing operation shown in FIG. 5 corresponding to the conventional method is an operation that starts printing from the close side beyond the printing data, and ends printing at the far side beyond the printing data. Then, upon performing printing on the entire side surface of the medium 50 or a similar printing range, by using printing data corresponding to a printing range approximately the same as the size of the medium 50, it becomes very likely that stray light would hit the inkjet head 102 at the positions of the above gaps in the front-rear direction. In contrast, in the present embodiment, even in the case of using printing data corresponding to a printing range approximately the same as the size of the medium 50, such a problem can be appropriately prevented from occurring.

[0062] Further, as can be understood from the operations of the first to second scans in the operations shown in FIG. 6, in the present embodiment, the control unit 30 causes the inkjet head 102 to perform the main scanning operation for a number of times corresponding to the number of passes, in a state where the positions of one end (front end) of the medium 50 and one end (front end) of the inkjet head 102 in the sub-scanning direction (front-rear direction) at the position opposed to the nozzle row are aligned in the sub-scanning direction. Aligning the positions of one end of the medium 50 and one end of the inkjet head 102 may be regarded as aligning the positions of one end of the medium 50 and one end of the nozzle rows in the inkjet head 102. The number of times corresponding to the number of passes refers to the number of main scanning operations that need to be performed at that position according to the number of passes. In the case of the operation shown in FIG. 6, this number of times is two. Further, in the present embodiment, after causing the inkjet head 102 to perform the main scanning operation for a number of times corresponding to the number of passes in such a state, before causing the inkjet head 102 to perform the main scanning operation for a next time, the control unit 30 causes the inkjet head

102 to perform a sub-scanning operation with a standard movement distance (feed amount). With such a configuration, the main scanning operations corresponding to the number of passes to be performed initially can be appropriately executed without performing a sub-scanning operation in which the inkjet head 102 passes the position of the gap between the cover 204 and the medium 50 on the one end side of the medium 50. Accordingly, ultraviolet rays can be prevented from hitting the inkjet head 102 at the position of such a gap during any sub-scanning operation or main scanning operation. Such an operation may also be regarded as starting the initial main scanning operation (main scanning operation of the first scan) with one end of the medium 50 and one end of the inkjet head 102 aligned with each other.

[0063] Further, as described above, for example, in the case of making the printing resolution in the sub-scanning direction higher than the resolution corresponding to the nozzle pitch, it is also contemplated to move the inkjet head 102 relatively with respect to the medium 50 by a distance less than the nozzle pitch between the first scan and the second scan. For example, it is contemplated to perform a sub-scanning operation at a distance shorter than the standard movement distance in the sub-scanning direction during the main scanning operations corresponding to the number of passes to be performed initially. More specifically, in at least a part of intervals between the main scanning operations of a number of times corresponding to the number of passes performed with the positions of one end of the medium 50 and one end of the inkjet head 102 aligned with each other, the sub-scanning drive unit 18 (see FIG. 1) moves the inkjet head 102 in the sub-scanning direction relatively with respect to the medium 50 by a distance less than the nozzle pitch. Further, as can be understood from the operations of the fourth to fifth scans in the operations shown in FIG. 6, in the present embodiment, the control unit 30 causes the inkjet head 102 to perform the main scanning operation and the sub-scanning operation such that a sub-scanning operation in which the inkjet head 102 is disposed at the position of the gap between the cover 204 and the medium 50 is not performed on the another end (rear end, far-side end) side of the medium 50 and the inkjet head 102, either. According, printing can be performed at a high resolution while more appropriately preventing ultraviolet rays from hitting the inkjet head 102 at the position of the gap between the cover 204 and the medium 50. Further, for simplicity of the illustration and description, FIG. 6 illustrates an example of the main scanning operation and the sub-scanning operation performed by the inkjet head 102 in a case where the width of the medium 50 in the sub-scanning direction is an integer multiple (4 times) of the standard movement distance in the sub-scanning operation. However, for example, as in the example shown in FIG. 7, the size of the medium 50 may be different from that shown in FIG. 6.

[0064] FIG. 7 is a diagram showing another example of the main scanning operation and the sub-scanning operation in the present embodiment, and shows an example of a case of using a medium 50 having a larger size in the sub-scanning direction than the example shown in FIG. 6. FIG. 7(a) shows an example of the position of the inkjet head 102 during the main scanning operations of an Nth scan and an (N+1)th scan performed on a medium 50 of a predetermined size. FIG. 7(b) shows an example of the position of the inkjet head 102 during the main scanning operations of an (N-1)th scan and an Nth scan performed on a medium 50 of a predetermined size different from FIG. 7(a). The width of the medium 50 in FIG. 7(a) in the sub-scanning direction is larger than the width of the medium 50 in FIG. 6 by an integer multiple of the standard movement distance of the sub-scanning operation. Then, in the sub-scanning operation performed immediately before performing the Nth main scanning operation (N is a predetermined integer), the far-side end portion (rear end) of the inkjet head 102 reaches the position of the far-side end portion of the medium 50. After performing the main scanning operation of the Nth scan, as shown as the main scanning operation of the (N+1)th scan in the figure, the inkjet head 102 is caused to perform the main scanning operation for the subsequently required number of times without substantially changing the position of the inkjet head 102 in the sub-scanning direction. In such a case, for example, similarly to the case illustrated as the main scanning operation of the fifth scan in FIG. 6, ink is discharged to the medium 50 using only a part (half) of the inkjet head 102 on the far side. Further, in such a case as well, in the interval between the plurality of times of the main scanning operation performed in such a state, as necessary, the inkjet head 102 is caused to perform a sub-scanning operation of performing relative movement by a distance less than the nozzle pitch.

[0065] FIG. 7(b) shows an example in which the width of the medium 50 in the sub-scanning direction is made slightly smaller compared to the medium 50 shown in FIG. 7(a). In FIG. 7(b), a region F in the figure is smaller compared to FIG. 7(a). The width of the medium 50 in the sub-scanning direction shown in FIG. 7(b) is not an integer multiple of the standard movement distance in the sub-scanning operation. In such a case, after performing the main scanning operation of the (N-1)th scan shown in the figure, if the inkjet head 102 is caused to perform a sub-scanning operation with the standard movement distance, the far-side end portion of the inkjet head 102 would exceed the position of the far-side end portion of the medium 50. Therefore, in the sub-scanning operation after the main scanning operation of the (N-1)th scan, the inkjet head 102 is caused to perform a sub-scanning operation with a movement distance smaller than the standard movement distance to align the position of the far-side end portion of the inkjet head 102 with the position of the far-side end portion of the medium 50. With such a configuration, the inkjet head 102 can be

appropriately prevented from extending outside the range opposed to the medium 50. Further, in the main scanning operations from the Nth scan onward performed thereafter, ink is discharged to the region serving as the ink discharge target using only a portion of the inkjet head 102. With such a configuration, even in the case where the width in the sub-scanning direction is not an integer multiple of the standard movement distance in the sub-scanning operation, ink can be discharged to the medium 50 without causing the inkjet head 102 to extend outside the range opposed the medium 50.

[0066] Further, regarding the operation described with reference to FIG. 6 and FIG. 7, the sub-scanning operation performed in the vicinity of the far-side end portion of the medium 50 may also be considered by focusing on the control of the control unit of the printing apparatus 10. The end portion of the inkjet head 102 in the following description may also be regarded as referring to the end portion of the nozzle rows of the inkjet head 102. More specifically, in the case where the movement distance of the sub-scanning operation is the standard movement distance, in the sub-scanning operation performed for a time in which the far-side end portion (another end) of the nozzle rows would exceed the position of the far-side end portion (another end) of the medium 50, the control unit 30 moves the inkjet head 102 by a distance such that the far-side end portion of the nozzle rows reaches the position of the far-side end portion of the medium 50, or does not move the inkjet head 102. Accordingly, a sub-scanning operation in which the end of the inkjet head 102 exceeds the end of the medium 50 on the far side can be prevented from being performed. Further, ultraviolet rays can be more appropriately prevented from hitting the inkjet head 102 at the position of the gap between the cover 204 (see FIG. 2) and the medium 50 in the holding jig 40. Further, as described above, after causing the inkjet head 102 to perform a sub-scanning operation in which the far-side end portion of the nozzle rows reaches the position of the far-side end portion of the medium 50 in the sub-scanning direction, the control unit 30 causes the inkjet head 102 to perform the main scanning operation for a plurality of times as necessary, with the positions of the far-side end portion of the medium 50 and the far-side end portion of the nozzle rows aligned with each other. Accordingly, the main scanning operation can be performed for a required number of times on the range including the far-side end portion of the medium 50. The state where the positions of the far-side end portion of the medium 50 and the far-side end portion of the nozzle rows are aligned with each other may also be a state where the distance between the far-side end portion of the medium and the far-side end portion of the nozzle rows is equal to or less than the nozzle pitch. Further, the far-side end portion of the medium 50 may also be the far-side end portion of the printing range. In such a case, aligning the positions of the far-side end portion of the medium 50 and the far-side end portion of the nozzle rows with each other may be regarded as aligning the

position of the end of the printing data on the far side of the medium 50 with the position of the far-side end portion of the nozzle rows. In such a state, the control unit 30 causes the inkjet head 102 to perform the main scanning operations corresponding to the number of passes. Further, in the above description, for convenience of illustration and description, the operation of performing printing in 2 passes has been mainly described. However, the number of passes for printing may also be a number other than 2. In such a case as well, by performing operations corresponding to the number of passes in a manner identical or similar to the above, ink can be appropriately discharged to the medium 50. Further, by appropriately varying the number of times of the main scanning operation performed without substantially changing the position of the inkjet head 102 in the sub-scanning direction on the close side and the far side of the medium 50, even in the case where the number of passes is greater than 2, operations corresponding to the number of passes can be appropriately executed.

[0067] As described above, in the present embodiment, by causing the inkjet head 102 to perform the main scanning operation and the sub-scanning operation at positions matching the size of the medium 50, stray light leaking from the holding jig 40 can be appropriately prevented from hitting the inkjet head 102. Further, for example, even in the case of performing printing on the full size of the medium 50, since nozzle clogging due to the influence of stray light is less likely to occur, printing using large-sized printing data can be performed more appropriately. Accordingly, printing can be performed more appropriately on the entire side surface of the medium 50. Furthermore, even without adding new components or the like to the printing apparatus 10, the influence of stray light can be appropriately reduced by the control on the main scanning operation and the sub-scanning operation performed by the control unit 30. Further, to more appropriately reduce the influence of stray light, it is more preferable to make stray light itself, which would leak outside the holding jig 40, less likely to occur. As described above, it is important not to form a large gap between the cover 204 of the holding jig 40 and the medium 50. In this regard, in the present embodiment, the status of the gap between the cover 204 and the medium 50 is detected using the sensor 20. Hereinafter, the operation of detecting the status of the gap using the sensor 20 will be described in more detail.

[0068] FIG. 8 is a diagram showing an example operation for detecting the status of the gap using the sensor 20, and shows an example of a path for moving the sensor 20 during status detection. As described above, in the holding jig 40 in the present embodiment, the white tape 232 is attached to predetermined positions of the magnet sheet 224 constituting the cover 204. The tape 232 enhances the reflectance of light, and accordingly, detection can be performed more appropriately using the sensor 20. The tape 232 indicates spots to be detected by the sensor 20. The tape 232 may also be attached to the

medium 50 as necessary. For example, in the case of using a medium 50 having a color that hardly reflects light, it is contemplated to attach the tape 232 to the medium 50.

[0069] The control unit 30 (see FIG. 1) of the printing apparatus 10 moves the sensor 20 along a path capable of detecting reflected light from the tape 232 of the cover 204 and the medium 50. The control unit 30 moves the sensor 20 by controlling the operation of the sensor moving means 22 (see FIG. 1). In the present embodiment, the control unit 30 moves the sensor 20 along a plurality of paths indicated by arrows in the figure. The plurality of paths include paths on the close side, the far side, and the center of the medium 50. The close-side path is an example of a one-end side path that passes the vicinity of one end of the medium 50 at a position opposed to the nozzle rows of the inkjet head 102 (see FIG. 1) during printing. The far-side path is an example of an other-end side path that passes the vicinity of the another end of the medium 50 at a position opposed to the inkjet head 102 during printing. The center path is an example of an intermediate position path that passes over the medium 50 between the one-end side path and the other-end side path. Such paths extend in a direction intersecting with the nozzle row direction. Further, as can be understood from the illustrated configuration and the like, such paths may also be regarded as paths that pass the edges of the opening 220 of the cover 204. The plurality of paths for moving the sensor 20 may further include paths other than the above. Further, in the present embodiment, the control unit 30 moves the sensor 20 along such paths and detects the status of the gap formed between the cover 204 and the medium 50 based on the acquired output of the sensor 20. Accordingly, unintended ultraviolet leakage due to displacement of the cover 204 or the like can be appropriately prevented from occurring.

[0070] As described above, in the present embodiment, the control unit 30 detects the status of the gap formed between the cover 204 and the medium 50 based on the output of the sensor 20. The control unit 30 detects, as the status of the gap, a change in the output of the sensor 20 that occurs at the position of the gap. As described above, in the present embodiment, by using the magnet sheet 224 having a shape that matches the shape of the medium 50, the cover 204 is formed in a shape with which an unnecessary gap is less likely to be formed with respect to the medium 50 at the opening 220. However, even in such a case, a certain degree of step difference is formed at the position of the edge of the opening 220. Therefore, in the case of moving the sensor 20 along a path that passes the position of the edge, a change in output corresponding to the step difference occurs at the position of the edge. Accordingly, the control unit 30 can detect the position of the edge of the opening 220. In such case, for example, as the gap at the position of the edge becomes large due to height deviation of the cover 204 or the like, the output of the sensor 20 changes

according to the size of the gap. Such a change in output reflects the status of the gap. The control unit appropriately detects the status of the gap based on such an output of the sensor 20 and a change in the output. Further, in the present embodiment, the sensor 20 detects reflected light from the cover 204 and the medium 50. The control unit 30 detects the status of the gap based on the light detected by the sensor 20. The control unit 30 determines that the gap has become large when the reflectance at the position of the edge of the opening 220 is smaller than a predetermined reference value. Further, the reflectance detected by the sensor 20 may also be regarded as reflecting the distance between the cover 204 and the medium 50. Therefore, it may also be contemplated that the control unit 30 is detecting such a distance. Further, in the present embodiment, as described above, the sensor 20 is moved along the close-side, far-side, and center paths. Accordingly, the status of the gap can be appropriately detected for a wide range of the medium 50. Further, it is possible to appropriately confirm that the medium 50 and the cover 204 are correctly disposed.

[0071] Further, during the operation for detecting the status of the gap using the sensor 20, it is contemplated to turn off the ultraviolet irradiator 208 (see FIG. 2) of the holding jig 40. With such a configuration, the change in reflectance that occurs at the position of the edge of the opening 220 can be detected more appropriately. Further, in a modified example operation for detecting the status of the gap, it is also contemplated to perform detection by the sensor 20 with the ultraviolet irradiator 208 turned on. Further, to more reliably prevent unintended ultraviolet rays from leaking from the gap between the cover 204 and the medium 50, it is also contemplated to directly detect ultraviolet rays that actually leak. For example, it is contemplated that, with ultraviolet rays irradiated to the outer surface of the medium 50 by the ultraviolet irradiator 208, the control unit 30 further detects ultraviolet rays leaking from the gaps between the edges of the opening 220 of the cover 204 and the medium 50 based on the output of the sensor 20. With such a configuration, if unintended ultraviolet leakage occurs due to displacement of the cover 204 or the like, the ultraviolet leakage can be detected more appropriately. In such a case as well, it is contemplated to move the sensor 20 along the same paths as those during detection of the status of the gap. Alternatively, during detection of ultraviolet rays that actually leak, the sensor 20 may also be moved along paths different from those during detection of the status of the gap. Further, it is preferable that the ultraviolet rays that actually leak be detected not only at positions corresponding to the gaps between the cover 204 and the medium 50 in the lateral direction of the medium 50, but also at positions corresponding to the gaps in the front-rear direction.

[0072] Next, the operation for detecting the status of the gap formed between the cover 204 and the medium 50 will be described in more detail. FIG. 9 is a flowchart

representing an example operation for detecting the status of the gap in the printing apparatus 10. The operation shown in FIG. 9 is an example operation of a detection method for detecting a state of the printing apparatus 10. Detecting the state of the printing apparatus 10 means detecting the state of the printing apparatus 10 and the holding jig 40 or the like used in the printing apparatus 10. Further, the operation shown in FIG. 9 may also be regarded as an example operation of a workpiece setting detection. The workpiece setting detection refers to detecting whether the medium 50 is appropriately disposed with respect to the holding jig 40. The medium 50 being appropriately disposed with respect to the holding jig 40 means that the medium 50 is appropriately disposed, and the height of the cover 204 of the holding jig 40 and the position of the magnet sheet 224 of the cover 204 are appropriate with respect to the position (height and the like) of the medium 50. In the present embodiment, the control unit 30 of the printing apparatus 10 starts control related to the workpiece setting detection in response to an instruction from a user. In such a case, for example, the user's instruction is received by displaying a menu (for example, a selection screen for executing the workpiece setting detection) on a monitor or the like of the printing apparatus 10 or a computer (control PC) that controls the operation of the printing apparatus 10.

[0073] In the operation of control related to the workpiece setting detection, the control unit 30 receives designation of a detection position for detecting the status of the gap from the user (S102). The control unit 30 receives the user's instruction by, for example, having the user operate an input means (for example, an LED pointer and up/down keys) for inputting information to the printing apparatus 10. Further, in the present embodiment, the control unit 30 receives, from the user, designation of detection positions corresponding to, for example, the close-side, far-side, and center paths shown in FIG. 8 as detection positions. With such a configuration, even if the printing range varies according to the chuck used as the shaft unit 226 in the rotation mechanism 206 of the holding jig 40 or varies according to the medium 50, preferable detection positions can be appropriately set. Further, after receiving the designation of detection positions from the user, the control unit 30 moves the sensor 20 along the paths corresponding to the detection positions by controlling the operation of the sensor moving means 22. Accordingly, the control unit 30 executes a detection operation for acquiring an output (sensor value) of the sensor 20 (S104).

[0074] Further, the control unit 30 detects the status of the gap formed between the cover 204 and the medium 50 based on the output of the sensor 20 detected in step S104, and determines whether there is a problem with the status of the gap (S106). Further, as described above, in the present embodiment, the control unit 30 determines that the gap is in a state of being large if the reflectance is smaller than a predetermined reference value at the position of the edge of the opening 220. Therefore, in

step S106, the control unit 30 determines that there is a problem with the status of the gap if the output of the sensor 20 falls below a predetermined threshold value at any of the positions.

[0075] Then, if the output of the sensor 20 does not fall below the threshold value in all paths, the control unit 30 determines that there is no problem with the status of the gap (S106, Yes), and ends the operation of the workpiece setting detection. In contrast, if the output of the sensor 20 falls below the threshold value at any of the positions in any of the paths, the control unit 30 determines that there is a problem with the status of the gap (S106, No). In such a case, the control unit 30 performs error display on, for example, the monitor or the like of the printing apparatus 10 or the computer controlling the operation of the printing apparatus 10 (S108). Further, in the present embodiment, after the user confirms the error display, the control unit 30 displays a screen on the monitor or the like prompting to perform setting (cover setting) of the cover 204 again (S110), and ends the operation of the workpiece setting detection.

[0076] In the present embodiment, in the operation of step S104, it is also contemplated that the influence of errors may occur. Therefore, in step S106, it is also contemplated that, if it is determined that the output of the sensor 20 falls below the threshold value at any of the positions in any of the paths, the operation returns to step S104 to acquire the output of the sensor 20 again. In such a case, in step S106, the control unit 30 determines that there is a problem with the status of the gap if the output of the sensor 20 falls below the threshold value at any of the positions even after performing the detection for a preset number of times (for example, about 3 times). With such a configuration, the operation of the workpiece setting detection can be performed more appropriately.

[0077] Next, supplementary descriptions regarding each of the configurations described above will be provided. As described above, in the present embodiment, the printing apparatus 10 performs printing on the medium 50 while rotating the medium 50. As the medium 50, for example, a cylindrical (tubular) medium may be suitably used. A cylindrical medium refers to a medium in a rotating body shape of which a cross-section in a plane orthogonal to the rotation axis is circular. Further, as the medium 50, it is also possible to use a medium having a shape other than a cylindrical shape. As a medium having a shape other than a cylindrical shape, a medium having a rotating body shape may be suitably used. As such a medium, for example, a medium in a conical shape or a truncated conical shape (truncated cone shape) may be considered. Further, in the case of using a medium having a shape such as a conical shape or a truncated conical shape, the holding jig 40 holds the medium such that the height of the medium becomes constant at a position (position at which ink lands) opposed to the inkjet head 102. In such a case, it is contemplated that, for example, by appropriately inclining the rotation axis, on which the medium is rotated, with respect to the horizon-

tal direction, the medium is held such that the generatrix of the medium in a conical shape or the like at the position opposed to the inkjet head 102 becomes horizontal.

[0078] Further, in the case of performing printing on the medium 50 while rotating the medium 50 as in the present embodiment, it is contemplated that, for example, as shown in FIG. 10, a seam 302a of an image is formed on the side surface of the medium 50. FIG. 10 is a diagram illustrating a method for printing on the side surface of the medium 50. FIG. 10(a) and (b) show example methods for printing on the side surface of the medium 50.

[0079] As can be understood from the seam 302a and the like shown in FIG. 10, the seam 302a of the image on the side surface of the medium 50 may be regarded as a boundary portion or the like between a position (drawing start position) where ink is initially discharged and a position (drawing end position) where ink is finally discharged to the side surface in the main scanning operation. The seam 302a is normally formed in a linear shape, for example, as shown in FIG. 10(a). The linear seam 302a is a seam in which ink dots formed by ink discharged to the drawing start position and the drawing end position in the main scanning operation are arranged in a straight line. In such a case, in an attempt to prevent the ground color of the medium 50 from being visible at the position of the seam 302a, for example, ink dots are overlapped at the position of the seam 302a, and as a result, a dark line corresponding to the seam 302a is drawn, which makes the seam 302a more conspicuous. In contrast, to make the seam 302a less conspicuous, for example, as shown in FIG. 10(b), it is contemplated to form a non-linear seam 302a. The non-linear seam 302a is a seam in which ink dots formed by ink discharged to the drawing start position and the drawing end position in the main scanning operation are not arranged in a straight line. In such a case, for example, as shown in the figure, it is contemplated to form a zigzag-shaped seam 302a. With such a configuration, the position of the seam 302a can be more appropriately prevented from being conspicuous. Accordingly, printing can be appropriately performed on the side surface of the medium 50 with higher quality.

[0080] Next, adjustment performed on the printing apparatus 10 in the present embodiment will be described. FIG. 11 is a diagram illustrating adjustment targets in an example of adjustment performed on the printing apparatus 10. FIG. 11(a) shows an example of a correct state where adjustment is not required. The state shown in FIG. 11(a) may also be regarded as a state where adjustment has been appropriately performed. FIG. 11(b) shows an example of a state where adjustment is required. As described above, in the present embodiment, the inkjet head 102 has two nozzle rows 112. As shown in FIG. 11(a), with one inkjet head 102 opposed to the medium 50, ink is discharged from the plurality of nozzle rows 112 to the medium 50. The main scanning drive unit 16 (see FIG. 1) causes the inkjet head 102 to discharge ink to discharge positions set according to the printing

resolution by causing the respective nozzle rows 112 to discharge ink at timings adjusted according to positional differences for the respective nozzle rows 112. Further, the inkjet head 102 discharges inks of different colors from the plurality of nozzle rows 112. In the example shown in FIG. 11, the inkjet head 102 has a nozzle row 112 indicated as A row in the figure and a nozzle row 112 indicated as B row. Further, the inkjet head 102 discharges ink of magenta color (M color) from the nozzle row 112 of the A row and discharges ink of black color (K color) from the nozzle row 112 of the B row. If the position of the inkjet head 102 relative to the medium 50 is correctly adjusted, magenta color and black color inks discharged to the same printing range will overlap in the same range, for example, as shown in the right portion of FIG. 11(a).

[0081] However, mechanical dimensional errors (errors in mechanical dimensions), for example, may be present in the positions of the holding jig 40, the inkjet head 102, and the like. As a result, the position (relative position of the inkjet head 102) of the inkjet head 102 relative to the medium 50 may deviate from a reference position. The reference position referred to here is a position corresponding to a predetermined correct position. Further, such positional deviation includes, for example, positional deviation between the center of the inkjet head 102 and the center of the medium 50 in the left-right direction (main scanning direction) in the figure. The left-right direction referred to here is an example of a direction orthogonal to the rotation axis of the medium 50.

[0082] Regarding this point, in the case of performing printing on a flat medium such as paper or a film, rather than performing printing on a three-dimensional medium 50 as in the present embodiment, even if deviation occurs in the relative position of the inkjet head 102 with respect to the medium 50, deviation only occurs in the range printed on the medium 50, and normally no change occurs in the printed content itself. In contrast, in the case of performing printing on a three-dimensional medium 50 as in the present embodiment, if deviation occurs in the relative position of the inkjet head 102 with respect to the medium 50, unintended deviation will occur in the head gap, which is the distance between the inkjet head 102 and the medium 50 during ink discharge. As a result, a change also occurs in the printed content itself. As described above, in the present embodiment, the intermediate position between the A row and the B row of the inkjet head 102 is aligned with the rotation axis of the medium 50 in the left-right direction to cause the inkjet head 102 to discharge ink. If no deviation occurs in the relative position of the inkjet head 102 with respect to the medium 50, for example, as shown in the left portion of FIG. 11(a), the head gaps at the positions of the nozzle rows 112 of the A row and the B row become the same distance. In contrast, if deviation occurs in the relative position of the inkjet head 102 with respect to the medium 50, the head gap at the position of one nozzle row 112 of the A row and the B row becomes larger than in the case

shown in FIG. 11(a), and the head gap at the position of the other nozzle row 112 becomes smaller than in the case shown in FIG. 11(a). For example, in the case shown in the left portion of FIG. 11(b), the head gap at the position of the nozzle row 112 of the A row, which discharges magenta ink, becomes large, and the head gap at the position of the nozzle row 112 of the B row, which discharges black ink, becomes small. In such a case, the ink discharged from one of the nozzle rows 112 travels a longer distance until landing on the medium 50, and the ink discharged from the other of the nozzle rows 112 travels a shorter distance until landing on the medium 50, thereby causing deviation in the ink landing position. In the case shown in FIG. 11(b), the magenta ink lands more rightward in the figure than the position assumed by design. Further, the black ink lands more leftward in the figure than the position assumed by design. As a result, even in the case of discharging magenta and black inks to the same printing range by design, deviation occurs in the range where ink is discharged, for example, as shown in the right portion of FIG. 11(b).

[0083] Therefore, to perform printing more appropriately on the three-dimensional medium 50, it is desired to perform adjustment on the printing apparatus 10 for preventing occurrence of the above-described deviation in the range where ink is discharged. Further, in the present embodiment, as an example of such adjustment, the relative position of the inkjet head 102 with respect to the medium 50 is adjusted, as will be described below. Further, as an example of such adjustment, adjustment is performed to align the center position of the inkjet head 102 in the left-right direction with the center position of the medium 50. Such adjustment may also be regarded as adjustment for reducing deviation in the ink landing position for each of the plurality of nozzle rows 112 in one inkjet head 102 (ink landing deviation adjustment for each nozzle row within one head). Further, in the present embodiment, such adjustment is performed by causing the printing apparatus 10 to print patterns shown in FIG. 12 and FIG. 13, and appropriately changing the position of the inkjet head 102 according to the state of the printed patterns.

[0084] FIG. 12 and FIG. 13 are diagrams illustrating patterns drawn by the printing apparatus 10 during adjustment of the printing apparatus 10. Such patterns are examples of patterns that the control unit 30 (see FIG. 1) causes the inkjet head 102 to draw during adjustment of the printing apparatus 10. FIG. 12(a) is a diagram illustrating patterns 302a and 302b drawn by the inkjet head 102. FIG. 12(b) shows an example of the state of the patterns 302a and 302b drawn in the case where no deviation occurs in the relative position of the inkjet head 102 with respect to the medium 50. FIG. 13(a) and (b) show examples of the state of the patterns 302a and 302b drawn in the case where deviation occurs in the relative position of the inkjet head 102 with respect to the medium 50.

[0085] In the present embodiment, the control unit 30

causes a plurality of nozzle rows 112 included in one inkjet head 102 to draw predetermined patterns 302a and 302b during the above adjustment. The inkjet head 102 draws the pattern 302a by discharging ink from one nozzle row 112 of the two nozzle rows 112. Then, the inkjet head 102 draws the pattern 302b by discharging ink from the other nozzle row 112. In the present embodiment, the pattern 302a is an example of a first pattern. The pattern 302b is an example of a second pattern. Further, the one nozzle row 112 that draws the pattern 302a is an example of a first nozzle row. The other nozzle row 112 that draws the pattern 302b is an example of a second nozzle row different from the first nozzle row. Further, in such a case, the position of the one nozzle row 112 that draws the pattern 302a is an example of a first position. The position of the other nozzle row 112 that draws the pattern 302b is an example of a second position different from the first position. Further, regarding the operation of the inkjet head 102, the operation of drawing the pattern 302a by the one nozzle row 112 is an example operation of drawing the first pattern with ink discharged from nozzles of the nozzle row 112 in a state where the position of the nozzle row 112 relative to the medium 50 is at the first position. The operation of drawing the pattern 302b by the other nozzle row 112 is an example operation of drawing the second pattern with ink discharged from nozzles of the nozzle row 112 in a state where the position of the nozzle row 112 relative to the medium 50 is at the second position. The inkjet head 102 shown in FIG. 12(a) draws the pattern 302a by the nozzle row 112 of the A row, which discharges magenta ink. The inkjet head 102 draws the pattern 302b by the nozzle row 112 of the B row, which discharges black ink.

[0086] Here, for convenience of illustration and description, in the right portion of FIG. 12(a), the pattern drawn in magenta is shown with a broken line and the pattern drawn in black is shown with a solid line to represent the difference in ink colors. Further, in the same figure, although the patterns 302a and 302b are drawn with shifted positions, during the actual adjustment, the control unit 30 causes the inkjet head 102 to draw the patterns 302a and 302b such that the pattern 302a and the pattern 302b, by design, overlap on the medium 50 in the main scanning direction corresponding to the left-right direction in the figure, for example, as shown in FIG. 12(b). Here, the pattern 302a and the pattern 302b overlapping by design means that the pattern 302a and the pattern 302b overlap in the case where the relative position of the inkjet head 102 with respect to the medium 50 is aligned with a reference position (in the case where there is no deviation from the reference position). Further, the patterns 302a and 302b, which are a plurality of patterns, are an example of patterns drawn at the same position in the main scanning direction on the medium 50 in the case where the relative position of the inkjet head 102 with respect to the medium 50 is at the reference position. Further, the patterns 302a and 302b being drawn at the same position in the main scanning direction

may be regarded as being drawn at substantially the same position at a precision corresponding to the quality or the like required for printing. Further, as in the present embodiment, in the case where the medium 50 is rotated by the holding jig 40 (see FIG. 1), the patterns 302a and 302b being drawn at the same position in the main scanning direction may also be regarded as the patterns 302a and 302b being drawn at the same position in the rotation direction of the medium 50.

[0087] Further, in the present embodiment, the positions of the medium 50 and the A row and the B row of the nozzle rows 112 are in a relationship shown in the left portion of FIG. 12(a). Specifically, the relative position of the inkjet head 102 is fixed such that the A row and the B row of the nozzle rows 112 are disposed on opposite sides with the position of the rotation center of the medium 50 in the main scanning direction as a boundary. In such a state, the control unit 30 causes the nozzles of the A row and the B row to discharge ink to cause the inkjet head 102 to draw the patterns 302a and 302b. With such a configuration, the patterns 302a and 302b can be appropriately drawn using a plurality of nozzle rows 112 included in one inkjet head 102. Further, in such a case, for example, similar to the example shown in FIG. 11(a), it is contemplated that the center position of the nozzle row 112 of the A row and the nozzle row 112 of the B row in the main scanning direction is aligned with the position of the rotation axis of the medium 50. With such a configuration, the head gaps of a plurality of nozzle rows 112 can be aligned in the case where the relative position of the inkjet head 102 with respect to the medium 50 is aligned with the reference position. Accordingly, in the case where the relative position of the inkjet head 102 is aligned with the reference position, the patterns 302a and 302b that overlap on the medium 50 can be easily and appropriately drawn by the inkjet head 102.

[0088] Further, in the present embodiment, in the case where the relative position of the inkjet head 102 with respect to the medium 50 deviates from the reference position, deviation in the ink landing position occurs, and as a result, for example, as shown in FIG. 13(a) and (b), deviation occurs in the positions (positions in the main scanning direction) where the patterns 302a and 302b are drawn on the medium 50. For example, in the case of rotating the medium 50 in the rotation direction indicated by an arrow in the figure, with the head gap becoming smaller due to deviation in the relative position of the inkjet head 102, the rotation amount by which the medium 50 rotates until the ink lands becomes smaller, so the ink landing position deviates leftward in the figure, which is the downstream side in the rotation direction of the medium 50. Further, with the head gap becoming larger, the rotation amount by which the medium 50 rotates until the ink lands becomes larger, so the ink landing position deviates rightward in the figure, which is the upstream side in the rotation direction of the medium 50. FIG. 13(a) shows an example in the case where the relative position of the inkjet head 102 with respect to the medium 50

deviates to the right side in the figure, as shown in the left portion of the figure. In such a case, the state of the patterns 302a and 302b is such that the pattern 302a corresponding to the nozzle row 112 of the A row deviates leftward with respect to the pattern 302b corresponding to the nozzle row 112 of the B row, as shown in the right portion of the figure. Therefore, in such a case, adjustment is performed to move the position of the inkjet head 102 leftward based on the state of the patterns 302a and 302b. Further, FIG. 13(b) shows an example in the case where the relative position of the inkjet head 102 with respect to the medium 50 deviates to the left side in the figure, as shown in the left portion of the figure. In such a case, the state of the patterns 302a and 302b is such that the pattern 302a deviates rightward with respect to the pattern 302b, as shown in the right portion of the figure. Therefore, in such a case, adjustment is performed to move the position of the inkjet head 102 rightward based on the state of the patterns 302a and 302b. According to the present embodiment, whether the relative position of the inkjet head 102 with respect to the medium 50 is aligned with the reference position can be appropriately detected. Accordingly, adjustment of the relative position of the inkjet head 102 can be appropriately performed as needed.

[0089] Here, in the present embodiment, the state where the patterns 302a and 302b overlap is a state where there is no problem with the relative position of the inkjet head 102. By adjusting the relative position of the inkjet head 102 such that the patterns 302a and 302b overlap, the relative position of the inkjet head 102 can be appropriately adjusted. By appropriately adjusting the relative position of the inkjet head 102, printing can be performed more appropriately on the three-dimensional medium 50. Further, in the present embodiment, the plurality of nozzle rows 112 of the inkjet head 102 have relative positions in a known relationship, and are formed at predetermined positions in the inkjet head 102. Adjusting the relative position of the inkjet head 102 with respect to the medium 50 corresponds to adjusting the relative positions of the nozzle rows 112 with respect to the medium 50. In such a case, the patterns 302a and 302b may also be regarded as patterns for performing adjustment to deviation in ink landing positions that occurs between the plurality of nozzle rows 112 having known relative positions. Further, adjusting the relative position of the inkjet head 102 may also be regarded as adjusting the relative positions of the nozzle rows 112 with respect to the medium 50 without changing the relative positional relationship between the nozzle rows 112 for the plurality of nozzle rows 112.

[0090] Further, as understood from the above description and the like, in the present embodiment, in the case where the relative position of the inkjet head 102 with respect to the medium 50 deviates, the patterns 302a and 302b will deviate in a direction corresponding to the direction in which the relative position of the inkjet head 102 deviates. Therefore, the patterns 302a and 302b

may also be regarded as patterns for detecting the direction of deviation in the relative position of the inkjet head 102. In the present embodiment, as the deviation in the relative position of the inkjet head 102 is greater, the deviation in the patterns 302a and 302b also becomes greater. Therefore, the patterns 302a and 302b may also be regarded as patterns in which the manner of overlap varies depending on the manner of positional deviation in the case where the relative position of the inkjet head 102 deviates from the reference position. Further, in a modified example of the adjustment operation for the printing apparatus 10, in the case of adjusting the relative position of the inkjet head 102 with higher accuracy, it is also contemplated to further use patterns for detecting the magnitude of deviation in the relative position of the inkjet head 102. For example, in addition to the patterns 302a and 302b described above, it is contemplated to use patterns that overlap in the case where the magnitude of deviation in the relative position of the inkjet head 102 is a predetermined magnitude. As such patterns, for example, it is contemplated to use a plurality of sets of patterns with differing magnitudes of deviation by which the patterns overlap. With such a configuration, the magnitude of deviation in the relative position of the inkjet head 102 can be appropriately detected.

[0091] Further, as described above, in the present embodiment, the printing apparatus 10 includes a plurality of inkjet heads 102. The relative position with respect to the medium 50 may be adjusted for any of the inkjet heads 102. Further, in such a case, it is also contemplated to adjust the positions of other inkjet heads 102 with respect to the inkjet head 102 of which the relative position with respect to the medium 50 has been adjusted. In such a case, the control unit 30 of the printing apparatus 10 causes the plurality of inkjet heads 102 to draw patterns for detecting deviation in the distance between the inkjet heads 102. Such patterns are an example of inter-head distance adjustment patterns used for adjusting the distance between the inkjet heads 102. In such a case, the control unit 30 causes the plurality of inkjet heads 102 to draw inter-head distance adjustment patterns in addition to the above patterns 302a and 302b.

[0092] FIG. 14 is a diagram illustrating a method for adjusting the distance between the inkjet heads 102. FIG. 14(a) and (b) are diagrams showing problems that occur in the case of deviation in the distance between the inkjet heads 102. FIG. 14(a) shows a state where no deviation occurs in the distance between the inkjet heads 102. FIG. 14(b) shows an example of a state where deviation occurs in the distance between the inkjet heads 102. As described above, in the present embodiment, a plurality of inkjet heads 102 are sequentially moved to directly above the rotating medium 50 to be opposed the medium 50. The control unit 30 causes the plurality of inkjet heads 102 to sequentially discharge ink to the medium 50. At this time, the control unit 30 moves the head unit 12 (see FIG. 1) having the plurality of inkjet heads 102 according to the designed distance between the inkjet heads 102.

[0093] If the plurality of inkjet heads 102 are attached to the head unit 12 at correct positions and no deviation occurs in the distance between the inkjet heads 102, for example, as shown in FIG. 14(a), even if the inkjet head 102 opposed to the medium 50 changes, the inkjet head 102 is always correctly opposed to the medium 50. More specifically, if the relative position of the leftmost inkjet head 102 in the figure with respect to the medium 50 is correctly adjusted, the second inkjet heads 102 onward from the left (second, third, and fourth inkjet heads 102) can also be sequentially and appropriately moved to directly above the medium 50. Accordingly, ink can be discharged with the center positions of all the inkjet heads 102 aligned with the center position of the medium 50 in the main scanning direction. However, for example, as shown in FIG. 14(b), in the case where deviation occurs in the distance between the inkjet heads 102 at any position of the head unit 12, the inkjet head 102 newly opposed to the medium 50 will not be correctly opposed to the medium 50. More specifically, in the case shown in FIG. 14(b), a distance L_h between the leftmost inkjet head 102 in the figure and the adjacent inkjet head 102 (second inkjet head 102) is larger than a correct distance (original distance). In such a case, since the actual distance L_h cannot be known, the control unit 30 moves the head unit 12 based on the designed distance between the inkjet heads 102. As a result, the positions of the second inkjet head 102 onward become positions deviated from directly above the medium 50. Upon performing printing in such a state, deviation occurs in the ink landing positions, and appropriate printing cannot be performed.

[0094] In this regard, in the present embodiment, the distance between the inkjet heads 102 is further adjusted by causing the plurality of inkjet heads 102 to draw patterns 304a and 304b shown in FIG. 14(c), for example. FIG. 14(c) shows an example of the patterns 304a and 304b used during adjustment to the distance between the inkjet heads 102. The patterns 304a and 304b are patterns for adjusting variations in the distance between the inkjet heads 102. Further, the patterns 304a and 304b may also be regarded as patterns for detecting deviation in ink landing positions occurring between the inkjet heads 102.

[0095] As described above, in the present embodiment, the inkjet head 102 has two nozzle rows 112. The control unit 30 causes the pattern 304a to be drawn with ink discharged from the nozzles of any one nozzle row 112 of any one of the inkjet heads 102. Further, the control unit 30 causes the pattern 304b to be drawn with ink discharged from the nozzles of any one nozzle row 112 of any other inkjet head 102. The control unit 30 sets any one of the plurality of inkjet heads 102 of the head unit 12 as a reference inkjet head 102, and causes such an inkjet head 102 to draw the pattern 304a. Then, one inkjet head 102 to be aligned with the reference inkjet head 102 is selected, and such an inkjet head 102 is caused to draw the pattern 304b. In such a case, as shown in the figure, for example, it is preferable to use patterns different from

each other as the patterns 304a and 304b. With such a configuration, the pattern 304a and the pattern 304b can be easily and appropriately identified. Further, as the patterns 304a and 304b, patterns that at least partially overlap on the medium 50 in the case where the distance between the inkjet heads 102 matches the correct distance may be suitably used. In the present embodiment, the pattern 304a includes vertical lines extending in the vertical direction in the figure and horizontal lines extending in the left-right direction. In contrast, the pattern 304b does not include horizontal lines and includes only vertical lines. In the case where the distance between the inkjet heads 102 is the correct distance, the vertical line portions of the pattern 304a overlap with the vertical line portions of the pattern 304b on the medium 50. With such a configuration, it is possible to appropriately detect whether the distance between the inkjet heads 102 is the correct distance. Based on such a detection result, the distance between the inkjet heads 102 can be adjusted.

[0096] Further, FIG. 14(c) shows an example of the patterns 304a and 304b in the case where the distance between the inkjet heads 102 deviates and needs to be adjusted. In FIG. 14(c), the pattern 304b drawn by the inkjet head 102 serving as the adjustment target is drawn on the left side in the figure with respect to the pattern 304a drawn by the reference inkjet head 102. This indicates that, with the distance between the inkjet heads 102 being wider than the correct distance, the ink discharged by the inkjet head 102 serving as the adjustment target deviates to the left side from the correct position. Further, contrary to the illustrated case, in the case where the pattern 304b is drawn on the right side in the figure with respect to the pattern 304a, the distance between the inkjet heads 102 is narrower than the correct distance. Further, in the present embodiment, as the adjustment to the distance between the inkjet heads 102, for example, it is contemplated to adjust the movement distance of the head unit 12 when changing the inkjet head 102 to be opposed to the medium 50. For example, in the case where the distance between the inkjet heads 102 is wider than the correct distance, it is contemplated to performing adjustment to lengthen the movement distance. Further, in the case where the distance between the inkjet heads 102 is narrower than the correct distance, it is contemplated to perform adjustment to shorten the movement distance.

[0097] Further, in the present embodiment, the patterns 304a and 304b are an example of patterns having a state that varies depending on the distance between the plurality of inkjet heads 102. Further, as a modified example of the adjustment operation for the printing apparatus 10, to adjust the distance between the inkjet heads 102 with higher accuracy, it is also contemplated to further use patterns for detecting the magnitude of deviation in the distance between the inkjet heads 102. For example, in addition to the patterns 304a and 304b described above, it is contemplated to use patterns that

overlap in the case where the magnitude of deviation in the distance between the inkjet heads 102 is a predetermined magnitude. Further, as such patterns, it is contemplated to use a plurality of sets of patterns having differing magnitudes of deviation by which the patterns overlap. With such a configuration, the magnitude of deviation in the distance between the inkjet heads 102 can be appropriately detected.

[0098] Next, supplementary descriptions regarding each of the configurations described above and descriptions of modified examples will be provided. As described above, in the present embodiment, the printing apparatus 10 is adjusted by causing the inkjet heads 102 to discharge ink based on the control by the control unit 30 of the printing apparatus 10. Further, as such an adjustment, an adjustment to the relative position of the inkjet head 102 with respect to the medium 50 and an adjustment to the distance between the inkjet heads 102 are performed. This may be regarded as the printing apparatus 10 having such adjustment functions. Further, such adjustments may also be regarded as adjustments to the ink landing positions of inks of respective colors discharged from the plurality of inkjet heads 102. The patterns drawn by the inkjet head 102 during adjustment are an example of adjustment patterns used for adjusting the ink landing positions. According to the present embodiment, if deviation occurs in the ink landing positions of ink discharged from any of the inkjet heads 102, the user (adjuster) who performs adjustment may be notified, in an easily understandable manner, that the ink landing positions are deviated. Further, in the present embodiment, the printing apparatus 10 may be regarded as having at least a part of the plurality of inkjet heads 102 that are arranged in a direction perpendicular to the direction of the rotation axis of the medium 50. To appropriately align the ink landing positions of ink discharged from all the nozzle rows 112 of all the inkjet heads 102, it becomes necessary to align the center of the inkjet head 102 in the left-right direction (main scanning direction) with the center of the medium 50. Further, on this basis, a function for adjusting the deviation in the distance between the inkjet heads 102 for the plurality of inkjet heads 102 becomes necessary. In this regard, as described above, according to the present embodiment, these adjustment functions can be appropriately realized. Accordingly, printing can be performed more appropriately on the three-dimensional medium 50.

[0099] Further, in the above description, regarding the adjustment to the relative position of the inkjet head 102 with respect to the medium 50, the example using a plurality of nozzle rows 112 included in one inkjet head 102 has been mainly described. In contrast, as a modified example of the adjustment operation, it is also contemplated to perform the adjustment using only one nozzle row 112 included in the inkjet head 102. In such a case, for example, it is contemplated to use any one nozzle row 112 of the inkjet head 102 having a plurality of nozzle rows 112. Further, as a modified example configuration of the

printing apparatus 10, it is also contemplated to use an inkjet head 102 having only one nozzle row 112, instead of an inkjet head 102 having a plurality of nozzle rows 112. More specifically, for example, it is contemplated to adjust the relative position of the inkjet head 102 with respect to the medium 50 according to an operation shown in FIG. 15.

[0100] FIG. 15 is a diagram showing a modified example of the adjustment operation in the printing apparatus 10, and shows an example operation for adjusting the relative position of the inkjet head 102 with respect to the medium 50 using one nozzle row 112 of the inkjet head 102. As described above, in the case of using an inkjet head 102 having a plurality of nozzle rows 112 for adjusting the relative position of the inkjet head 102 with respect to the medium 50, it is contemplated to discharge ink from nozzles of the plurality of nozzle rows 112 located at positions different from each other to draw the patterns 302a and 302b (see FIG. 12), for example, as in the operation shown in FIG. 12(a). In contrast, in the case of the modified example shown in FIG. 15(a), the control unit 30 of the printing apparatus 10 causes the inkjet head 102 to draw a pattern corresponding to the pattern 302a in a state where the relative position of the inkjet head 102 with respect to the medium 50 is set to a first position, as shown in the left portion of the figure. Then thereafter, as shown in the right portion of the figure, the control unit 30 moves the inkjet head 102 relatively with respect to the medium 50, and sets the relative position of the inkjet head 102 with respect to the medium 50 at a second position different from the first position. At such a position, the control unit 30 causes the inkjet head 102 to draw a pattern corresponding to the pattern 302b. In the case of such a configuration as well, deviation in the relative position of the inkjet head 102 with respect to the medium 50 can be appropriately detected.

[0101] Further, it is also contemplated to detect a change in the ink landing position caused by deviation in the relative position of the inkjet head 102 with respect to the medium 50, by changing the rotation direction of the medium 50, for example, as shown in FIG. 15(b). That is, the control unit 30 detects deviation in the relative position by causing the inkjet head 102 to draw patterns corresponding to the patterns 302a and 302b with rotation directions of the medium 50 being different from each other. More specifically, the control unit 30 causes the inkjet head 102 to draw a pattern corresponding to the pattern 302a in a state where the medium 50 is rotated in a first rotation direction by the rotation mechanism 206 (see FIG. 2) included in the holding jig 40, as shown in the left portion of the figure. Then thereafter, the control unit 30 causes the inkjet head 102 to draw a pattern corresponding to the pattern 302b in a state where the medium 50 is rotated in a second rotation direction opposite to the first rotation direction, as shown in the right portion of the figure. In the case of such a configuration as well, deviation in the relative position of the inkjet head 102 with respect to the medium 50 can be appropriately detected.

Accordingly, printing can be performed more appropriately on the three-dimensional medium 50.

[0102] Further, in a further modified example of the adjustment operation in the printing apparatus 10, it is also contemplated to adjust the relative position of the inkjet head 102 with respect to the medium 50 using a plurality of inkjet heads 102 for which the relative position has been adjusted appropriately and sufficiently. In such a case, for example, it is contemplated to use a head group in which the positions of the plurality of inkjet heads 102 are already fixed. This may be regarded as performing the operation described with reference to FIG. 12 and FIG. 13, for example, using a plurality of nozzle rows 112 in the plurality of inkjet heads 102. More specifically, in such a case, the control unit 30 causes a first inkjet head 102 among the plurality of inkjet heads 102 to draw a pattern corresponding to the pattern 302a, and causes a second inkjet head 102 different from the first inkjet head 102 to draw a pattern corresponding to the pattern 302b. In the case of such a configuration as well, deviation in the relative position of the inkjet head 102 with respect to the medium 50 can be appropriately detected.

[0103] Further, as described above, in the present embodiment, the printing apparatus 10 performs printing on the medium 50 while rotating the medium 50. As the medium 50, for example, a cylindrical (tubular) medium may be suitably used. A cylindrical medium refers to a medium in a rotating body shape of which a cross-section in a plane orthogonal to the rotation axis is circular. Further, as the medium 50, it is also possible to use a medium having a shape other than a cylindrical shape. As a medium having a shape other than a cylindrical shape, a medium having a rotating body shape may be suitably used. As such a medium, it is contemplated to use a medium in a conical shape or a truncated conical shape (truncated cone shape). Further, in the case of using a medium having a shape such as a conical shape or a truncated conical shape, the holding jig 40 holds the medium such that the height of the medium becomes constant at a position (position at which ink lands) opposed to the inkjet head 102. In such a case, it is contemplated that, for example, by appropriately inclining the rotation axis, on which the medium is rotated, with respect to the horizontal direction, the medium is held such that the generatrix of the medium in a conical shape or the like at the position opposed to the inkjet head 102 becomes horizontal.

[0104] Further, when performing printing on media having various shapes as described above, the printing apparatus 10 uses a plurality of nozzle rows 112 included in the inkjet head 102 in the case of using at least a part of the shapes of the media. For example, in the case of using a medium 50 having a shape of which a cross-sectional shape in a plane orthogonal to the rotation axis is constant or substantially constant, such as a cylindrical or substantially cylindrical medium, it is contemplated to perform printing using the plurality of nozzle rows 112 of the inkjet head 102. In such a case, the relative position of

the inkjet head 102 with respect to the medium 50 can be easily and appropriately adjusted according to, for example, the operation described with reference to FIG. 12 and FIG. 6. On the other hand, in the case of using a medium having a more complex shape compared to a cylindrical medium, such as a conical or truncated conical medium, if printing with higher quality is desired, it may be preferable to use only one nozzle row 112 in the inkjet head 102. In such a case, it is also contemplated to perform printing using only any one nozzle row 112 among the plurality of nozzle rows 112 included in the inkjet head 102. In such a case, it is contemplated to align the position of the nozzle row 112 to be used with the position of the rotation axis in the main scanning direction. Further, depending on the manner of controlling the printing operation or the like, the position of the nozzle row 112 to be used may be shifted from the position of the rotation axis as necessary. In such a case as well, the relative position of the inkjet head 102 with respect to the medium 50 can be adjusted according to the operation described with reference to FIG. 12 and FIG. 6, using the plurality of nozzle rows 112 of the inkjet head 102. Further, it is also contemplated to adjust the relative position of the inkjet head 102 with respect to the medium by, for example, the operation described with reference to FIG. 15(a) and (b), according to the required accuracy of adjustment or the like.

[0105] Further, regarding the three-dimensional medium 50, the problem that the head gap varies due to deviation in the relative position of the inkjet head 102 with respect to the medium 50 occurs not only in the case of rotating the medium 50. Therefore, even if not rotating the medium 50, the same or similar adjustment as described above may also be performed on the relative position of the inkjet head 102 with respect to the medium 50. In such a case as well, by causing the nozzle rows disposed at positions different from each other to draw patterns corresponding to the patterns 302a and 302b, the relative position of the inkjet head 102 with respect to the medium 50 can be appropriately adjusted. Further, in the adjustment to the relative position of the inkjet head 102 with respect to the medium 50, for example, in the case of the configuration of rotating the medium, the positional relationship between the rotation axis of the medium and the inkjet head 102 becomes important. Therefore, it is preferable to perform adjustment to move the inkjet head 102 relatively with respect to the medium 50 such that the position of the inkjet head 102 with respect to the rotation axis becomes a predetermined position. In contrast, in the case of performing printing on the three-dimensional medium 50 with a configuration that does not rotate the medium 50, as the adjustment to the relative position of the inkjet head 102 with respect to the medium 50, it is also contemplated to perform adjustment without moving the inkjet head 102 relatively with respect to the medium 50. In such a case, for example, it is contemplated to perform adjustment such as varying the timing at which the inkjet head 102 discharges ink.

Industrial Applicability

[0106] The present invention may be suitably utilized in, for example, a printing apparatus.

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Reference Signs List

[0107] 10 ... printing apparatus, 102 ... inkjet head, 112 ... nozzle row, 12 ... head unit, 14 ... platform unit, 16 ... main scanning drive unit, 18 ... sub-scanning drive unit, 20 ... sensor, 202 ... housing unit, 204 ... cover, 206 ... rotation mechanism, 208 ... ultraviolet irradiator, 210 ... light source holding unit, 212 ... cover moving means, 22 ... sensor moving means, 220 ... opening, 222 ... base unit, 224 ... magnet sheet, 226 ... shaft unit, 228 ... rotation drive unit, 232 ... tape, 242 ... lighting unit, 244 ... eave, 30 ... control unit, 302a ... seam, 302 ... pattern, 304 ... pattern, 40 ... holding jig, 50 ... medium

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Claims

1. A printing apparatus performing printing using an ultraviolet-curable ink on a three-dimensional medium held by a holding member, which holds the medium serving as a printing target, the printing apparatus comprising:

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an inkjet head having a nozzle row in which a plurality of nozzles are arranged with positions different from each other in a predetermined nozzle row direction;

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a sub-scanning drive unit causing the inkjet head to perform a sub-scanning operation of moving the inkjet head relatively with respect to the medium in a sub-scanning direction parallel to the nozzle row direction; and

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a control unit configured to control operations of the inkjet head and the sub-scanning drive unit, wherein

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the holding member comprises:

a rotation mechanism rotating the medium while holding the medium at a position opposed to the nozzle row;

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an ultraviolet irradiator irradiating ultraviolet rays to an outer surface of the medium; and

a cover that is a member covering at least the ultraviolet irradiator from a side of an upper surface of the holding member, which is a surface on a side opposed to the inkjet head, the cover having an opening at a position opposed to the nozzle row and covering the upper surface of the holding member while allowing the nozzle row and the medium to be opposed to each other at the position of the opening,

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the rotation mechanism rotates the medium

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such that a direction of movement of the outer surface of the medium at the position opposed to the nozzle row is a main scanning direction orthogonal to the sub-scanning direction, and the control unit is configured to:

further perform control on a rotation operation of rotating the medium by the rotation mechanism, and cause the inkjet head to perform a main scanning operation of discharging ink to the rotating medium by causing the inkjet head to discharge ink while rotating the medium with the rotation mechanism, cause the inkjet head to discharge ink to a printing range having a wider range in the sub-scanning direction than a nozzle row length, which is a length of the nozzle row in the sub-scanning direction, by causing the inkjet head to perform the main scanning operation for a plurality of times while causing the inkjet head to perform the sub-scanning operation in an interval between at least a part of the plurality of times of the main scanning operation, and cause the inkjet head to perform the sub-scanning operation within a range that does not move a position of the nozzle row in the sub-scanning direction to outside an opposed position medium range, the opposed position medium range being defined as a range from one end to another end in the sub-scanning direction of the medium disposed at the position opposed to the nozzle row.

2. The printing apparatus according to claim 1, performing printing according to a multi-pass technique in which a number of times of the main scanning operation performed with one position of the medium being opposed to the nozzle row is a plurality of times, and the control unit is configured to:

cause the inkjet head to perform the main scanning operation for a number of times corresponding to a preset number of passes, in a state where the one end in the sub-scanning direction of the medium disposed at the position opposed to the nozzle row and one end of the nozzle row, which is an end portion on a same side in a same direction, are aligned with each other in the sub-scanning direction, and after causing the inkjet head to perform the main scanning operation for the number of times cor-

responding to the number of passes, before causing the inkjet head to perform the main scanning operation for a next time, cause the inkjet head to perform the sub-scanning operation of moving relatively with respect to the medium in the sub-scanning direction by a pass number corresponding distance, which is a movement distance corresponding to a distance obtained by dividing the nozzle row length by the number of passes.

3. The printing apparatus according to claim 2, wherein

a printing resolution in the sub-scanning direction is made higher than a resolution corresponding to a nozzle pitch by performing printing according to the multi-pass technique to perform printing on the medium, the nozzle pitch being defined as a pitch in the sub-scanning direction of the nozzles in the nozzle row, and in an interval between at least a part of the number of times of the main scanning operation corresponding to the number of passes performed with the one end of the medium and the one end of the nozzle row aligned with each other, the sub-scanning drive unit moves the inkjet head relatively with respect to the medium in the sub-scanning direction by a distance less than the nozzle pitch.

4. The printing apparatus according to claim 2, wherein in the sub-scanning operation performed for a time in which a position of another end of the nozzle row is to exceed a position of the another end of the medium in the sub-scanning direction upon setting a movement distance of the inkjet head relative to the medium to the pass number corresponding distance, the control unit is configured to cause the inkjet head to perform the sub-scanning operation such that the inkjet head moves relatively with respect to the medium by a movement distance by which the another end of the nozzle row moves until reaching the position of the another end of the medium.

5. The printing apparatus according to claim 4, wherein the control unit is configured to:

after causing the inkjet head to perform the sub-scanning operation in which the another end of the nozzle row reaches the position of the another end of the medium in the sub-scanning direction, cause the inkjet head to perform the main scanning operation for a plurality of times with the another end of the medium and the another end of the nozzle row aligned with each other.

6. The printing apparatus according to claim 1, further

comprising:

a sensor used for detecting a position of the upper surface of the holding member; and a sensor moving means moving the sensor relatively with respect to the holding member, wherein the holding member further comprises a cover moving means moving the cover in a direction in which a distance between the inkjet head and the cover varies, and the control unit is further configured to control the sensor and the sensor moving means, and detect a status of a gap formed between the cover and the medium based on an output of the sensor acquired while moving the sensor by the sensor moving means along a path passing an edge of the opening of the cover.

7. The printing apparatus according to claim 1, performing printing according to a multi-pass technique in which a number of times of the main scanning operation performed with one position of the medium opposed to the nozzle row is a plurality of times, wherein the control unit is configured to:

cause the inkjet head to perform the main scanning operation for a number of times corresponding to a preset number of passes in a state where a position corresponding to one end of printing data in the sub-scanning direction and one end of the nozzle row, which is an end portion on a same side in the sub-scanning direction, are aligned with each other, and after causing the inkjet head to perform the main scanning operation for the number of times corresponding to the number of passes, before causing the inkjet head to perform the main scanning operation for a next time, cause the inkjet head to perform the sub-scanning operation of moving relatively with respect to the medium in the sub-scanning direction by a pass number corresponding distance, which is a movement distance corresponding to a distance obtained by dividing the nozzle row length by the number of passes.

8. The printing apparatus according to claim 7, wherein in the sub-scanning operation performed for a time in which a position of another end of the nozzle row is to exceed a position corresponding to another end of the printing data in the sub-scanning direction upon setting a movement distance of the inkjet head relative to the medium to the pass number corresponding distance, the control unit is configured to cause the inkjet head to perform the sub-scanning operation such that the inkjet head moves relatively with

respect to the medium by a movement distance by which the another end of the nozzle row moves until reaching the position corresponding to the another end of the printing data.

9. A printing apparatus performing printing using an ultraviolet-curable ink on a three-dimensional medium held by a holding member, which holds the medium serving as a printing target, the printing apparatus comprising:

an inkjet head having a nozzle row in which a plurality of nozzles are arranged with positions different from each other in a predetermined nozzle row direction;

a sensor used for detecting a position of an upper surface of the holding member, which is a surface of the holding member opposed to the inkjet head;

a sensor moving means moving the sensor relatively with respect to the holding member; and a control unit configured to control operations of the inkjet head, the sensor, and the sensor moving means, wherein

the holding member comprises:

a rotation mechanism rotating the medium while holding the medium at a position opposed to the nozzle row;

an ultraviolet irradiator irradiating ultraviolet rays to an outer surface of the medium;

a cover that is a member covering at least the ultraviolet irradiator from a side of the upper surface of the holding member, has an opening at a position opposed to the nozzle row, and covers the upper surface of the holding member while allowing the nozzle row and the medium to be opposed to each other at the position of the opening; and

a cover moving means moving the cover in a direction in which a distance between the inkjet head and the cover varies, wherein the control unit is configured to detect a status of a gap formed between the cover and the medium based on an output of the sensor acquired while moving the sensor by the sensor moving means along a path passing an edge of the opening of the cover.

10. The printing apparatus according to claim 9, wherein

the control unit is configured to move the sensor along a plurality of paths in a direction intersecting the nozzle row direction, and the plurality of paths comprise:

a one-end side path passing a vicinity of one

end of the medium in the nozzle row direction;

an other-end side path passing a vicinity of another end of the medium; and

an intermediate position path passing over the medium between the one-end side path and the other-end side path.

11. The printing apparatus according to claim 9, wherein

the sensor is a photosensor detecting light, and detects reflected light from the cover and the medium in a state where a light reflective member is attached to at least a part of at least one of the medium and the cover, and

the control unit is configured to move the sensor along a path where the sensor is capable of detecting reflected light from the light reflective member on at least one of the medium and the cover.

12. The printing apparatus according to claim 9, wherein

the sensor is a photosensor detecting light, and in a state where ultraviolet rays are irradiated to the outer surface of the medium by the ultraviolet irradiator, the control unit is further configured to detect ultraviolet rays leaking from a gap between the edge of the opening of the cover and the medium based on the output of the sensor.

13. A printing method for performing printing using an ultraviolet-curable ink on a three-dimensional medium held by a holding member, which holds the medium serving as a printing target, the printing method comprising:

causing an inkjet head, which has a nozzle row in which a plurality of nozzles are arranged with positions different from each other in a predetermined nozzle row direction, to perform a sub-scanning operation of moving the inkjet head relatively with respect to the medium in a sub-scanning direction parallel to the nozzle row direction, wherein the holding member comprises:

a rotation mechanism rotating the medium while holding the medium at a position opposed to the nozzle row;

an ultraviolet irradiator irradiating ultraviolet rays to an outer surface of the medium; and

a cover that is a member covering at least the ultraviolet irradiator from a side of an upper surface of the holding member, which is a surface on a side opposed to the inkjet head, the cover having an opening at a position opposed to the nozzle row and

covering the upper surface of the holding member while allowing the nozzle row and the medium to be opposed to each other at the position of the opening, the rotation mechanism rotates the medium such that a direction of movement of the outer surface of the medium at the position opposed to the nozzle row is a main scanning direction orthogonal to the sub-scanning direction, in control of a rotation operation of rotating the medium by the rotation mechanism, the inkjet head is caused to perform a main scanning operation of discharging ink to the rotating medium by causing the inkjet head to discharge ink while rotating the medium with the rotation mechanism, the inkjet head is caused to discharge ink to a printing range having a wider range in the sub-scanning direction than a nozzle row length, which is a length of the nozzle row in the sub-scanning direction, by causing the inkjet head to perform the main scanning operation for a plurality of times while causing the inkjet head to perform the sub-scanning operation in an interval between at least a part of the plurality of times of the main scanning operation, and the inkjet head is caused to perform the sub-scanning operation within a range that does not move a position of the nozzle row in the sub-scanning direction to outside an opposed position medium range, the opposed position medium range being defined as a range from one end to another end in the sub-scanning direction of the medium disposed at the position opposed to the nozzle row.

14. A detection method for detecting a state of a printing apparatus performing printing using an ultraviolet-curable ink on a three-dimensional medium held by a holding member, which holds the medium serving as a printing target, wherein the printing apparatus comprises:

an inkjet head having a nozzle row in which a plurality of nozzles are arranged with positions different from each other in a predetermined nozzle row direction;
a sensor used for detecting a position of an upper surface of the holding member, which is a surface of the holding member opposed to the inkjet head; and
a sensor moving means moving the sensor relatively with respect to the holding member, the holding member comprises:

a rotation mechanism rotating the medium while holding the medium at a position opposed to the nozzle row;
an ultraviolet irradiator irradiating ultraviolet rays to an outer surface of the medium;
a cover that is a member covering at least the ultraviolet irradiator from a side of the upper surface of the holding member, has an opening at a position opposed to the nozzle row, and covers the upper surface of the holding member while allowing the nozzle row and the medium to be opposed each other at the position of the opening; and
a cover moving means moving the cover in a direction in which a distance between the inkjet head and the cover varies, and a status of a gap formed between the cover and the medium is detected based on an output of the sensor acquired while moving the sensor by the sensor moving means along a path passing an edge of the opening of the cover.

15. A printing apparatus performing printing on a three-dimensional medium, the printing apparatus comprising:

an inkjet head having a nozzle row in which a plurality of nozzles are arranged in a predetermined nozzle row direction;
a main scanning drive unit causing the inkjet head to perform a main scanning operation of discharging ink while moving relatively along a preset main scanning direction over a printing surface of the medium; and
a control unit configured to control operations of the inkjet head and the main scanning drive unit, wherein
the control unit is configured to cause the inkjet head to draw a first pattern and a second pattern in adjusting a position of the inkjet head, with a relative position of the inkjet head with respect to the medium being at a predetermined reference position, the first pattern and the second pattern are drawn at a same position in the main scanning direction on the medium, and the inkjet head draws the first pattern with ink discharged from the nozzles of the nozzle row in a state where a relative position of the nozzle row with respect to the medium is at a first position, and draws the second pattern with ink discharged from the nozzles of the nozzle row in a state where the relative position of the nozzle row with respect to the medium is at a second position different from the first position.

16. The printing apparatus according to claim 15, where-

in

the medium is held by a holding member,
the holding member comprises a rotation mechanism rotating the medium while holding the medium at a position opposed to the nozzle row, and
the main scanning drive unit moves the inkjet head relatively in the main scanning direction with respect to the printing surface of the medium by rotating the medium with the rotation mechanism.

17. The printing apparatus according to claim 16, wherein
the inkjet head has a plurality of the nozzle rows having positions different from each other in the main scanning direction, draws the first pattern by discharging ink from the nozzles of a first nozzle row of the plurality of the nozzle rows, and draws the second pattern by discharging ink from the nozzles of a second nozzle row of the plurality of the nozzle rows different from the first nozzle row.
18. The printing apparatus according to claim 17, wherein
the control unit is configured to cause the first nozzle row and the second nozzle row to draw the first pattern and the second pattern in a state where the inkjet head is disposed such that the first nozzle row and the second nozzle row are disposed on sides opposite to each other, with a position of a rotation center of the medium in the main scanning direction as a boundary.
19. The printing apparatus according to claim 15, wherein
with the relative position of the inkjet head with respect to the medium deviating from the reference position, an overlapping manner of the first pattern and the second pattern varies depending on a deviation manner thereof.
20. The printing apparatus according to claim 19, wherein
the printing apparatus comprises a plurality of the inkjet heads, and
the control unit is further configured to cause the plurality of inkjet heads to draw a pattern of which a printing result varies depending on a distance in the main scanning direction between the plurality of inkjet heads.
21. A printing apparatus performing printing on a three-dimensional medium held by a holding member, which holds the medium serving as a printing target, the printing apparatus comprising:

an inkjet head having a nozzle row in which a plurality of nozzles are arranged in a predetermined nozzle row direction;
a main scanning drive unit causing the inkjet head to perform a main scanning operation of discharging ink while moving relatively along a preset main scanning direction over a printing surface of the medium; and
a control unit configured to control operations of the inkjet head and the main scanning drive unit, wherein
the holding member comprises a rotation mechanism rotating the medium while holding the medium at a position opposed to the nozzle row, the main scanning drive unit moves the inkjet head relatively in the main scanning direction with respect to the printing surface of the medium by rotating the medium with the rotation mechanism,
the control unit is configured to cause the inkjet head to draw a first pattern and a second pattern in adjusting a position of the inkjet head, with a relative position of the inkjet head with respect to the medium being at a predetermined reference position, the first pattern and the second pattern are drawn at a same position in the main scanning direction on the medium, and the inkjet head draws the first pattern in a state where the medium is rotated in a first rotation direction by the rotation mechanism, and draws the second pattern in a state where the medium is rotated in a second rotation direction opposite to the first rotation direction.

22. An adjustment method for a printing apparatus performing printing on a three-dimensional medium, the adjustment method comprising:
causing an inkjet head included in the printing apparatus to draw a first pattern and a second pattern, wherein
the inkjet head has a nozzle row in which a plurality of nozzles are arranged in a predetermined nozzle row direction,
the inkjet head is caused to perform a main scanning operation of discharging ink while moving relatively along a preset main scanning direction over a printing surface of the medium, with a relative position of the inkjet head with respect to the medium being at a predetermined reference position, the first pattern and the second pattern are drawn at a same position in the main scanning direction on the medium, and the inkjet head is caused to draw the first pattern in a state where a relative position of the nozzle row with respect to the medium is at a first position, and draw the second pattern in a state where the relative position of the nozzle row with

respect to the medium is at a second position different from the first position.

23. An adjustment method for a printing apparatus performing printing on a three-dimensional medium held by a holding member, which holds the medium serving as a printing target, the adjustment method comprising:

causing an inkjet head included in the printing apparatus to draw a first pattern and a second pattern, wherein
the inkjet head has a nozzle row in which a plurality of nozzles are arranged in a predetermined nozzle row direction,
the inkjet head is caused to perform a main scanning operation of discharging ink while moving relatively along a preset main scanning direction over a printing surface of the medium, the holding member comprises a rotation mechanism rotating the medium while holding the medium at a position opposed to the nozzle row, in the main scanning operation, the inkjet head is moved relatively in the main scanning direction with respect to the printing surface of the medium by rotating the medium with the rotation mechanism,
with a relative position of the inkjet head with respect to the medium being at a predetermined reference position, the first pattern and the second pattern are drawn at a same position in the main scanning direction on the medium, and the inkjet head is caused to draw the first pattern in a state where the medium is rotated in a first rotation direction by the rotation mechanism, and draw the second pattern in a state where the medium is rotated in a second rotation direction opposite to the first rotation direction.

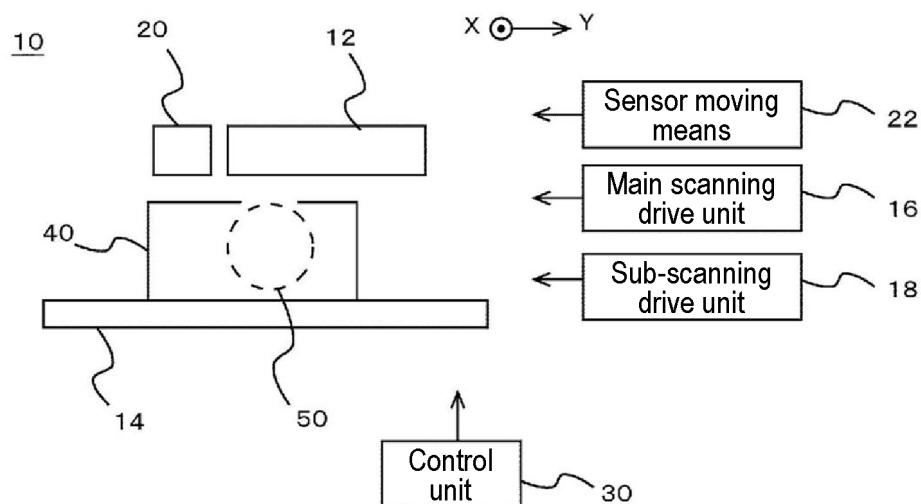
40

45

50

55

(a)



(b)

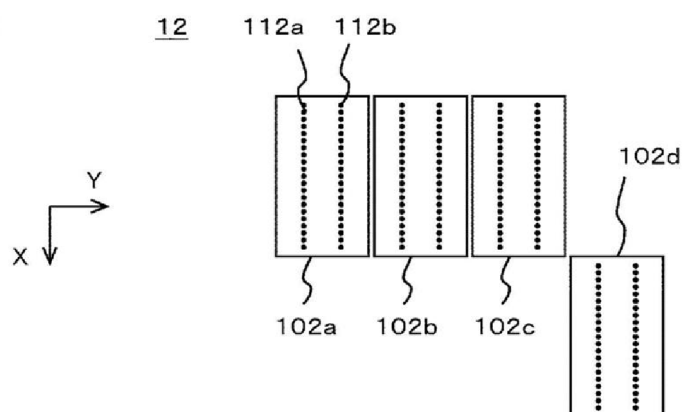


FIG. 1

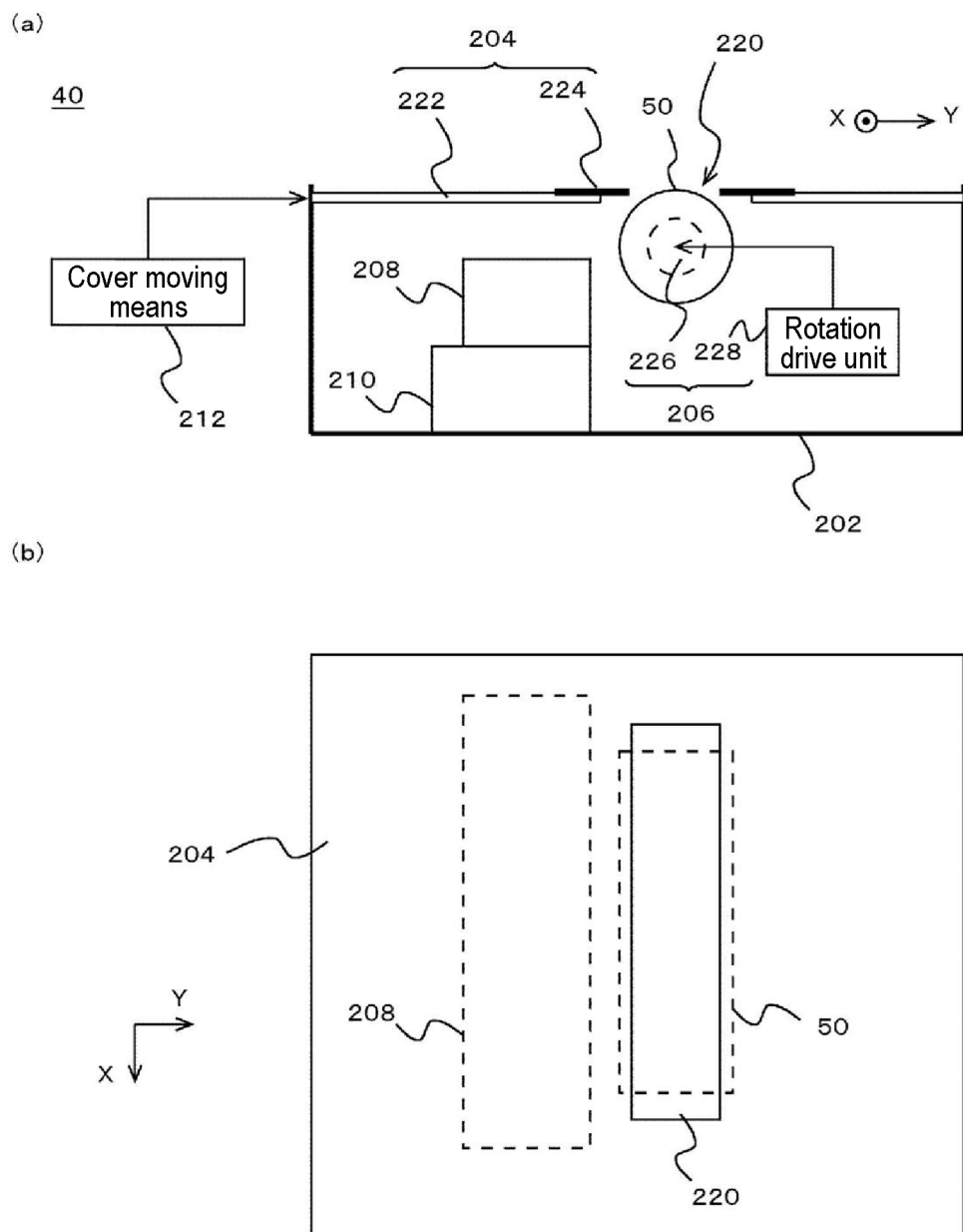


FIG. 2

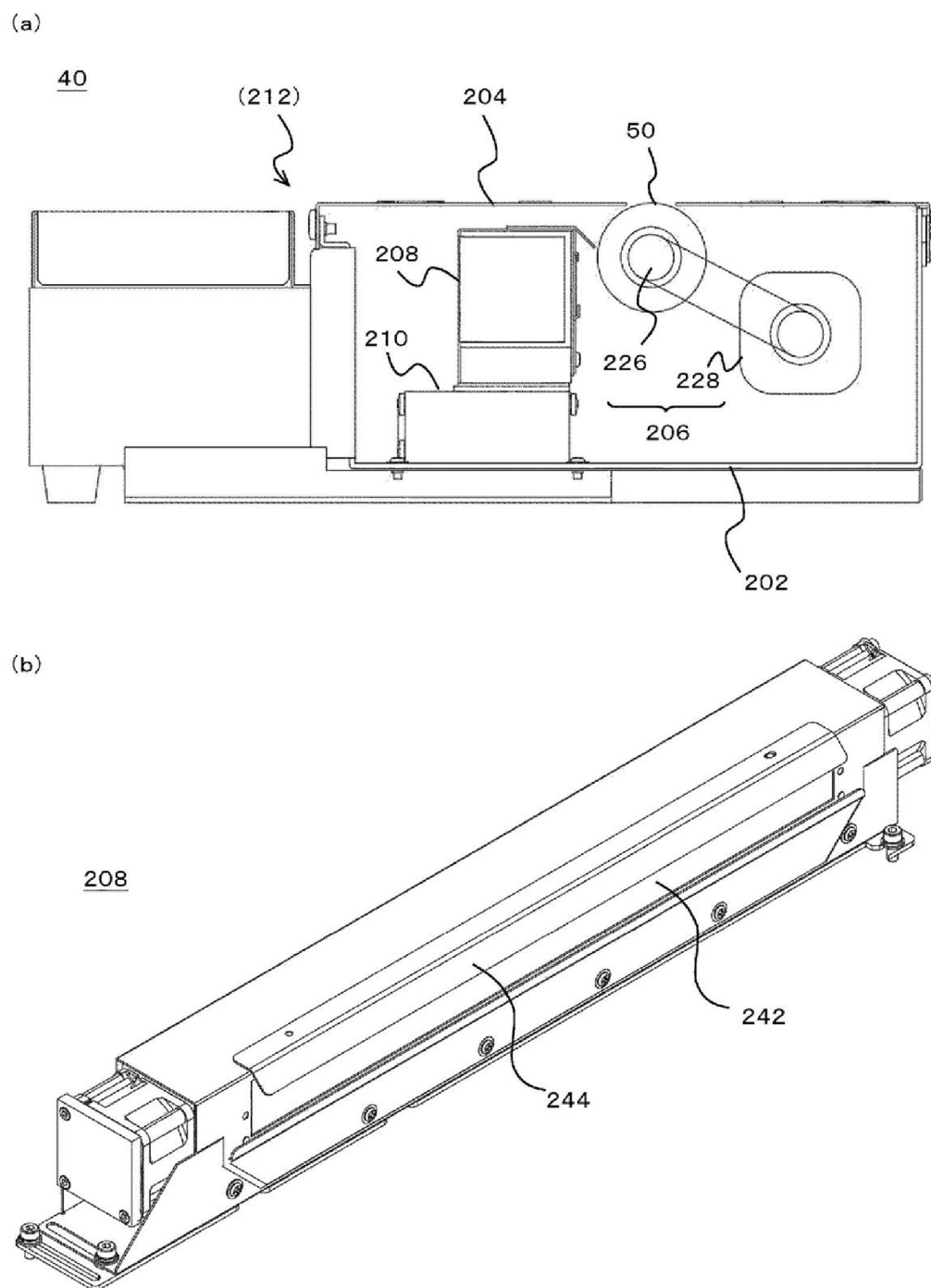


FIG. 3

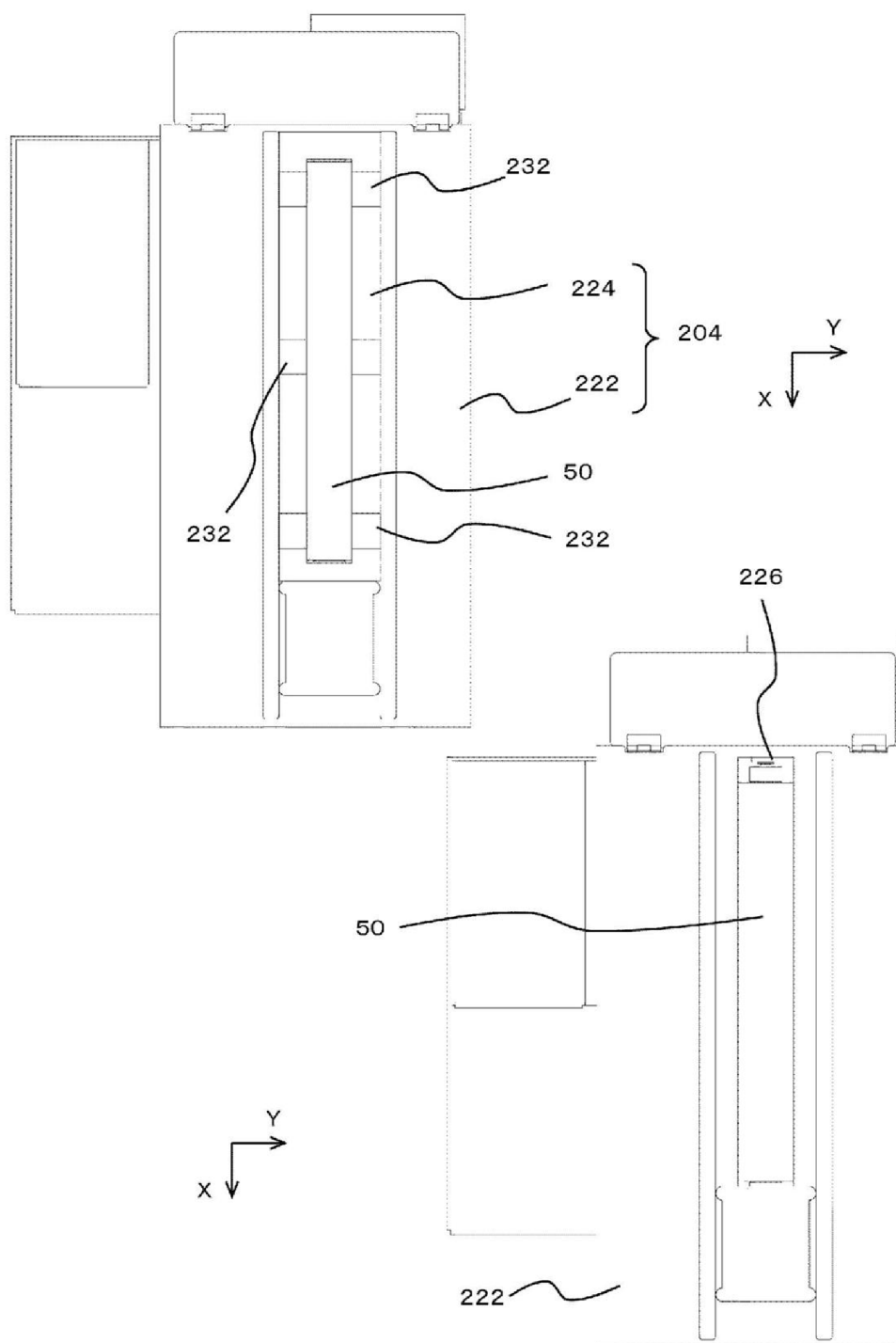


FIG. 4

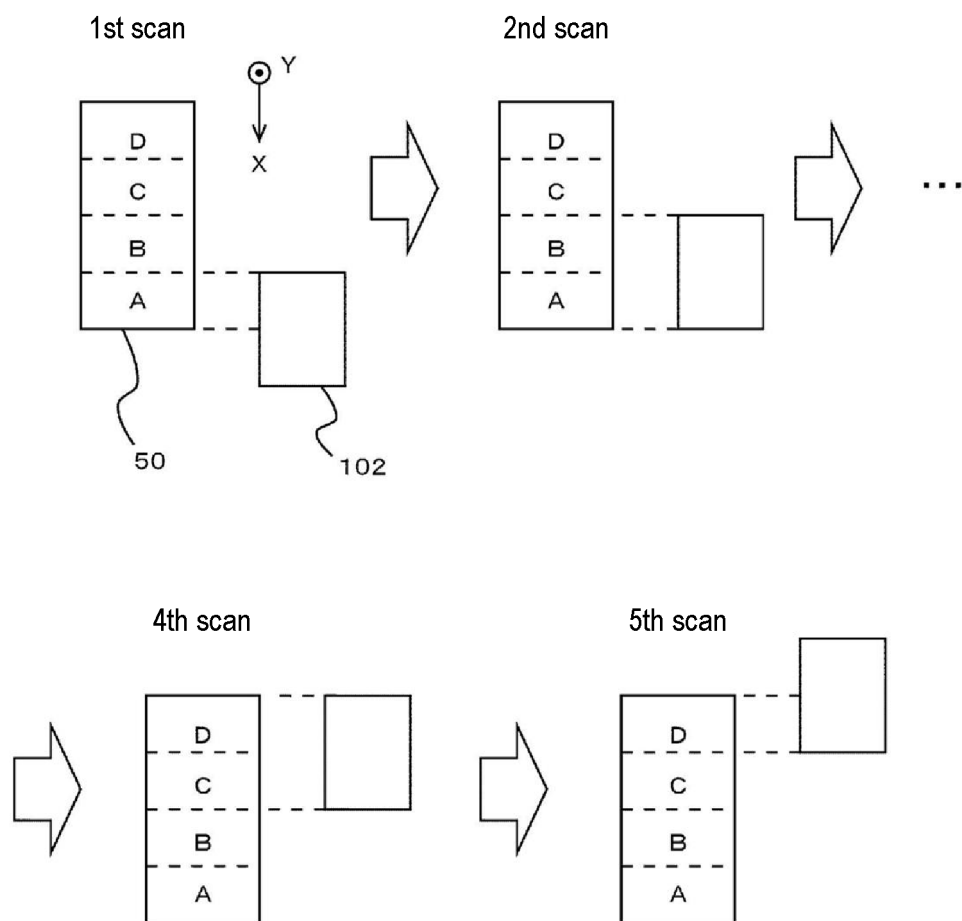


FIG. 5

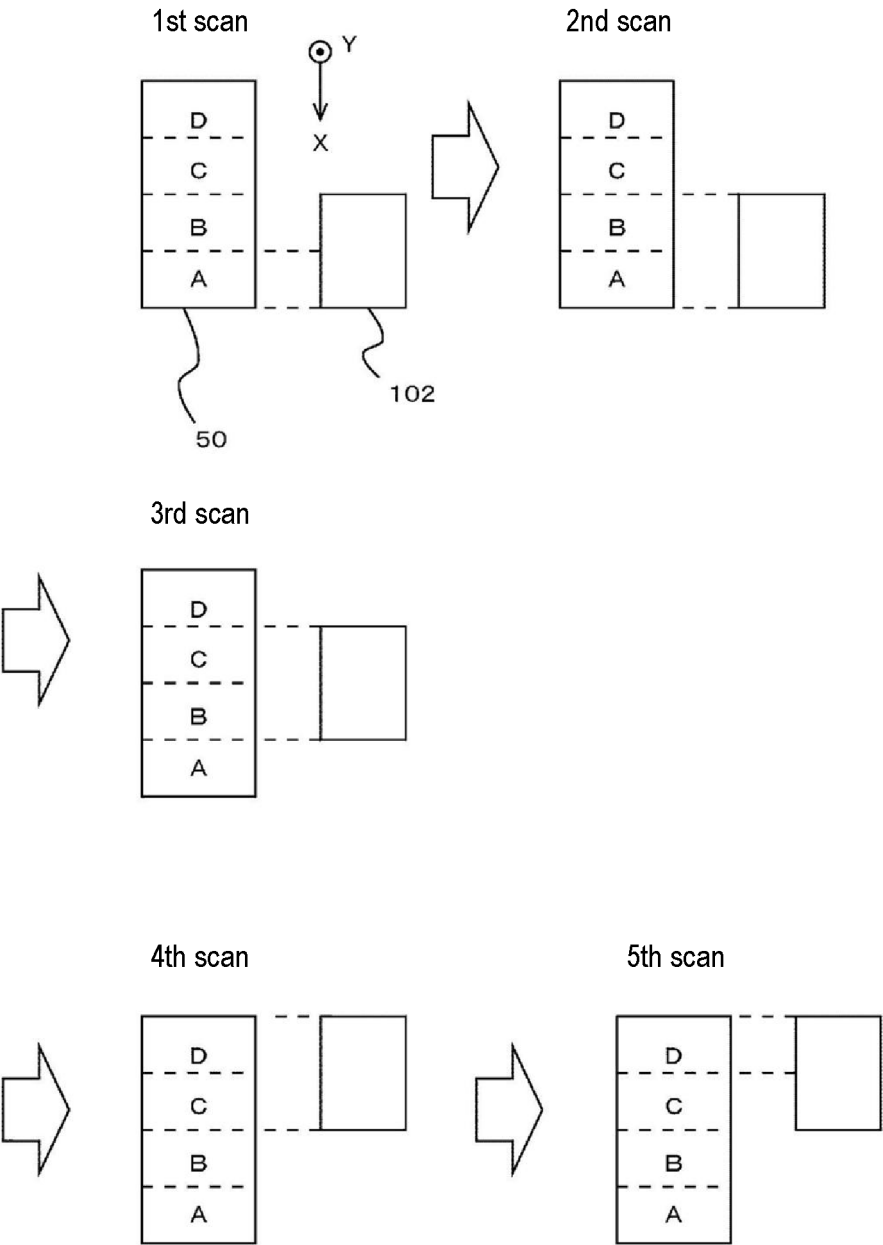
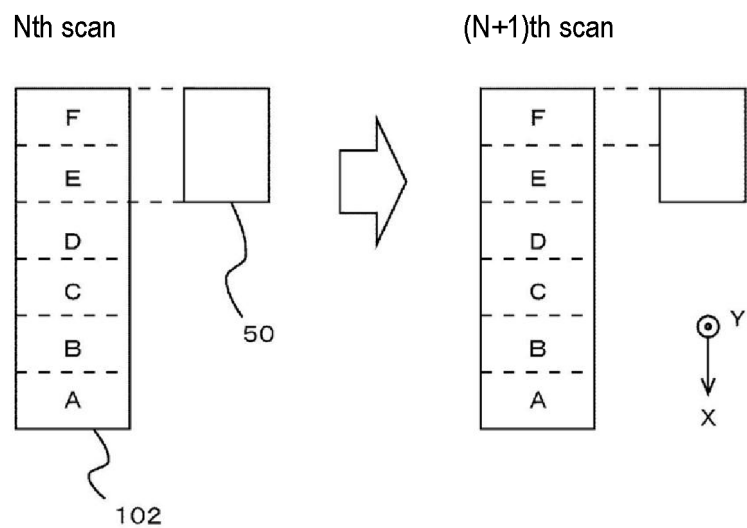


FIG. 6

(a)



(b)

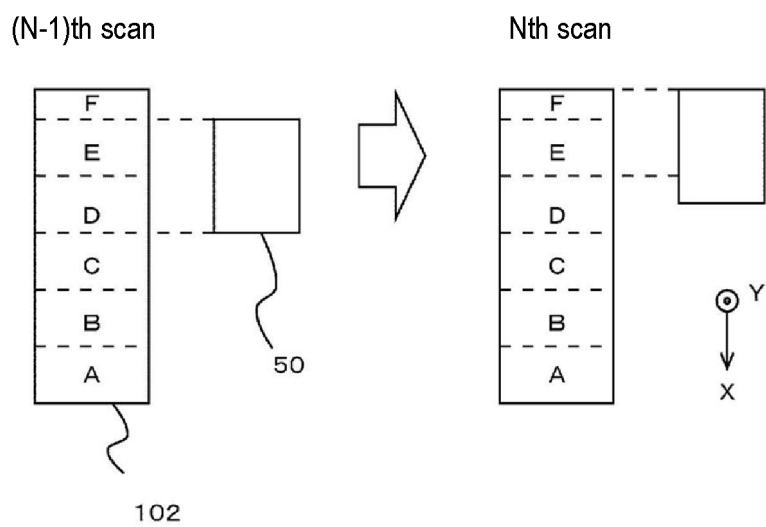


FIG. 7

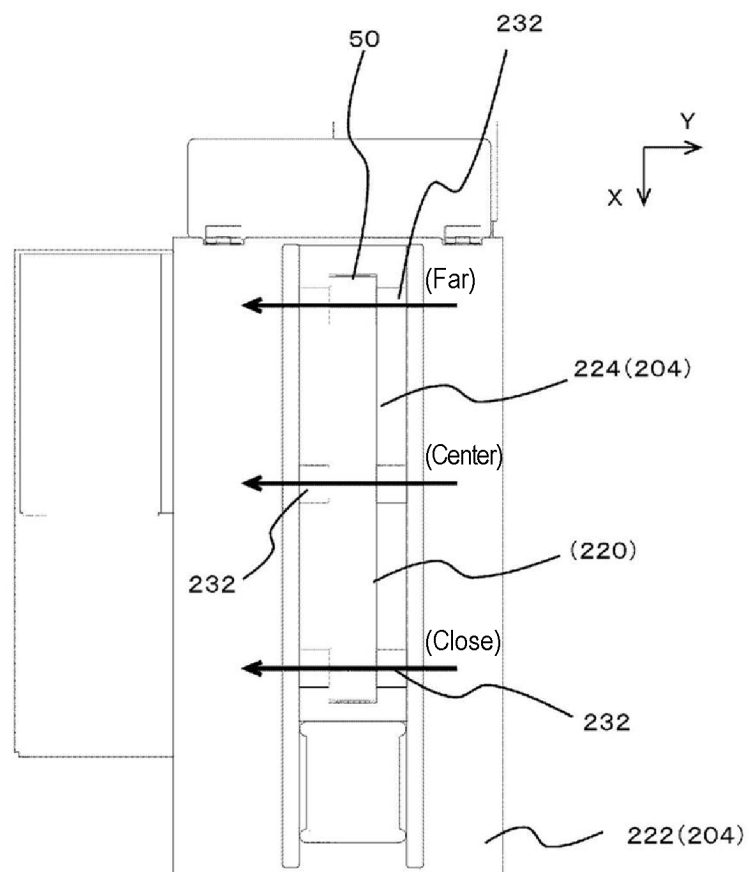


FIG. 8

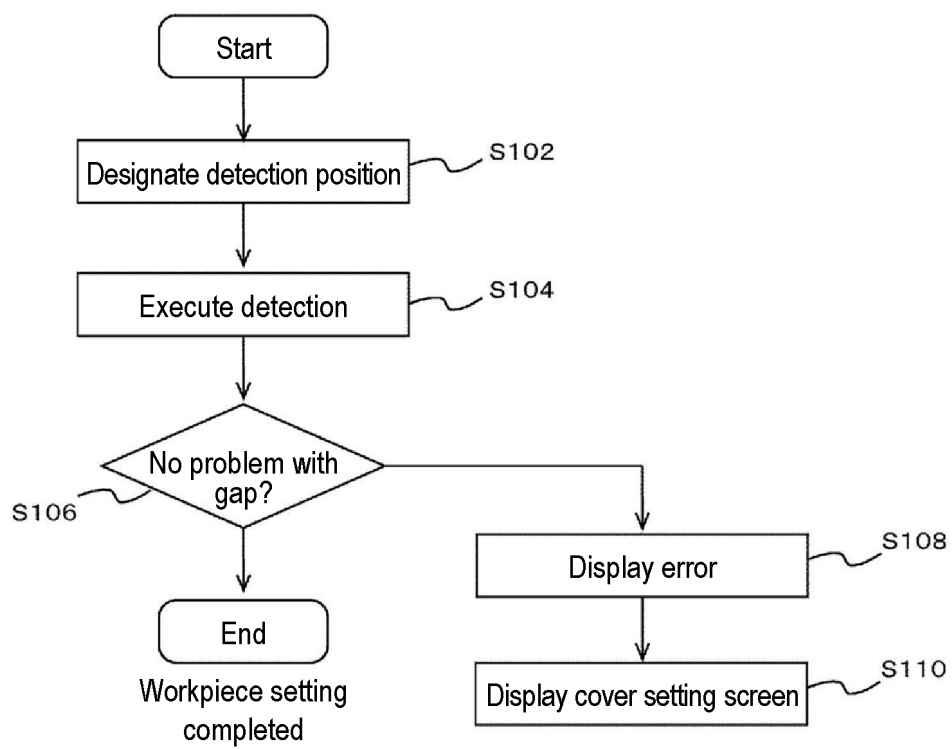


FIG. 9

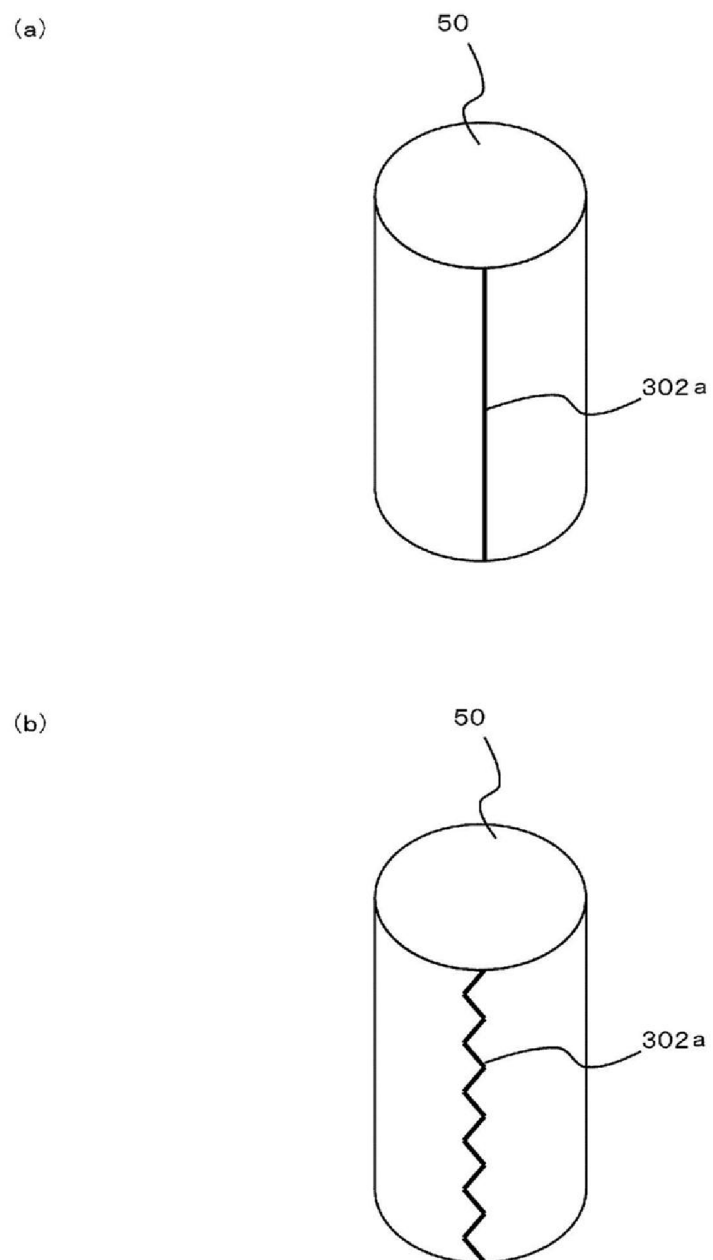


FIG. 10

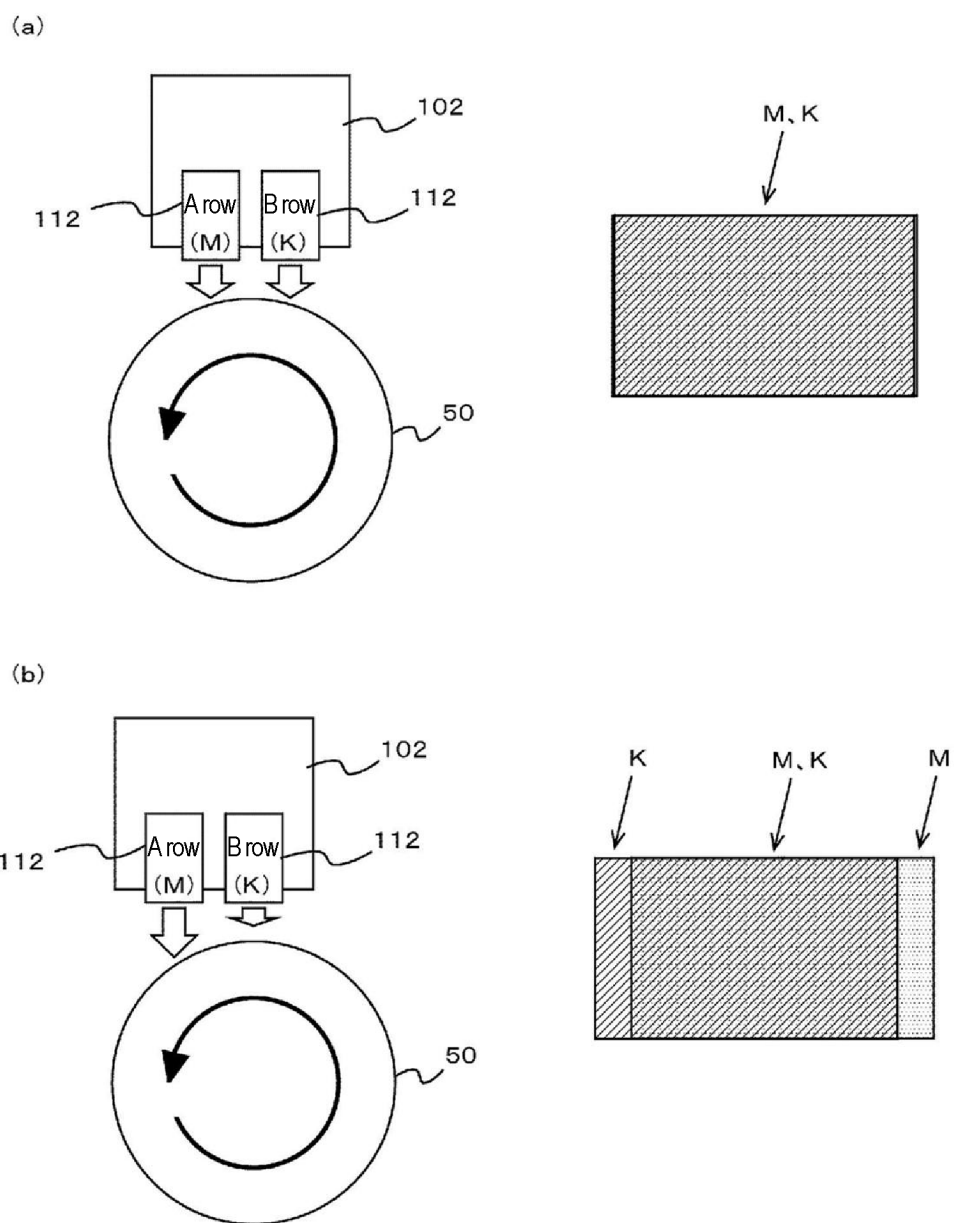
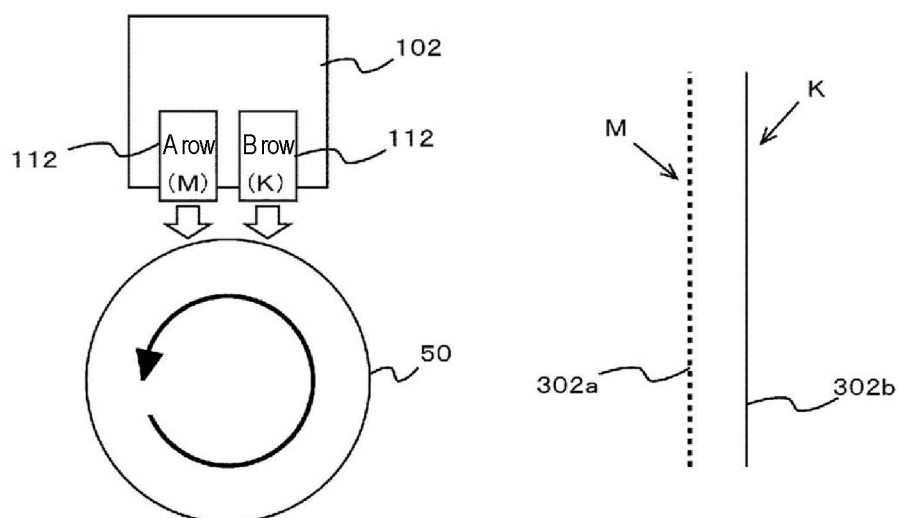


FIG. 11

(a)



(b)

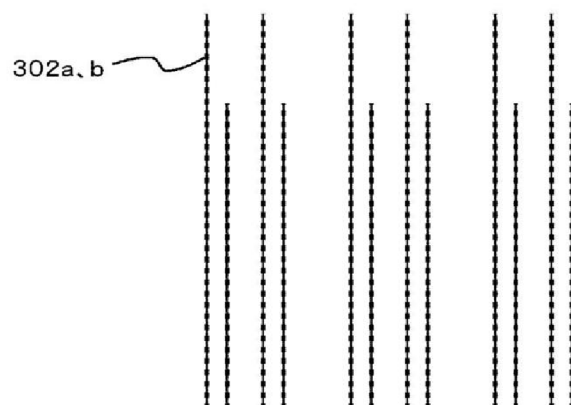


FIG. 12

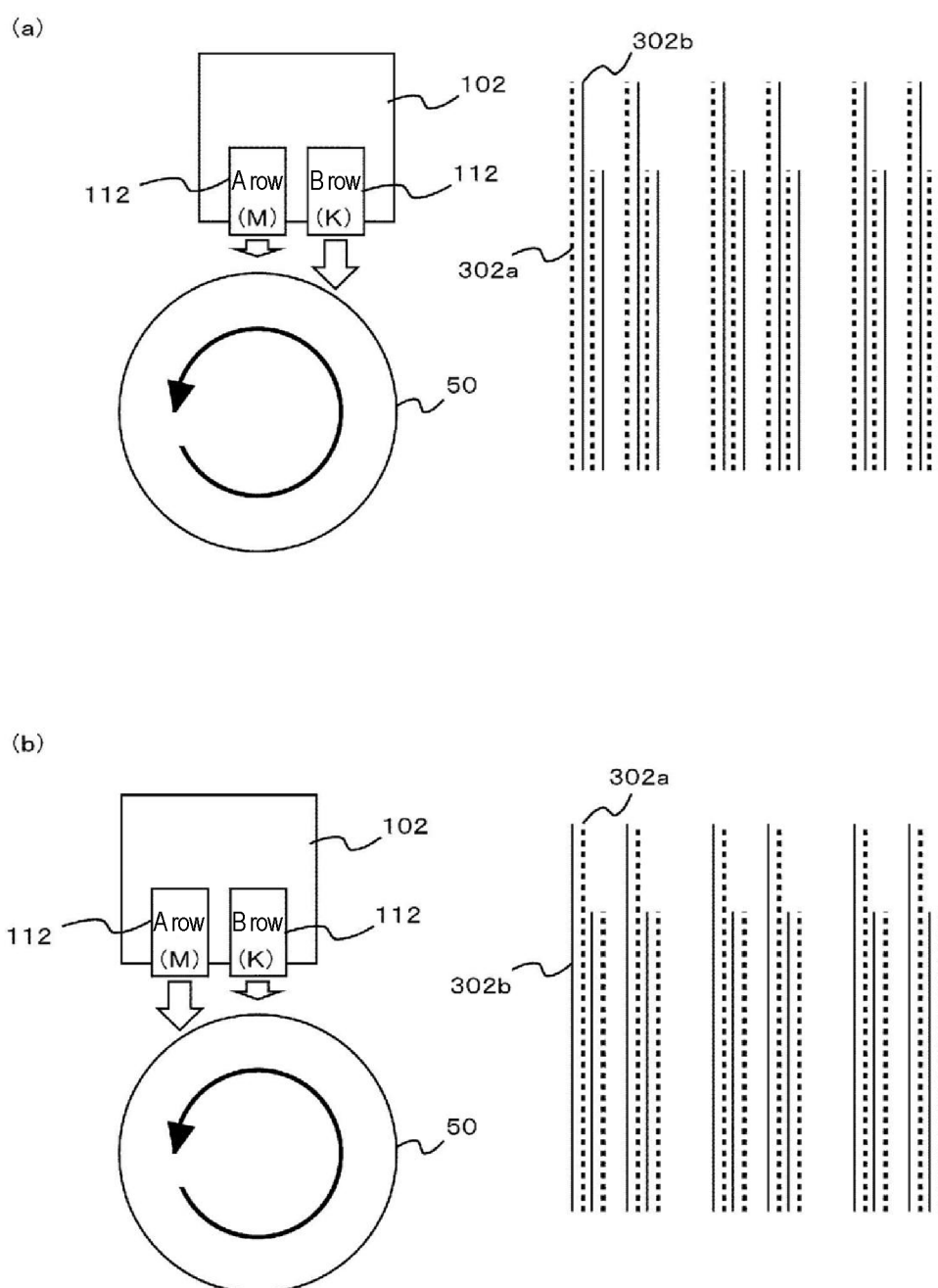


FIG. 13

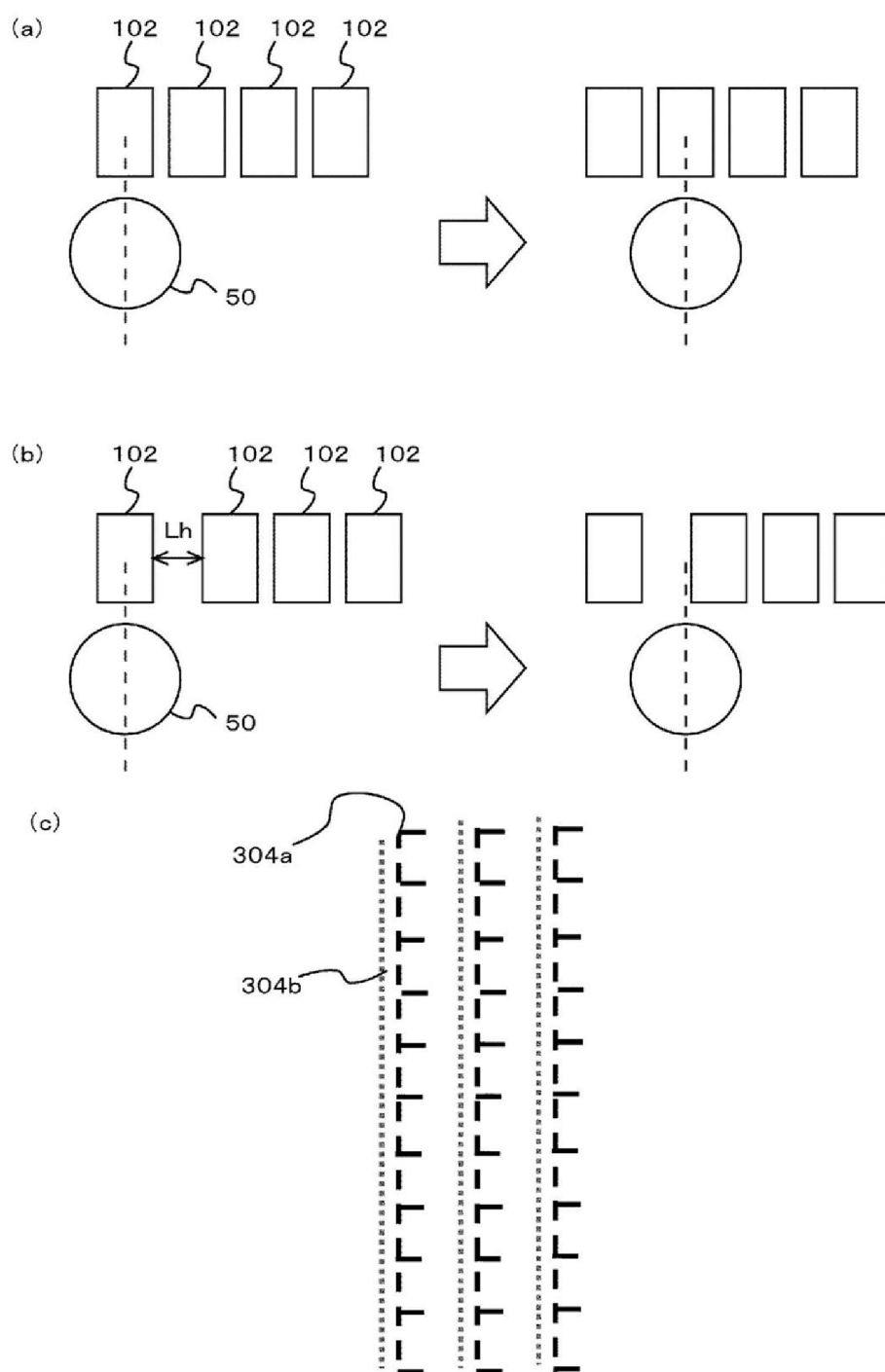


FIG. 14

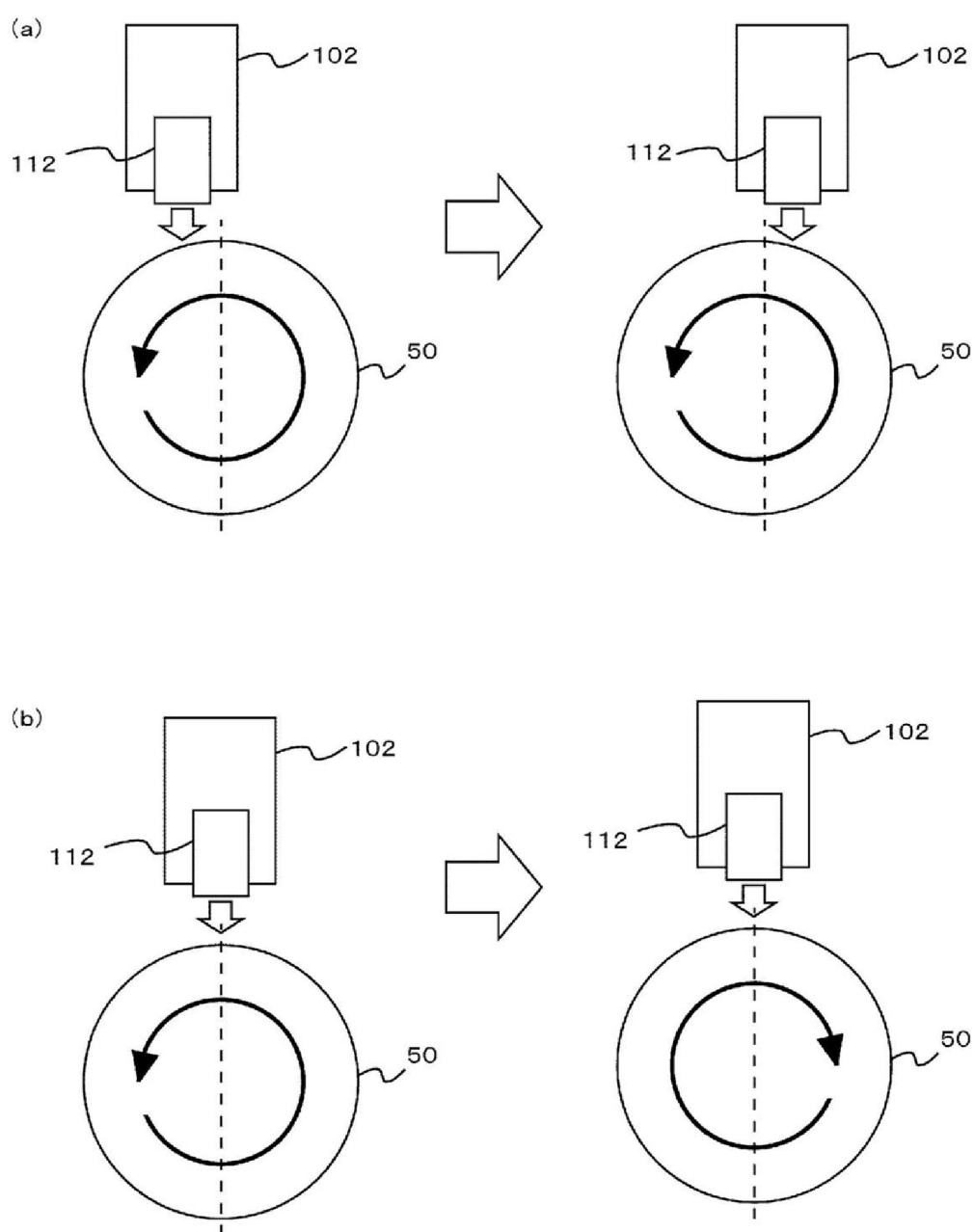


FIG. 15

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2024/030930

A. CLASSIFICATION OF SUBJECT MATTER

B41J 2/01(2006.01)i

FI: B41J2/01 203; B41J2/01 127; B41J2/01 451; B41J2/01 213; B41J2/01 303; B41J2/01 109; B41J2/01 209; B41J2/01 307; B41J2/01 305

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)

B41J2/01

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2024

Registered utility model specifications of Japan 1996-2024

Published registered utility model applications of Japan 1994-2024

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 2023-88834 A (MIMAKI ENG CO., LTD.) 27 June 2023 (2023-06-27) paragraphs [0033]-[0179]	15-23
Y	JP 2005-1278 A (FUJI XEROX CO., LTD.) 06 January 2005 (2005-01-06) paragraphs [0023]-[0053]	15-23
A	JP 2019-18582 A (BROTHER KOGYO KABUSHIKI KAISHA) 07 February 2019 (2019-02-07) entire text	1-23
A	JP 2017-222111 A (CANON KABUSHIKI KAISHA) 21 December 2017 (2017-12-21) entire text	1-23
A	JP 2000-1015 A (CANON KABUSHIKI KAISHA) 07 January 2000 (2000-01-07) entire text	1-23



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"D" document cited by the applicant in the international application

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2024/030930

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