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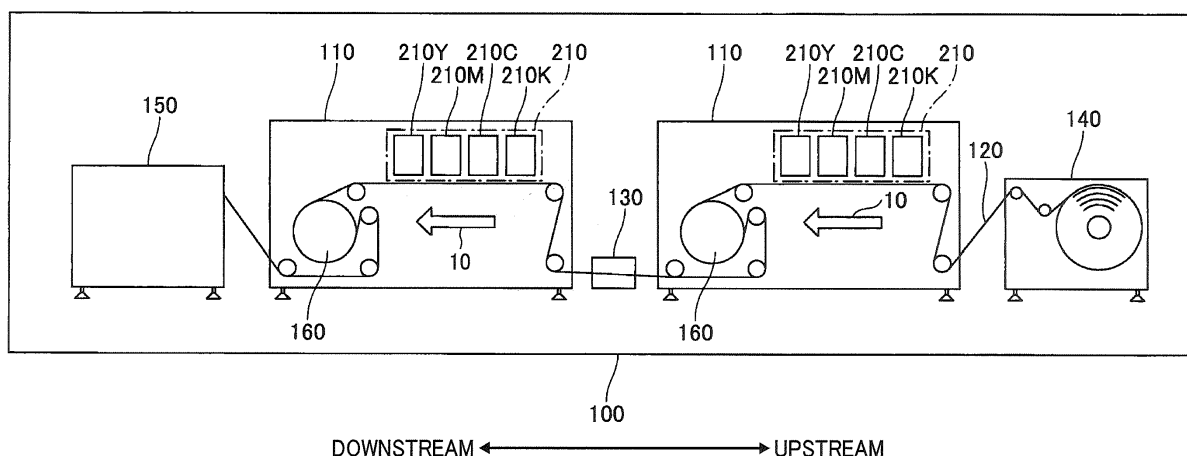
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(54) **APPARATUS TO PERFORM OPERATION ON CONVEYED OBJECT**

(57) An apparatus (110) includes a head (210) to perform an operation on a conveyed object; a plurality of sensors (SEN) to detect surface data of the conveyed object, a moving device (MEC) to move the plurality of sensors (SEN) in an orthogonal direction orthogonal to a conveyance direction in which the conveyed object is conveyed, a first support (CR1) and a second support (CR2) to support the conveyed object. The first and second supports are respectively disposed upstream and

downstream, in the conveyance direction, from an operation position at which the head (210) performs the operation on the conveyed object. At least one of the plurality of sensors (SEN) is disposed between the first support (CR1) and the second support (CR2) in the conveyance direction. The plurality of sensors (SEN) is mounted on a sensor holder (HLD) as a single unit to be moved by the moving device (MEC).

FIG. 1



Description

Technical Field

5 **[0001]** Embodiments of the present disclosure relate to an apparatus to perform an operation on a conveyed object and a liquid discharge apparatus.

Description of the Related Art

10 **[0002]** There are various types of operation using a head. For example, there are image forming methods that include discharging ink from a print head (so-called inkjet methods). In an apparatus including a head to perform an operation on an object being conveyed (i.e., a conveyed object), if the timing of the operation is not proper or the position of the conveyed object deviates from a reference position, the outcome of the operation may include a deviation or misalignment.

15 **[0003]** To improve the quality of the operation performed by the head, there are methods for detecting the amount of displacement of the conveyed object. For example, JP-2015-013476-A proposes detecting fluctuations in position of a recording medium (e.g., a web) conveyed through a print system for printing on continuous sheets. Specifically, a sensor detects fluctuations in position of the recording medium in a width direction of the recording medium orthogonal to the direction in which the recording medium is conveyed (hereinafter "conveyance direction").

20 **[0004]** To further improve the accuracy of the operation, it is preferred to accurately detect the position of the conveyed object in conveyance direction or the direction orthogonal to the conveyance direction. In conventional methods, in some cases, the accuracy is not sufficient in detecting the position of the conveyed object in the conveyance direction or the orthogonal direction.

25 **[0005]** In view of the foregoing, an object of this disclosure is to improve the accuracy in detecting the position or the like of the conveyed object in either the conveyance direction in which the conveyed object is conveyed or the direction orthogonal thereto.

SUMMARY

30 **[0006]** In order to achieve the above-described object, there is provided an apparatus to perform an operation on a conveyed object as described in appended claims.

35 **[0007]** Advantageously, the apparatus includes a head to perform the operation on the conveyed object, a plurality of sensors to detect surface data of the conveyed object, a moving device to move the plurality of sensors in an orthogonal direction orthogonal to a conveyance direction in which the conveyed object is conveyed, a first support and a second support to support the conveyed object. The first support and the second support are disposed, respectively, upstream and downstream from an operation position at which the head performs the operation on the conveyed object in the conveyance direction. At least one of the plurality of sensors is disposed between the first support and the second support in the conveyance direction. The plurality of sensors is mounted on a sensor holder as a single unit to be moved by the moving device.

40 **[0008]** Advantageously, the apparatus is a liquid discharge apparatus including a liquid discharge head to discharge liquid onto the conveyed object.

[0009] Accordingly, the accuracy in detecting the position or the like of the conveyed object in either the conveyance direction or the direction orthogonal thereto is improved.

BRIEF DESCRIPTION OF THE DRAWINGS

45 **[0010]** A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

50 FIG. 1 is a schematic view illustrating a general structure of a system including liquid discharge apparatuses according to an embodiment;

FIG. 2 is a schematic view illustrating a general structure of the liquid discharge apparatus illustrated in FIG. 1;

FIG. 3 is a schematic plan view illustrating an arrangement of sensor devices and actuators of the liquid discharge apparatus illustrated in FIG. 2;

55 FIGS. 4A and 4B are schematic views illustrating an external shape of a liquid discharge head unit according to an embodiment;

FIG. 5 is a schematic block diagram illustrating a hardware configuration to implement a conveyed object detector according to an embodiment;

FIG. 6 is an external view of the sensor device of the conveyed object detector illustrated in FIG. 5;
 FIG. 7 is a schematic block diagram of a functional configuration of the conveyed object detector illustrated in FIG. 5;
 FIGS. 8A and 8B are plan views of a recording medium fluctuating in position in a direction orthogonal to a conveyance direction thereof, while being conveyed;
 FIG. 9 is a plan view of the recording medium being conveyed and illustrates creation of an image out of color registration;
 FIG. 10 is a schematic block diagram of a control configuration of the liquid discharge apparatus illustrated in FIG. 2;
 FIG. 11 is a block diagram of a hardware configuration of a data management device illustrated in FIG. 10;
 FIG. 12 is a block diagram of a hardware configuration of an image output device illustrated in FIG. 11;
 FIG. 13 is a schematic cross-sectional view of a moving device to move the sensor devices of the liquid discharge apparatus illustrated in FIG. 2;
 FIG. 14 is a perspective view of the liquid discharge apparatus illustrated in FIG. 2, before parallel motion of the sensor devices by the moving device illustrated in FIG. 13;
 FIG. 15 is a perspective view of the liquid discharge apparatus, illustrating a state after the parallel motion ;
 FIG. 16 is a perspective view of the liquid discharge apparatus according to an embodiment, before rotational motion of the sensor devices by the moving device illustrated in FIG. 13;
 FIG. 17 is a perspective view of the liquid discharge apparatus, after the rotational motion;
 FIG. 18 is an illustration of a test pattern used by a liquid discharge apparatus according to an embodiment;
 FIG. 19 is a schematic diagram of a conveyed object detector according to Variation 1;
 FIG. 20 is a schematic diagram of a sensor device according to Variation 2;
 FIGS. 21A and 21B are schematic diagrams of a sensor device according to Variation 3;
 FIG. 22 is a schematic view of a sensor device including a plurality of imaging lenses, according to another embodiment; and
 FIG. 23 is a schematic view illustrating a general structure of a liquid discharge apparatus according to another embodiment;

[0011] The accompanying drawings are intended to depict embodiments of the present invention and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted.

DETAILED DESCRIPTION

[0012] In describing embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this patent specification is not intended to be limited to the specific terminology so selected, and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner and achieve a similar result.

[0013] Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views thereof, and particularly to FIG. 1, an image forming apparatus according to an embodiment of this disclosure is described. As used herein, the singular forms "a", "an", and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0014] The suffixes Y, M, C, and K attached to each reference numeral indicate only that components indicated thereby are used for forming yellow, magenta, cyan, and black images, respectively, and hereinafter may be omitted when color discrimination is not necessary.

[0015] An embodiment is described below, with reference to the drawings. Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views thereof, and particularly to FIG. 1, an image forming apparatus according to an embodiment of this disclosure is described.

General configuration

[0016] Descriptions are given below of an embodiment in which an apparatus including a head is a liquid discharge apparatus, the head is a liquid discharge head unit, and an operation position is a position at which the liquid discharge head unit discharges liquid onto a web (recording medium).

[0017] FIG. 1 is a schematic view of a system including a liquid discharge apparatus according to an embodiment. FIG. 1 illustrates a print system 100 including two liquid discharge apparatuses 110, which are, for example, production printers (image forming apparatuses), coupled to each other. The liquid discharge apparatuses 110 discharge recording liquid such as aqueous ink or oil-based ink. Descriptions are given below of the print system 100 including the image forming apparatuses 110 as an example of the liquid discharge apparatus according to the present embodiment.

[0018] The print system 100 conveys a recording medium such as a web 120 (hereinafter "conveyed object"). The

print system 100 includes a turn bar 130 disposed between the liquid discharge apparatuses 110 (e.g., the production printers), to turn over the web 120. The turn bar 130 enables the print system 100 to perform so-called duplex printing. The print system 100 illustrated in FIG. 1 further includes an unwinder 140 and a sheet processing apparatus 150, respectively disposed upstream and downstream from the liquid discharge apparatuses 110 in the direction of conveyance of the web 120. The unwinder 140 feeds the web 120 to the liquid discharge apparatus 110, and the sheet processing apparatus 150 reels the web 120 and performs bookbinding of the web 120.

[0019] The liquid discharge apparatus 110 further includes a drying roller 160 to inhibit transferring of ink to a conveyance roller.

[0020] Further, the print system 100 includes a cutter to cut the web 120 to change sheet type. Additionally, the web 120 is cut when the web 120 is consumed close to an end. During a print job, the web 120 extends from the unwinder 140 to the sheet processing apparatus 150. Note that a print job includes, in addition to discharging ink for image formation (i.e., printing operation), loss sheet conveyance performed before and after the printing operation. In the loss sheet conveyance, a portion of the web 120 on which printing is not performed is conveyed, resulting in loss (waste) of the web 120. Specifically, before printing, the sheet loss occurs, at least, in a section extending from the drying roller 160 of the upstream liquid discharge apparatus 110 to a print head 210 of the downstream liquid discharge apparatus 110 in the conveyance direction of the web 120 because, in this section, cockling of the web 120 due to drying affects images to be formed. After printing, sheet loss occurs, at least in a section extending from the print head 210 of the downstream liquid discharge apparatus 110 to the sheet processing apparatus 150.

[0021] In the illustrated example, the liquid discharge apparatus 110 discharges liquid onto the web 120 (a recording medium) being conveyed by a roller and the like, to form an image thereon. The web 120 is a so-called continuous sheet. That is, the web 120 is, for example, paper in the form of a roll to be reeled. The description below concerns an example in which a roller adjusts the tension of the web 120 and conveys the web 120 in the conveyance direction indicated by arrow 10 in FIG. 2 (hereinafter "conveyance direction 10"). Hereinafter, unless otherwise specified, "upstream" and "downstream" mean those in the conveyance direction 10. A direction orthogonal to the conveyance direction 10 is referred to as an orthogonal direction 20 (e.g., a width direction of the web 120). In the illustrated example, the liquid discharge apparatus 110 (e.g., the production printer) is an inkjet printer to discharge four color inks, namely, black (K), cyan (C), magenta (M), and yellow (Y) inks, to perform an operation (i.e., image formation) at a predetermined position on the web 120.

[0022] FIG. 2 is a schematic view illustrating a general structure of a liquid discharge apparatus according to an embodiment. As illustrated in FIG. 2, the liquid discharge apparatus 110 includes four liquid discharge head units 210 (210Y, 210M, 210C, and 210K) to discharge the four inks, respectively.

[0023] Each liquid discharge head unit 210 discharges the ink onto the web 120 conveyed in the conveyance direction 10. The liquid discharge apparatus 110 includes two pairs of nip rollers, a roller 230, and the like, to convey the web 120. One of the two pairs of nip rollers is a first nip roller pair NR1 disposed upstream from the liquid discharge head units 210 in the conveyance direction 10. The other is a second nip roller pair NR2 disposed downstream from the first nip roller pair NR1 and the liquid discharge head units 210 in the conveyance direction 10. Each nip roller pair rotates while nipping the conveyed object, such as the web 120, as illustrated in FIG. 2. The nip roller pairs and the roller 230 together convey the conveyed object (e.g., the web 120) in a predetermined direction.

[0024] The recording medium such as the web 120 is a continuous sheet. Specifically, the recording medium is preferably longer than the distance between the first nip roller pair NR1 and the second nip roller pair NR2. The recording medium is not limited to rolled sheets. For example, the recording medium can be a folded sheet (so-called fanfold paper or Z-fold paper).

[0025] In the structure illustrated in FIG. 2, the liquid discharge head units 210 are arranged, for example, in the order of black, cyan, magenta, and yellow in the conveyance direction 10. Specifically, a liquid discharge head unit 210K for black is disposed extreme upstream, and a liquid discharge head unit 210C for cyan is disposed next to and downstream from the liquid discharge head unit 210K. Further, the liquid discharge head unit 210M for magenta is disposed next to and downstream from the liquid discharge head unit 210C for cyan, and the liquid discharge head unit 210Y for yellow is disposed extreme downstream in the conveyance direction 10. The color arrangement order is not limited to the order illustrated.

[0026] Each liquid discharge head unit 210 discharges the ink to a predetermined position on the web 120, according to image data. The position at which the liquid discharge head unit 210 discharges ink (hereinafter "ink discharge position") is almost identical to the position at which the ink discharged from the liquid discharge head (e.g., 210K-1, 210K-2, 210K-3, or 210K-4 in FIG. 4A) lands on the recording medium. In other words, the ink discharge position can be directly below the liquid discharge head. In the present embodiment, black ink is discharged to the ink discharge position of the liquid discharge head unit 210K (hereinafter "black ink discharge position PK"). Similarly, cyan ink is discharged at the ink discharge position of the liquid discharge head unit 210C (hereinafter "cyan ink discharge position PC"). Magenta ink is discharged at the ink discharge position of the liquid discharge head unit 210M (hereinafter "magenta ink discharge position PM"). Yellow ink is discharged at the ink discharge position of the liquid discharge head unit 210Y (hereinafter

"yellow ink discharge position PY"). Note that, for example, a controller 520 operably connected to the liquid discharge head units 210 controls the respective timings of ink discharge of the liquid discharge head units 210 and actuators AC1, AC2, AC3, and AC4 (collectively "actuators AC") to move the liquid discharge head units 210. In one embodiment, each of the timing control and the actuator control is performed by two or more controllers (or control circuits). The actuators AC are described later.

[0027] In the description below, the ink discharge position serves as an operation position of the liquid discharge head unit 210.

[0028] In the illustrated structure, each liquid discharge head unit 210 is provided with a plurality of rollers. As illustrated in the drawings, for example, the liquid discharge apparatus 110 includes the rollers respectively disposed upstream and downstream from each liquid discharge head unit 210 in the conveyance passage of the web 120. In the illustrated example, the roller disposed upstream from the liquid discharge head unit 210 is referred to as a first roller to convey the web 120 to the ink discharge position.

[0029] Similarly, the roller disposed downstream from the liquid discharge head unit 210 is referred to as a second roller to convey the web 120 from the ink discharge position. Disposing the first roller and the second roller for each ink discharge position can suppress fluttering of the recording medium conveyed. For example, the first roller and the second roller used to convey the recording medium are driven rollers. Alternatively, the first roller and the second roller can be a driving roller driven by a motor or the like.

[0030] Note that, instead of the first and second rollers that are rotators such as driven rollers, first and second supports to support the conveyed object can be used. For example, each of the first and second supports can be a pipe or a shaft having a round cross section. Alternatively, each of the first and second supports can be a curved plate having an arc-shaped face to contact the conveyed object. In the description below, the first and second supporters are rollers.

[0031] Specifically, a first roller CR1Y, disposed upstream from the liquid discharge head unit 210K, conveys the web 120 to the yellow ink discharge position PY so that the yellow ink is applied to a specific portion of the web 120. A second roller CR2Y conveys the web 120 from the yellow ink discharge position PY to the downstream side. Similarly, a first roller CR1M and a second roller CR2M are disposed upstream and downstream from the liquid discharge head unit 210M, respectively. Similarly, a first roller CR1C and a second roller CR2C are disposed upstream and downstream from the liquid discharge head unit 210C for cyan, respectively. Similarly, a first roller CR1K and a second roller CR2K are disposed upstream and downstream from the liquid discharge head unit 210K, respectively.

[0032] In FIG. 2, each liquid discharge head unit 210 is provided with one of first, second, third, fourth, and fifth sensor devices SEN1, SEN2, SEN3, SEN4, and SEN5 (collectively "sensor devices SEN"). For example, the sensor device SEN includes a sensor employing air pressure, photoelectric, or ultrasonic; or an optical sensor employing visible light, laser light, infrared, or the like. For example, the optical sensor is a charge-coupled device (CCD) camera or a complementary metal oxide semiconductor (CMOS) camera. That is, the sensor device SEN includes a sensor to detect surface data of the conveyed object. The liquid discharge apparatus 110 detects, with the sensor device SEN, the surface of the conveyed object during image formation and detects at least one of the relative position, speed of movement, and the amount of movement of the conveyed object based on a plurality of detection results.

[0033] As illustrated in FIG. 2, the first, second, third, fourth, and fifth sensor devices SEN1, SEN2, SEN3, SEN4, and SEN5 are mounted on a base such as a metal plate, to be moved together by a moving device MEC. The moving device MEC is described in detail later.

[0034] Further, the term "location of sensor" means the position where the sensor device SEN performs detection. Accordingly, it is not necessary that all components relating to the detection are disposed at the "location of sensor". In one embodiment, some of the components are coupled to the sensor via a cable and disposed away therefrom. In the description below, the sensor devices SEN1, SEN2, SEN3, SEN4, and SEN5 may be simply referred to as "sensors".

[0035] As illustrated, the location of sensor is preferably close to the first roller CR1. That is, the distance between the ink discharge position and the location of sensor is preferably short. When the distance between the ink discharge position and the sensor device SEN is short, detection error can be suppressed. Accordingly, the liquid discharge apparatus 110 can accurately detect, with the sensor, the position of the recording medium in at least one of the conveyance direction 10 and the orthogonal direction 20.

[0036] Specifically, the sensor device SEN is disposed between the first roller CR1 and the second roller CR2. In the structure illustrated in FIG. 2, the sensor device SEN2 performs detection in an inter-roller range INT between the first and second rollers CR1K and CR2K between which the liquid discharge head unit 210K for black is interposed in the conveyance direction 10.

[0037] Similarly, the sensor device SEN3 performs detection in an inter-roller range INT between the first and second rollers CR1C and CR2C between which the liquid discharge head unit 210C for cyan is interposed in the conveyance direction 10.

[0038] Similarly, the sensor device SEN4 performs detection in an inter-roller range INT between the first and second rollers CR1M and CR2M between which the liquid discharge head unit 210M for magenta is interposed in the conveyance direction 10.

[0039] Similarly, the sensor device SEN5 performs detection in an inter-roller range INT between the first and second rollers CR1Y and CR2Y between which the liquid discharge head unit 210Y for yellow is interposed in the conveyance direction 10. The sensor device SEN disposed between the first and second rollers CR1 and CR2 can detect the recording medium at a position close to the ink discharge position. The conveyance speed of the conveyed object in the conveyance direction 10 or the orthogonal direction 20 is relatively stable in a portion between the rollers. Accordingly, the liquid discharge apparatus 110 can accurately detect the amount or speed of movement of the recording medium in at least one of the conveyance direction 10 and the orthogonal direction 20.

[0040] More preferably, in the inter-roller ranges INT, each of the second, third, fourth, and fifth sensor devices SEN2, SEN3, SEN4, and SEN5 is disposed between the ink discharge position and the first roller CR1 (closer to the first roller CR1 than the ink discharge position). In other words, the sensor device SEN is preferably disposed upstream from the ink discharge position in the conveyance direction 10.

[0041] Specifically, the second sensor device SEN2 is preferably disposed in a range extending from the black ink discharge position PK upstream to the first roller CR1K for black in the conveyance direction 10 (hereinafter "upstream inter-roller range").

[0042] Similarly, the third sensor device SEN3 is preferably disposed in a range extending from the cyan ink discharge position PC upstream to the first roller CR1C for cyan (hereinafter "upstream inter-roller range").

[0043] Further, the fourth sensor device SEN4 is preferably disposed in a range extending from the magenta ink discharge position PM upstream to the first roller CR1M for magenta (hereinafter "upstream inter-roller range").

[0044] Further, the fifth sensor device SEN5 is preferably disposed in a range extending from the yellow ink discharge position PY upstream to the first roller CR1Y for yellow (hereinafter "upstream inter-roller range").

[0045] When the sensor devices SEN are respectively disposed in the upstream inter-roller ranges, the liquid discharge apparatus 110 can detect the recording medium (conveyed object) with a high accuracy. When the sensor devices SEN are thus disposed upstream from the respective ink discharge positions in the conveyance direction 10, initially, on the upstream side of the ink discharge position, the liquid discharge apparatus 110 can accurately detect the position of the conveyed object in the conveyance direction 10, the orthogonal direction 20, or both. Then, the liquid discharge apparatus 110 can calculate at least one of the ink discharge timing and the amount by which the liquid discharge head unit 210 is to be moved. In other words, in a period from when the position of a given portion of the web 120 (conveyed object) is detected on the upstream side of the ink discharge position to when the detected portion of the web 120 reaches the ink discharge position, the operation timing is calculated or the liquid discharge head unit is moved. Therefore, the liquid discharge apparatus 110 can change the ink discharge position with high accuracy.

[0046] Note that, assuming that the sensor device SEN is disposed directly below the liquid discharge head unit 210, in some cases, a delay of control action renders an image out of color registration. Accordingly, when the location of sensor is upstream from the ink discharge position, misalignment in color superimposition is suppressed, improving image quality. There are cases where layout constraints hinder disposing the sensor close to the ink discharge position. Accordingly, the location of sensor is preferably closer to the first roller CR1 than the ink discharge position, that is, upstream from the ink discharge position.

[0047] The sensor can be disposed directly below the liquid discharge head unit 210. In the example described below, the sensor is disposed directly below the liquid discharge head unit 210. The sensor disposed directly below the head unit can accurately detect the amount of movement of the recording medium directly below the head unit. Therefore, in a configuration in which the speed of control action is relatively fast, the sensor is preferably disposed closer to the position directly below the liquid discharge head unit 210. However, the location of sensor is not limited to a position directly below the liquid discharge head unit 210, and similar calculation is feasible when the sensor is disposed otherwise.

[0048] Alternatively, in a configuration in which error is tolerable, the sensor can be disposed directly below the liquid discharge head unit 210, or between the first and second rollers and downstream from the position directly below the liquid discharge head unit 210.

[0049] Further, as illustrated in FIG. 2, the liquid discharge apparatus 110 preferably includes one or more sensor devices SEN (e.g., SEN1) disposed upstream from the sensor device SEN (e.g., SEN2) corresponding to the liquid discharge head unit 210 (e.g., 210K). Specifically, the liquid discharge apparatus 110 preferably includes the first sensor device SEN1, in addition to the second, third, fourth, and fifth sensor devices SEN2, SEN3, SEN4, and SEN5 respectively corresponding to the liquid discharge head units 210K, 210C, 210M, and 210Y. Aspects of this disclosure are further described using the structure including the first sensor device SEN1.

[0050] Although the structure illustrated in FIG. 2 supports the web 120 in a flat shape, the structure to support the web 120 is not limited thereto. For example, the head units and the rollers can be arranged so that the web 120 supported thereby has a curvature. When the web 120 has a curvature, the web 120 is kept taut.

[0051] FIG. 3 is a schematic plan view illustrating an arrangement of the sensor devices SEN and the actuators AC of the liquid discharge apparatus illustrated in FIG. 3. Referring to FIG. 2, when viewed in the direction vertical to the recording surface of the web 120, for example, the sensor device SEN is preferably disposed at a position close to an end of the web 120 in the width direction of the web 120 and overlapping with the web 120. The sensor devices SEN1,

SN2, SN3, SN4, and SN5 are disposed at positions PS1, PS2, PS3, PS4, and PS5 in FIG. 2, respectively. In the configuration illustrated in FIGS. 2 and 3, the controller 520 controls the actuators AC1, AC2, AC3, and AC4 to move the liquid discharge head units 210Y, 210M, 210C, and 210K, respectively, in the orthogonal direction 20 orthogonal to the direction of conveyance of the web 120.

[0052] In the configuration illustrated in FIG. 2, the sensor devices SEN are disposed facing a back side (lower side in FIG. 2) of the web 120 opposite the liquid discharge head units 210. To the actuators AC1, AC2, AC3, and AC4, actuator controllers CTL1, CTL2, CTL3, and CTL4 are connected to control the actuators AC1, AC2, AC3, and AC4, respectively.

[0053] The actuator AC is, for example, a linear actuator or a motor. The actuator AC can include a control circuit, a power circuit, and a mechanical component.

[0054] For example, the actuator controller CTL1, CTL2, CTL3, and CTL4 (hereinafter collectively "actuator controllers CTL") include driver circuits.

[0055] An example outer shape of the liquid discharge head unit 210 is described below with reference to FIGS. 4A and 4B. FIG. 4A is a schematic plan view of one of the four liquid discharge head units 210Y, 210M, 210C, and 210K of the liquid discharge apparatus 110.

[0056] As illustrated in FIG. 4A, the liquid discharge head unit 210 according to the present embodiment is a line-type head unit. That is, the liquid discharge apparatus 110 includes the four liquid discharge head units 210K, 210C, 210M, and 210Y arranged in the order of black, cyan, magenta, and yellow in the conveyance direction 10 of the recording medium.

[0057] The liquid discharge head unit 210K includes four heads 210K-1, 210K-2, 210K-3, and 210K-4 arranged in a staggered manner in the orthogonal direction 20. The heads 210K-1, 210K-2, 210K-3, and 210K-4 have a shape illustrated in FIG. 4B. With this arrangement, the liquid discharge apparatus 110 can form an image throughout the image formation area of the web 120 in the width direction (orthogonal to the conveyance direction 10). The liquid discharge head units 210C, 210M, and 210Y are similar in structure to the liquid discharge head unit 210K, and the descriptions thereof are omitted to avoid redundancy.

[0058] Although the description above concerns a liquid discharge head unit including four heads, a liquid discharge head unit including a single head can be used.

Conveyed object detector

[0059] FIG. 5 is a schematic block diagram illustrating a hardware configuration to implement a conveyed object detector 600 of the liquid discharge apparatus 110, to detect the conveyed object. For example, the conveyed object detector 600 is implemented by hardware such as the sensor device SEN, a control circuit 152, a memory device 53, and the controller 520.

[0060] The sensor device SEN is described below.

[0061] FIG. 6 is an external view of the sensor device SEN according to the present embodiment. The sensor device SEN is configured to capture a pattern, which appears on the conveyed object (i.e., a target in FIG. 6) such as the web 120 when the conveyed object is irradiated with light from a light source. Specifically, the sensor device SEN includes the light source such as a semiconductor laser light source (e.g., a laser diode or LD) and an optical system such as a collimate optical system 510. To obtain image data of the pattern, the sensor device SEN illustrated in FIG. 6 further includes an optical sensor OS, such as a CMOS image sensor, and a telecentric optical system 512 for condensation of light and imaging of the pattern on the CMOS image sensor. The pattern is an example of surface data.

[0062] In the structure illustrated in FIG. 6, the CMOS image sensor performs imaging of a range including the pattern to obtain the image data. Then, the controller 520 performs correlation operation using the image data generated by one CMOS image sensor and the image generated by the CMOS image sensor of another sensor device SEN. Based on a displacement of a correlation peak position obtained through the correlation operation, the controller 520 calculates the amount of movement of the conveyed object (e.g., the recording medium) from one CMOS image sensor to the other CMOS image sensor. Note that the CMOS image sensor of the sensor device SEN can obtain image data of the pattern multiple times, for example, at each of a time TM1 and a time TM2. Based on the image data obtained at the time TM1 and the image data obtained at the time TM2, the controller 520 performs cross-correlation operation to calculate, for example, the amount by which the conveyed object has moved from the time TM1 to the time TM2. In the illustrated example, the sensor device SEN has a width W of 15 mm, a depth D of 60 mm, and a height H of 32 mm (15×60×32). The correlation operation is described in detail later.

[0063] The CMOS image sensor is an example hardware structure to implement an imaging unit 16 (16A or 16B) illustrated in FIG. 7. Although the controller 520 performs the correlation operation in the description above, alternatively, a circuit, such as a field-programmable gate array (FPGA) circuit, mounted on one of the sensor devices SEN can perform the correlation operation.

[0064] Referring back to FIG. 5, the control circuit 152 controls the sensor device SEN. Specifically, the control circuit

152 outputs trigger signals to the optical sensor OS to control the shutter timing of the optical sensor OS. The control circuit 152 controls the optical sensor OS to acquire the two-dimensional image data therefrom. Then, the control circuit 152 transmits the two-dimensional image data generated by the optical sensor OS to the memory device 53.

[0065] The memory device 53 is a so-called memory. The memory device 53 preferably has a capability to divide the two-dimensional image data transmitted from the control circuit 152 and store the divided image data in different memory ranges.

[0066] For example, the controller 520 is a microcomputer. The controller 520 performs operations using the image data stored in the memory device 53, to implement a variety of processing.

[0067] The control circuit 152 and the controller 520 are, for example, central processing units (CPUs) or electronic circuits. Note that a single device can double as the control circuit 152 and the controller 520. For example, the control circuit 152 and the controller 520 can be implemented by a single CPU. For example, the control circuit 152 and the controller 520 can be implemented by a single FPGA circuit.

[0068] FIG. 7 is a schematic block diagram of a functional configuration using the conveyed object detector 600. Descriptions below are based on a combination of detecting units 52A and 52B for the liquid discharge head units 210K and 210C as illustrated in FIG. 7, of the detecting units 52 provided for the liquid discharge head units 210, respectively. In the illustrated example, the detecting unit 52A is the detecting function of the second sensor device SEN2 disposed in the inter-roller range INT for the black liquid discharge head unit 210K, and the detecting unit 52B is the detecting function of the sensor device SEN3 disposed in the inter-roller range INT for the cyan liquid discharge head unit 210C. The detecting units 52A and 52B output detection results concerning positions A and B, respectively. The detecting units 52A and 52B are collectively referred to as "detecting units 52". The detecting unit 52A includes, for example, the imaging unit 16A, an imaging controller 14A, and an image memory 15A. In this example, the detecting unit 52B is similar in configuration to the detecting unit 52A and includes the imaging unit 16B, an imaging controller 14B, and an image memory 15B. The detecting unit 52A is described below.

[0069] The imaging unit 16A performs imaging of the web 120 conveyed in the conveyance direction 10. The imaging unit 16A is implemented by, for example, the optical sensor OS (illustrated in FIG. 5).

[0070] The imaging controller 14A includes a shutter controller 141A and an image acquisition unit 142A. The imaging controller 14A is implemented by, for example, the control circuit 152 (illustrated in FIG. 5).

[0071] The image acquisition unit 142A acquires the image data generated by the imaging unit 16A.

[0072] The shutter controller 141A controls the timing of imaging by the imaging unit 16A.

[0073] The image memory 15A stores the image data acquired by the imaging controller 14A. The image memory 15A is implemented by, for example, the memory device 53 (illustrated in FIG. 5).

[0074] A calculator 53F calculates, based on the image data recorded in the image memories 15A and 15B, the position of the pattern on the web 120, the speed at which the web 120 moves (hereinafter "moving speed"), and the amount of movement of the web 120. Additionally, the calculator 53F outputs, to the shutter controllers 141A and 141B, data on time difference Δt indicating the timing of shooting (shutter timing). In other words, the calculator 53F instructs the shutter controllers 141A and 141B of shutter timings so that the image data at the position A and the image data at the position B are obtained with the time difference Δt . The calculator 53F can also control the motor and the like to convey the web 120 at the calculated moving speed. The calculator 53F is implemented by, for example, the microcomputer of the controller 520 (illustrated in FIG. 2).

[0075] The web 120 has diffusiveness on a surface or in an interior thereof. Accordingly, when the web 120 is irradiated with light (e.g., laser beam), the reflected light is diffused. The diffuse reflection creates a pattern on the web 120. The pattern is made of spots called "speckles" (i.e., a speckle pattern). Accordingly, when an image of the web 120 is taken, image data representing a pattern such as the speckle pattern is obtained. From the image data, the position of the pattern is known, and the position of a specific portion of the web 120 can be detected. Such a pattern is generated as the light emitted to the web 120 interferes with a rugged shape, caused by a projection and a recess, on the surface or inside of the web 120. The speckle pattern is an example of surface data.

[0076] As the web 120 is conveyed, the pattern of the web 120 is conveyed as well. When an identical pattern is detected at different time points, the amount of movement in the conveyance direction 10 is obtained. That is, when an identical pattern is detected at a first position and a second position downstream from the first position, the calculator 53F can calculate the amount of movement of the pattern and accordingly the amount of movement of the web 120 in the conveyance direction 10. Further, converting the calculated amount into an amount of movement per unit time, the calculator 53F can obtain the moving speed of the web 120 in the conveyance direction 10.

[0077] As illustrated in FIG. 7, the imaging unit 16A and the imaging unit 16B are disposed at a regular interval (given reference "L" in FIG. 7) from each other in the conveyance direction 10. Via the imaging units 16A and 16B, images of the web 120 are taken at the respective positions.

[0078] The shutter controllers 141A and 141B cause the imaging units 16A and 16B to perform imaging of the web 120 at a time interval of time difference Δt . Then, based on the pattern represented by the image data generated by the imaging, the calculator 53F obtains the amount of movement of the web 120. The time difference Δt can be expressed

by Formula 1 below, where V represents a conveyance speed (mm/s) of the web 120 under an ideal condition without displacement, and L represents a relative distance, which is the distance (mm) between the imaging unit 16A and the imaging unit 16B in the conveyance direction 10.

$$\Delta t = L/V \cdots \cdots \cdots \text{Formula 1}$$

[0079] In Formula 1 above, the relative distance L (mm) between the imaging unit 16A and the imaging unit 16A and is obtained preliminarily. The calculator 53F performs cross-correlation operation of image data D1(n) generated by the detecting unit 52A and image data D2(n) generated by the detecting unit 52B. Hereinafter image data generated by the cross-correlation operation is referred to as "correlated image data". For example, based on the correlated image data, the calculator 53F calculates the displacement amount $\Delta D(n)$, which is the amount of displacement from the position detected with the previous frame or by another sensor device.

[0080] For example, the cross-correlation operation is expressed by Formula 2 below.

$$D1 \star D2^* = F^{-1} [F[D1] \cdot F[D2]^*] \cdots \cdots \cdots \text{Formula 2}$$

[0081] Note that, the image data D1(n) in Formula 2, that is, the data of the image taken at the position A, is referred to as the image data D1. Similarly, the image data D2(n) in Formula 2, that is, the data of the image taken at the position B, is referred to as the image data D2. In Formula 2, "F[]" represents Fourier transform, "F⁻¹[]" represents inverse Fourier transform, "*" represents complex conjugate, and "\star" represents cross-correlation operation.

[0082] As represented in Formula 2, the correlated image data is obtained through cross-correlation operation "D1 \star D2" performed on the first image data D1 and the second image data D2. Note that, when the first image data D1 and the second image data D2 are two-dimensional image data, the correlated image data is two-dimensional image data. When the first image data D1 and the second image data D2 are one-dimensional image data, the correlated image data is one-dimensional image data.

[0083] Regarding the correlated image data, when a broad luminance distribution causes an inconvenience, phase only correlation can be used. For example, phase only correlation is expressed by Formula 3 below.

$$D1 \star D2^* = F^{-1} [P[F[D1]] \cdot P[F[D2]^*]] \cdots \cdots \cdots \text{Formula 3}$$

[0084] In Formula 3, "P[]" represents taking only phase out of complex amplitude, and the amplitude is considered to be "1".

[0085] Thus, the calculator 53F can obtain the displacement amount $\Delta D(n)$ based on the correlated image data even when the luminance distribution is relatively broad.

[0086] The correlated image data represents the correlation between the first image data D1 and the second image data D2. Specifically, as the match rate between the first image data D1 and the second image data D2 increases, a luminance causing a sharp peak (so-called correlation peak) is output at a position close to a center of the correlated image data. When the first image data D1 matches the second image data D2, the center of the correlated image data overlaps with the peak position. Based on the correlation operation, the calculator 53F outputs the displacement in position, the amount of movement, and the speed of movement between the first image data D1 and the second image data D2 obtained at the time difference Δt . For example, the conveyed object detector 600 detects the amount by which the web 120 has moved in the orthogonal direction 20 from the position of the first image data D1 to the position of the second image data D2. Alternatively, the result of correlation operation can be the speed of movement instead of the amount of movement. The calculator 53F can calculate the amount of movement of the liquid discharge head unit 210C for cyan based on the result of the correlation operation. Based on the calculation result generated by the calculator 53F, a head moving unit 57F controls the actuator AC2 illustrated in FIG. 3, thereby controlling the landing position of the liquid. The head moving unit 57F is implemented by, for example, the actuator controller CTL. Alternatively, the head moving unit 57F can be implemented by a combination of the actuator controller CTL and the controller 520. Yet alternatively, the head moving unit 57F can be implemented by the controller 520.

[0087] Further, based on the result of correlation operation, the calculator 53F can obtain the difference between the conveyance amount of the web 120 in the conveyance direction 10 and the relative distance L. That is, the calculator 53F can be used to calculate the positions of the web 120 in both of the conveyance direction 10 and the orthogonal direction 20, based on the two-dimensional (2D) image data generated by the imaging units 16A and 16B. Sharing the sensor in detecting positions in both directions can reduce the cost. Additionally, the space for the detection can be

small since the number of sensors is reduced.

[0088] Based on the calculated difference of the conveyance amount of the web 120 from an ideal distance, the calculator 53F calculates the timing of ink discharge from the liquid discharge head unit 210C for cyan. Based on the calculation result, a discharge controller 54F controls ink discharge from the liquid discharge head unit 210C for cyan. The discharge controller 54F outputs a second signal SIG2 to control the timing of ink discharge from the liquid discharge head unit 210C. When the timing of ink discharge from the liquid discharge head unit 210K is calculated, the discharge controller 54F outputs a first signal SIG1 to control the ink discharge from the liquid discharge head unit 210K. The discharge controller 54F is implemented by, for example, the controller 520 illustrated in FIG. 2 (e.g., a microcomputer).

[0089] The liquid discharge apparatus according to the present embodiment can further include a measuring instrument such as an encoder. Descriptions are given below of a configuration including an encoder serving as the measuring instrument. For example, the encoder is attached to a rotation shaft of the roller 230 (i.e., the driving roller). Then, the encoder can measure the amount of movement of the web 120 in the conveyance direction 10, based on the amount of rotation of the roller 230. When the measurement results are used in combination with the detection results generated by the sensor device SEN, the liquid discharge apparatus 110 can discharge liquid onto the web 120 more accurately.

[0090] Descriptions are given below of displacement of the recording medium in the orthogonal direction 20, with reference to FIGS. 8A and 8B, which are plan views of the web 120 being conveyed. In FIG. 8A, the web 120 is conveyed in the conveyance direction 10 by the rollers 230, CR1, and CR2 and the like. While being conveyed, the position of the web 120 may fluctuate in the orthogonal direction 20 as illustrated in FIG. 8B. That is, the web 120 may meander as illustrated in FIG. 8B.

[0091] The fluctuation of the position of the web 120 in the orthogonal direction 20 (hereinafter "orthogonal position of the web 120"), that is, the meandering of the web 120, is caused by eccentricity of a conveyance roller (the driving roller in particular), misalignment, or tearing of the web 120 by a blade. When the web 120 is relatively narrow in the orthogonal direction 20, for example, thermal expansion of the roller affects fluctuation of the web 120 in the orthogonal position.

[0092] Descriptions are given below of the occurrence of misalignment in color superimposition (an image out of color registration) with reference to FIG. 9. Due to fluctuations (meandering illustrated in FIG. 8B) of the web 120 (a recording medium) in the orthogonal direction, images become out of color registration as illustrated in FIG. 9.

[0093] Specifically, to form a multicolor image on the recording medium using a plurality of colors, the liquid discharge apparatus 110 superimposes a plurality of different color inks discharged from the liquid discharge head units 210, through so-called color plane, on the web 120.

[0094] As illustrated in FIG. 8B, the web 120 can fluctuate in position and meanders, for example, with reference to lines 320. Assuming that the liquid discharge head units 210 discharge respective inks to an identical portion (i.e., an intended droplet landing position) on the web 120 in this state, a portion 330 out of color registration is created since the intended droplet landing position fluctuates in the orthogonal direction 20 while the web 120 meanders between the liquid discharge head units 210. The portion 330 out of color registration is created as the position of a line or the like, drawn by the respective inks discharged from the liquid discharge head units 210, shakes in the orthogonal direction 20. The portion 330 out of color registration degrades the quality of the image on the web 120.

Controller

[0095] The configuration of the controller 520 (in FIG. 2) is described below.

[0096] FIG. 10 is a schematic block diagram of control configuration according to the present embodiment. For example, the controller 520 is constructed of an apparatus-side controller 72 connected to a host 71, such as an information processing apparatus. In the illustrated example, with the apparatus-side controller 72, the controller 520 controls image formation on the conveyed object according to image data and control data input from the host 71.

[0097] Examples of the host 71 include a client computer (personal computer or PC) and a server. The apparatus-side controller 72 includes a printer controller 72C and a printer engine 72E.

[0098] The printer controller 72C governs operation of the printer engine 72E. The printer controller 72C transmits and receives the control data to and from the host 71 via a control line 70LC. The printer controller 72C further transmits and receives the control data to and from the printer engine 72E via a control line 72LC. Through such data transmission and reception, the control data indicating printing conditions and the like are input to the printer controller 72C. The printer controller 72C stores the printing conditions, for example, in a resistor. The printer controller 72C then controls the printer engine 72E according to the control data to form an image based on print job data, that is, the control data.

[0099] The printer controller 72C includes a CPU 72Cp, a print control device 72Cc, and a memory FN201700528 Specification.docx. The CPU 72Cp and the print control device 72Cc are connected to each other via a bus 72Cb to communicate with each other. The bus 72Cb is connected to the control line 70LC via a communication interface (I/F) or the like.

[0100] The CPU 72Cp controls the entire apparatus-side controller 72 based on a control program and the like. That

is, the CPU 72Cp is a processor as well as a controller.

[0101] The print control device 72Cc transmits and receives data indicating a command or status to and from the printer engine 72E, based on the control data transmitted from the host 71. Thus, the print control device 72Cc controls the printer engine 72E.

[0102] To the printer engine 72E, a plurality of data lines, namely, data lines 70LD-C, 70LDM, 70LD-Y, and 70LD-K are connected. The printer engine 72E receives the image data from the host 71 via the plurality of data lines. Then, the printer engine 72E performs image formation of respective colors, controlled by the printer controller 72C.

[0103] The printer engine 72E includes a plurality of data management devices, namely, data management devices 72EC, 72EM, 72EY, and 72EK. The data management devices 72EC, 72EM, 72EY, and 72EK include memories 72ECm, 72EMm, 72EYm, and 72EKm to store cyan, magenta, yellow, and black image data Ic, Im, Iy, and Ik, respectively. The printer engine 72E includes an image output 72Ei, a conveyance controller 72Ec, and a moving device controller 72Ecmc.

[0104] FIG. 11 is a block diagram of a configuration of the data management device 72EC. For example, the data management devices 72EC, 72EM, 72EY, and 72EK have a similar configuration, and the data management device 72EC is described below as a representative. Redundant descriptions are omitted.

[0105] The data management device 72EC includes a logic circuit 72ECI and the memory 72ECm. As illustrated in FIG. 11, the logic circuit 72ECI is connected via the data line 70LD-C to the host 71. The logic circuit 72ECI is connected via the control line 72LC to the print control device 72Cc. That the logic circuit 72ECI is implemented by, for example, an application specific integrated circuit (ASIC) or a programmable logic device (PLD).

[0106] According to a control signal input from the printer controller 72C (illustrated in FIG. 10), the logic circuit 72ECI stores, in the memory 72ECm, the image data input from the host 71.

[0107] According to a control signal input from the printer controller 72C, the logic circuit 72ECI retrieves, from the memory 72ECm, the cyan image data Ic. The logic circuit 72ECI then transmits the cyan image data Ic to the image output 72Ei.

[0108] The memory 72ECm preferably has a capacity for storing image data extending about three pages. With the capacity for storing image data extending about three pages, the memory 72ECm can store the image data input from the host 71, data image being used current image formation, and image data for subsequent image formation.

[0109] FIG. 12 is a block diagram of a configuration of the image output 72Ei. In this block diagram, the image output 72Ei is constructed of an output control device 72Eic and the liquid discharge head units 210K, 210C, 210M, and 210Y.

[0110] The output control device 72Eic outputs the image data for respective colors to the liquid discharge head units 210. That is, the output control device 72Eic controls the liquid discharge head units 210 based on the image data input thereto.

[0111] The output control device 72Eic controls the plurality of liquid discharge head units 210 either simultaneously or individually. That is, the output control device 72Eic receives timing commands and changes the timings at which the liquid discharge head units 210 discharge respective color inks. The output control device 72Eic can control one or more of the liquid discharge head units 210 based on the control signal input from the printer controller 72C (illustrated in FIG. 10). Alternatively, the output control device 72Eic can control one or more of the liquid discharge head units 210 based on user instructions.

[0112] In the example illustrated in FIG. 10, in the apparatus-side controller 72, a route for inputting the image data from the host 71 is different from a route for transmission and reception of control data, with the host 71 and the apparatus-side controller 72.

[0113] The conveyance controller 72Ec (in FIG. 10) includes a motor, a mechanism, and a driver for conveying the web 120. For example, the conveyance controller 72Ec controls the motor coupled to the rollers to convey the web 120.

Sensor moving device

[0114] FIG. 13 is a schematic cross-sectional view of the moving device MEC, as an example of the mechanism to move the sensor device SEN. The lateral direction and the direction of depth in FIG. 13 are the orthogonal direction 20 and the conveyance direction 10, respectively.

[0115] As illustrated in FIG. 13, the moving device MEC includes a sensor holder HLD on which the first to five sensor devices SEN1 to SEN5 are mounted. In the illustrated example, the sensor holder HLD is mounted on a base plate BP. Between first and second frames FR1 and FR2 of the liquid discharge apparatus 110 facing each other in the orthogonal direction 20, guide shafts GS extend in the orthogonal direction 20.

[0116] The moving device MEC includes an actuator to move the base plate BP in the orthogonal direction 20, with the position of the base plate BP kept parallel to the conveyance direction 10 (i.e., parallel motion). Specifically, the moving device MEC includes a bearing BR, a ball screw BSR, a coupling CP, a second motor MR2, and a second encoder ENC2. These components attain a certain degree of freedom in the parallel motion of the base plate BP in the orthogonal direction 20 (hereinafter "X-axis freedom XDOP"). The X-axis freedom XDOP is the degree of freedom to move the first to fifth sensor devices SEN1 to SEN5 together as a unit, in the lateral direction in FIG. 13, as the parallel

motion.

[0117] Specifically, the moving device MEC rotates the second motor MR2 to rotate the ball screw BSR via the coupling CP. As illustrated in FIG. 13, the bearing BR is supported by the ball screw BSR and the guide shafts GS. As the ball screw BSR rotates, the base plate BP moves in the parallel motion, guided by the guide shafts GS. The second encoder ENC2 detects the base plate BP. Based on the detection by the second encoder ENC2, the liquid discharge apparatus 110 controls the position of the base plate BP between the first and second frames FR1 and FR2. With this structure, the first to fifth sensor devices SEN1 to SEN5 united together are moved in the orthogonal direction 20, in the parallel motion.

[0118] Note that the base plate BP preferably has a certain degree of freedom (hereinafter "yaw freedom YAWDOF") to rotate around an axis (vertical in FIG. 13) perpendicular to the orthogonal direction 20. The yaw freedom YAWDOF is the degree of freedom to rotate the sensor holder HLD around a vertical axis perpendicular to the base plate BP in FIG. 13, thereby rotating the unit including the first to fifth sensor devices SEN1 to SEN5.

[0119] In the illustrated example, the moving device MEC includes an actuator to rotate the sensor holder HLD around the vertical axis. Specifically, in the illustrated example, the moving device MEC includes a spring SPR, an eccentric cam ECC, a gear GR, a first motor MR1, and a first encoder ENC1.

[0120] The liquid discharge apparatus 110 rotates the first motor MR1 to rotate the eccentric cam ECC via the gear GR. As the eccentric cam ECC rotates, the sensor holder HLD rotates relative to the base plate BP.

[0121] The structure of the moving device MEC is not limited to the illustrated structure. For example, instead of the eccentric cam ECC, a screw can be used. Additionally, instead of the actuator such as the motor, the moving device MEC can include a structure to manually cause the rotational motion or the parallel motion of the sensor devices SEN. Each of the base plate BP and the sensor holder HLD is not necessarily made of a single plate (e.g., a metal plate) but can be made of two or more plates connected together.

[0122] The liquid discharge apparatus 110 can further have a degree of freedom to perform the parallel motion of the sensor devices SEN in the conveyance direction 10 (the depth direction in FIG. 13) and the vertical direction (vertical in FIG. 13).

[0123] The parallel motion of the sensor devices SEN is described in detail below.

[0124] FIG. 14 is a perspective view of the liquid discharge apparatus 110 before the parallel motion. FIG. 14 is a perspective view illustrating the structure illustrated in FIG. 13 from above the liquid discharge head units 210. In FIGS. 14 to 17, the web 120 is conveyed from the right to the left (i.e., the conveyance direction 10), and the orthogonal direction 20 is vertical in FIGS. 14 to 17.

[0125] For example, the base plate BP is disposed between the first and second frames FR1 and FR2 and parallel to the conveyance direction 10, with reference to the guide shafts GS. As the second motor MR2 rotates, the base plate BP moves between the first and second frames FR1 and FR2, in the parallel motion, in the conveyance direction 10. The base plate BP is located at a first position P1 before the parallel motion.

[0126] FIG. 15 is a perspective view of the liquid discharge apparatus 110 after the parallel motion. Through the parallel motion, the base plate BP moves from the first position P1 illustrated in FIG. 14 to a second position P2 illustrated in FIG. 15.

[0127] With the parallel motion of the base plate BP from the first position P1 to the second position P2, the first to fifth sensor devices SEN1 to SEN5, mounted on the sensor holder HLD, move together as a unit.

[0128] The locations of the sensor devices SEN on the sensor holder HLD are close to the respective ink discharge positions.

[0129] In some cases, when the first to fifth sensor devices SEN1 to SEN5 are located at an initial position (the first position P1 in the illustrated example), the accuracy in detecting the amount or speed of movement of the conveyed object may be low. For example, in the structure illustrated in FIG. 1 to form images on both sides of the web 120, a letter or the like may be formed on surface of the web 120 to be imaged by the sensor device SEN. The letter or the like on the web 120 can degrade the accuracy in detecting the amount or speed of movement of the web 120. Generally, an area detectable by a sensor is predetermined. Therefore, if letters or the like are present in the detectable area thereof, the accuracy in detection by the sensor is degraded. In this case, for example, the liquid discharge apparatus 110 notifies an operator that the conditions are insufficient for the specifications of the light source or specifications to capture image data and the accuracy in detection is degraded (i.e., a sensor error). With the notification, the operator knows that the object to be imaged has an inconvenience for the detection or the position of detection by the sensor device SEN is improper. In response to the notification, the operator inputs, to the liquid discharge apparatus 110, an operation to cause the parallel motion of the sensor devices SEN.

[0130] As the base plate BP moves in the parallel motion, the liquid discharge apparatus 110 can move the sensor devices SEN to avoid a portion including the letters or the like. Specifically, the sensor devices SEN are moved to, for example, an end of the web 120 in the orthogonal direction 20. Then, the sensor devices SEN can perform imaging, avoiding the portion including letters or the like. Accordingly, the liquid discharge apparatus 110 can detect the amount or speed of movement of the web 120 accurately.

[0131] When the sensor devices SEN are mounted on the sensor holder HLD and moved together in the parallel

motion, the relative positions of the sensor devices SEN are maintained. This configuration is advantageous in reducing the time of alignment or time for moving the sensor devices SEN, compared with a configuration in which the sensor devices SEN are moved one by one.

[0132] The rotational motion of the sensor devices SEN is described below.

[0133] FIG. 16 is a perspective view of the liquid discharge apparatus 110 before the rotational motion. Similar to FIGS. 14 and 15, FIG. 16 is a perspective view of the structure illustrated in FIG. 13 from above the liquid discharge head units 210.

[0134] Described below is an example in which the web 120 is conveyed obliquely (e.g., skew) from the lower right to the upper left in FIGS. 16 and 17. In other words, FIGS. 16 and 17 illustrate a case where the parallelism of the web 120 relative to the first and second frames FR1 and FR2 is low.

[0135] In the case of skew of the web 120 as illustrated in FIG. 16, for example, it is possible that the area detected by the first sensor device SEN1 is out of the area detectable by the second, third, fourth, or fifth sensor device SEN2, SEN3, SEN4, or SEN5 located downstream from the first sensor device SEN1. In such a case, the liquid discharge apparatus 110 causes the rotational motion of the sensor holder HLD.

[0136] FIG. 17 is a perspective view of the liquid discharge apparatus 110 after the rotational motion of the sensor devices SEN. FIG. 17 illustrates a state after the sensor holder HLD has yawed from the state illustrated in FIG. 16. In FIG. 17, the sensor holder HLD is at an angle AG relative to the conveyance direction 10.

[0137] As illustrated in FIG. 17, as the sensor holder HLD rotates around a rotation center RC by the angle AG, the sensor holder HLD becomes almost parallel to the web 120. With the rotation, for example, the area detected by the first sensor device SEN1 falls within the area detectable by the second, third, fourth, or fifth sensor device SEN2, SEN3, SEN4, or SEN5 located downstream from the first sensor device SEN1.

[0138] The rotation center RC is, for example, a center of the sensor holder HLD. When the rotation center RC is disposed at the center of the sensor holder HLD, rotating the sensor holder HLD is easy and additionally, the amount by which the sensor holder HLD is rotatable is large.

[0139] However, the rotation center RC is not limited to the center of the sensor holder HLD. For example, the rotation center RC can be disposed upstream from the first sensor device SEN1 in the conveyance direction 10. Such an arrangement facilitates adjustment corresponding to the web 120 when the web 120 is oblique.

[0140] As described above, when the web 120 is conveyed obliquely (so-called "meandering"), the liquid discharge apparatus 110 having the yaw freedom YAWDOF can adjust the positions of the sensor devices SEN corresponding to the angle of the web 120 being conveyed.

[0141] Thus, in the state in which the positions of the sensor devices SEN are adjusted, the liquid discharge apparatus 110 can perform the detection of the web 120, to control the ink discharge timing and the positions of the liquid discharge head units 210.

[0142] FIG. 18 is an illustration of a test pattern used by the liquid discharge apparatus 110. In the example illustrated in FIG. 18, first color is black. In a test print, initially, the liquid discharge apparatus 110 forms, with the black ink, a straight line extending in the conveyance direction 10 as illustrated in FIG. 18. Based on the test print, a distance Lk from the edge is determined. When the distance Lk from the edge is adjusted in the orthogonal direction 20 manually by a user or by the apparatus, the ink discharge position of the first color (e.g., black), which serves as a reference. The ink discharge position of black can be determined in a different manner.

[0143] According to an aspect of this disclosure, the liquid discharge apparatus 110 has the X-axis freedom XDof, and the moving device MEC can move a plurality of sensors together at a time in at least in parallel motion. Accordingly, the sensors can perform detection avoiding a portion that is inconvenient for the detection (e.g., the portion includes a letter or an image). Consequently, the liquid discharge apparatus 110 can detect at least one of the position and speed of movement of the conveyed object in the conveyance direction 10 or the orthogonal direction 20.

[0144] In image formation with liquid discharged onto a recording medium, as the accuracy in droplet landing positions improves, misalignment in color superimposition is suppressed, improving image quality. In particular, in liquid discharge apparatuses, image quality is improved when the liquid discharge head unit is moved to eliminate the misalignment in droplet landing positions during image formation.

Variation of sensor device

[0145] Variations of the sensor devices are described below.

[0146] FIG. 19 is a schematic block diagram of the conveyed object detector 600 according to another variation. For example, the conveyed object detector 600 is implemented by the sensor device SEN illustrated in FIG. 19, which includes a first light source 51AA, a second light source 51AB, and the control circuit 152. The conveyed object detector 600 illustrated in FIG. 19 further includes the memory device 53 and the controller 520. This configuration is different from the configuration illustrated in FIG. 5 in computation performed by the sensor device SEN and the controller 520, as described below.

[0147] The first light source 51AA and the second light source 51AB emit laser light or the like to the web 120, which is an example of an object to be detected. The first light source 51AA irradiates a position AA with light, and the second light source 51AB irradiates a position AB with light.

[0148] Each of the first light source 51AA and the second light source 51AB includes a light-emitting element to emit laser light and a collimator lens to approximately collimate the laser light emitted from the light-emitting element. The first light source 51A and the second light source 51B are disposed to emit light in an oblique direction relative to the surface of the web 120.

[0149] The sensor device SEN includes an area sensor 11, a first imaging lens 12AA disposed opposing the position AA, and a second imaging lens 12AB disposed opposing the position AB.

[0150] The area sensor 11 includes, for example, an image sensor 112 on a silicon substrate 111. The image sensor 112 includes an area 11AA and an area 11AB, to obtain two-dimensional image data. For example, the area sensor 11 is a CCD sensor, a complementary metal oxide semiconductor (CMOS) sensor, a photodiode array, or the like. The area sensor 11 is housed in a case 13. The first imaging lens 12AA and the second imaging lens 12AB are held by a first lens barrel 13AA and a second lens barrel 13AB, respectively.

[0151] In the illustrated structure, the optical axis of the first imaging lens 12AA matches a center of the area 11AA. Similarly, the optical axis of the second imaging lens 12AB matches a center of the area 11AB. The first imaging lens 12AA and the second imaging lens 12AB focus light on the area 11AA and the area 11AB, respectively, to generate two-dimensional image data.

[0152] In this case, the sensor device SEN can detect displacement or speed between the positions AA and AB. Further, the sensor device can perform calculation using such a detection result and a detection result generated by a sensor device disposed at a different position in the conveyance direction 10, thereby detecting the displacement and speed between the sensor devices disposed at different positions from each other.

[0153] For example, the sensor device SEN can have the following structure.

[0154] FIG. 20 is a schematic block diagram of the sensor device SEN according to another variation. Differently from the structure illustrated in FIG. 19, in the sensor device SEN illustrated in FIG. 20, the first imaging lens 12AA and the second imaging lens 12AB are integrated into a lens 12C. Other structures, such as the area sensor 11, can be similar to those illustrated in FIG. 19.

[0155] Additionally, in this structure, use of an aperture 121 or the like is preferable to prevent interference between the images generated by the first imaging lens 12AA and the second imaging lens 12AB. The aperture 121 or the like can limit a range in which each of the first imaging lens 12AA and the second imaging lens 12AB generates an image. Accordingly, the interference between the images is suppressed. Then, the sensor device SEN can generate image data at the position AA and image data at the position AB illustrated in FIG. 19.

[0156] FIGS. 21A and 21B are schematic views of the sensor device SEN according to another variation. Differently from the structure illustrated in FIG. 20, the optical sensor OS illustrated in FIG. 21A includes an area sensor 11' instead of the area sensor 11. The first imaging lens 12AA, the second imaging lens 12AB, and the like are similar in structure to those illustrated in FIG. 20.

[0157] The area sensor 11' has a structure illustrated in FIG. 21B, for example. Specifically, as illustrated in FIG. 21B, a wafer 11a includes a plurality of image sensors b. The plurality of image sensors b illustrated in FIG. 21B is cut out of the wafer 11a. The image sensors b serve as a first image sensor 112AA and a second image sensor 112AB and are disposed on the silicon substrate 111. The first imaging lens 12AA and the second imaging lens 12AB are disposed in accordance with the distance between the first image sensor 112A and the second image sensor 112B.

[0158] Image sensors are generally manufactured for imaging. Therefore, image sensors have an aspect ratio (ratio between X-direction size and Y-direction size), such as square, 4:3, or 16:9, that fits an image format. In the present embodiment, an image data covering at least two different points spaced apart is captured. Specifically, image data is captured at each of points spaced apart in the X direction, one direction in two dimensions. The X direction corresponds to the conveyance direction 10 illustrated in FIG. 19. By contrast, the image sensor has an aspect ratio fit for the image format. Accordingly, when an image is captured at the two points spaced apart in the X direction, it is possible that an image sensor relating to the Y direction is not used. To enhance pixel density, an image sensor having a higher pixel density is used in either the X direction or the Y direction. In such a case, the cost increases.

[0159] In view of the foregoing, in the structure illustrated in FIG. 21A, on the silicon substrate 111, the first image sensor 112A and the second image sensor 112B spaced apart are disposed. This structure can reduce the number of unused image sensors of the image sensors relating to the Y direction. In other words, waste of image sensors is inhibited. Additionally, since the first image sensor 112AA and the second image sensor 112AB are produced through a semiconductor process with high accuracy, the distance between the first image sensor 112AA and the second image sensor 112AB is set with high accuracy.

[0160] FIG. 22 is a schematic view of a plurality of imaging lenses, as an example structure for the above-described detection of the conveyed object. The lens array illustrated can be used to implement the sensor device SEN.

[0161] In the lens array illustrated in FIG. 22, two or more lenses are integrated. Specifically, the lens array illustrated

in FIG. 22 includes, for example, nine imaging lenses A1, A2, A3, B1, B2, B3, C1, C2, and C3 arranged in three rows and three columns. When such a lens array is used, image data representing nine points is captured. In this case, an area sensor having nine imaging ranges is used.

[0162] In this structure, for example, arithmetic of the two imaging ranges can be performed concurrently, that is, in parallel. When the results of arithmetic of each range are averaged, or error is removed from the results, the accuracy and stability of arithmetic can be higher, compared with a case in which one arithmetic result is used. There are cases where the arithmetic is performed based on application software, the speed of which fluctuates. Even in such case, the result of arithmetic can have a high accuracy since a range for performing correlation operation is expanded.

[0163] FIG. 23 is a schematic view illustrating a general structure of a liquid discharge apparatus according to another embodiment. This configuration differs from the configuration illustrated in FIG. 2 regarding the locations of the first support and the second support. The liquid discharge apparatus 110 illustrated in FIG. 23 includes supports RL1, RL2, RL3, RL4, and RL5, serving as the first and second supports, to support the sheet P. In other words, one support can double as the second support (e.g., the conveyance roller CR2K in FIG. 2) disposed upstream from the downstream one of adjacent two liquid discharge head units and the first support (e.g., the conveyance roller CR1C in FIG. 2) disposed upstream from the upstream one of the adjacent two liquid discharge head units. Note that, the support that doubles as the first and second supports can be either a roller or a curved plate.

[0164] One or more of aspects of this disclosure can adapt to a liquid discharge system including at least one liquid discharge apparatus. For example, the liquid discharge head unit 210K and the liquid discharge head unit 210C are housed in one case as one apparatus, and the liquid discharge head unit 210M and the liquid discharge head unit 210Y are housed in another case as another apparatus. The liquid discharge system includes the two apparatuses.

[0165] Further, one or more of aspects of this disclosure can adapt a liquid discharge apparatus and a liquid discharge system to discharge liquid other than ink. For example, the liquid is a recording liquid of another type or a fixing solution.

[0166] The liquid discharge apparatus (or system) to which one or more of aspects of this disclosure are applicable is not limited to image forming apparatuses to form two-dimensional images but can be apparatuses to fabricate three-dimensional articles (3D-fabricated object).

[0167] The conveyed object is not limited to recording media such as paper sheets but can be any material to which liquid adheres, even temporarily. Examples of the material to which liquid adheres include paper, thread, fiber, cloth, leather, metal, plastic, glass, wood, ceramics, and a combination thereof.

[0168] Further, aspects of this disclosure are applicable to a method of discharging liquid from a liquid discharge apparatus, an information processing apparatus, or a computer as a combination thereof, and at least a portion of the method can be implemented by a program.

[0169] The light source is not limited to laser light sources but can be, for example, a light emitting diode (LED) or an organic electro luminescence (EL). Depending on the type of light source, the pattern to be detected is not limited to the speckle pattern.

[0170] That is, the surface data of the conveyed object is not limited to the speckle pattern. The surface data is, for example, information that changes depending on the position on the conveyed object to be detected by the sensor.

[0171] The light source to irradiate the conveyed object can be either a light source to emit a single wavelength of light or a light source to emit a broad wavelength of light.

[0172] Although the above-described liquid discharge apparatus 110 is an image forming apparatus including the four liquid discharge head units for black, cyan, magenta, and yellow to form images, the image forming apparatus is not limited thereto. Aspects of this disclosure are applicable to, for example, an image forming apparatus including a plurality of black liquid discharge head units to form images.

[0173] Further, aspects of this disclosure can adapt to any apparatus including a head to perform an operation on the conveyed object or processing of the conveyed object. A plurality of such heads can be lined in the orthogonal direction.

[0174] For example, aspects of this disclosure can adapt to a conveyance device that conveys a substrate (conveyed object) and includes a laser head to perform laser patterning on the substrate. A plurality of such laser heads can be lined in the direction orthogonal to the direction of conveyance of the substrate. The conveyance device detects the position of the substrate and moves the head based on the detection result. In this case, the position at which the laser irradiates the substrate is the operation position of the head.

[0175] Alternatively, the head to perform an operation on the conveyed object can be a reading head to perform reading of the conveyed object. In this case, the position read by the head unit is the operation position of the head.

[0176] The number of the heads of the conveyance device is not necessarily to two or more. Aspects of this disclosure can adapt to a device configured to keep operation at to a reference position, on a conveyed object.

Claims

1. An apparatus (110) to perform an operation on a conveyed object, the apparatus comprising:

a head (210) to perform the operation on the conveyed object;
 a plurality of sensors (SEN) to detect surface data of the conveyed object;
 a moving device (MEC) to move the plurality of sensors (SEN) in an orthogonal direction orthogonal to a conveyance direction in which the conveyed object is conveyed;
 5 a first support (CR1K; CR1C; CR1M; CR1Y) disposed upstream, in the conveyance direction, from an operation position at which the head (210) performs the operation on the conveyed object, the first support (CR1K; CR1C; CR1M; CR1Y) to support the conveyed object; and
 a second support (CR2K; CR2C; CR2M; CR2Y) disposed downstream from the operation position in the conveyance direction, the second support (CR2K; CR2C; CR2M; CR2Y) to support the conveyed object,
 10 wherein at least one of the plurality of sensors (SEN) is disposed between the first support (CR1K; CR1C; CR1M; CR1Y) and the second support (CR2K; CR2C; CR2M; CR2Y) in the conveyance direction, and
 wherein the plurality of sensors (SEN) is mounted on a sensor holder (HLD) as a single unit to be moved by the moving device (MEC).

15 2. The apparatus (110) according to claim 1, wherein the moving device (MEC) moves the sensor holder (HLD) in the orthogonal direction to move the plurality of sensors (SEN) in parallel motion.

3. The apparatus (110) according to claim 1 or 2, wherein the moving device (MEC) includes a rotation device (MR1, ENC1, ECC, GR) to rotate the sensor holder (HLD) around an axis perpendicular to the orthogonal direction.

20 4. The apparatus (110) according to any one of claims 1 through 3, wherein the at least one of the plurality of sensors (SEN) is disposed between the operation position of the head (210) and the first support (CR1K; CR1C; CR1M; CR1Y) in the conveyance direction.

25 5. The apparatus (110) according to any one of claims 1 through 4, further comprising:

a light source (51) to irradiate the conveyed object with light; and
 a calculator (53F) configured to generate a calculation result including at least one of a position of the conveyed object, an amount of movement of the conveyed object, or a speed of movement of the conveyed object, based
 30 on the surface data,
 wherein the surface data is image data representing a pattern generated by interference of the light reflected on a rugged shape of the conveyed object.

35 6. The apparatus (110) according to claim 5, further comprising a head moving device (AC1; AC2; AC3; AC4) to move the head (210) in the orthogonal direction based on the calculation result generated by the calculator (53F).

7. The apparatus (110) according to claim 5 or 6, further comprising a discharge controller (54F) to control a timing at which the head (210) performs the operation on the conveyed object, based on the calculation result generated by the calculator (53F).

40 8. The apparatus (110) according to any one of claims 1 through 7, wherein the conveyed object is a continuous sheet.

9. The apparatus (110) according to any one of claims 1 through 8, wherein the head (210) is a liquid discharge head to discharge liquid onto the conveyed object.

FIG. 1

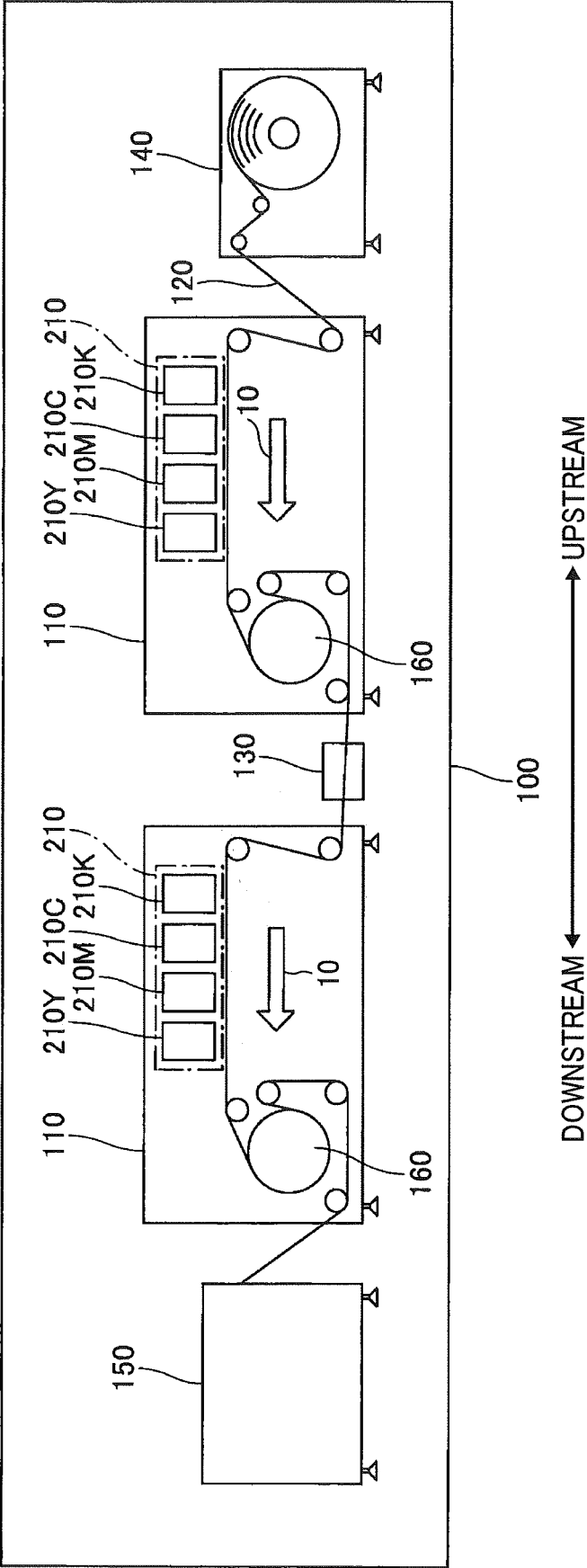


FIG. 2

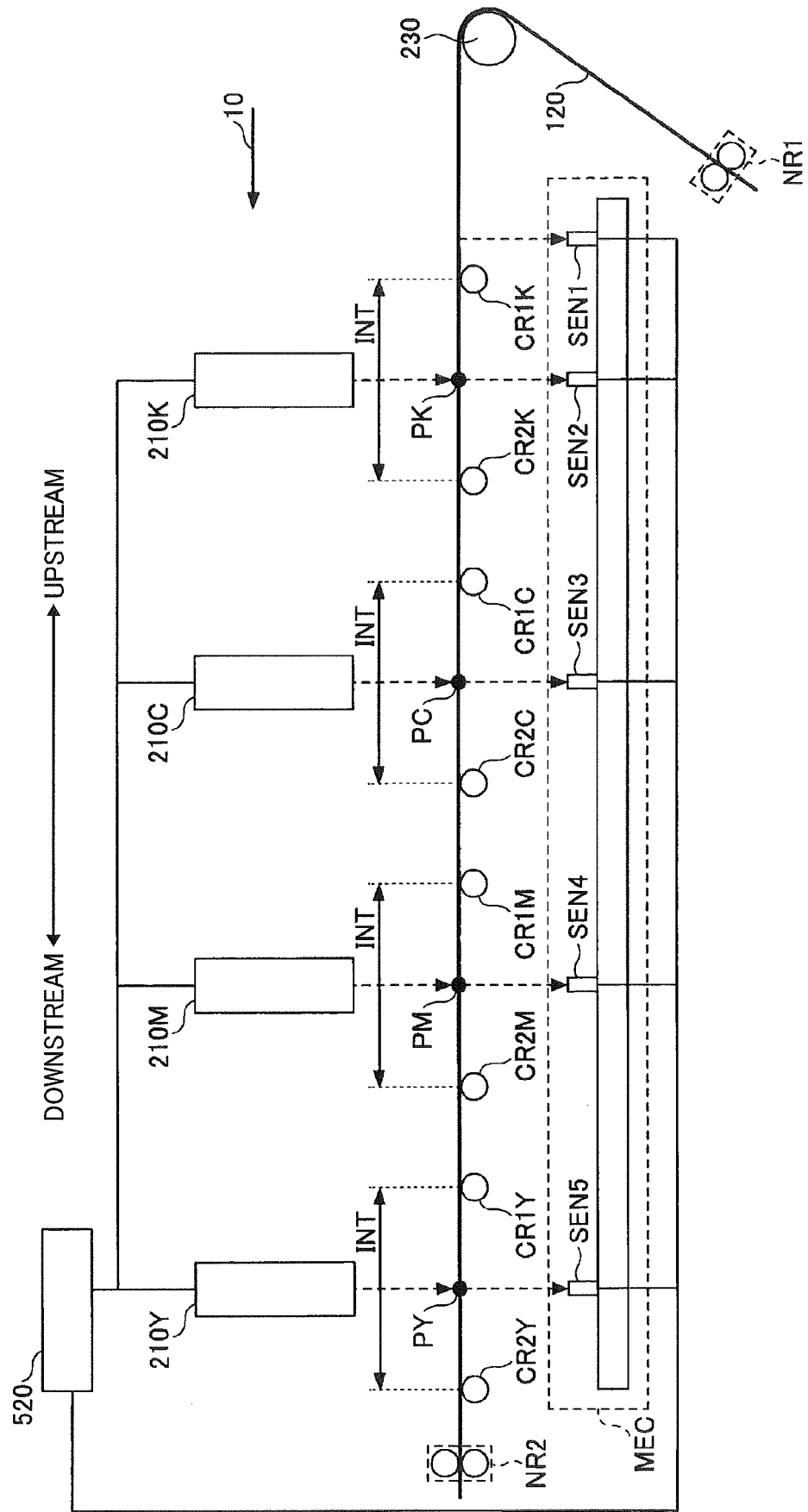


FIG. 3

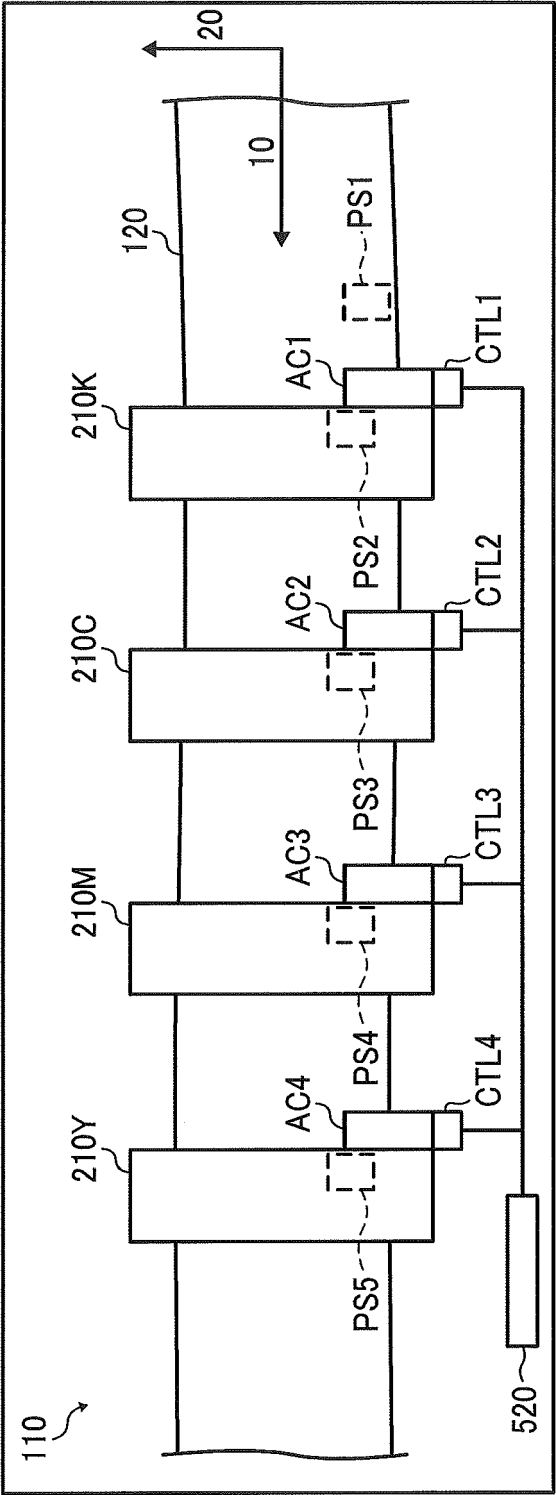


FIG. 4A

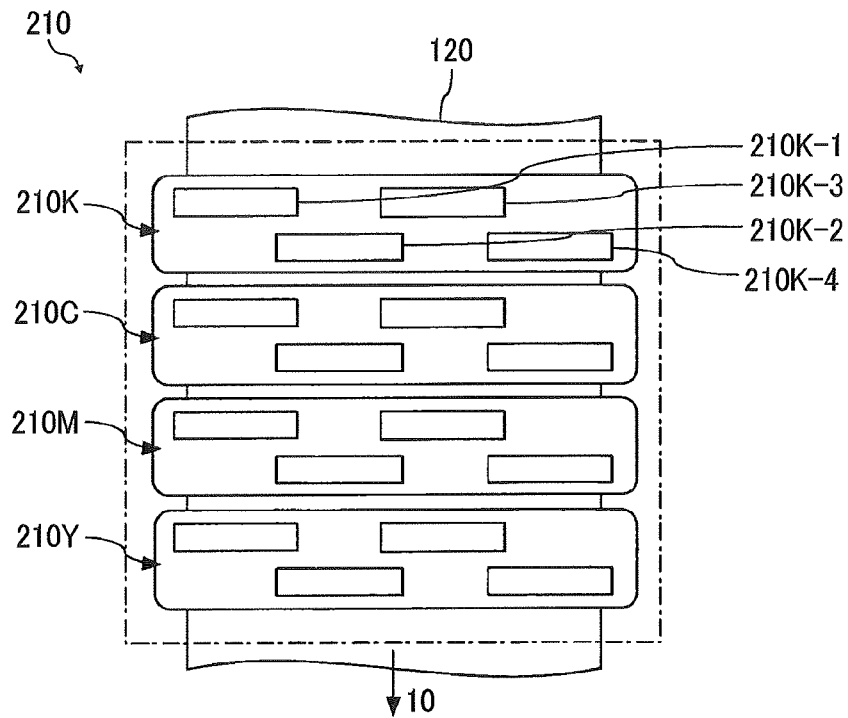


FIG. 4B

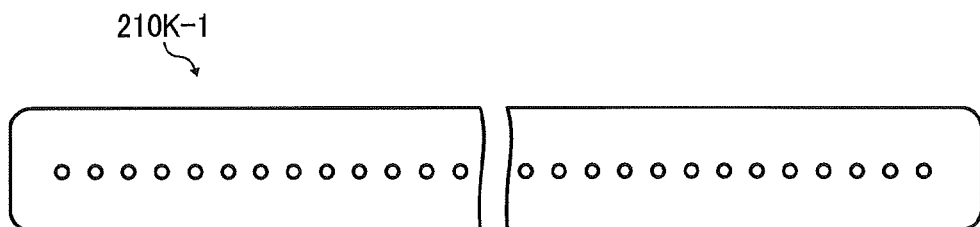


FIG. 5

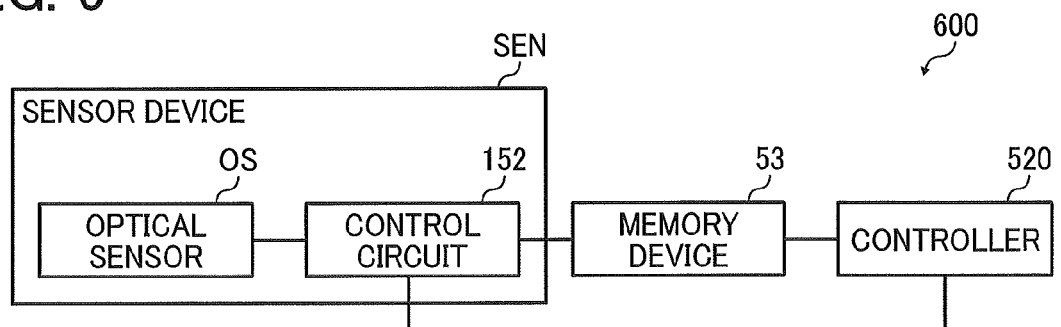


FIG. 6

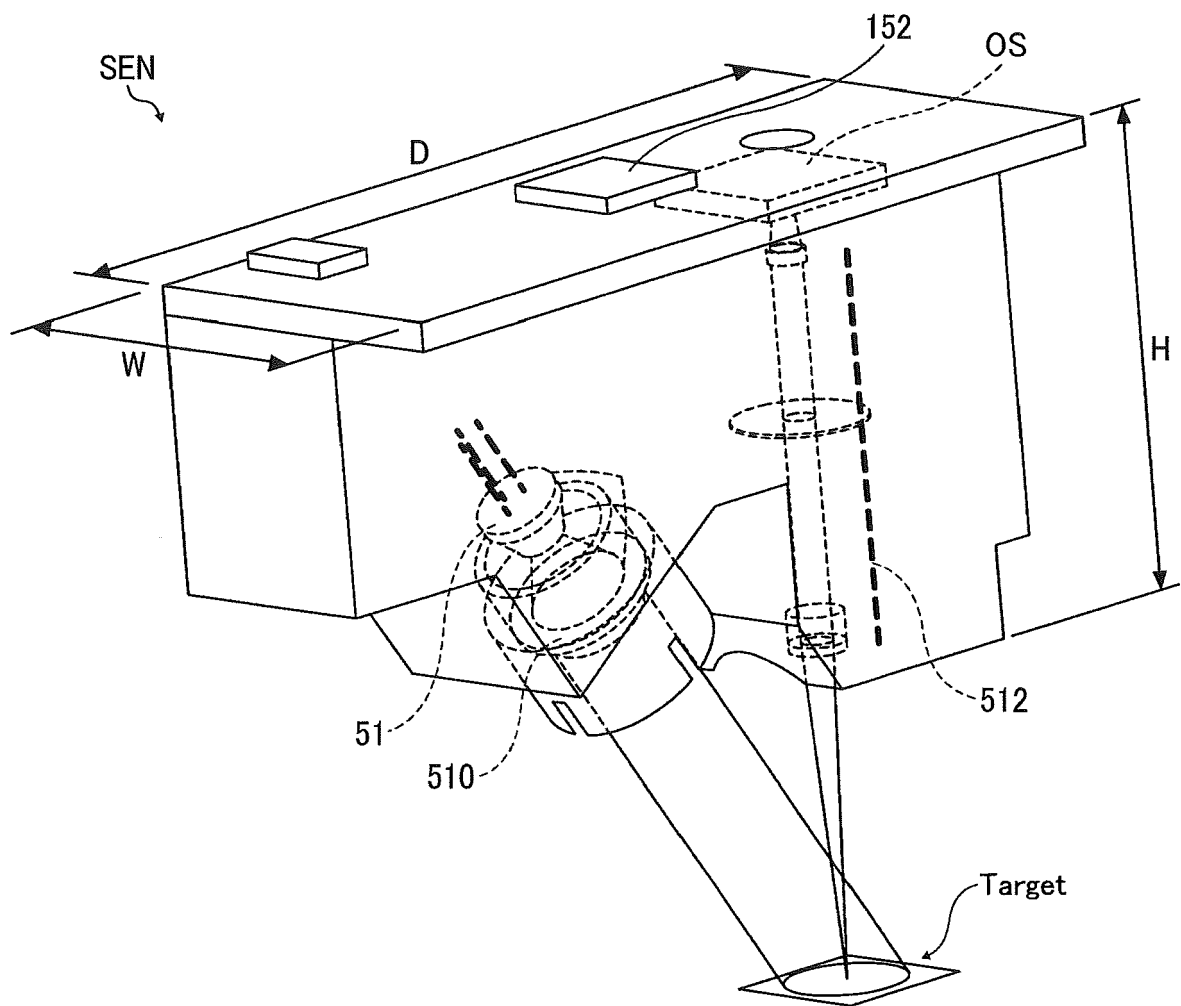


FIG. 7

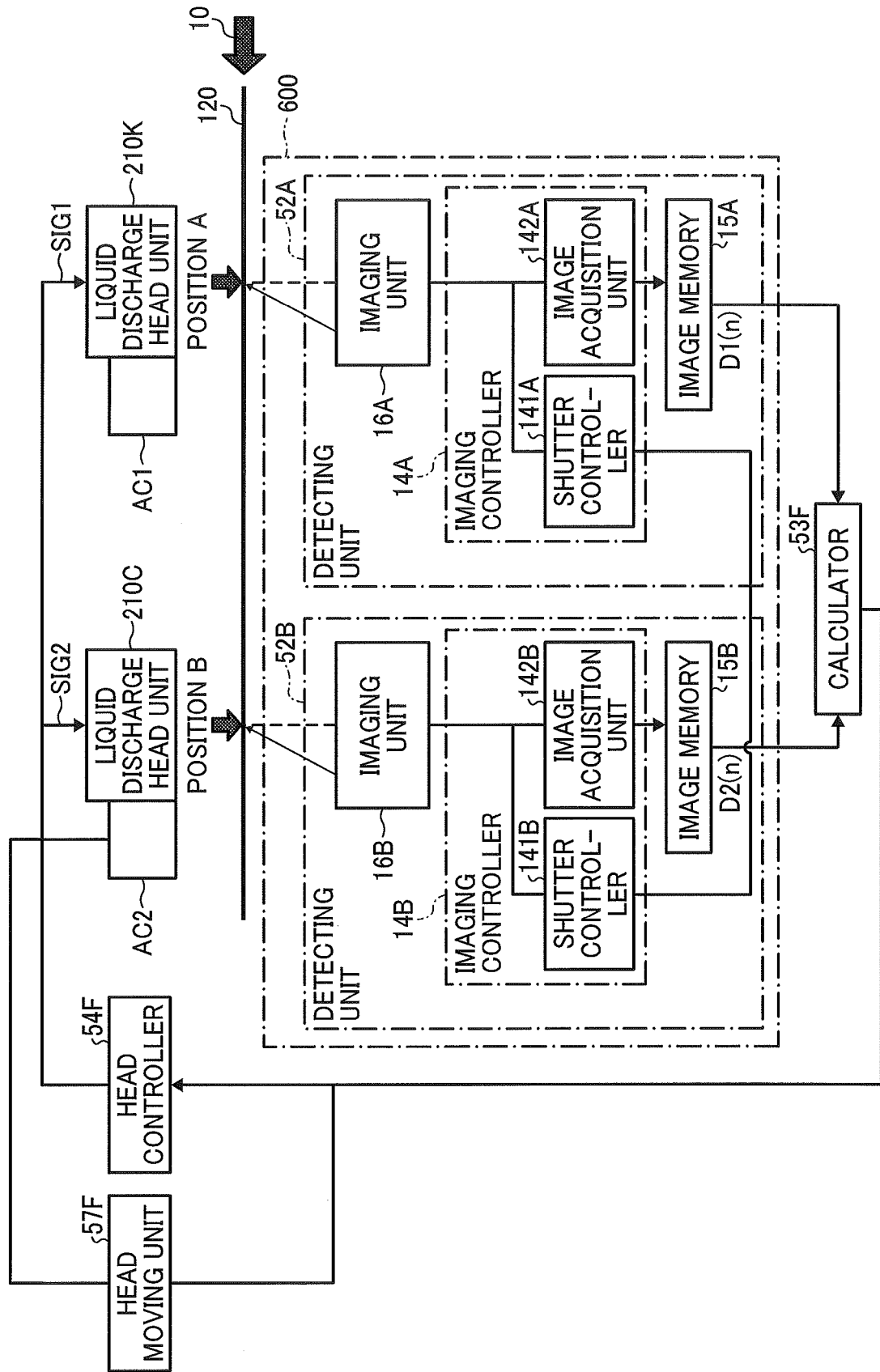


FIG. 8A

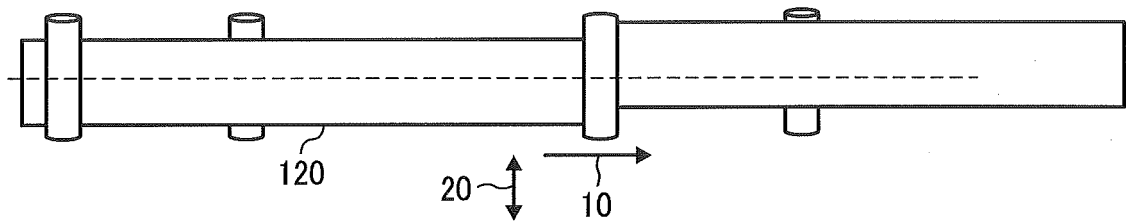


FIG. 8B

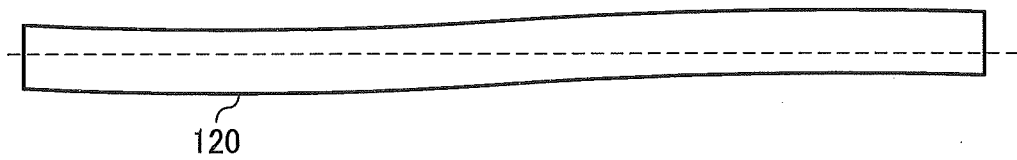


FIG. 9

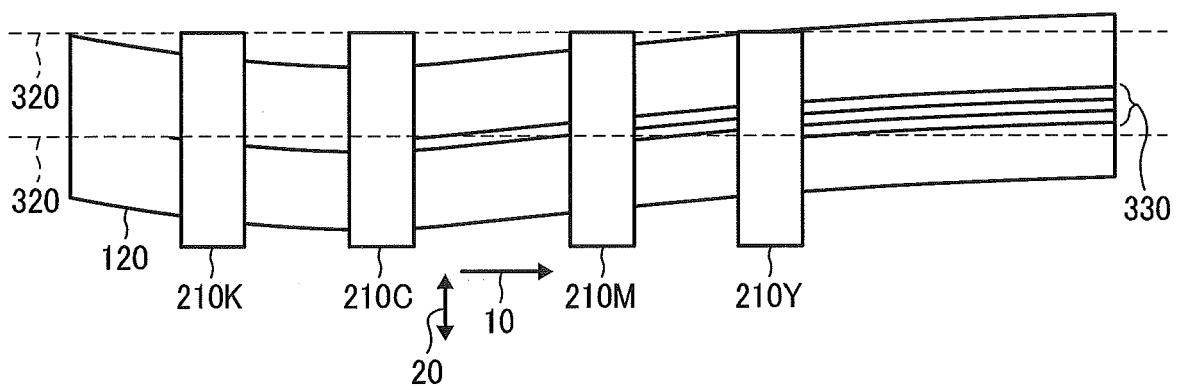


FIG. 10

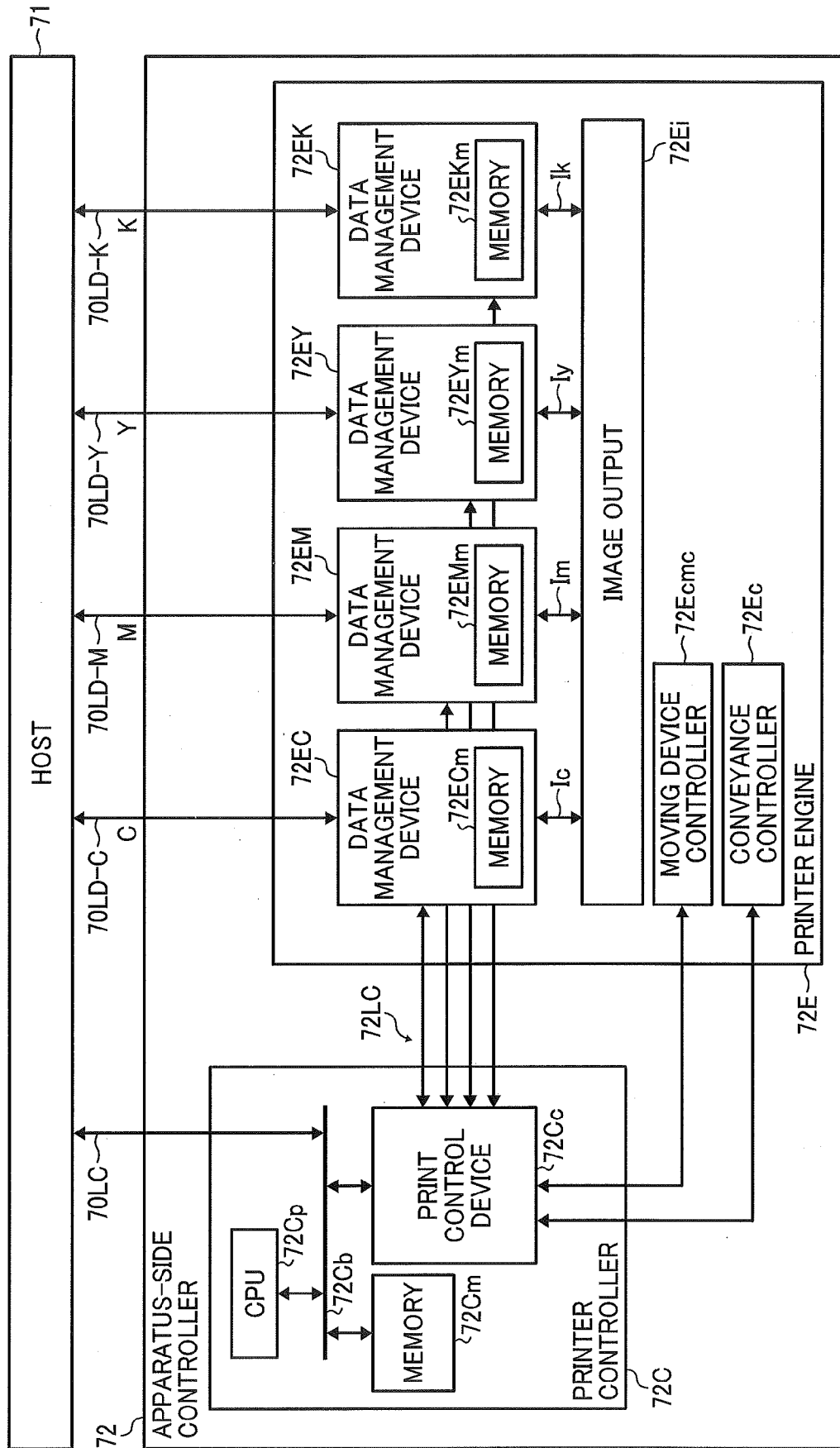


FIG. 11

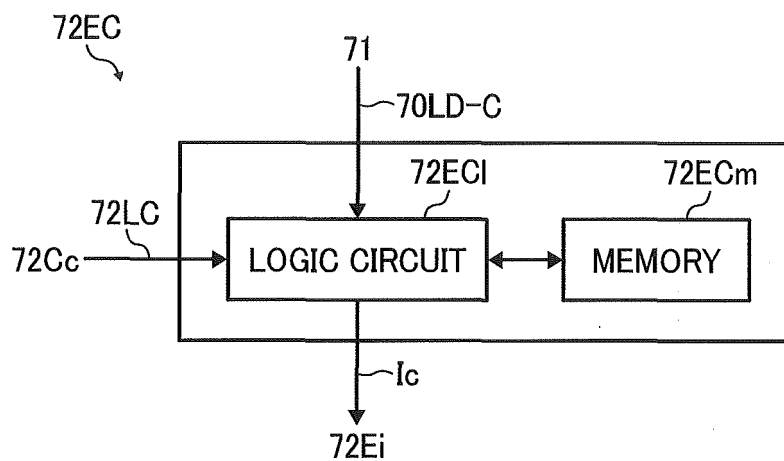


FIG. 12

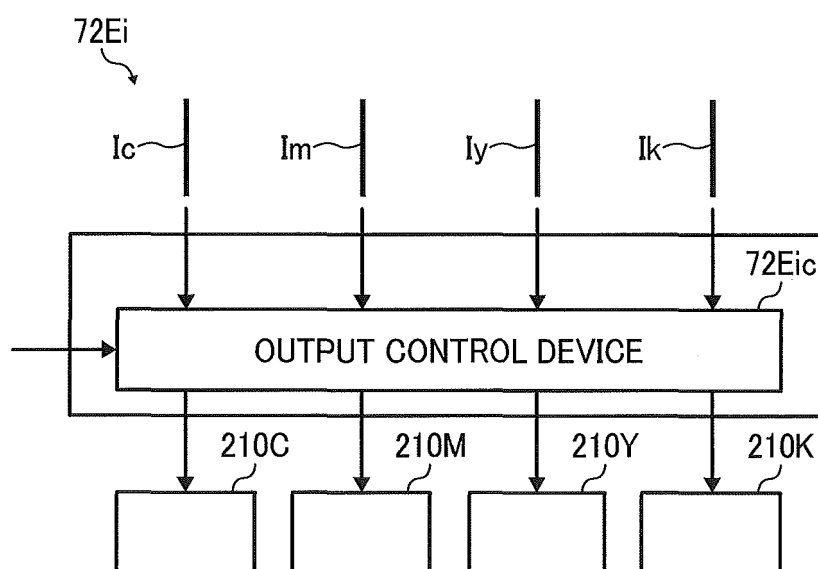


FIG. 13

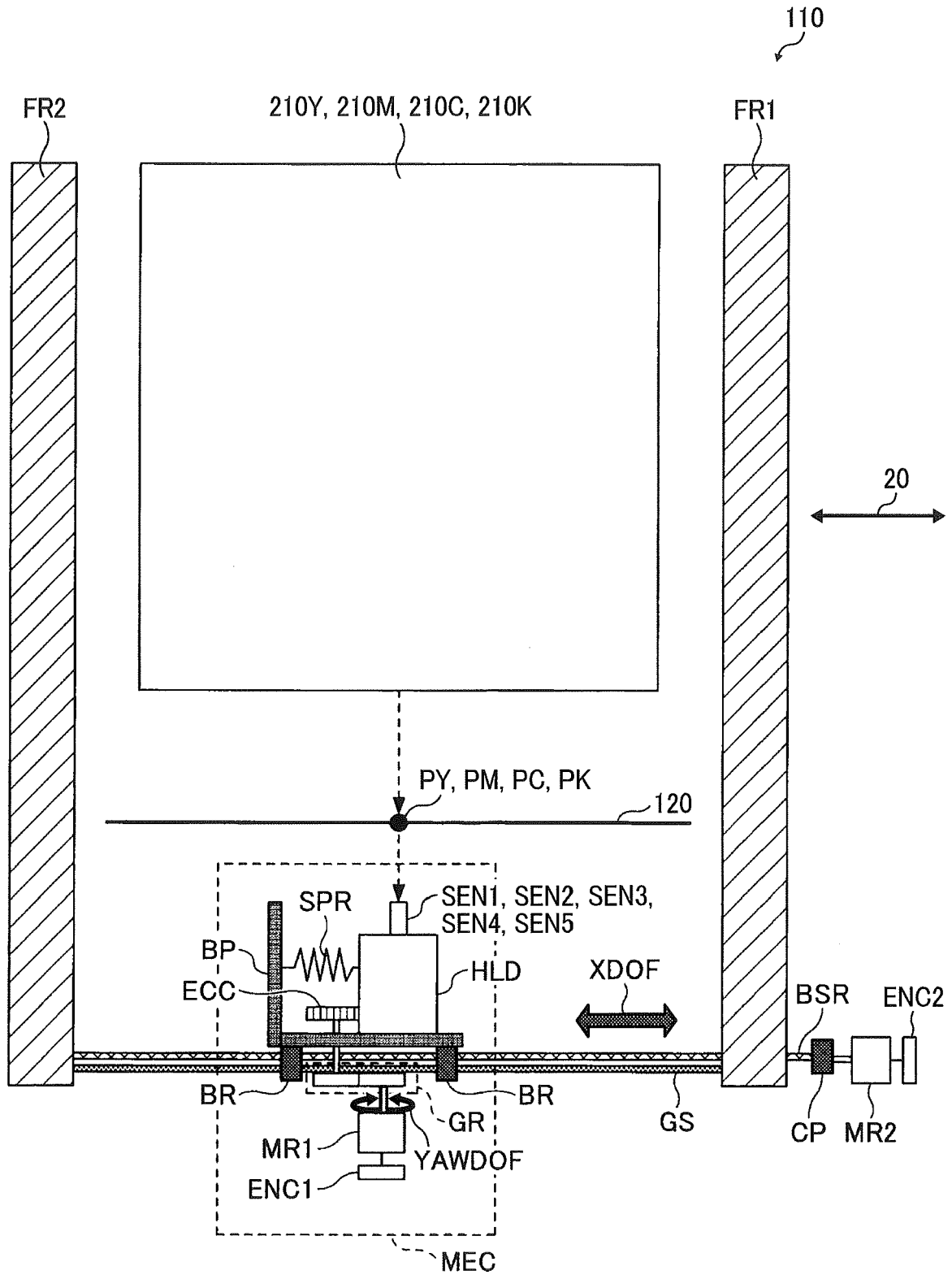


FIG. 14

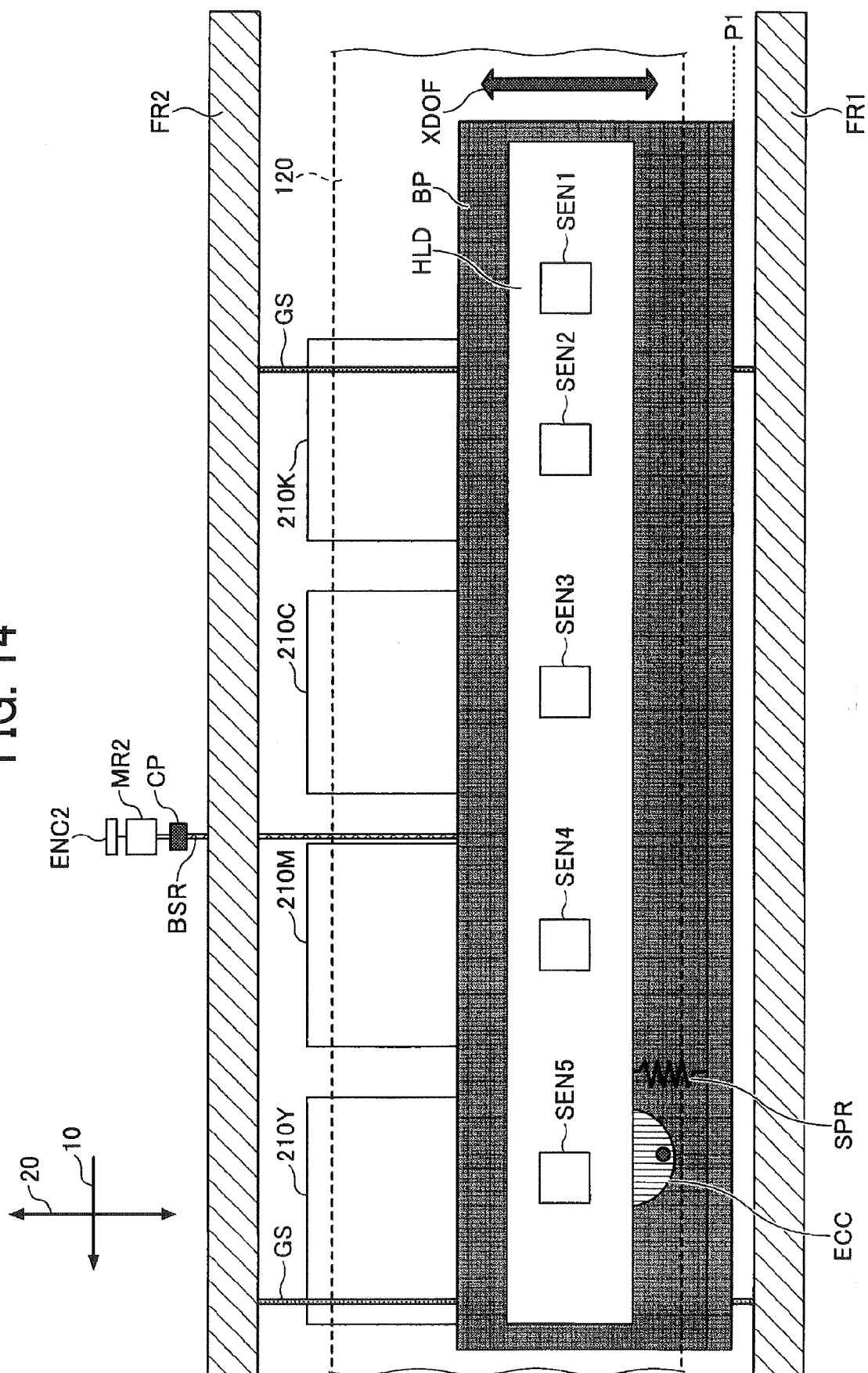


FIG. 15

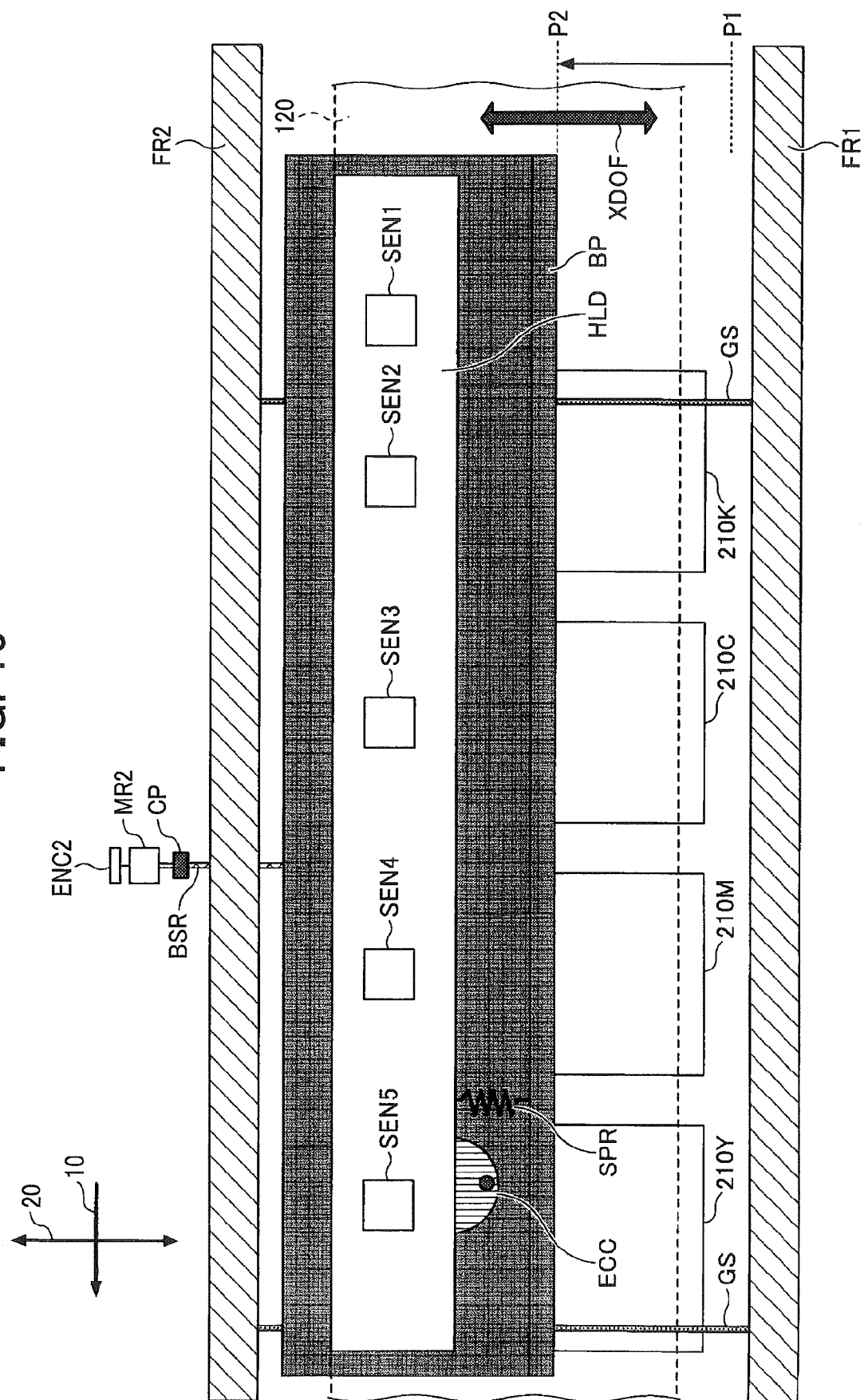


FIG. 16

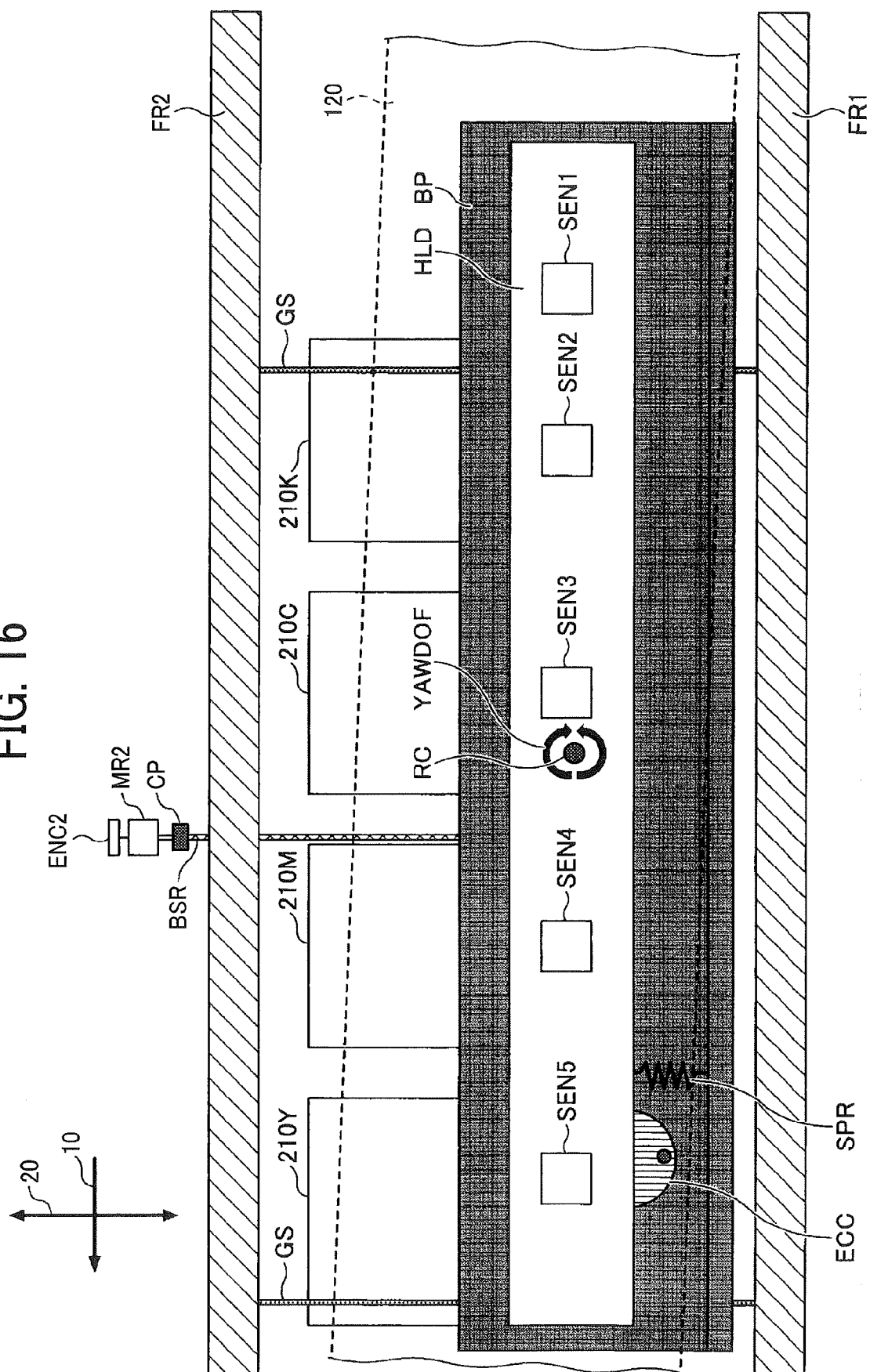


FIG. 17

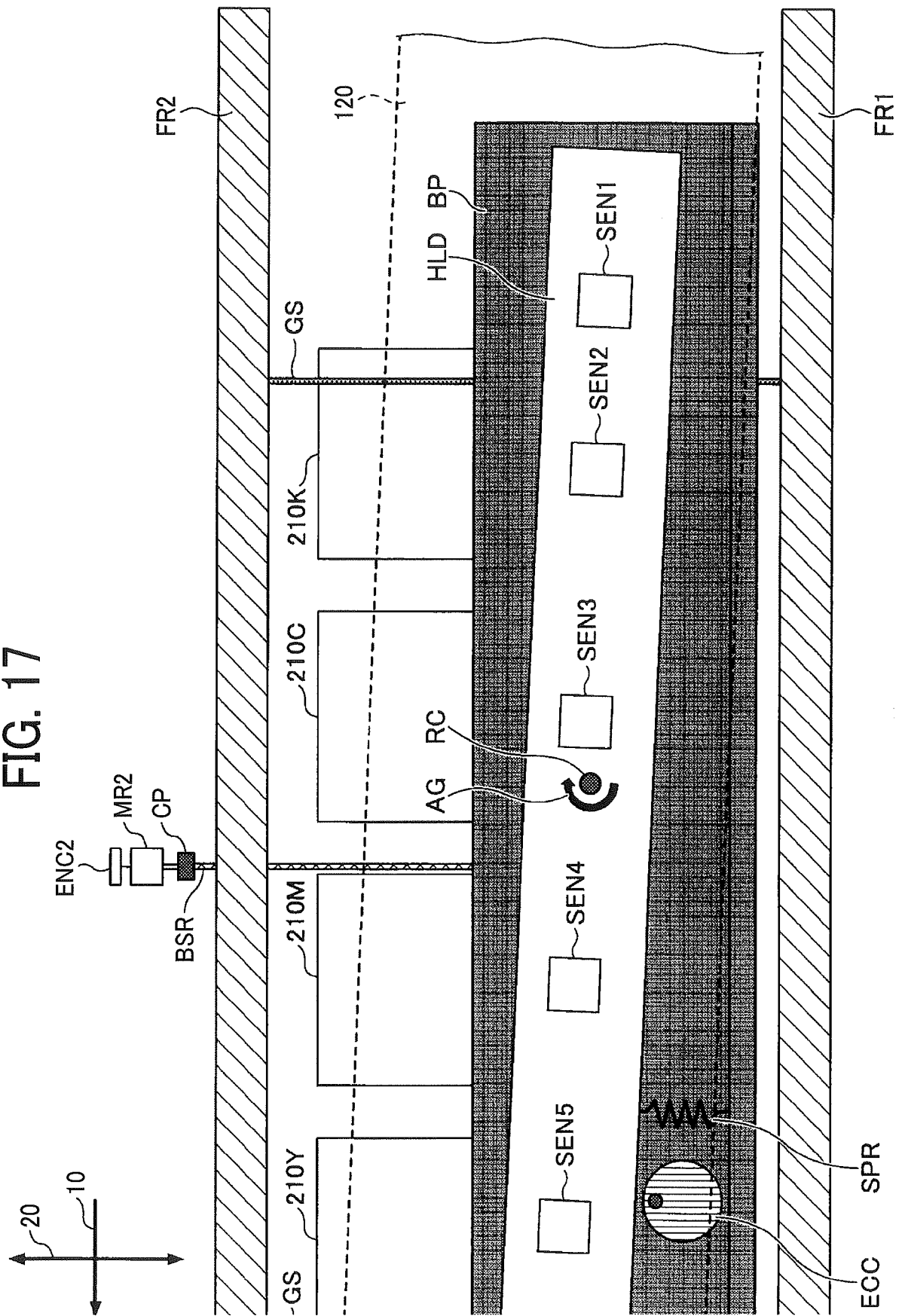


FIG. 18

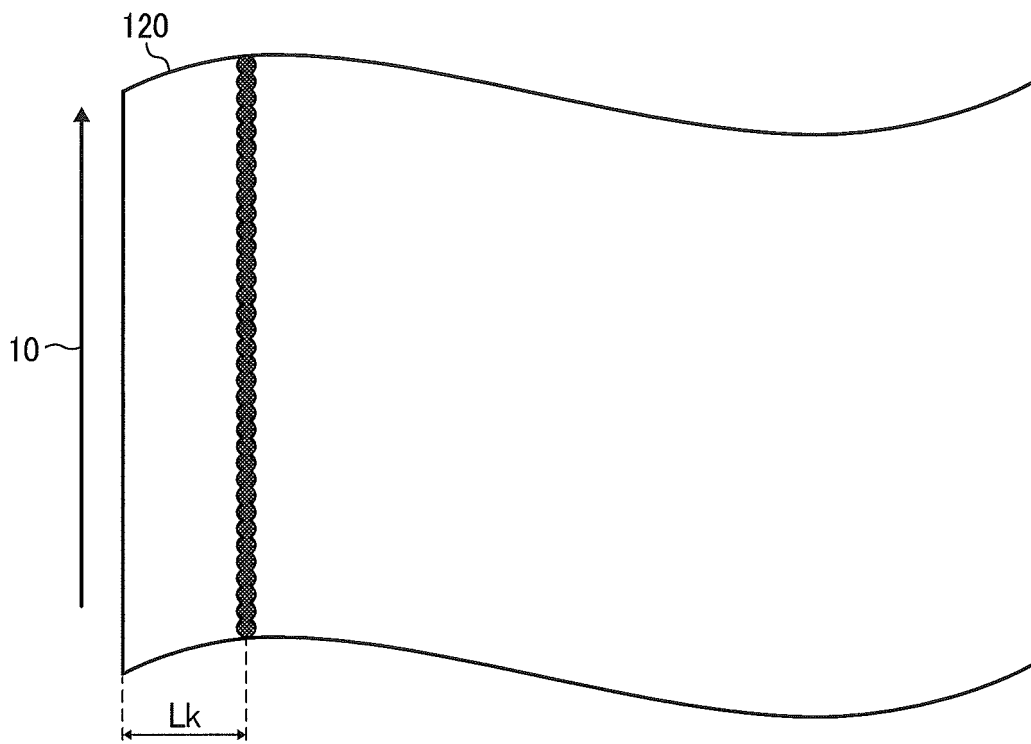


FIG. 19

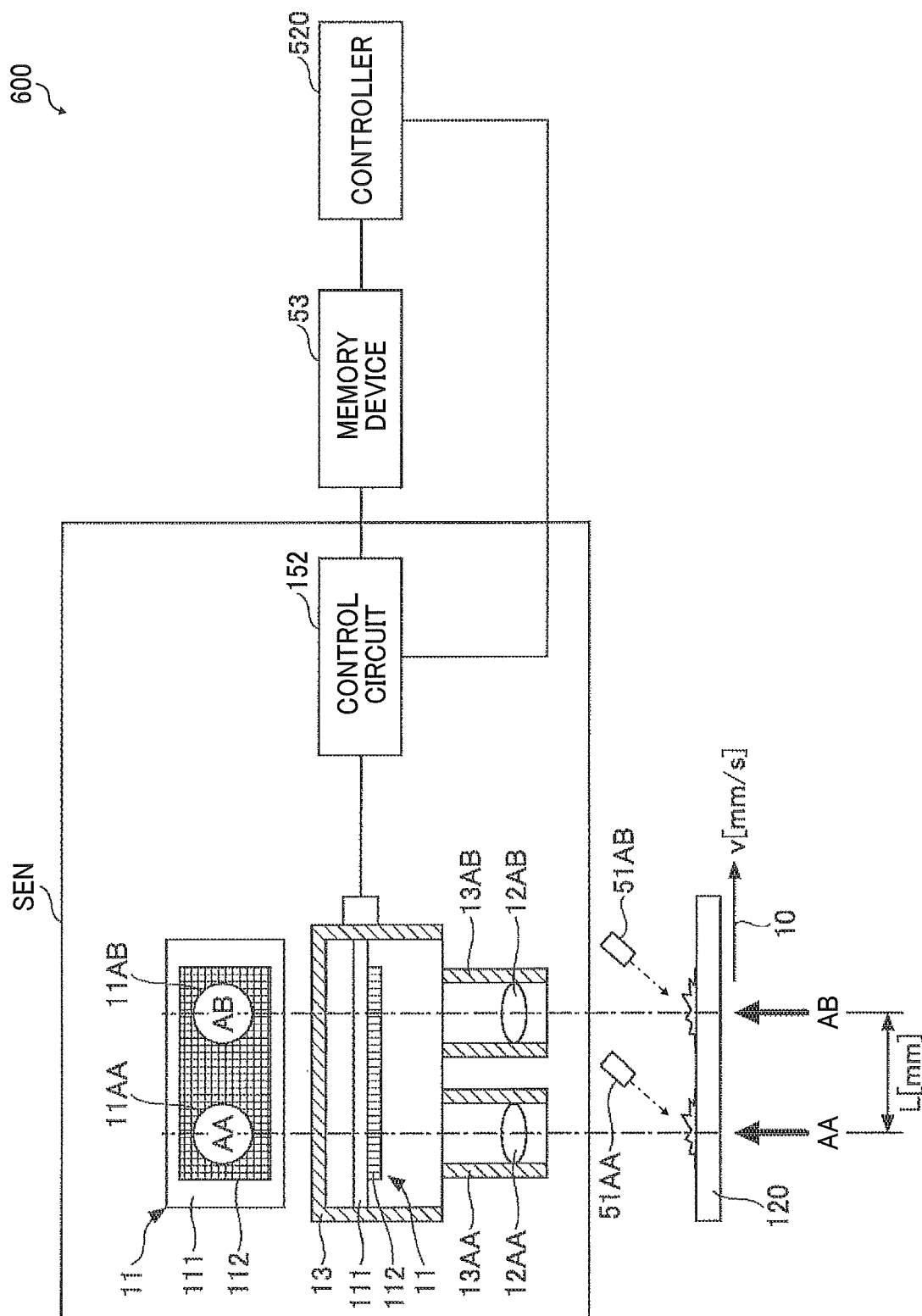


FIG. 20

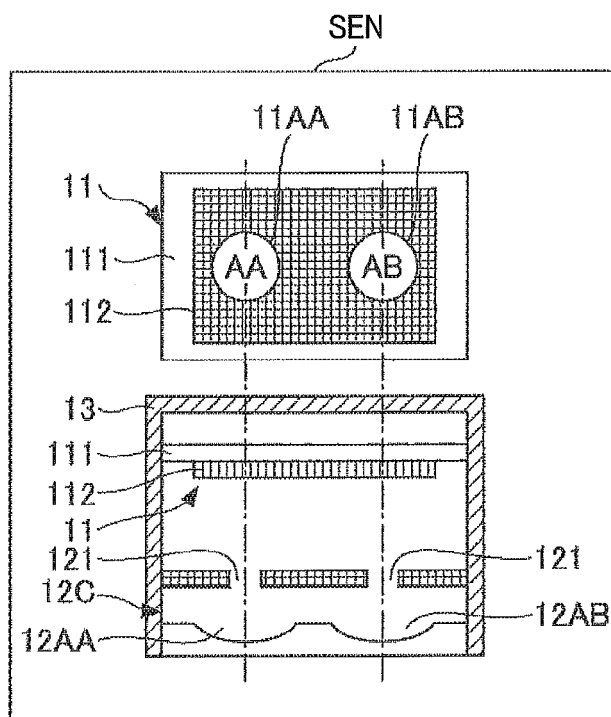


FIG. 21A

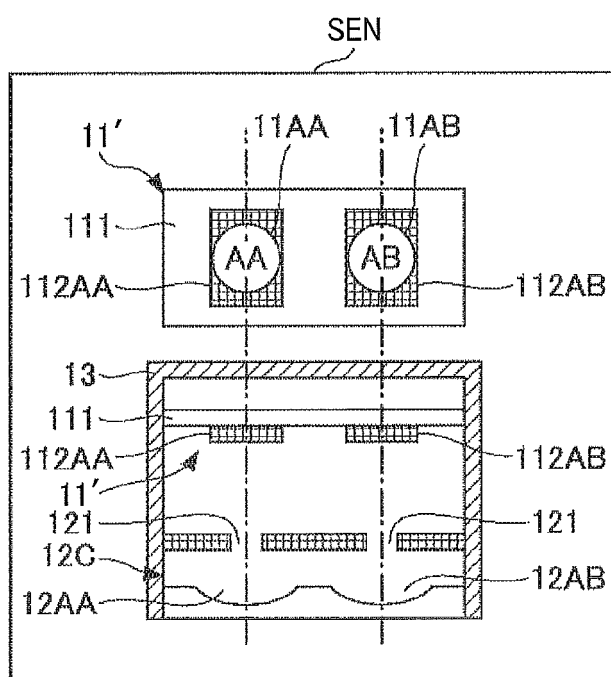


FIG. 21B

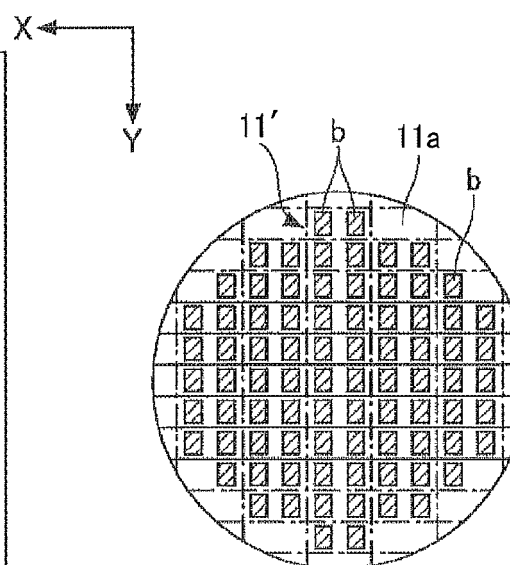


FIG. 22

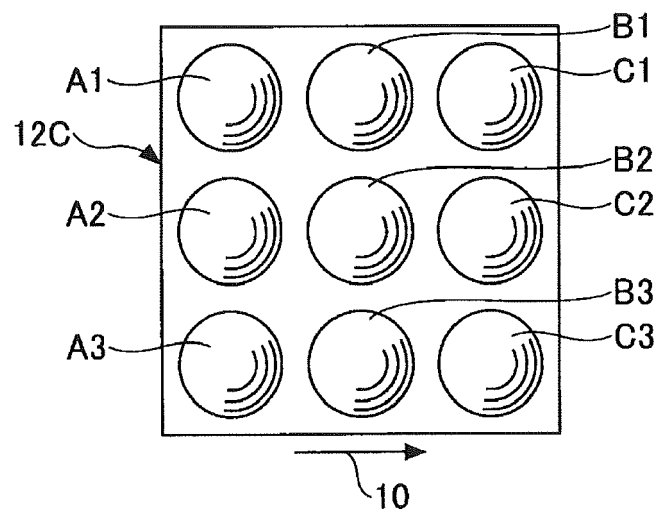
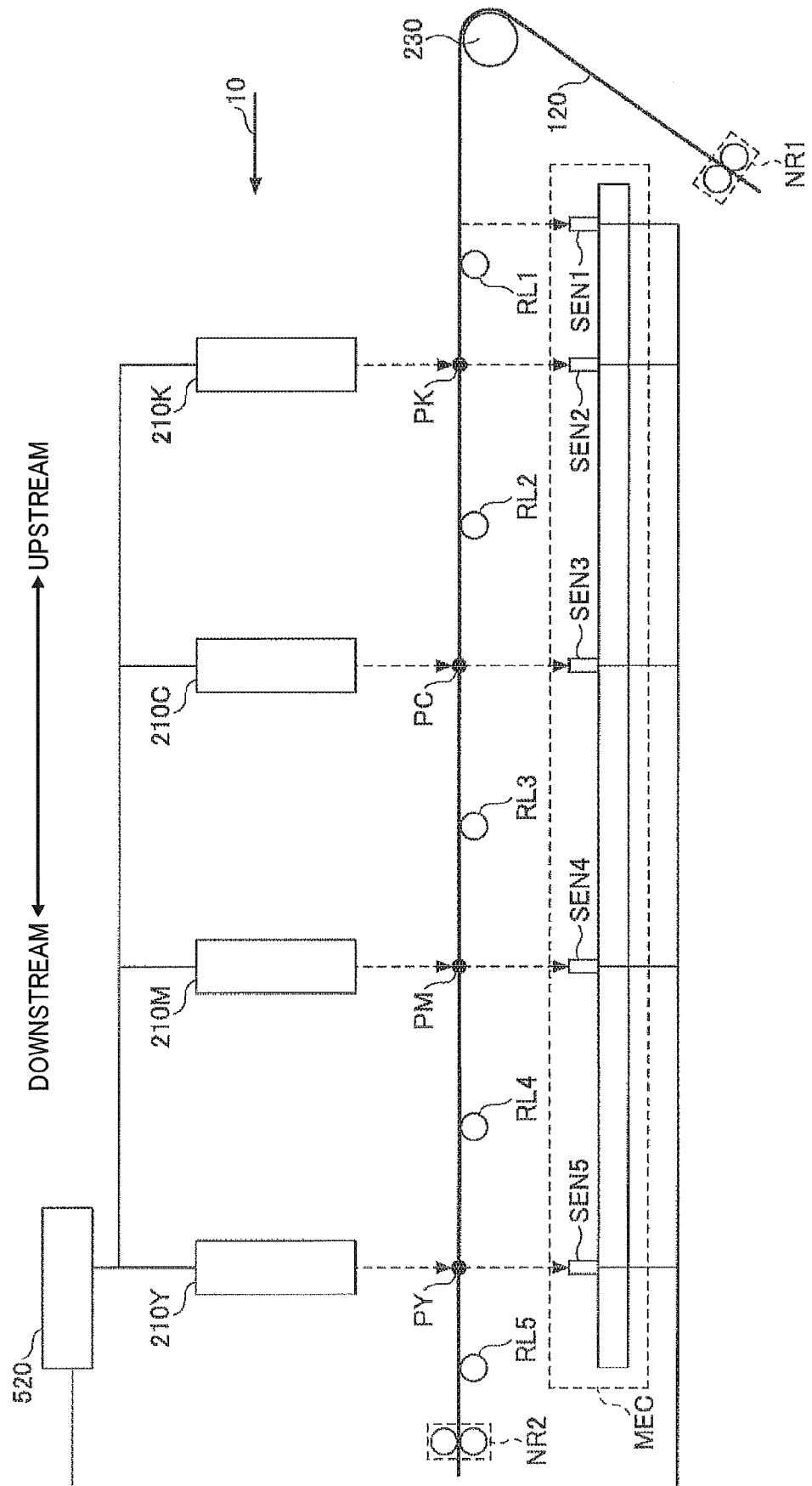


FIG. 23





EUROPEAN SEARCH REPORT

Application Number
EP 17 18 2996

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			B41J
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 17 November 2017	Examiner Wehr, Wolfhard
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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