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(54) **SWING CONTROLLER**

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(57) **ABSTRACT**

A swing controller includes a swing member including a swing shaft on which the swing member swings and a contact portion, and a torsion coil spring. The torsion coil spring includes a rotation support shaft on which the torsion coil spring rotates, a fixed first arm, and a second arm on which the contact portion slides. The rotation support shaft is at a position different from a position of the swing shaft. When the swing member swings in a predetermined direction, a reaction force in a direction opposite to the predetermined direction is applied to the swing member by a friction force between the contact portion and the second arm.

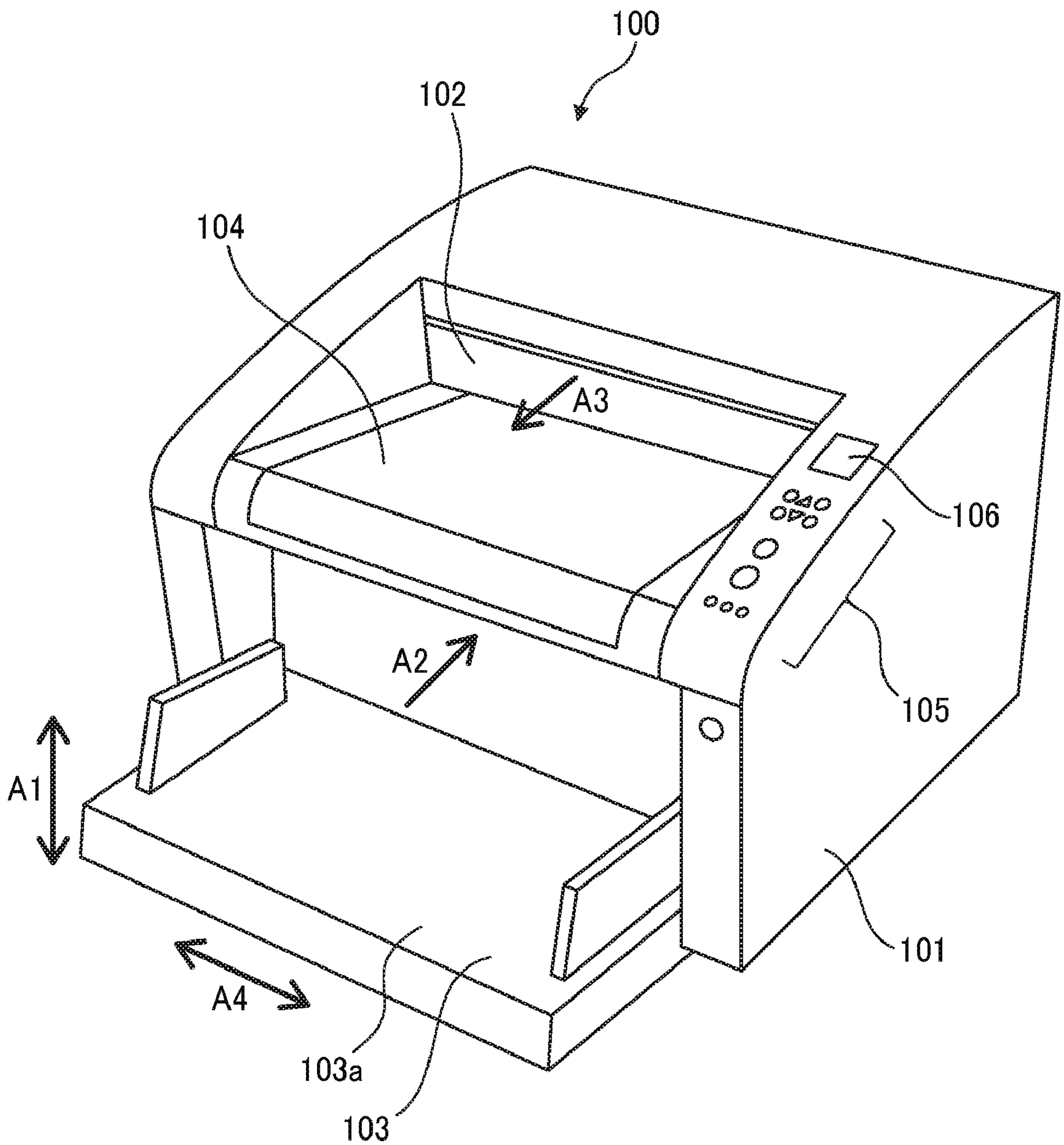


FIG. 1

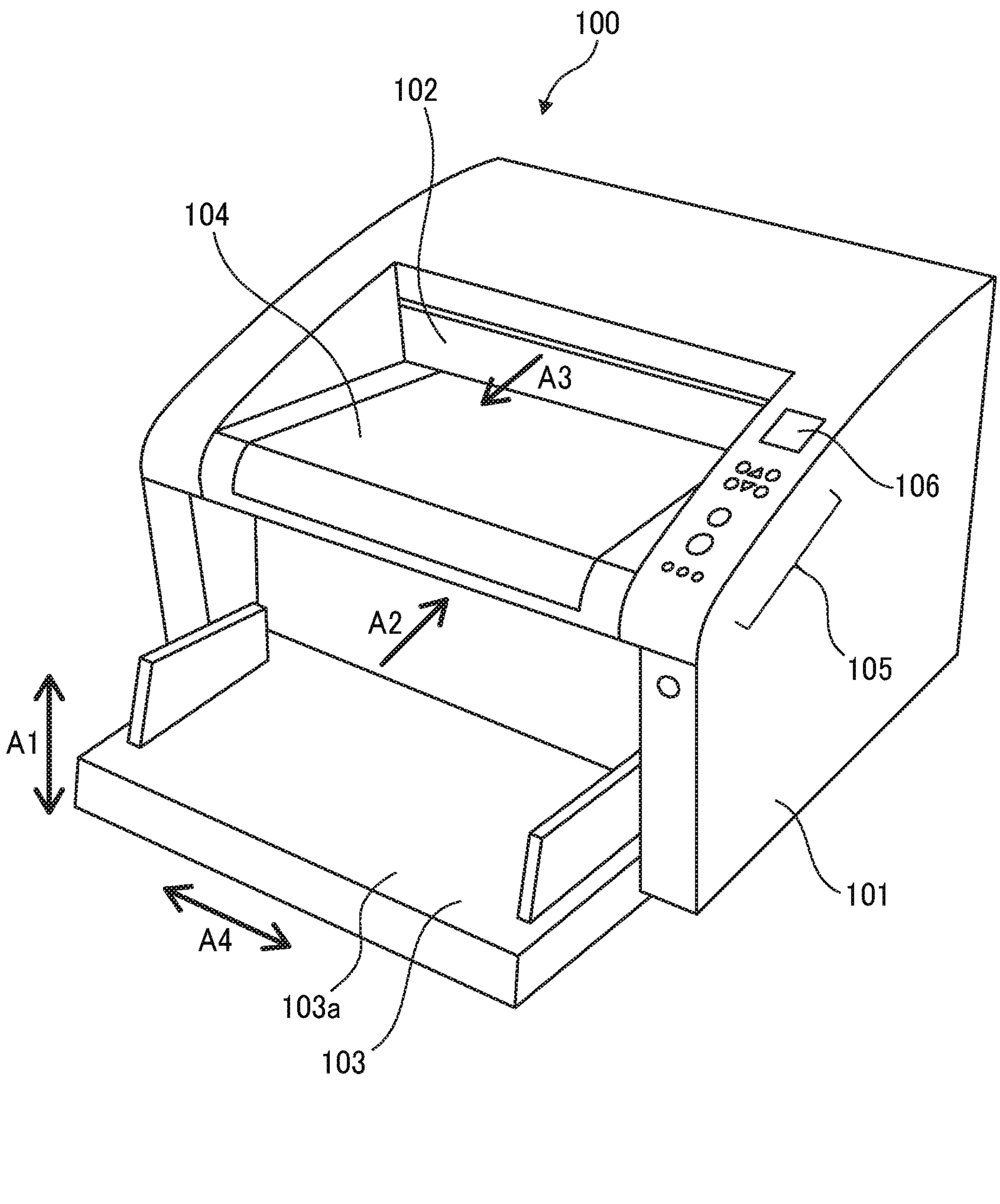


FIG. 2

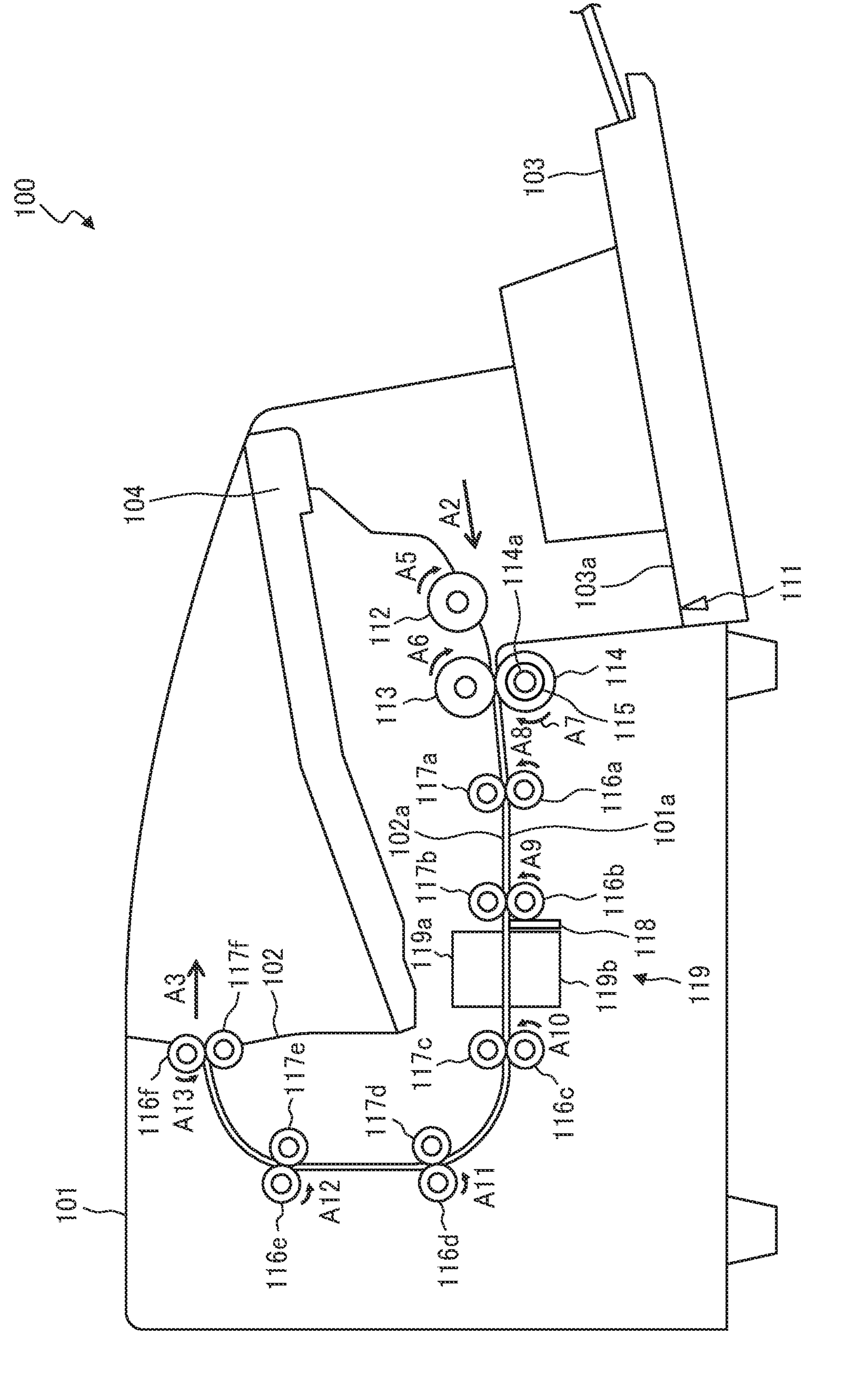

100
103
104
A2
A5
114a
103a
111
112
A6
113
114
115
A7
A8
117a
116a
102a
101a
117b
A9
116b
118
119a
119b
119
A3
117f
102
117e
116f
A13
117c
A10
116c
117d
A12
A11
116e
116d
101

FIG. 3

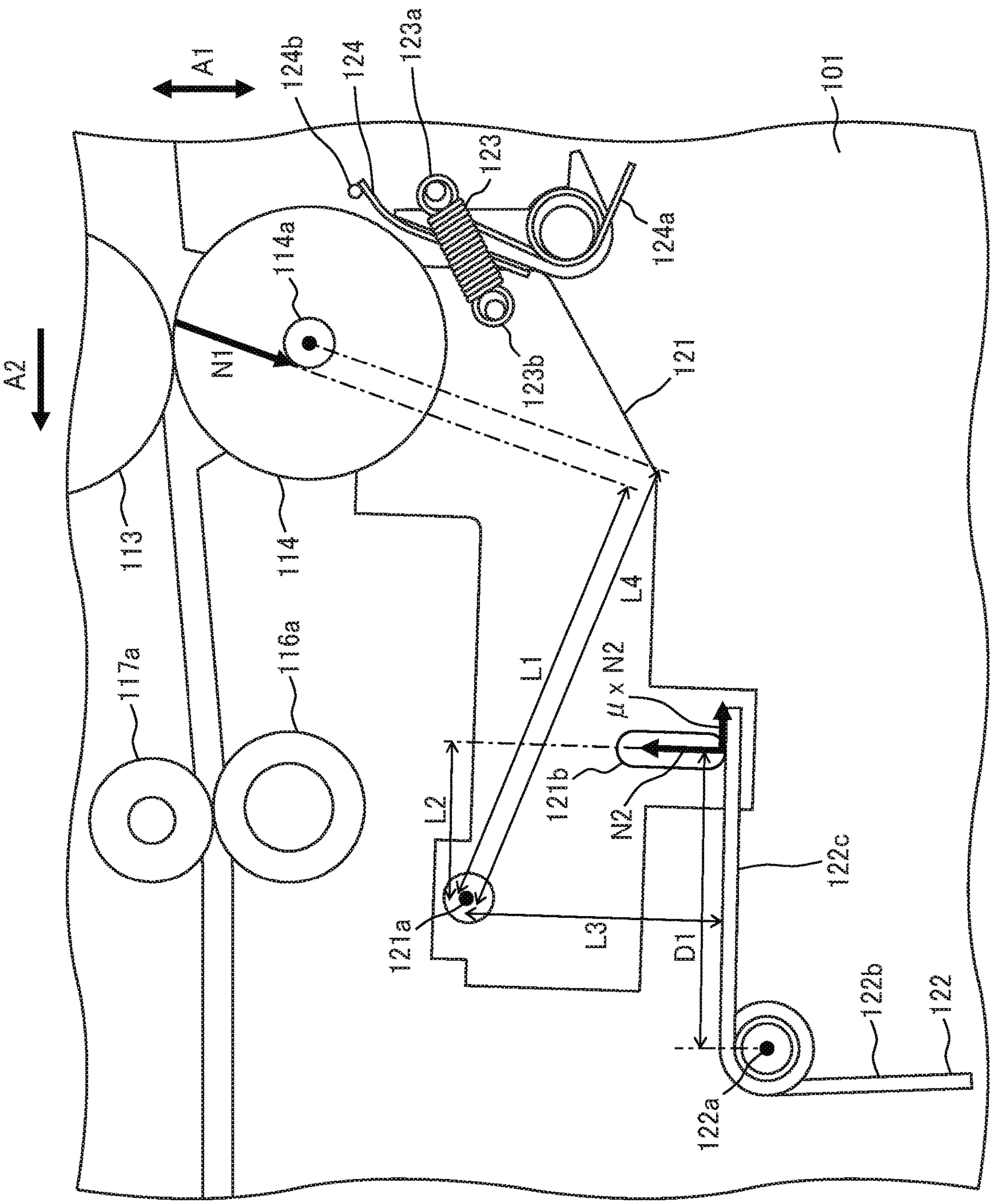

A1
A2
101
113
114
114a
116a
117a
121
121a
121b
122
122a
122b
122c
123
123a
123b
124
124a
124b
N1
N2
μ x N2
L1
L2
L3
L4
D1

FIG. 4

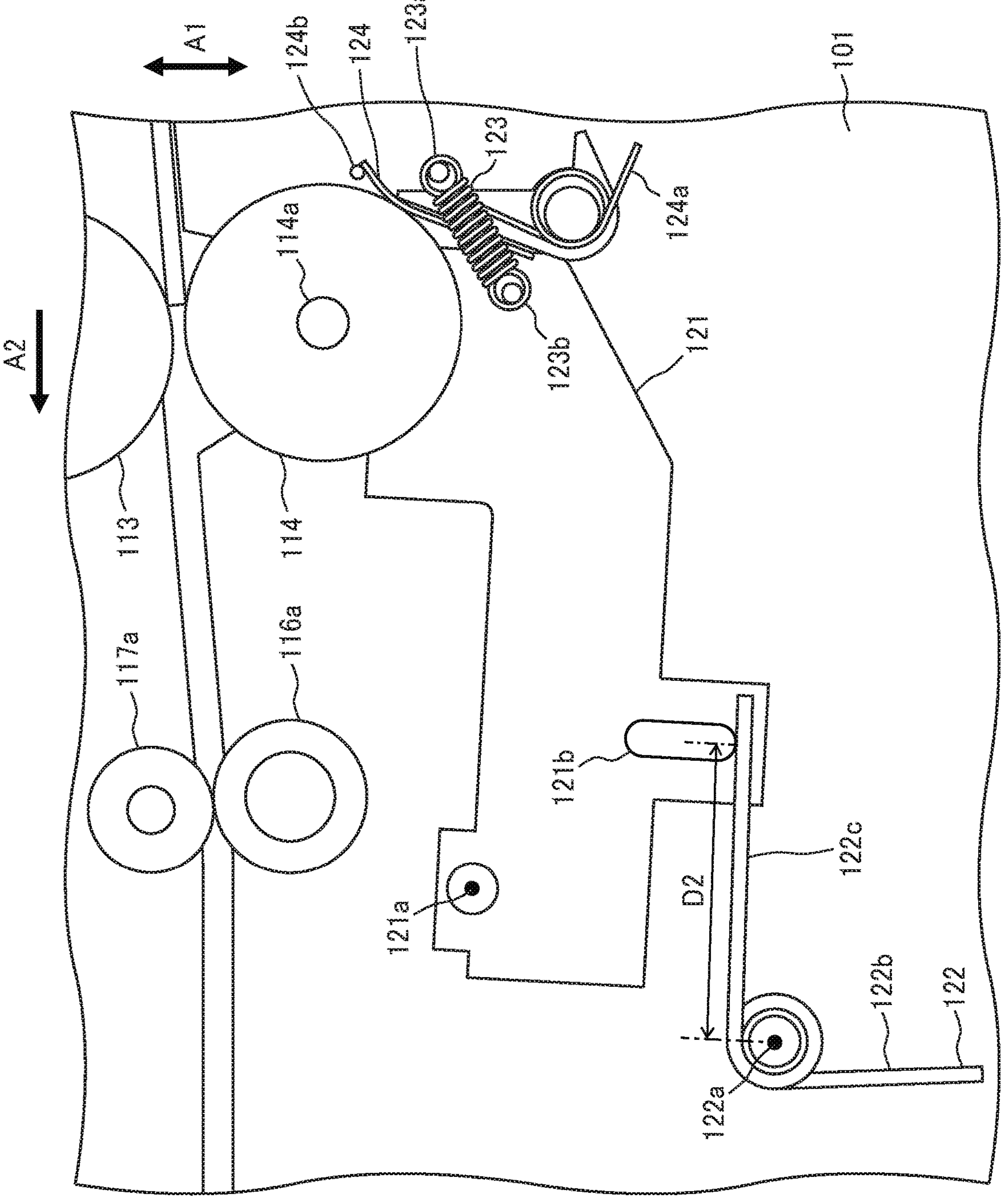

A1
A2
124b
124
123a
123
124a
101
114a
123b
121
113
114
116a
117a
121b
122c
D2
121a
122b
122
122a

FIG. 5

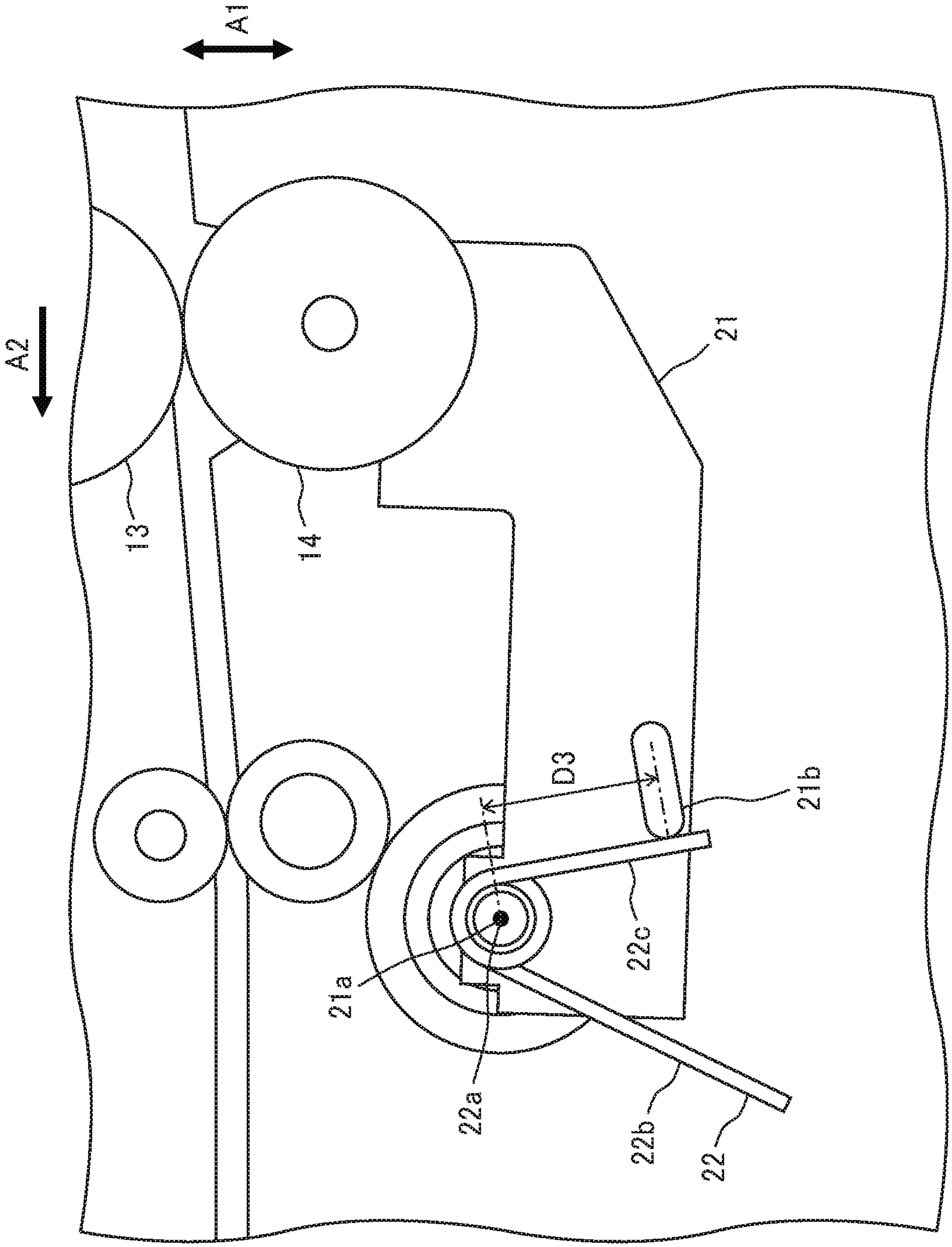


FIG. 6

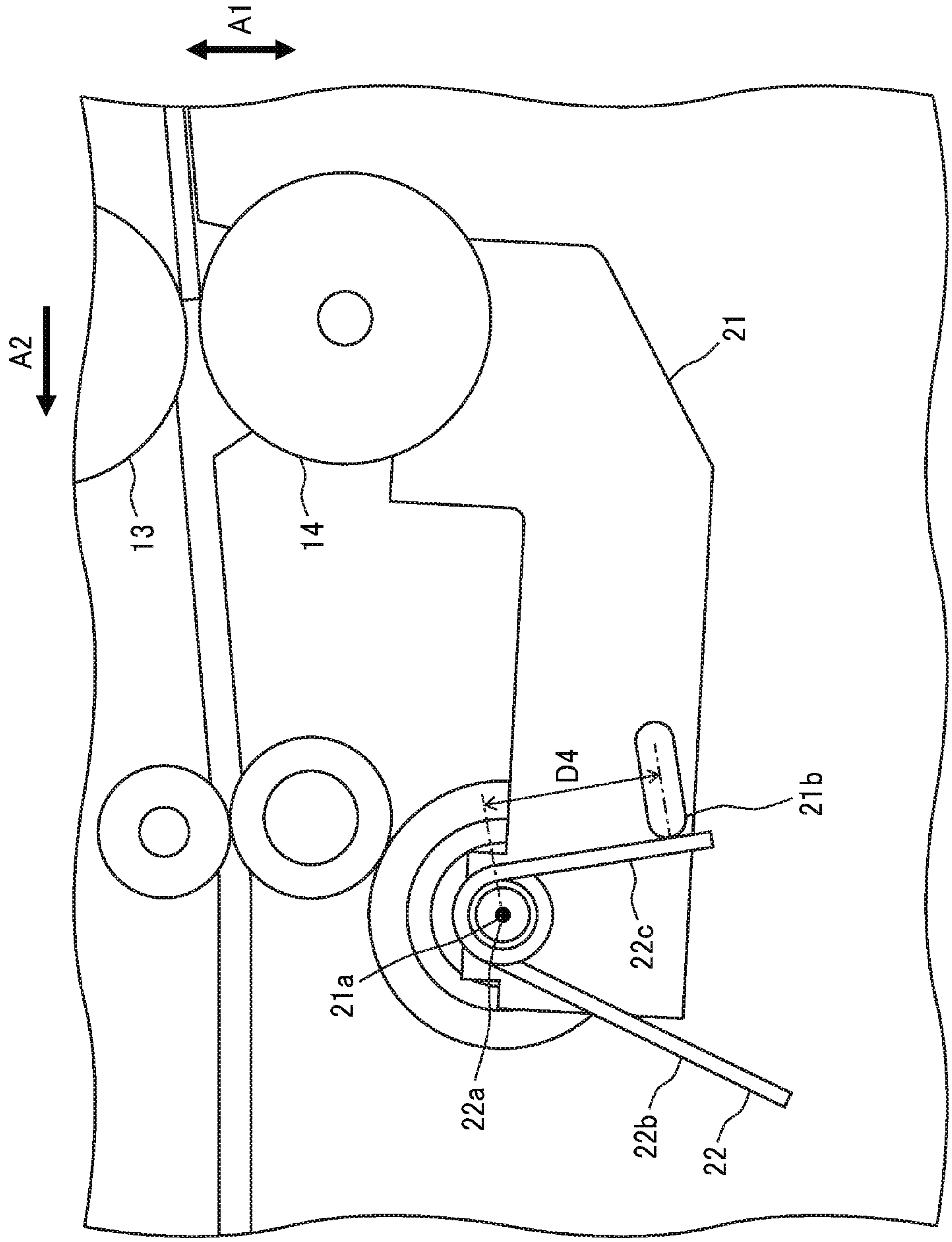


FIG. 7A

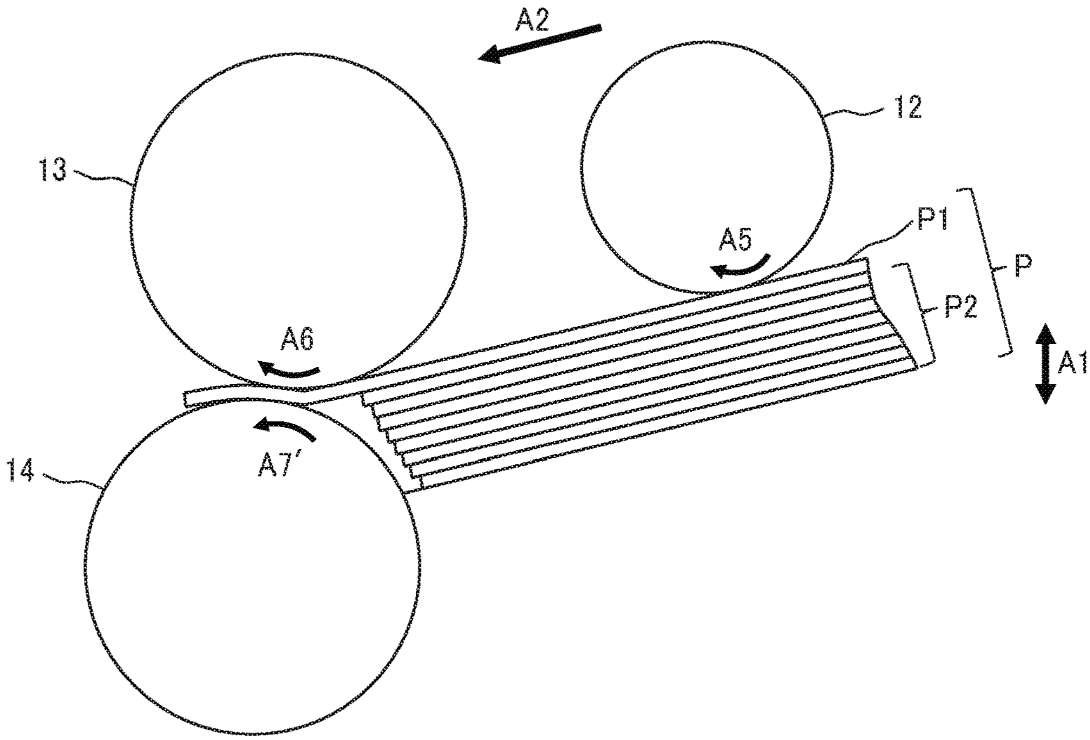


FIG. 7B

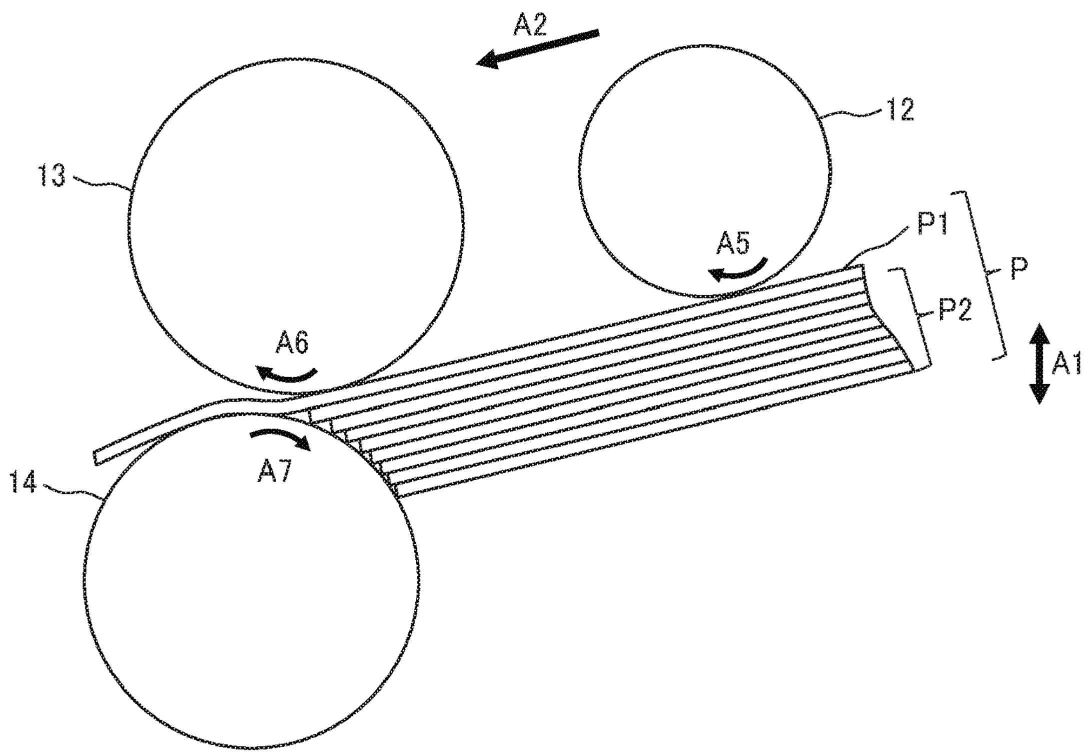


FIG. 8A

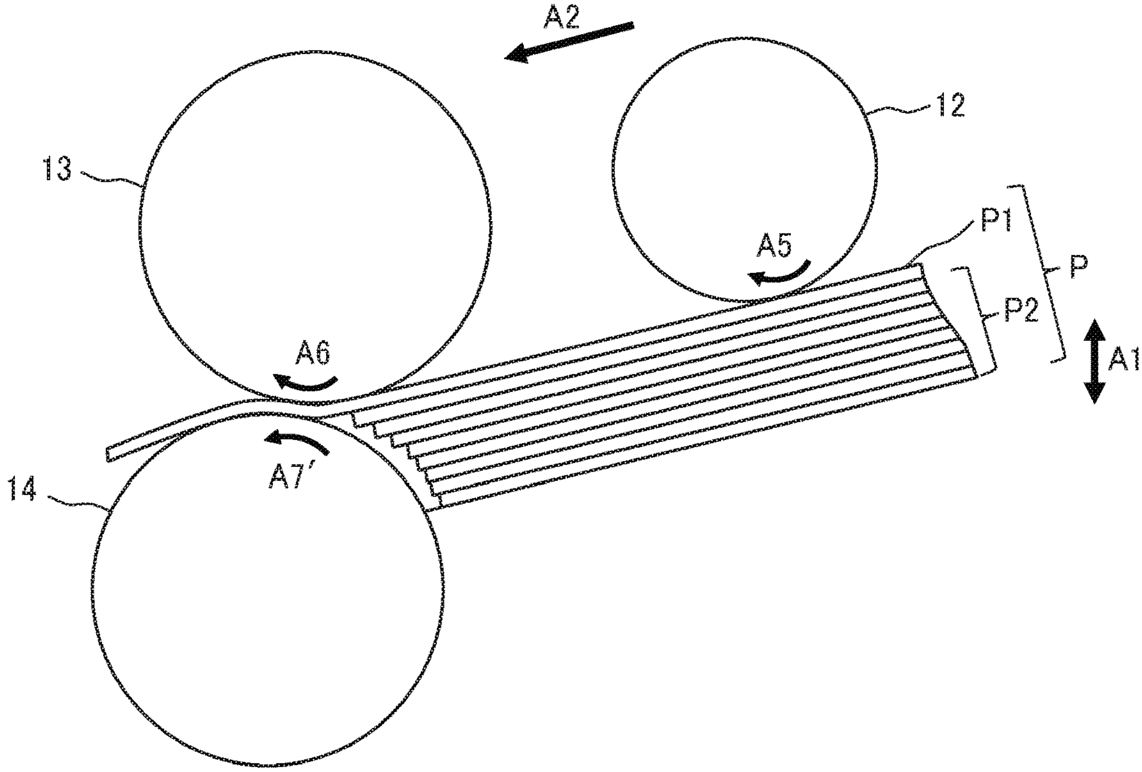


FIG. 8B

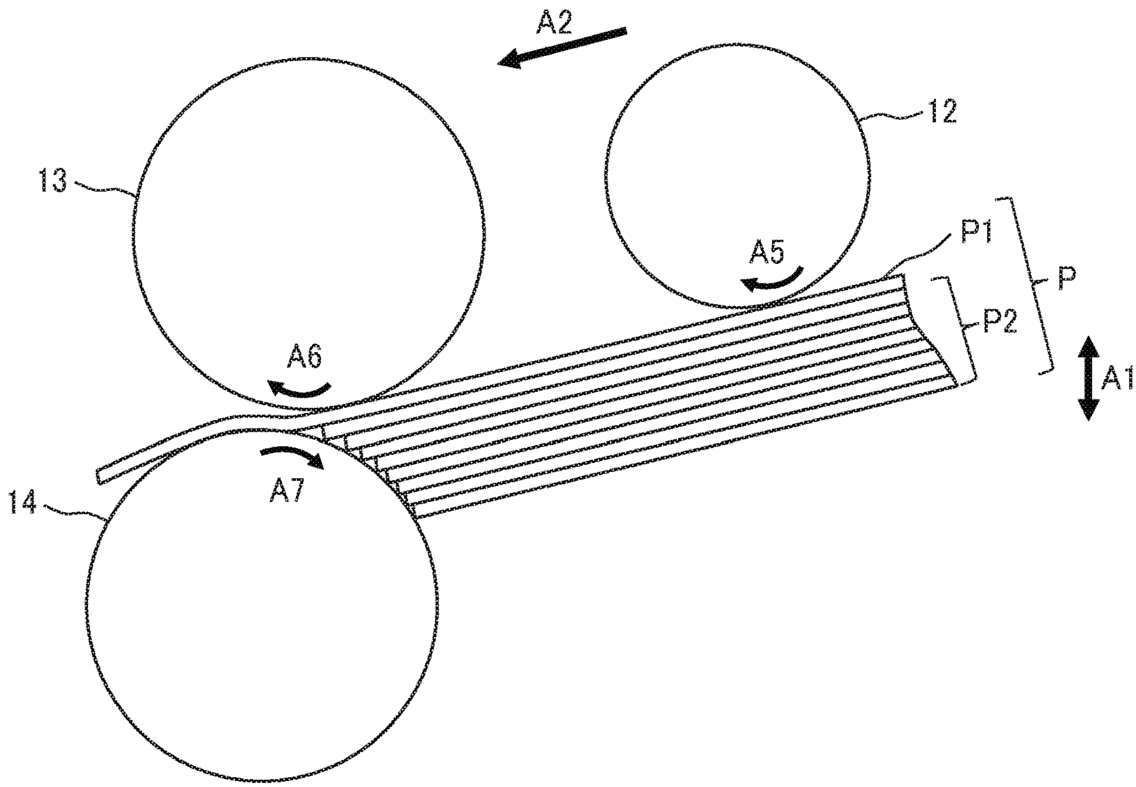


FIG. 9A

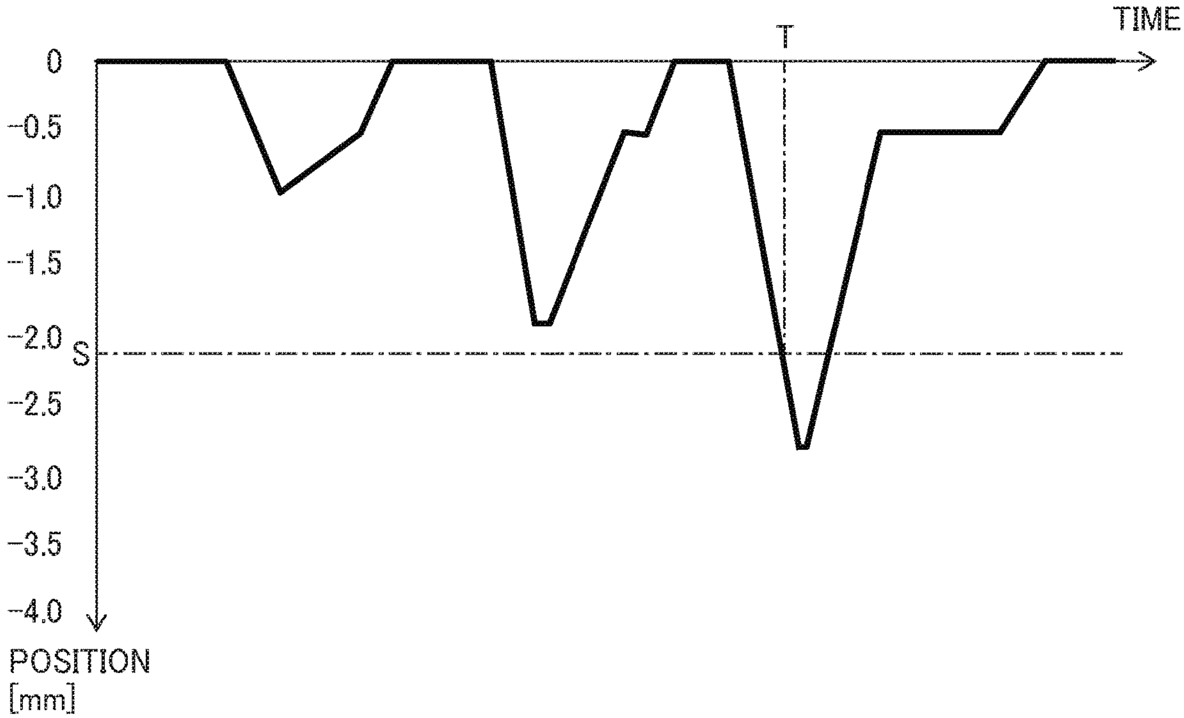

TIME
T
0
−0.5
−1.0
−1.5
−2.0
S
−2.5
−3.0
−3.5
−4.0
POSITION
[mm]

FIG. 9B

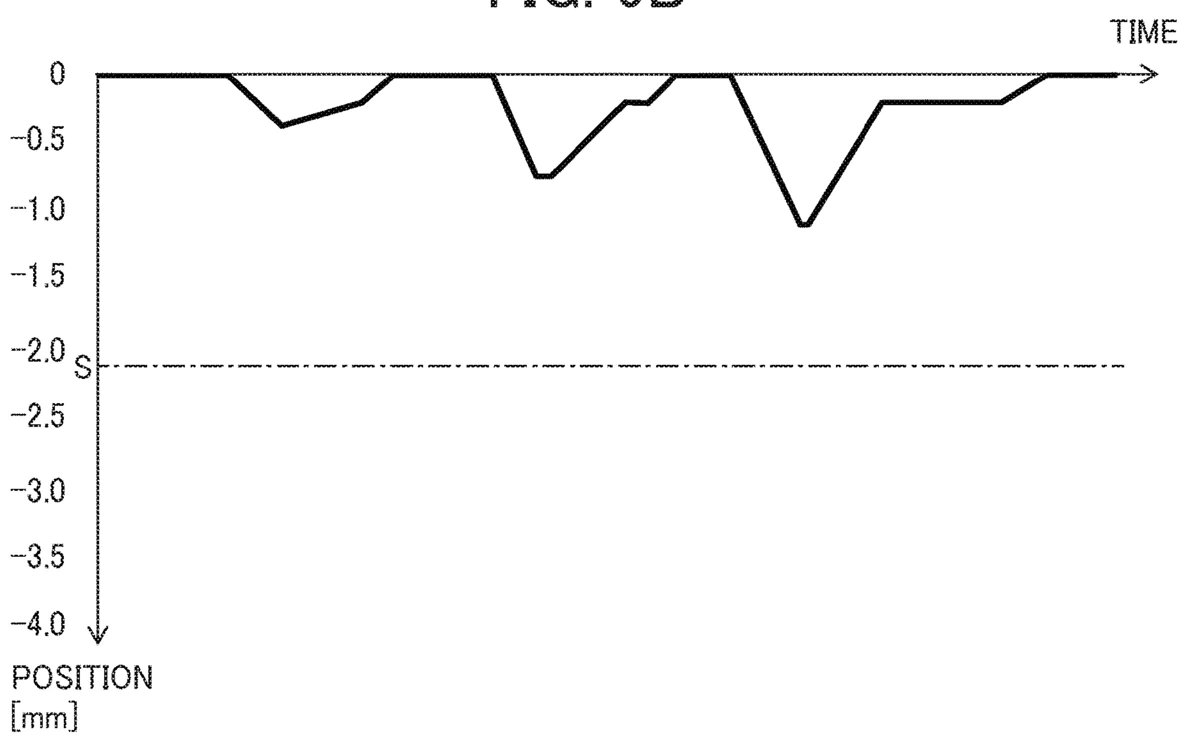

TIME
0
−0.5
−1.0
−1.5
−2.0
S
−2.5
−3.0
−3.5
−4.0
POSITION
[mm]

FIG. 10

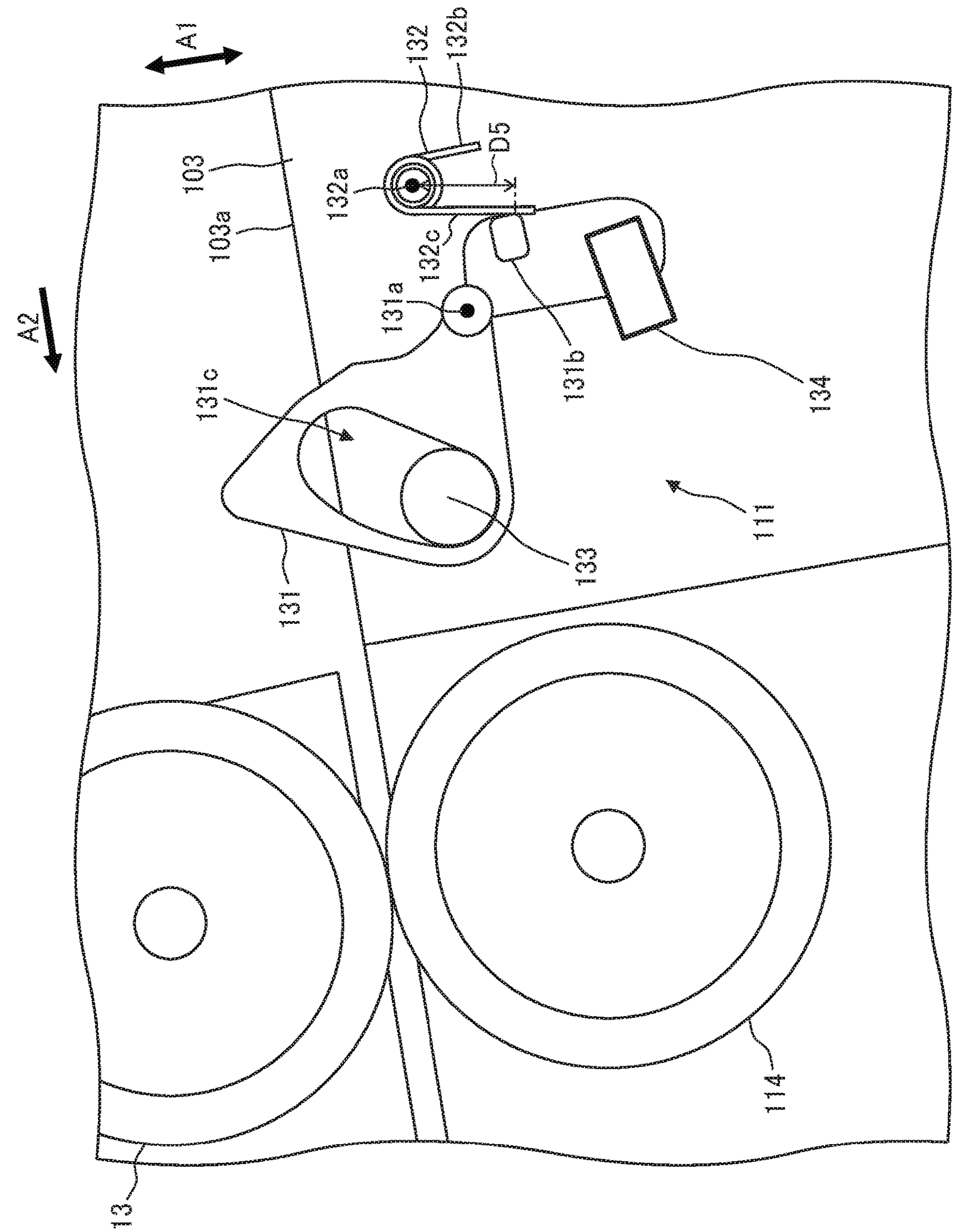

A1
A2
132
132b
D5
103
132a
103a
132c
131a
131b
134
131c
111
133
131
114
113

FIG. 11

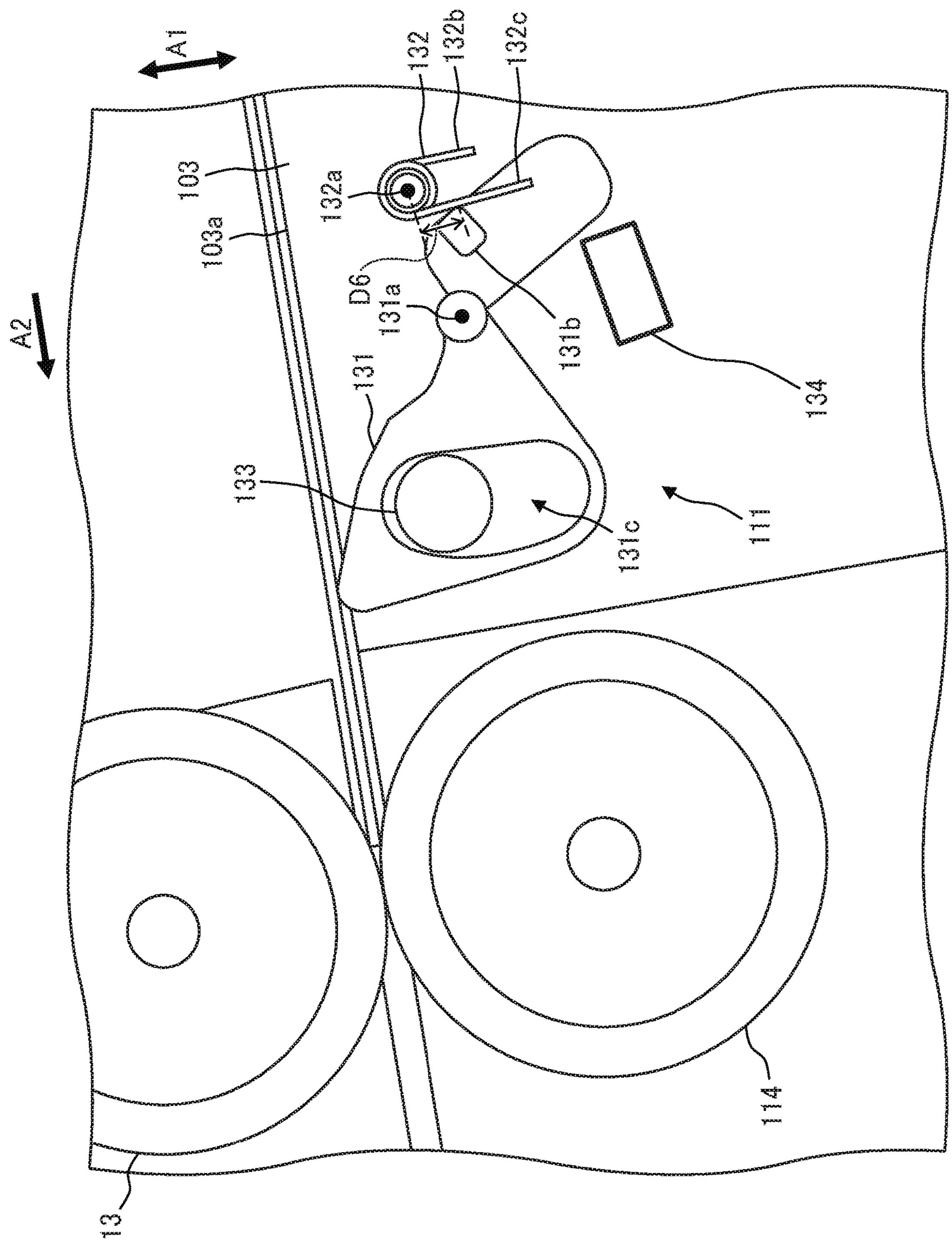

A1
A2
132
132b
132c
103
132a
103a
D6
131a
131b
134
131
133
131c
111
114
113

FIG. 12

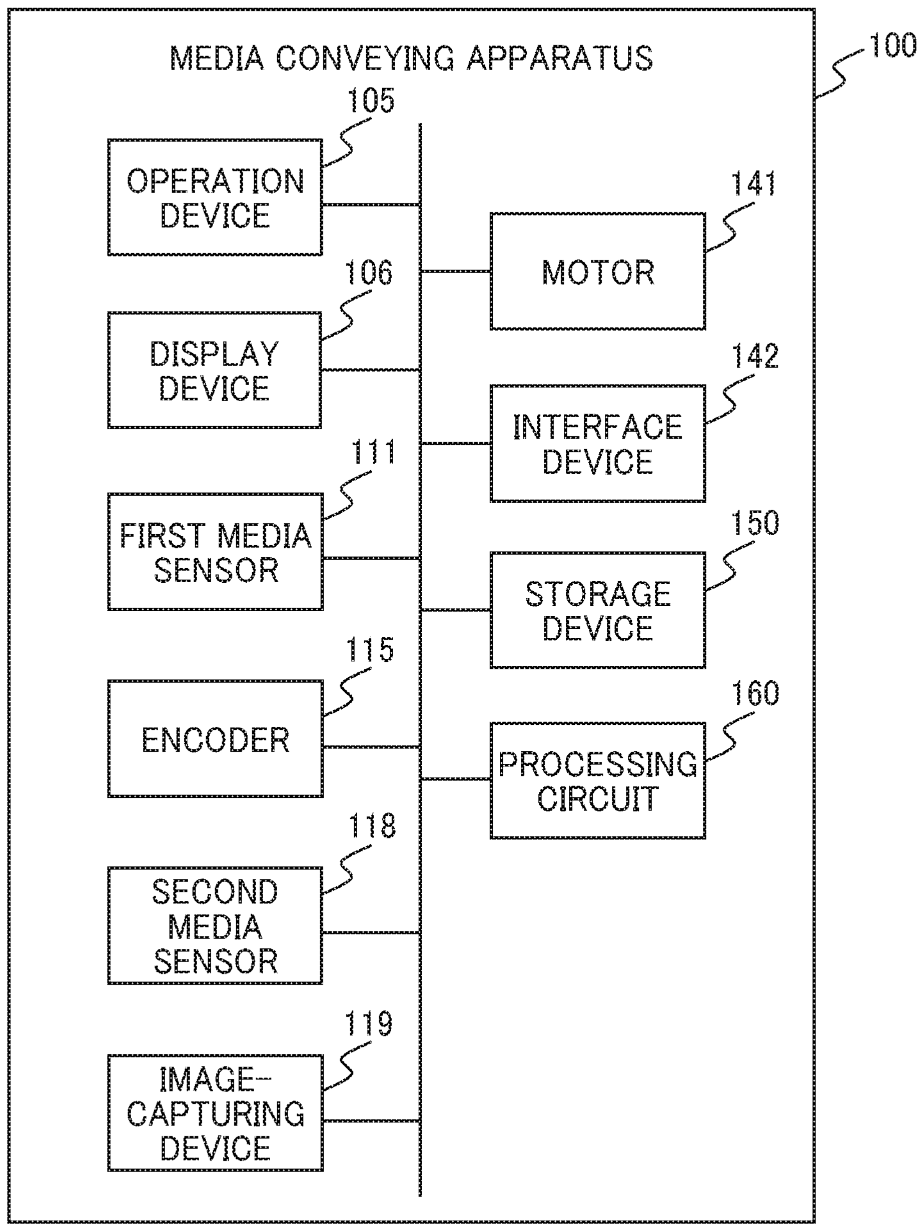

MEDIA CONVEYING APPARATUS
100
105
OPERATION DEVICE
106
DISPLAY DEVICE
111
FIRST MEDIA SENSOR
115
ENCODER
118
SECOND MEDIA SENSOR
119
IMAGE-CAPTURING DEVICE
141
MOTOR
142
INTERFACE DEVICE
150
STORAGE DEVICE
160
PROCESSING CIRCUIT

FIG. 13

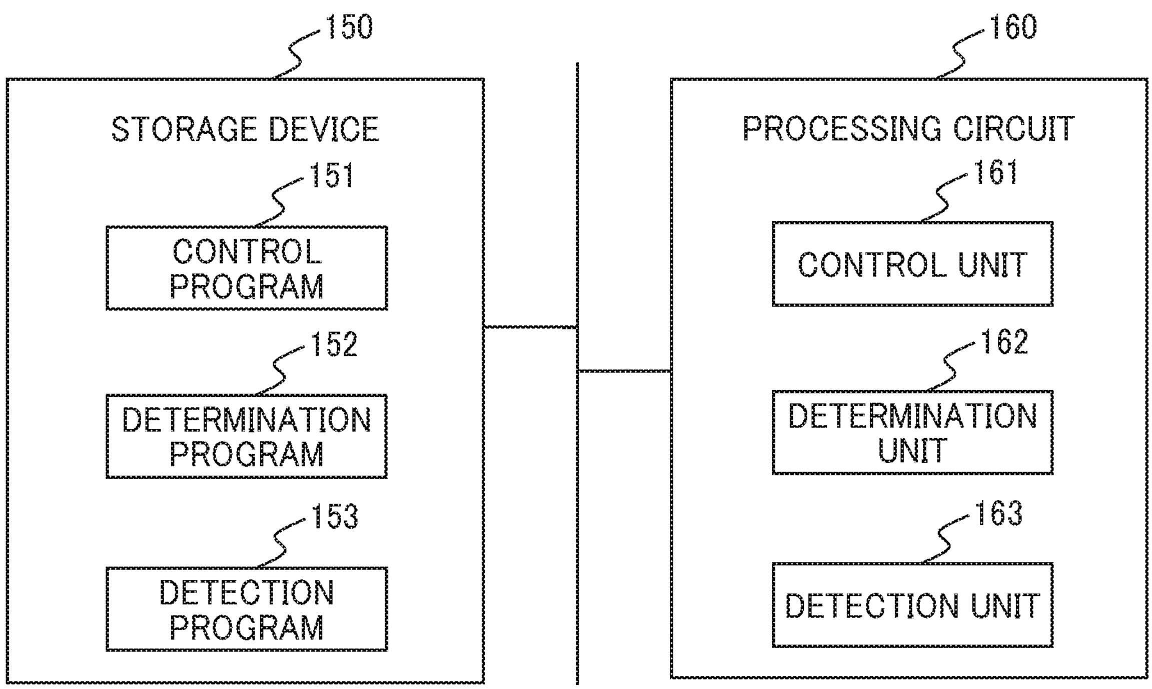

150
STORAGE DEVICE
151
CONTROL PROGRAM
152
DETERMINATION PROGRAM
153
DETECTION PROGRAM
160
PROCESSING CIRCUIT
161
CONTROL UNIT
162
DETERMINATION UNIT
163
DETECTION UNIT

FIG. 14

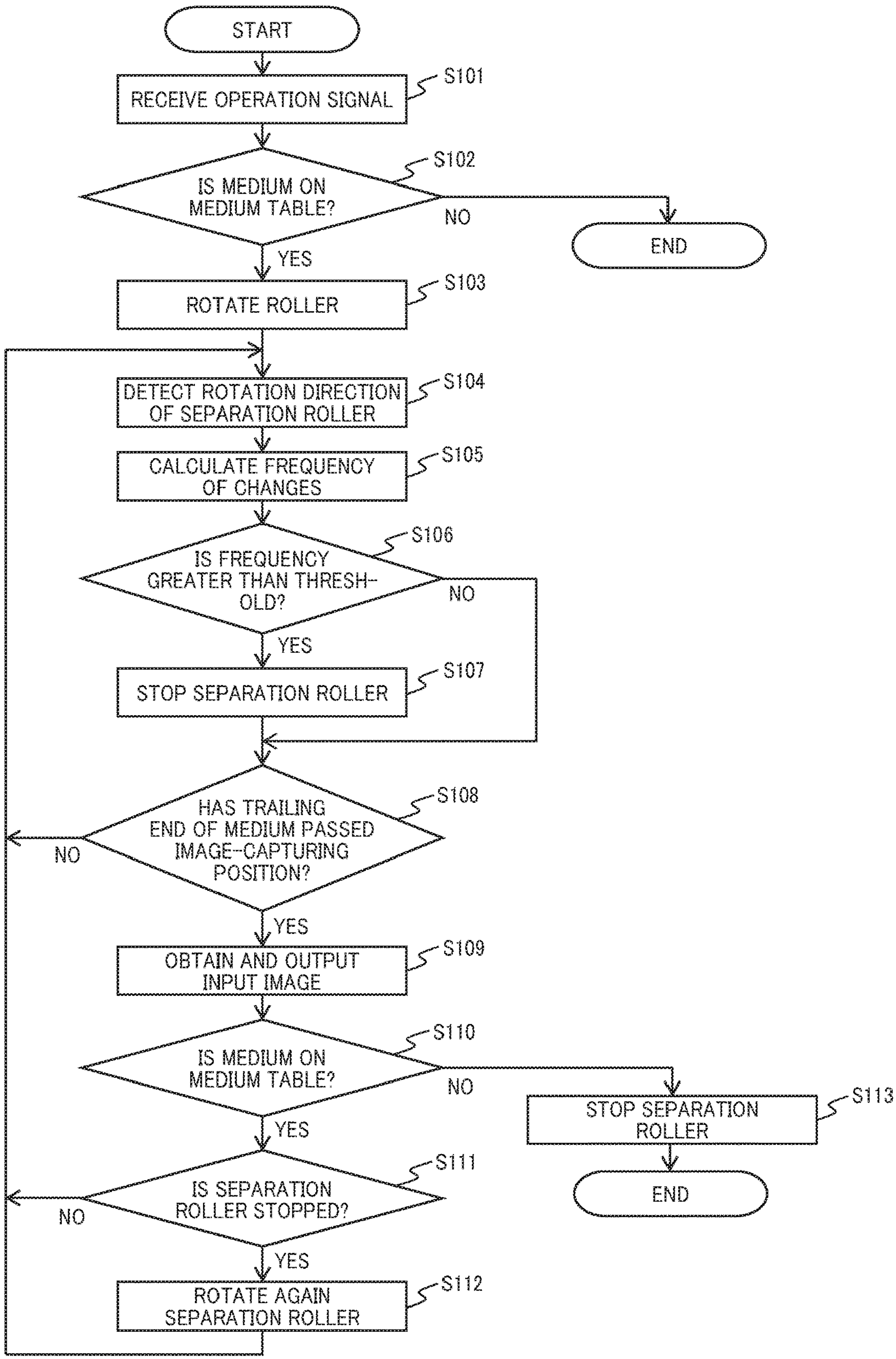
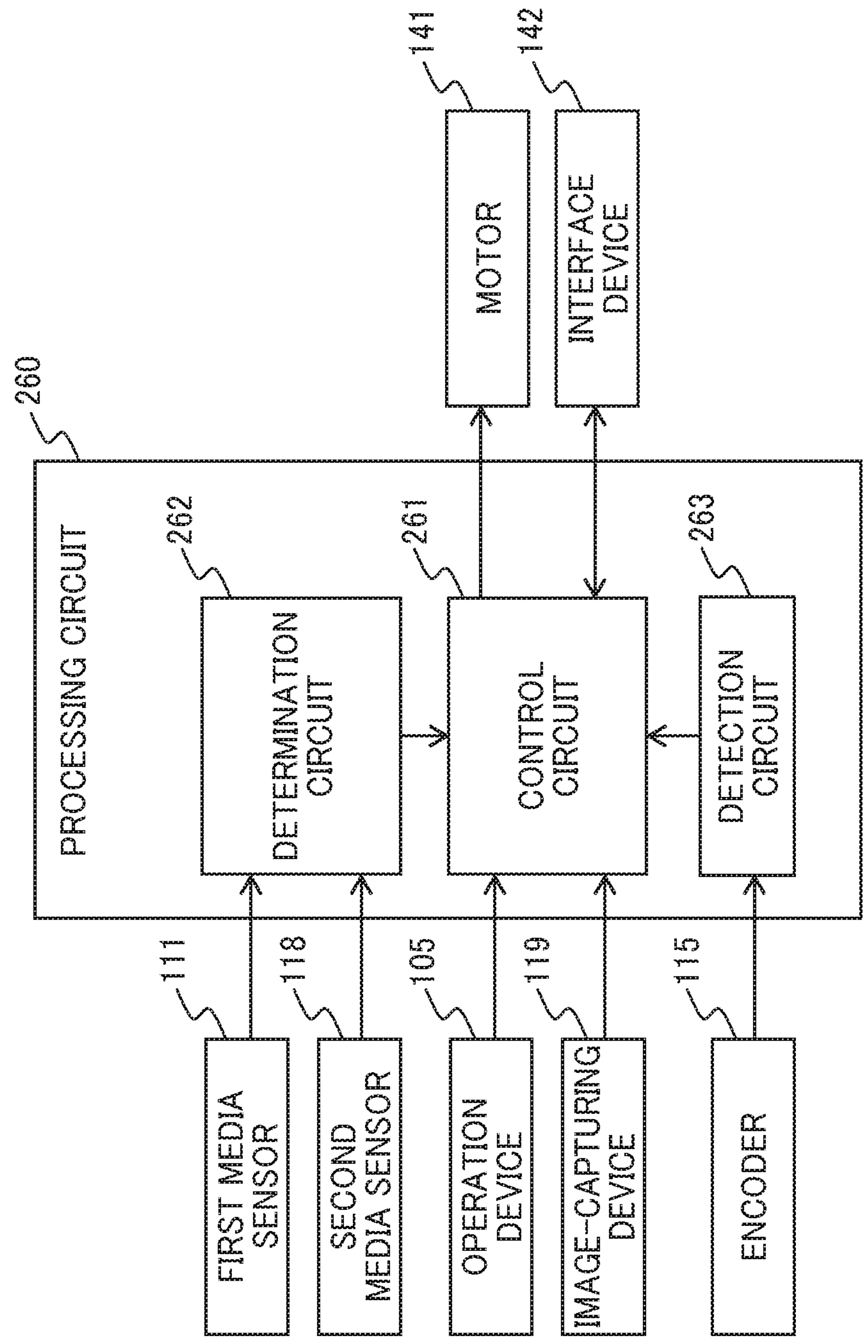

START
RECEIVE OPERATION SIGNAL
S101
IS MEDIUM ON MEDIUM TABLE?
S102
NO
END
YES
ROTATE ROLLER
S103
DETECT ROTATION DIRECTION OF SEPARATION ROLLER
S104
CALCULATE FREQUENCY OF CHANGES
S105
IS FREQUENCY GREATER THAN THRESH-OLD?
S106
NO
YES
STOP SEPARATION ROLLER
S107
HAS TRAILING END OF MEDIUM PASSED IMAGE-CAPTURING POSITION?
S108
NO
YES
OBTAIN AND OUTPUT INPUT IMAGE
S109
IS MEDIUM ON MEDIUM TABLE?
S110
NO
STOP SEPARATION ROLLER
S113
END
YES
IS SEPARATION ROLLER STOPPED?
S111
NO
YES
ROTATE AGAIN SEPARATION ROLLER
S112

FIG. 15


260
PROCESSING CIRCUIT
262
DETERMINATION CIRCUIT
261
CONTROL CIRCUIT
263
DETECTION CIRCUIT
141
MOTOR
142
INTERFACE DEVICE
111
FIRST MEDIA SENSOR
118
SECOND MEDIA SENSOR
105
OPERATION DEVICE
119
IMAGE-CAPTURING DEVICE
115
ENCODER

SWING CONTROLLER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application is based on and claims priority pursuant to 35 U.S.C. § 119(a) to Japanese Patent Application No. 2023-013130, filed on Jan. 31, 2023, in the Japan Patent Office, the entire disclosure of which is hereby incorporated by reference herein.

BACKGROUND

Technical Field

[0002] Embodiments of the present disclosure relate to a swing controller.

Related Art

[0003] In the related art, apparatuses such as scanners that include a feed roller and a separation roller to feed multiple recording media placed on a table (i.e., a sheet table) while separating the media have been used. In some of such apparatuses, the separation roller is swingably supported to enable the feeding of media of various thicknesses. Further, in order to determine whether a medium is placed on the media table, some of such apparatuses include an arm that pivots or swings depending on the presence of the medium. These apparatuses perform a control operation to allow components such as the separation roller or the arm to swing appropriately.

[0004] For example, a sheet conveying apparatus including a separation roller attached to a separation roller shaft is known in the art. Such a sheet conveying apparatus known in the art includes, for example, an arm member that holds the separation roller shaft, an intermediate shaft that holds the arm member swingably, a coil spring that biases the arm member in the direction of the axis of the swing, and a regulating portion to regulate the position of the arm member biased by the coil spring.

SUMMARY

[0005] According to an embodiment of the present disclosure, a swing controller includes a swing member including a swing shaft on which the swing member swings and a contact portion, and a torsion coil spring. The torsion coil spring includes a rotation support shaft on which the torsion coil spring rotates, a fixed first arm; and a second arm on which the contact portion slides. The rotation support shaft is at a position different from a position of the swing shaft. When the swing member swings in a predetermined direction, a reaction force in a direction opposite to the predetermined direction is applied to the swing member by a friction force between the contact portion and the second arm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] A more complete appreciation of embodiments of the present disclosure and many of the attendant advantages and features thereof can be readily obtained and understood from the following detailed description with reference to the accompanying drawings, wherein:

[0007] FIG. **1** is a perspective view of a media conveying apparatus according to one embodiment of the present disclosure;

[0008] FIG. **2** is a diagram illustrating a conveyance passage inside the media conveying apparatus illustrated in FIG. **1**;

[0009] FIG. **3** is a schematic diagram used for explaining a separation roller of the media conveying apparatus illustrated in FIG. **1**;

[0010] FIG. **4** is another schematic diagram for explaining the separation roller of the media conveying apparatus illustrated in FIG. **1**;

[0011] FIG. **5** is a schematic diagram illustrating a media conveying apparatus according to a comparative example;

[0012] FIG. **6** is another schematic diagram illustrating the media conveying apparatus according to the comparative example;

[0013] FIGS. **7**A and **7**B are schematic diagrams each illustrating the feeding of media by the media conveying apparatus illustrated in FIGS. **5** and **6**;

[0014] FIGS. **8**A and **8**B are schematic diagrams each illustrating the feeding of media by the media conveying apparatus illustrated in FIGS. **5** and **6**;

[0015] FIG. **9**A is a graph illustrating an example of changes in position of a separation roller in the media conveying apparatus illustrated in FIGS. **5** and **6**;

[0016] FIG. **9**B is a graph illustrating changes in position of the separation roller in the media conveying apparatus illustrated in FIG. **1**, according to one embodiment of the present disclosure;

[0017] FIG. **10** is a schematic diagram schematic diagram used for explaining a first media sensor of the media conveying apparatus illustrated in FIG. **1**;

[0018] FIG. **11** is another schematic diagram used for explaining a first media sensor of the media conveying apparatus illustrated in FIG. **1**;

[0019] FIG. **12** is a block diagram illustrating a schematic configuration of the media conveying apparatus of FIG. **1**;

[0020] FIG. **13** is a block diagram illustrating a schematic configuration of a storage device and a processing circuit of the media conveying apparatus of FIG. **1**;

[0021] FIG. **14** is a flowchart of a medium reading process according to an embodiment of the present disclosure; and

[0022] FIG. **15** is a schematic block diagram illustrating a configuration of a processing circuit according to another embodiment of the present disclosure.

[0023] The accompanying drawings are intended to depict embodiments of the present disclosure 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. Also, identical or similar reference numerals designate identical or similar components throughout the several views.

DETAILED DESCRIPTION

[0024] In describing embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this 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 have a similar function, operate in a similar manner, and achieve a similar result.

[0025] Referring now to the drawings, embodiments of the present disclosure are described below. 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.

[0026] A description is given below of a swing controller according to an embodiment of the present disclosure, with reference to the drawings. The technical scope of the present disclosure, however, is not limited to the embodiments described below but includes the scope of the appended claims and the equivalents thereof.

[0027] FIG. **1** is a perspective view of a media conveying apparatus **100**, which is an image scanner, according to an embodiment of the present disclosure.

[0028] The media conveying apparatus **100** serves as a swing controller. The media conveying apparatus **100** conveys media that are documents and captures images of the media. The media are, for example, sheets of plain paper, sheets of thick paper, or cards. Alternatively, the media conveying apparatus **100** may be, for example, a facsimile machine, a copier, or a multifunction peripheral (MFP). An MFP may be also called a multifunction printer. The media to be conveyed may be, for example, printing material (e.g., paper sheets) instead of documents. In this case, the media conveying apparatus **100** may be, for example, a printer.

[0029] In FIG. **1**, arrow A**1** indicates the substantially vertical direction (may be referred to as the height direction A**1** in the following direction), and arrow A**2** indicates the direction in which media are conveyed (may be referred to as the media conveyance direction A**2** in the following description). Further, arrow A**3** indicates the direction in which the media are ejected (may be referred to as the medium ejection direction A**3** in the following description), and arrow A**4** indicates the width direction of the media conveying apparatus **100** (may be referred to as the width direction A**4** in the following description) orthogonal to the media conveyance direction A**2** or the media ejection direction A**3**. In the following description, “upstream” refers to “upstream” in the media conveyance direction A**2** or the media ejection direction A**3**, and “downstream” refers to “downstream” in the media conveyance direction A**2** or the media ejection direction A**3**.

[0030] The media conveying apparatus **100** includes a first housing **101**, a second housing **102**, a media table **103**, an output table **104**, an operation device **105**, and a display device **106**.

[0031] The second housing **102** is disposed inside the first housing **101**. The second housing **102** is rotatably hinged to the first housing **101** to open and close for removing a jammed medium or cleaning the inside of the media conveying apparatus **100**.

[0032] The media table **103** has a table face **103***a* and is engaged with the first housing **101** such that the media to be conveyed can be placed on the table face **103***a*. The media table **103** is disposed on a side of the first housing **101** from which the media are fed into the first housing **101**. The media table **103** is movable in the height direction A**1**. When no media are conveyed, the media table **103** is positioned at the lower end of the movable range to facilitate the placement of media thereon. When a medium is conveyed, the media table **103** is raised to the position at which the medium on the top of the media table **103** contacts a pick roller described later. The output table **104** is formed on the second housing **102**. The output table **104** receives the media ejected from the ejection ports of the first housing **101** and the second housing **102**.

[0033] The operation device **105** includes an input device such as buttons and an interface circuit that receives signals from the input device. The operation device **105** receives an input operation performed by a user and outputs an operation signal corresponding to the input operation performed by the user. The display device **106** includes a display and an interface circuit that outputs image data to the display and displays the image data on the display. Examples of the display include a liquid crystal and an organic electroluminescence (EL). The display device **106** may be a liquid crystal display with a touch panel function. In this case, the operation device **105** includes an interface circuit that receives input signals from the touch panel.

[0034] FIG. **2** is a diagram illustrating a conveyance passage inside the media conveying apparatus **100** according to the present embodiment.

[0035] The media conveying apparatus **100** includes, along a media conveyance passage, a first media sensor **111**, a pick roller **112**, a feed roller **113**, a separation roller **114**, an encoder **115**, first to sixth conveyance rollers **116***a* to **116***f*, first to sixth driven rollers **117***a* to **117***f*, a second media sensor **118**, and first and second image-capturing devices **119***a* and **119***b* (may be collectively referred to as the image-capturing devices **119** in the following description).

[0036] The number of each of the pick roller **112**, the feed roller **113**, the separation roller **114**, the first to sixth conveyance rollers **116***a* to **116***f*, and the first to sixth driven rollers **117***a* to **117***f* is not limited to one, and may be two or more. When one or more of the pick roller **112**, the feed roller **113**, the separation roller **114**, the first to sixth conveyance rollers **116***a* to **116***f*, and the first to sixth driven rollers **117***a* to **117***f* are formed of multiple rollers, the multiple rollers are arranged at intervals in the width direction A**4**.

[0037] The first housing **101** has a face that faces the second housing **102** and serves as a first guide **101***a* of the media conveyance passage. The second housing **102** has a face that faces the first housing **101** and serves as a second guide **102***a* of the media conveyance passage. The first guide **101***a* and the second guide **102***a* define a so-called U-turn path.

[0038] The pick roller **112** is disposed in the second housing **102**. The pick roller **112** contacts the medium on the media table **103** raised to substantially the same height as the height of the media conveyance passage, and feeds the medium downstream in the media conveyance passage.

[0039] The feed roller **113** is disposed downstream from the pick roller **112** in the second housing **102**, and feeds the medium fed from the media table **103** by the pick roller **112** further downstream in the media conveyance passage. The separation roller **114** is disposed in the first housing **101**, opposite to the feed roller **113**. The separation roller **114** is a so-called brake roller or retard roller and is rotatable in the direction opposite to the rotation direction for conveying the media (may be referred to as a feeding direction in the following description). Alternatively, the separation roller **114** is stoppable.

[0040] The media conveying apparatus **100** further includes a torque limiter disposed between the separation roller **114** and a motor that applies a driving force to the separation roller **114**. The torque limiter defines the limit value of the torque applied to the separation roller **114**. The torque limiter has a limit value to satisfy the following conditions. When there is one medium, the rotational force via the torque limiter is cut off, and when there are multiple media, the rotational force via the torque limiter is transmitted.

[0041] As a result, when only one medium is conveyed, the separation roller **114** is rotated by the feed roller **113**, without receiving the driving force from the motor. By contrast, when multiple media are conveyed, the separation roller **114** rotates in the direction indicated by arrow A**7** (may be referred to as the opposite direction A**7** in the following description) opposite to the feeding direction, and separates the medium in contact with the feed roller **113** from the other media so as to prevent the occurrence of multiple feeding. At this time, instead of rotating in the opposite direction A**7**, the separation roller **114** may be kept stationary such that the outer circumferential surface of the separation roller **114** applies, to the media, the force in the opposite direction A**7** to the feeding direction.

[0042] The feed roller **113** and the separation roller **114** perform the above-described operation to separate the media and convey the media one by one. The feed roller **113** is disposed above the separation roller **114**, and the media conveying apparatus **100** feeds media from the top.

[0043] The encoder **115** is a sensor disposed on a shaft **114***a* that is a rotation shaft of the separation roller **114**. The encoder **115** detects the rotation and the rotation direction of the separation roller **114**. The encoder **115** includes a disk, a light emitter, and a light receiver. The light emitter and the light receiver face each other with the disk interposed therebetween. In the disk, a large number of slits (light transmission holes) are formed. The disk rotates, driven by the rotation of the separation roller **114**. The light emitter is, for example, a light emitting diode (LED) and emits light toward the disk (more specifically, toward the light receiver). The light receiver is, for example, a photodiode and receives the light from the light emitter through the disk.

[0044] The light receiver detects the number of changes within a predetermined period from a state where the slits are located between the light emitter and the light receiver to a state where the slits are not located therebetween and the light is blocked by the disk. The light receiver multiplies the detected number of changes by the distance moved by the outer circumferential surface of the separation roller **114** while the disk rotates the distance between two adjacent slits. In this way, the light receiver detects the distance by which the outer circumferential surface of the separation roller **114** has moved (i.e., the movement distance). Between the light emitter and the light receiver, a fixed slit is present to convert the output signals (pulses) to the pulse signals of two phases, and the light receiver detects the rotation direction of the disk based on the respective rising timings of the pulse signals of the two phases. The encoder **115** generates and outputs rotation signals indicating the detected movement distance and the rotation direction of the disk. The rotation direction of the disk is one of stop, forward direction, and reverse direction. The encoder **115** is not limited to an optical encoder but may be any encoder such as a mechanical encoder, a magnetic encoder, or an electromagnetic induction encoder.

[0045] The first to sixth conveyance rollers **116***a* to **116***f* and the first to sixth driven rollers **117***a* to **117***f* are disposed downstream from the feed roller **113** and the separation roller **114**. The first to sixth conveyance rollers **116***a* to **116***f* are disposed opposite to the first to sixth driven rollers **117***a* to **117**, respectively, and convey the media fed by the feed roller **113** and the separation roller **114** downstream in the media conveyance passage.

[0046] The second media sensor **118** is disposed downstream from the feed roller **113** and the separation roller **114** and upstream from the image-capturing devices **119** in the media conveyance direction A**2**, and detects a medium conveyed to the position where the second media sensor **118** is disposed. More specifically, the second media sensor **118** is disposed downstream from the second conveyance roller **116***b* and the second driven roller **117***b*. The second media sensor **118** includes a light emitter and a light receiver disposed on one side of the media conveyance passage, and a light guide disposed opposite to the light emitter and the light receiver with the media conveyance passage in between. The light emitter is, for example, an LED and emits light toward the media conveyance passage. By contrast, the light receiver is, for example, a photodiode and receives the light that is emitted by the light emitter and guided by the light guide. The second media sensor **118** generates and outputs a second media signal based on the intensity of the light received by the light receiver. The second media signal changes in signal value depending on whether or not a medium is located at the position of the second media sensor **118**.

[0047] The second media sensor **118** may include a reflector such as a mirror instead of the light guide. In the second media sensor **118**, the light emitter and the light receiver may be disposed facing each other with the media conveyance passage in between. The second media sensor **118** which detects the presence of the medium may be a contact detection sensor similar to the first media sensor **111**.

[0048] The image-capturing devices **119** are disposed downstream from the first and second conveyance rollers **116***a* and **116***b* in the media conveyance direction A**2**, and capture images of the medium conveyed by the first and second conveyance rollers **116***a* and **116***b* and the first and second driven rollers **117***a* and **117***b*. The first image-capturing device **119***a* and the second image-capturing device **119***b* face each other with the media conveyance passage in between.

[0049] The first image-capturing device **119***a* includes, as a line sensor, an equal-magnification contact image sensor (CIS) including, as imaging elements, complementary metal oxide semiconductors (CMOSs) arranged linearly in the main-scanning direction. The first image-capturing device **119***a* further includes a lens that forms an image on the imaging elements and an analog-to-digital (A/D) converter. The A/D converter amplifies the electrical signals output from the imaging elements and performs analog-to-digital (A/D) conversion. The first image-capturing device **119***a* captures an image of the front side of the medium being conveyed, generates an input image, and outputs the input image.

[0050] Similarly, the second image-capturing device **119***b* includes, as a line sensor, an equal-magnification CIS including, as imaging elements, CMOSs arranged linearly in the main-scanning direction. The second image-capturing device **119***b* further includes a lens that forms an image on the imaging elements and an A/D converter. The A/D converter amplifies the electrical signals output from the imaging elements and performs A/D conversion. The second image-capturing device **119***b* captures an image of the back side of the medium being conveyed, generates an input image, and outputs the input image.

[0051] The media conveying apparatus **100** may include only one of the first image-capturing device **119***a* and the second image-capturing device **119***b* to read only one side of the medium. Further, the line sensor may be, instead of the equal-magnification CIS including CMOSs as imaging elements, an equal-magnification CIS including charge-coupled devices (CCDs) as imaging elements. Alternatively, a line sensor employing a reduction optical system and including, as imaging elements, CMOSs or CCDs may be used.

[0052] The media placed on the media table **103** are conveyed between the first guide **101***a* and the second guide **102***a* in the media conveyance direction A**2** as the pick roller **112** and the feed roller **113** rotate in the feeding directions indicated by arrows A**5** and A**6**, respectively. The media conveying apparatus **100** has two feeding modes: a separation mode in which media are fed while being separated and a non-separation mode in which media are fed without being separated. The feeding mode is set by the user using the operation device **105** or an information processing device connected to the media conveying apparatus **100** for communication. When the feeding mode is set to the separation mode, the separation roller **114** rotates in the direction indicated by arrow A**7** opposite to the feeding direction or stops. This operation prevents the feeding of a medium other than the separated medium (prevents multiple feeding). By contrast, when the feeding mode is set to the non-separation mode, the separation roller **114** rotates in the feeding direction (opposite to the direction indicated by arrow A**7**).

[0053] The medium is fed to the imaging-capturing position of the image-capturing devices **119** by the first and second conveyance rollers **116***a* and **116***b* rotating in the directions indicated by arrows A**8** A**9** while being guided by the first guide **101***a* and the second guide **102***a*. Then, the images of the medium are captured by the image-capturing devices **119**. Further, the medium is ejected onto the output table **104** by the third to sixth conveyance rollers **116***c* to **116***f* rotating in the directions indicated by arrows A**10** to A**13**, respectively.

[0054] FIGS. **3** and **4** are schematic diagrams each used for explaining the separation roller **114** according to the present embodiment.

[0055] As illustrated in FIGS. **3** and **4**, the media conveying apparatus **100** further includes a first swing member **121**, a first torsion coil spring **122**, an elastic member **123**, and a plate **124**.

[0056] The first swing member **121** serves as a swing member. The first swing member **121** extends in the media conveyance direction A**2**. The first swing member **121**A is swingable in the height direction A**1** on a swing shaft **121***a* disposed in a downstream end portion in the media conveyance direction A**2**. The first swing member **121** has an upstream end portion to which the shaft **114***a* of the separation roller **114** is attached. Thus, the first swing member **121** supports the separation roller **114** such that the separation roller **114** swings together with the first swing member **121**.

[0057] The first swing member **121** supports the separation roller **114** such that the separation roller **114** is separated from the feed roller **113** when the first swing member **121** swings downward in the height direction A**1** and such that the separation roller **114** presses the feed roller **113** when the first swing member **121** swings upward in the height direction A**1**. The downward direction in the height direction A**1** is an example of a predetermined direction, and the upward direction in the height direction A**1** is an example of a direction opposite to the predetermined direction. In the following description, the position at which the first swing member **121** supports the separation roller **114** to be in contact with the feed roller **113** as illustrated in FIG. **3** may be referred to as a contact position. By contrast, the position at which the first swing member **121** supports the separation roller **114** to be separated from the feed roller **113** as illustrated in FIG. **4** may be referred to as a non-contact position. The first swing member **121** includes a contact portion **121***b* that contacts the first torsion coil spring **122**.

[0058] The first torsion coil spring **122** serves as a torsion coil spring that is rotatable on a rotation support shaft positioned different from the swing shaft of the swing member. The first torsion coil spring **122** is rotatable on a rotation support shaft **122***a* which is a coil center shaft.

[0059] The first torsion coil spring **122** includes a first arm **122***b* and a second arm **122***c*.

[0060] The first arm **122***b* is fixed to the first housing **101**. The second arm **122***c* is swingable on the rotation support shaft **122***a* so as to generate an elastic force in a direction away from the first arm **122***b* (the upward direction in the height direction A1 in the configuration illustrated in FIGS. **3** and **4**).

[0061] The contact portion **121***b* of the first swing member **121** contacts the second arm **122***c*. The second arm **122***c* presses the first swing member **121** via the contact portion **121***b* in a direction away from the first arm **122***b* (the upward direction in the height direction A1). Receiving the elastic force from the first torsion coil spring **122**, the first swing member **121** applies force toward the feed roller **113** to the separation roller **114**.

[0062] The rotation support shaft **122***a* of the first torsion coil spring **122** is positioned different from the swing shaft **121***a* of the first swing member **121**. For example, the first torsion coil spring **122** is disposed such that the swing shaft **121***a* of the first swing member **121** is positioned outside the coil portion. As a result, as illustrated in FIGS. **3** and **4**, when the first swing member **121** swings, the contact portion **121***b* moves (swings) in the direction different from the direction in which the second arm **122***c* moves (swings). Accordingly, when the first swing member **121** swings, the position on the second arm **122***c* contacted by the contact portion **121***b* changes. In other words, a distance D1 (see FIG. **3**) between the rotation support shaft **122***a* and the contact portion **121***b* when the first swing member **121** is positioned at the contact position is different from a distance D2 (see FIG. **4**) between the rotation support shaft **122***a* and the contact portion **121***b* when the first swing member **121** is positioned at the non-contact position. Accordingly, when the first swing member **121** swings, the contact portion **121***b* slides on the second arm **122***c*.

[0063] In this way, the second arm **122***c* is disposed to allow the contact portion **121***b* to slide while being in contact with the second arm **122***c*. Accordingly, when the first swing member **121** swings downward in the height direction A**1**, a reaction force in the upward direction in the height direction A**1** is applied to the first swing member **121** by a friction force generated between the contact portion **121***b* and the second arm **122***c*. The friction force generated between the contact portion **121***b* and the second arm **122***c* includes a dynamic friction force, generated by the sliding between the contact portion **121***b* and the second arm **122***c*, and a static friction force, generated before the contact portion **121***b* slides on the second arm **122***c*.

[0064] The elastic member **123** is a spring such as a tension coil spring. The elastic member **123** and the first torsion coil spring **122** are separate components. The clastic member **123** has an upstream end **123***a* fixed to the first housing **101**, and a downstream end **123***b* attached to an upstream end of the first swing member **121**. The terms "upstream" and "downstream" used herein refer to those in the media conveyance direction A**2**.

[0065] With this structure, the elastic member **123** applies an upward force in the height direction A**1** to the first swing member **121**. Note that the elastic member **123** may be other springs such as a compression coil spring or, for example, a rubber member.

[0066] The plate **124** is disposed at a position upstream from the separation roller **114** and facing the surface of the separation roller **114**. The plate **124** is urged downstream by a spring **124***a* such as a torsion coil spring and is stopped by a stopper **124***b*. The plate **124** is disposed to satisfy the following conditions. The plate **124** does not contact the surface of the separation roller **114** when the first swing member **121** is positioned at the contact position, and contacts the surface of the separation roller **114** when the first swing member **121** is positioned at the non-contact position. As a result, when the first swing member **121** swings downward in the height direction A**1**, the plate **124** contacts the surfaces of the separation roller **114** and prevents or reduces the rotation of the separation rollers **114**.

[0067] A description is given below of the technical significance of positioning the rotation support shaft **122***a* of the first torsion coil spring **122** different from the swing shaft **121***a* of the first swing member **121**.

[0068] FIGS. **5** and **6** are diagrams each illustrating a media conveying apparatus according to a comparative example. In the media conveying apparatus illustrated in FIGS. **5** and **6**, the rotation support shaft of the first torsion coil spring is located at the same position as that of the swing shaft of the first swing member.

[0069] The media conveying apparatus illustrated in FIGS. **5** and **6** includes the feed roller **13**, the separation roller **14**, a first swing member **21**, and a first torsion coil spring **22**. The feed roller **13**, the separation roller **14**, and the first swing member **21** have configurations similar to those of the feed roller **113**, the separation roller **114**, and the first swing member **121** of the media conveying apparatus **100** according to the present embodiment, respectively. The first swing member **21** is swingable on a swing shaft **21***a* and includes a contact portion **21***b*. The first torsion coil spring **22** is rotatable about the rotation support shaft **22***a* and includes a fixed first arm **22***b* and a second arm **22***c* contacted by the contact portion **21***b*. However, the rotation support shaft **22***a* of the first torsion coil spring **22** is disposed at the same position as that of the swing shaft **21***a* of the first swing member **21**.

[0070] Since the rotation support shaft **22***a* and the swing shaft **21***a* are disposed at the same position, when the first swing member **21** swings, the direction in which the contact portion **21***b* moves (swings) matches the direction in which the second arm **22***c* moves (swings). Accordingly, when the first swing member **21** swings, the position on the second arm **22***c* contacted by the contact portion **21***b* does not change. In other words, a distance D**3** (see FIG. **5**) between the rotation support shaft **22***a* and the contact portion **21***b* when the first swing member **21** is positioned at the contact position does not change from a distance D**4** (see FIG. **6**) between the rotation support shaft **22***a* and the contact portion **21***b* when the first swing member **21** is positioned at the non-contact position. Accordingly, when the first swing member **21** swings, the contact portion **21***b* does not slide on the second arm **22***c*.

[0071] FIGS. **7**A, **7**B, **8**A, and **8**B are schematic diagrams each illustrating the feeding of media by the media conveying apparatus illustrated in FIGS. **5** and **6**, according to the comparative example. In FIGS. **7**A, **7**B, **8**A, and **8**B, multiple media P are placed on the media table, and a medium P**1** on the top of the media P is being fed. As illustrated in FIGS. **7**A, **7**B, **8**A, and **8**B, the media conveying apparatus illustrated in FIGS. **5** and **6** includes a pick roller **12** similar to the pick roller **112** of the media conveying apparatus **100**.

[0072] As illustrated in FIG. **7**A, as the pick roller **12** contacting the medium P**1** rotates in the feeding direction A**5**, the medium P**1** is fed into the nip between the feed roller **13** and the separation roller **14**. When only the medium P**1** is located in the nip between the feed roller **13** and the separation roller **14**, the separation roller **14** is driven by the feed roller **13** and rotates in the feeding direction indicated by arrow A**7**' (may be referred to as the feeding direction A**7**'). The media P under the medium P**1**, placed on the media table are referred to as standby media P**2**. The standby media P**2** receive friction force with the medium P**1**, generated by the pressing force of the pick roller **12** and the feed roller **13**, and the inertia force due to the gravity of the standby media P**2**.

[0073] As illustrated in FIG. **7**B, these forces cause standby media P**2** to move downstream, and the leading end of standby media P**2** collides with the separation roller **14**. The separation roller **14** is pressed by the standby media P**2** and is pushed downward in the height direction A**1** against the elastic force of the first torsion coil spring **22**. At this time, the driving force from a motor is transmitted to the separation roller **14**, and the outer circumferential surface of the separation roller **14** rotates in the direction indicated by arrow A**7** opposite to the feeding direction. Accordingly, the standby media P**2** receive the force due to the reverse rotation of the separation roller **14**, the back load of the separation roller **14**, and the rubber repulsive force of the separation roller **14**.

[0074] As illustrated in FIG. **8**A, these forces push back the standby media P**2** to the upstream side.

[0075] As a result, the standby media P**2** are separated from the separation roller **14** and no longer press the separation roller **14**. Then, the separation roller **14** is pushed back upward in the height direction A**1** by the elastic force of the first torsion coil spring **22**. As a result, the separation roller **14** is driven again by the feed roller **13** and rotates in the feeding direction A**7**'.

[0076] As illustrated in FIG. **8**B, after separated from separation roller **14**, the standby media P**2** move again downstream due to the friction force with the medium P**1** and the inertia force due to the gravity of the standby media P**2**. Then, the standby media P**2** collide with the separation roller **14**. The separation roller **14** is pressed by the standby media P**2** again and is pushed downward in the height direction A**1** against the elastic force of the first torsion coil spring **22**. At this time, the driving force from the motor is transmitted to the separation roller **14**, and the outer circumferential surface of the separation roller **14** rotates in the direction indicated by arrow A**7** opposite to the feeding direction. After that, the separation roller **14** moves up and down and vibrates in the height direction A**1** while repeating the movement illustrated in FIG. **8**A and the movement illustrated in FIG. **8**B.

[0077] FIG. **9**A is a graph illustrating an example of changes in position of the separation roller **14** when media are fed by the media conveying apparatus illustrated in FIGS. **5** and **6**.

[0078] In FIG. **9**A, the horizontal axis indicates the elapsed time from the start of feeding of media, and the vertical axis indicates the position of the separation roller **14** in the height direction A**1** relative to the initial position at the start of feeding of media. As illustrated in FIG. **9**A, each time the standby media P**2** collide with the separation roller **14**, the separation roller **14** is pushed down. Each time the separation roller **14** moves up and down (self-excited vibration), the amount by which the separation roller **14** is pushed down increases. In the example illustrated in FIG. **9**A, when a time T has elapsed from the start of feeding of media, the separation roller **14** is below a position S at which the separation roller **14** contacts the feed roller **13** forming the nip therebetween. As a result, the standby media P**2** flow downstream from the separation roller **14** and the feed roller **13**, resulting in the occurrence of the multiple feeding of media.

[0079] By contrast, as described above, in the media conveying apparatus **100** according to the present embodiment, when the first swing member **121** swings, the reaction force is applied to the first swing member **121** by the friction force generated between the contact portion **121***b* and the second arm **122***c*. The reaction force reduces the amount of movement of the separation roller **114** (the first swing member **121**) when the separation roller **114** is pushed down by the standby media P**2** and when the separation roller **114** is pushed up by the elastic force of the first torsion coil spring **22**.

[0080] FIG. **9**B is a graph illustrating an example of changes in position of the separation roller **114** when media are fed by the media conveying apparatus **100** according to the present embodiment.

[0081] In FIG. **9**B, the horizontal axis indicates the elapsed time from the start of feeding of media, and the vertical axis indicates the position of the separation roller **114** in the height direction A**1** relative to the initial position at the start of feeding of media. As illustrated in FIG. **9**B, the amounts by which the separation roller **114** is pushed down and pushed up are reduced by the reaction force applied to the first swing member **121**, and the separation roller **114** is kept above the position S at which the separation roller **114** contacts the feed roller **13** forming the nip therebetween. As a result, the standby media P**2** are prevented from flowing downstream from the separation roller **114** and the feed roller **113**, and the occurrence of the multiple feeding of the media is prevented.

[0082] A description is given below of the friction force generated between the contact portion **121***b* and the second arm **122***c* of the first torsion coil spring **122**.

[0083] When the standby media P**2** collide with the separation roller **114**, force M**1** calculated by the following Equation 1 is applied to the collision point between the standby media P**2** and the separation roller **114**.

$$M1 = N1 \times L1 \qquad \text{Equation 1}$$

[0084] Referring to FIG. **3**, in Equation 1, N**1** represents a load (vertical load) applied to the collision point between the standby media P**2** and the separation roller **114** in the swing direction (tangential direction) of the separation roller **114** (the first swing member **121**) (indicated by arrow N**1** in FIG. **3**). Further, L**1** represents the distance between a straight line passing through the collision point between the standby media P**2** and the first swing member **121** and extending in the swing direction of the separation roller **114** and the swing shaft **121***a* of the first swing member **121** (see FIG. **3**).

[0085] By contrast, the elastic force of the first torsion coil spring **122** applies force M**2** calculated by the following Equation 2 to the contact portions **121***b* of the first swing members **121**.

$$M2 = N2 \times L2 \qquad \text{Equation 2}$$

[0086] In Equation 2, N**2** represents a load (vertical load) applied to the contact position between the contact portion **121***b* and the second arm **122***c* in the swing direction (tangential direction) of the second arm **122***c* (see FIG. **3**). Further, L**2** represents the distance between the swing shaft **121***a* of the first swing member **121** and a straight line (indicated by an alternate long and short dashed line in FIG. **3**) passing through the contact position between the contact portion **121***b* and the second arm **122***c* and extending in the swing direction of the second arm **122***c* (see FIG. **3**).

[0087] Further, due to the friction between the contact portion **121***b* and the second arm **122***c*, force M**3** calculated by the following Equation 3 is applied to the contact portion **121***b* of the first swing member **121**.

$$M3 = \mu \times N2 \times L3 \qquad \text{Equation 3}$$

[0088] In Equation 3, μ represents the friction coefficient between the contact portion **121***b* and the second arm **122***c*, and μ×N2 represents the friction force between the contact portion **121***b* and the second arm **122***c* (see FIG. **3**). Further, L**3** represents the distance between the swing shaft **121***a* of the first swing member **121** and a straight line passing through the contact position between the contact portion **121***b* and the second arm **122***c* and extending in the direction in which the second arm **122***c* extends (the sliding direction of the contact portion **121***b*) (see FIG. **3**).

[0089] The first swing member **121** and the first torsion coil spring **122** are designed to reduce the vibration of the first swing member **121** due to the forces M**1** and M**2** with the force M**3**.

[0090] Further, due to the friction force between the contact portion **121***b* and the second arm **122***c*, force F**1** calculated by the following Equation 4 is applied to the separation roller **114**.

$$F1 = M3/L4 = N2 \times \mu \times L3/L4 \qquad \text{Equation 4}$$

[0091] In Equation 4, **L4** represents the distance between the swing shaft **121***a* of the first swing member **121** and a straight line passing through the rotation axis of the separation roller **114** and extending in the swing direction of the separation roller **114** (see FIG. **3**).

[0092] The separation roller **114** further receives force **F2** calculated by the following Equation 5 due to the elastic force of the first torsion coil spring **122** (see FIG. **3**).

$$F2 = M2/L4 = N2 \times L2/L4 \qquad \text{Equation 5}$$

[0093] As presented in Equations 4 and 5, the force **F1** varies depending on the distance **L3**, but the force **F2** does not depend on the distance **L3**. In the media conveying apparatus **100**, adjusting the force **L3** enables the adjustment of the force **F1** for reducing the vibration of the separation roller **114** while the force **F2** applied to the separation roller **114** by the elastic force of the first torsion coil springs **122** is kept constant.

[0094] The distance **L3** is set to a distance that does not to cause multiple feeding of media in a preliminary experiment.

[0095] Further, as described above, the elastic member **123** applies the force to the first swing member **121** to press the separation roller **114** against the feed roller **113**. Accordingly, the media conveying apparatus **100** can increase the upward reaction force applied to the first swing member **121** when the first swing member **121** swings downward. Accordingly, the media conveying apparatus **100** can reduce the vibration of the separation roller **114**, thereby preventing the occurrence of multiple feeding of media.

[0096] As described above, when first swing member **121** swings downward in the height direction **A1**, the plate **124** stops the rotation of the separation roller **114**, and the standby media **P2** are not pushed back by the separation roller **114**. With this configuration, the media conveying apparatus **100** can reduce the vibration of the separation roller **114** and prevent the occurrence of multiple feeding of media.

[0097] FIGS. **10** and **11** are schematic diagrams used for explaining the first media sensor **111**.

[0098] As illustrated in FIGS. **10** and **11**, the first media sensor **111** is disposed on the table face **103***a* of the media table **103**, i.e., upstream side of the feed roller **113** and the separation roller **114**. The first media sensor **111** detects the state of the media placed on the media table **103**.

[0099] The first media sensor **111** includes a second swing member **131**, a second torsion coil spring **132**, a stopper **133**, and an optical unit **134**.

[0100] The second swing member **131** serves as the swing member. The second swing member **131** extends in the media conveyance direction **A2** and is swingable in the height direction **A1** on a swing shaft **131***a* positioned in a central portion of the second swing member **131** in the media conveyance direction **A2**. In particular, the second swing member **131** is disposed to allow the downstream end portion thereof swings in the height direction **A1**. In the following description, the upward direction in the height direction **A1** in which the downstream end portion moves may be referred to as a first direction, and the downward direction in the height direction **A1** in which the downstream end portion moves may be referred to as a second direction. The first direction is an example of the predetermined direction, and the second direction is an example of the direction opposite to the predetermined direction. Further, in the following description, the position of the second swing member **131** illustrated in FIG. **10** at which the downstream end portion is positioned upward may be referred to as a first position, and the position of the second swing member **131** illustrated in FIG. **11** at which the downstream end is positioned downward may be referred to as a second position. The second swing member **131** includes a contact portion **131***b* that contacts the second torsion coil spring **132**.

[0101] The second torsion coil spring **132** serves as the torsion coil spring. The second torsion coil spring **132** is rotatable on a rotation support shaft **132***a* which is a coil center shaft.

[0102] The second torsion coil spring **132** includes a first arm **132***b* and a second arm **132***c*.

[0103] The first arm **132***b* is fixed to the inside of the media table **103**. The second arm **132***c* is swingable on the rotation support shaft **132***a* so as to generate an elastic force in a direction away from the first arm **132***b* (downstream in the configuration illustrated in FIGS. **10** and **11**). The contact portion **131***b* of the second swing member **131** contacts the second arm **132***c*. The second arm **132***c* presses the second swing member **131** via the contact portion **131***b* in a direction (the downstream direction) away from the first arm **132***b*. Due to the elastic force from the second torsion coil spring **132**, the second swing member **131** is applied with force that moves the downstream end portion upward.

[0104] The rotation support shaft **132***a* of the second torsion coil spring **132** is disposed at a position different from the swing shaft **131***a* of the second swing member **131**. For example, the second torsion coil spring **132** is disposed such that the swing shaft **131***a* of the second swing member **131** is positioned outside the coil portion thereof. As a result, as illustrated in FIGS. **10** and **11**, when the second swing member **131** swings, the contact portion **131***b* moves (swings) in the direction that is different from the direction in which the second arm **132***c* moves (swings). Accordingly, when the second swing member **131** swings, the position on the second arm **132***c* contacted by the contact portion **131***b* changes. In other words, a distance **D5** between the rotation support shaft **132***a* and the contact portion **131***b* with the second swing member **131** positioned at the first position is different from a distance **D6** between the rotation support shaft **132***a* and the contact portion **131***b* with the second swing member **131** positioned at the second position. Accordingly, when the second swing member **131** swings, the contact portion **131***b* slides on the second arm **132***c*.

[0105] In this way, the second arm **132***c* is disposed to allow the contact portion **131***b* to slide while being in contact with the second arm **132***c*. Accordingly, when the second swing member **131** swings in the first direction, a reaction force in the second direction is applied to the second swing member **131** by a friction force generated between the contact portion **131***b* and the second arm **132***c*. The friction force generated between the contact portion **131***b* and the second arm **132***c* includes a dynamic friction force generated by the sliding of the contact portion **131***b* on the second arm

132c, and a static friction force generated before the contact portion **131**b slides on the second arm **132**c.

[0106] The stopper **133** is fixed to the inside of the media table **103**, accommodated in a hole **131**c formed in the second swing member **131**. The second swing member **131** is positioned at the first position as the lower end of the rim surrounding the hole **131**c contacts the lower end of the stopper **133**, and is positioned at the second position as the upper end of the rim surrounding the hole **131**c contacts the upper end of the stopper **133**.

[0107] The optical unit **134** includes a light emitter and a light receiver disposed facing each other across the second swing member **131** positioned at the first position. The light emitter is, for example, an LED and emits light toward the light receiver. The light receiver is, for example, a photodiode and receives the light from the light emitter. The light receiver generates and outputs a first media signal which is an electrical signal corresponding to the intensity of the received light. When the media are placed on the media table **103**, the second swing member **131** is pushed down to the second position by the weight of the media and is not located between the light emitter and the light receiver. By contrast, when no media are placed on the media table **103**, the second swing member **131** is pushed up to the first by the elastic force of the second torsion coil spring **132** and is located between the light emitter and the light receiver.

[0108] When the second swing member **131** is not located between the light emitter and the light receiver, the light receiver receives the light emitted from the light emitter. By contrast, when the second swing member **131** is located between the light emitter and the light receiver, the light emitted from the light emitter is blocked by the second swing member **131**. Accordingly, the signal value of the first media signal changes depending on the position of the second swing member **131**, which differs depending on whether or not media are placed on the media table **103**.

[0109] The first media sensor **111** is not limited to a contact detection sensor. The first media sensor **111** may be any other sensor such as an optical detection sensor having the capability of detecting the presence of a medium.

[0110] The second swing member **131** and the second torsion coil spring **132** have a relation similar to that between the first swing member **121** and the first torsion coil spring **122**. If the rotation support shaft **132**a of the second torsion coil spring **132** is disposed at the same position as that of the swing shaft **131**a of the second swing member **131**, the contact portion **131**b does not slide on the second arm **132**c when the second swing member **131** swings. Accordingly, when all the media placed on the media table **103** are fed and the second swing member **131** moves from the second position to the first position, the second swing member **131** repeatedly moves up and down and vibrates.

[0111] By contrast, as described above, in the media conveying apparatus **100** according to the present embodiment, when the second swing member **131** swings, the friction force generated between the contact portion **131**b and the second arm **132**c applies the reaction force to the second swing member **131**. When all the media placed on the media table **103** are fed, the reaction force reduces the amount by which the second swing member **131** is pushed up by the elastic force of the second torsion coil spring **132** and the amount by which the second swing member **131** is pushed down by its own weight. This reduction can prevent the erroneous determination of the presence of media on the media table **103** even though no medium is on the media table **103**, caused by the vibration of the second swing member **131**.

[0112] FIG. **12** is a block diagram illustrating a schematic configuration of the media conveying apparatus **100** according to the present embodiment.

[0113] The media conveying apparatus **100** further includes a motor **141**, an interface device **142**, a storage device **150**, and a processing circuit **160** in addition to the above-described components.

[0114] The motor **141** includes one or more motors. According to a control signal from the processing circuit **160**, the motor **141** rotates the pick roller **112**, the feed roller **113**, the separation roller **114**, and/or the first to sixth conveyance rollers **116**a to **116**f to convey the media and further move the media table **103**. The first to sixth driven rollers **117**a to **117**f may rotate by receiving the driving force of the motor **141**, instead of being rotated by the first to sixth conveyance rollers **116**a to **116**f.

[0115] The interface device **142** includes an interface circuit in compliance with a serial bus such as a universal serial bus (USB) and is electrically connected to an information processing device (for example, a personal computer or a mobile information processing terminal) to transmit and receive an input image and various kinds of information to and from the information processing device. The interface device **142** may be substituted by a communication unit including an antenna to transmit and receive radio signals and a wireless communication interface circuit to transmit and receive the signals through a wireless communication line according to a predetermined communication protocol.

[0116] The predetermined communication protocol is, for example, a wireless local area network (LAN) communication protocol. The communication unit may include a wired communication interface circuit for transmitting and receiving signals through a wired communication line according to, for example, a wired LAN communication protocol.

[0117] The storage device **150** includes memories such as a random-access memory (RAM) and a read-only memory (ROM); a fixed disk device such as a hard disk; or a portable memory such as a flexible disk or an optical disk. The storage device **150** stores, for example, computer programs, databases, and tables used for various processes performed by the media conveying apparatus **100**. The computer programs may be installed in the storage device **150** from a computer-readable portable recording medium using, for example, a known setup program. The portable recording medium is, for example, a compact disc read-only memory (CD-ROM) or a digital versatile disc read-only memory (DVD-ROM).

[0118] The processing circuit **160** operates according to a program stored in the storage device **150** in advance. The processing circuit **160** is, for example, a central processing unit (CPU). Alternatively, as the processing circuit **160**, for example, a digital signal processor (DSP), a large-scale integration (LSI), an application-specific integrated circuit (ASIC), or a field-programmable gate array (FPGA) may be used.

[0119] The processing circuit **160** is connected to, for example, the operation device **105**, the display device **106**, the first media sensor **111**, the encoder **115**, the image-capturing device **119**, the motor **141**, the interface device **142**, and the storage device **150**, and controls these components. The processing circuit **160** controls, for example, the driving of the motor **141** and the image capturing by the image-capturing device **119** according to the media signals received from the media sensors and the rotation signals received from the encoder **115**. The processing circuit **160** acquires an input image from the image-capturing device **119** and transmits the input image to the information processing device via the interface device **142**.

[0120] FIG. **13** is a block diagram illustrating a schematic configuration of the storage device **150** and the processing circuit **160** according to the present embodiment.

[0121] As illustrated in FIG. **13**, the storage device **150** stores, for example, a control program **151**, a determination program **152**, and a detection program **153**. These programs are functional modules implemented by software operating on the processor. The processing circuit **160** reads the programs from the storage device **150** and operates according to the read programs. Thus, the processing circuit **160** functions as a control unit **161**, a determination unit **162**, and a detection unit **163**.

[0122] FIG. **14** is a flowchart of a medium reading process performed by the media conveying apparatus **100** according to the present embodiment.

[0123] A description is given below of a medium reading process performed by the media conveying apparatus **100** according to the present embodiment, with reference to the flowchart of FIG. **14**. The operation process described below is executed, for example, by the processing circuit **160** in cooperation with the components of the media conveying apparatus **100** based on the program prestored in the storage device **150**.

[0124] In step S**101**, the control unit **161** waits for an operation signal instructing the reading of media, received from the operation device **105** or the interface device **142**. The operation signal is output when the user inputs an instruction to read media using the operation device **105** or the information processing device.

[0125] In step S**102**, the determination unit **162** receives the first media signal from the first media sensor **111** and determines whether media are placed on the media table **103** based on the first media signal.

[0126] In this way, the determination unit **162** determines whether media are on the media table **103** based on the position of the second swing member **131**, i.e., based on whether the second swing member **131** is positioned at the first position or the second position. As described above, the first media sensor **111** reduces the amount of swing of the second swing member **131**. This configuration can prevent the erroneous determination by the media conveying apparatus **100** about whether media are on the media table **103**. When no media are placed on the media table **103**, the control unit **161** ends the series of steps.

[0127] By contrast, when media are placed on the media table **103**, in step S**103**, the control unit **161** drives the motor **141** to raise the media table **103** to the position where the media can be fed, and rotates the rollers to feed the media.

[0128] In step S**104**, the detection unit **163** receives the rotation signal from the encoder **115**, and detects the rotation direction of the separation roller **114** based on the rotation signal. The detection unit **163** stores the detected rotation direction in the storage device **150**.

[0129] In step S**105**, the detection unit **163** reads the history of the rotation direction of the separation roller **114** stored in the storage device **150**, and calculates the frequency of changes in the rotation direction of the separation roller **114**. Specifically, the detection unit **163** reads the rotation directions of the separation roller **114** stored in the storage device **150** in a predetermined period, and calculates the number of times the rotation direction changes within the predetermined period as the frequency of changes in the rotation direction of the separation roller **114**. The predetermined period is, for example, one second immediately preceding step S**105**. The predetermined period may be the entire period from the start of the feeding of the medium being fed to the current time.

[0130] In step S**106**, the control unit **161** determines whether the frequency of changes in the rotation direction of the separation roller **114** calculated by the detection unit **163** is equal to or greater than a threshold. For determining the threshold of the frequency of changes in the rotation direction of the separation roller **114**, an experiment in which various types of media are fed is preliminarily performed. The threshold is set to a value between a frequency of changes resulting in multiple feeding of media in the experiment and a frequency of changes not resulting in multiple feeding of media in the experiment. When the frequency of changes in the rotation direction of the separation roller **114** is smaller than the threshold, the control unit **161** proceeds to step S**108**.

[0131] By contrast, when the frequency of changes in the rotation direction of the separation roller **114** is equal to or greater than the threshold, the control unit **161** controls the motor **141** to stop the separation roller **114** in step S**107**. In this way, the control unit **161** stops the rotation of the separation roller **114** based on the frequency of changes in the rotation direction of the separation roller **114**. Accordingly, the media conveying apparatus **100** can prevent the occurrence of multiple feeding of media due to the vibration of the separation roller **114** caused by the standby media P**2** as illustrated in FIGS. **7**A, **7**B, **8**A, and **8**B.

[0132] In step S**108**, the determination unit **162** receives the second media signal from the second media sensor **118** and determines whether the trailing end of the medium has passed through the image-capturing position of the image-capturing device **119** based on the second media signal. The determination unit **162** determines that the trailing end of the medium has passed through the position of the second media sensor **118** when the signal value of the second media signal changes from the value indicating the presence of medium to the value indicating the absence of the medium. The determination unit **162** determines that the trailing end of the medium has passed through the image-capturing position of the image-capturing device **119** after the elapse of a predetermined time from when the leading end of the medium reaches the position of the second media sensor **118**. The predetermined time is set to the time for the medium to move from the position of the second media sensor **118** to the image-capturing position of the image-capturing device **119**.

[0133] In this way, the determination unit **162** determines whether the medium is present at the position of the second media sensor **118** based on the second media signal from the second media sensor **118**. When the second media sensor **118** is a contact detection sensor similar to the first media sensor **111**, the determination unit **162** determines that whether the medium is present at the position of the second media sensor **118** based on the position of the second swing member **131**.

[0134] In this case, the media conveying apparatus **100** can reduce errors in the determination of whether a medium is present at the position of the second media sensor **118**. Alternatively, the determination unit **162** may determine that the trailing end of the medium has passed through the image-capturing position after the elapse of a predetermined time from the start of the feeding of the medium. If the trailing end of the medium has not yet passed the image-capturing position of the image-capturing device **119**, the control unit **161** returns the process to step S**104** and repeats the process from step S**104**.

[0135] By contrast, when the trailing end of the medium has passed the image-capturing position of the image-capturing device **119**, the control unit **161** acquires the input image from the image-capturing device **119**, and transmits (i.e., outputs) the acquired input image to the information processing device via the interface device **142** in step S**109**.

[0136] In step S**110**, the control unit **161** acquires the first media signal from the first media sensor **111** in the manner similar to that of step S**102**, and determines whether media remain on the media table **103** based on the first media signal.

[0137] When the media remain on the media table **103**, the control unit **161** determines whether the separation roller **114** has been stopped in step S**107** in step S**111**. When the separation roller **114** has not been stopped in step S**107**, the control unit **161** returns the process to step S**104** and repeats the process from step S**104**.

[0138] By contrast, when the separation roller **114** has been stopped, the motor **141** is controlled to again rotate the separation roller **114** in step S**112**. Subsequently, the control unit **161** returns the process to step S**104** and repeats the process from step S**104**.

[0139] By contrast, when no media remain on the media table **103**, the control unit **161** controls the motor **141** to stop the rollers in step S**113**, and ends the series of steps.

[0140] As described above in detail, in the media conveying apparatus **100**, the swing shaft of the swing member (e.g., the first swing member **121** or the second swing member **131**) is shifted from the rotation support shaft of the torsion coil spring (e.g., the first torsion coil spring **122** or the second torsion coil spring **132**) that applies force to the swing member, to reduce the amount of swing of the swing member with the frictional force generated between the swing member and the torsion coil spring when the swing member receives force in the predetermined direction.

[0141] As a result, the media conveying apparatus **100** can reduce the vibration of the swing member and appropriately control the swing of the swing member.

[0142] FIG. **15** is a schematic block diagram illustrating a configuration of a processing circuit **260** of a media conveying apparatus according to another embodiment of the present disclosure.

[0143] The processing circuit **260** substitutes for the processing circuit **160** of the media conveying apparatus **100**, and executes, for example, the medium reading process instead of the processing circuit **160**. The processing circuit **260** includes, for example, a control circuit **261**, a determination circuit **262**, and a detection circuit **263**. These circuits may be implemented by, for example, independent integrated circuits, microprocessors, or firmware; or a combination thereof.

[0144] The control circuit **261** an example of a control unit to stop the rotation of the separation roller and functions similarly to the control unit **161**. The control circuit **261** receives an operation signal from the operation device **105** or the interface device **142**, the result of determination of the presence of the medium from the determination circuit **262**, and the result of detection of the frequency of changes in the rotation direction of the separation roller **114** from the detection circuit **263**. The control circuit **261** controls the motor **141** based on the received information, acquires an input image from the image-capturing device **119**, and outputs the input image to the interface device **142**.

[0145] The determination circuit **262** an example of a determination unit to determine whether a medium is present and functions similar to the determination unit **162**. The determination circuit **262** receives the first medium signal from the first media sensor **111** and the second medium signal from the second media sensor **118**.

[0146] The determination circuit **262** determines the presence of the medium based on the received signals and outputs the determination result to the control circuit **261**.

[0147] The detection circuit **263** is an example of a detection unit to detect the rotation direction of the separation roller and functions similar to the detection unit **163**. The detection circuit **263** receives the rotation signals from the encoder **115**. The detection circuit **263** detects the rotation direction of the separation roller **114** and the frequency of changes in the rotation direction based on the received rotation signals, and outputs the detection result to the control circuit **261**.

[0148] As described above, the media conveying apparatus according to embodiments of the present disclosure can appropriately control the swing of the swing member even when the processing circuit **260** is used.

[0149] Although several embodiments of the present disclosure have been described above, the embodiments are not limited thereto. For example, the media conveying apparatus may include a so-called straight path to feed the media on the media table in order from the bottom. In this case, the feed roller is disposed below the separation roller, opposite to the separation roller.

[0150] Further, the swing member and the torsion coil spring according to the embodiments of the present disclosure are applicable to not only the media conveying apparatus but also other devices. The swing member and the torsion coil spring according to the embodiments of the present disclosure are applicable to any object that swings, such as a hinged door of a storage or a room, or an opening-closing portion of a foldable laptop computer or a foldable cellular phone. In these cases, the vibration of the swing member is reduced, and the swing of the swing member is appropriately controlled.

[0151] The above-described embodiments are illustrative and do not limit the present invention. Thus, numerous additional modifications and variations are possible in light of the above teachings. For example, elements and/or features of different illustrative embodiments may be combined with each other and/or substituted for each other within the scope of the present invention. Any one of the above-described operations may be performed in various other ways, for example, in an order different from the one described above.

[0152] The functionality of the elements disclosed herein may be implemented using circuitry or processing circuitry which includes general purpose processors, special purpose processors, integrated circuits, application specific integrated circuits (ASICs), digital signal processors (DSPs), field programmable gate arrays (FPGAs), conventional circuitry and/or combinations thereof which are configured or programmed to perform the disclosed functionality. Processors are considered processing circuitry or circuitry as they include transistors and other circuitry therein. In the disclosure, the circuitry, units, or means are hardware that carry out or are programmed to perform the recited functionality. The hardware may be any hardware disclosed herein or otherwise known which is programmed or configured to carry out the recited functionality. When the hardware is a processor which may be considered a type of circuitry, the circuitry, means, or units are a combination of hardware and software, the software being used to configure the hardware and/or processor.

1. A swing controller comprising:

a swing member including a swing shaft on which the swing member swings and a contact portion;

a torsion coil spring including:

a rotation support shaft on which the torsion coil spring rotates, the rotation support shaft being disposed at a position different from a position of the swing shaft;

a fixed first arm; and

a second arm on which the contact portion slides,

wherein, when the swing member swings in a predetermined direction, a reaction force in a direction opposite to the predetermined direction is applied to the swing member by a friction force between the contact portion and the second arm.

2. The swing controller according to claim **1**, further comprising:

a feed roller to feed a medium; and

a separation roller disposed oppose the feed roller,

wherein the swing member supports the separation roller to swing the separation roller away from the feed roller when the swing member swings in the predetermined direction.

3. The swing controller according to claim **1**, further comprising processing circuitry configured to determine whether a medium is present at the location of the swing member based on a position of the swing member.

4. The swing controller according to claim **2**, further comprising an elastic member disposed separate from the torsion coil spring, the elastic member applying a force to the swing member in the direction opposite to the predetermined direction.

5. The swing controller according to claim **2**, further comprising a plate configured to contact a surface of the separation roller and prevent the separation roller from rotating when the swing member swings in the predetermined direction.

6. The swing controller according to claim **2**, further comprising processing circuitry configured to:

determine a rotation direction of the separation roller; and

stop the separation roller from rotating based on a frequency of changes in the rotation direction of the separation roller.

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