US012384647B2

(12) **United States Patent**
Shibasaki et al.

(10) **Patent No.: US 12,384,647 B2**
(45) **Date of Patent: Aug. 12, 2025**

(54) **SHEET FOLDING APPARATUS, IMAGE FORMING APPARATUS, AND IMAGE FORMING SYSTEM**

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(72) Inventors: **Yuusuke Shibasaki**, Tokyo (JP); **Yusuke Hirono**, Kanagawa (JP); **Atsushi Shinoda**, Kanagawa (JP); **Shuuto Tohkaishi**, Kanagawa (JP); **Satoshi Hirata**, Kanagawa (JP); **Shingo Yoshizawa**, Kanagawa (JP); **Suzuka Fujita**, Kanagawa (JP); **Naofumi Yoshida**, Kanagawa (JP); **Ryota Takayama**, Tokyo (JP); **Takahiro Watanabe**, Kanagawa (JP); **Takuya Morinaga**, Tokyo (JP); **Yuji Suzuki**, Kanagawa (JP); **Wataru Nozaki**, Kanagawa (JP); **Kanako Fujisaki**, Kanagawa (JP); **Jun Yamada**, Kanagawa (JP)

(73) Assignee: **RICOH COMPANY, LTD.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 117 days.

(21) Appl. No.: **18/528,801**

(22) Filed: **Dec. 5, 2023**

(65) **Prior Publication Data**

US 2024/0182258 A1 Jun. 6, 2024

(30) **Foreign Application Priority Data**

Dec. 6, 2022 (JP) 2022-195096

(51) **Int. Cl.**
B65H 45/16 (2006.01)

(52) **U.S. Cl.**
CPC ***B65H 45/16*** (2013.01); *B65H 2403/732* (2013.01); *B65H 2404/7414* (2013.01)

(58) **Field of Classification Search**
CPC B65H 2404/7414; B65H 45/16; B65H 2403/732; B65H 45/14; B65H 2404/63
See application file for complete search history.

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Primary Examiner — Jennifer Bahls
(74) *Attorney, Agent, or Firm* — XSENSUS LLP

(57) **ABSTRACT**

A sheet folding apparatus includes a conveyor, a first folding roller, a second folding roller, a third folding roller, a guide, a motor, and a driving force transmission mechanism. The motor causes the second folding roller to perform either forward rotation in which the second folding roller rotates to convey a sheet on a main conveying path in a conveying direction and to convey the sheet on a reflux conveying path from a joining position toward a branching position or backward rotation in a direction opposite to the forward rotation. The driving force transmission mechanism rotates the guide toward a first posture from a second posture in conjunction with the forward rotation of the second folding roller and rotates the guide from the first posture toward the second posture in conjunction with the backward rotation of the second folding roller.

12 Claims, 19 Drawing Sheets

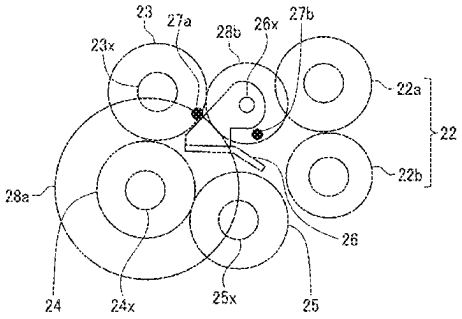

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FIG. 1

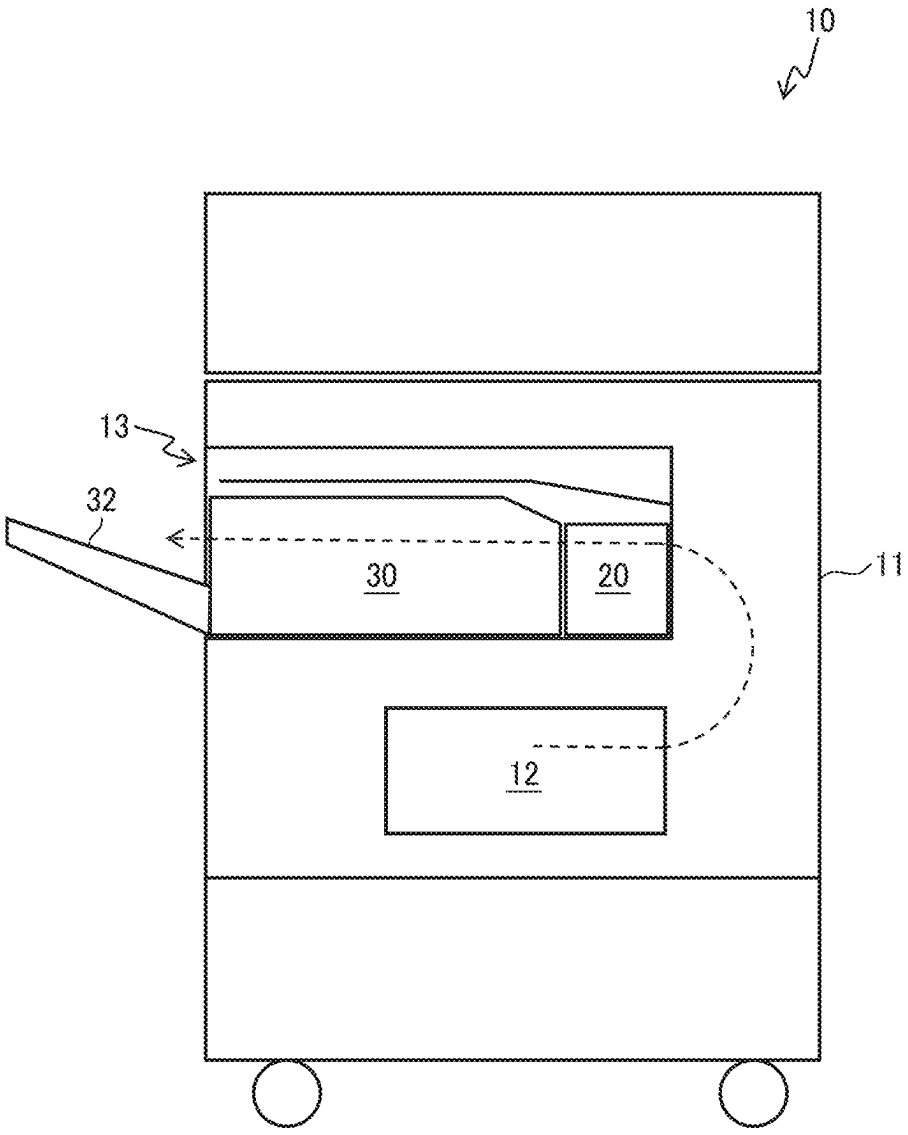
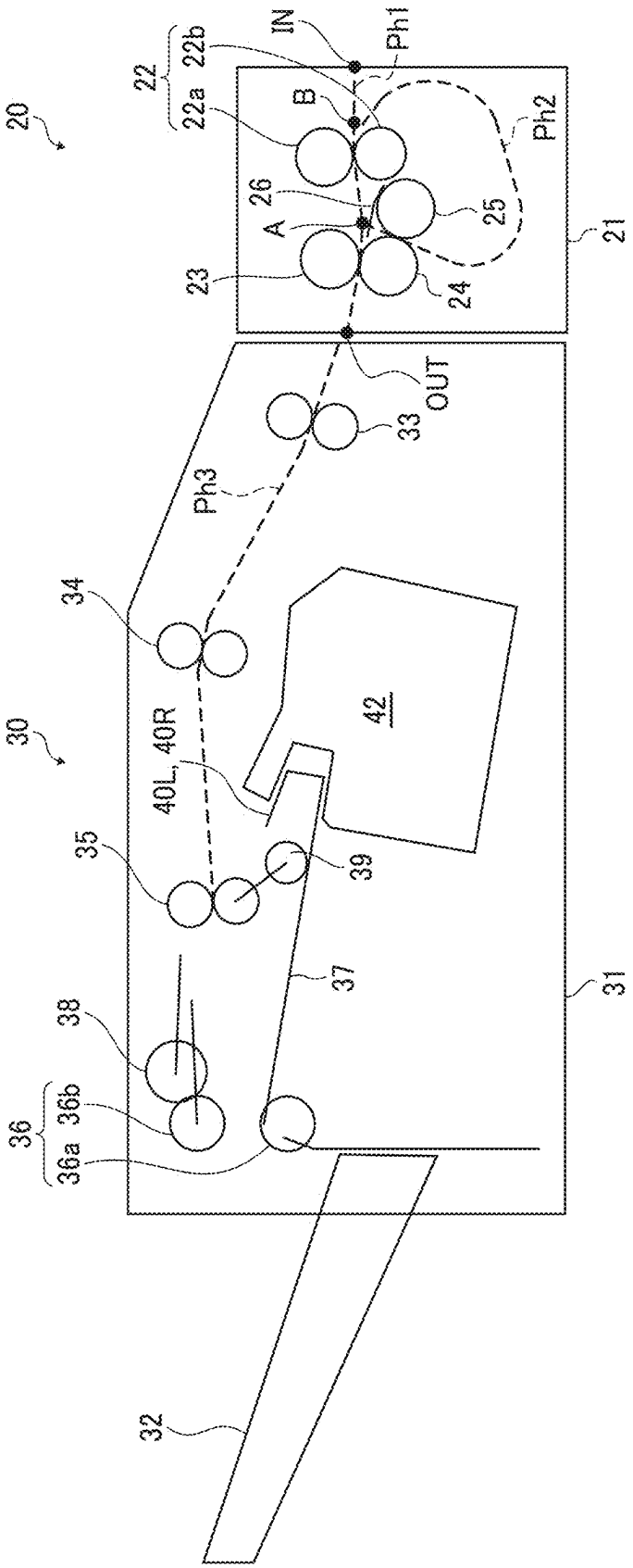


FIG. 2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22
22b
22a
IN
Ph1
B
Ph2
26
A
25
21
23
24
OUT
33
Ph3
34
30
42
40L, 40R
35
39
37
31
38
36
36b
36a
32

FIG. 3A

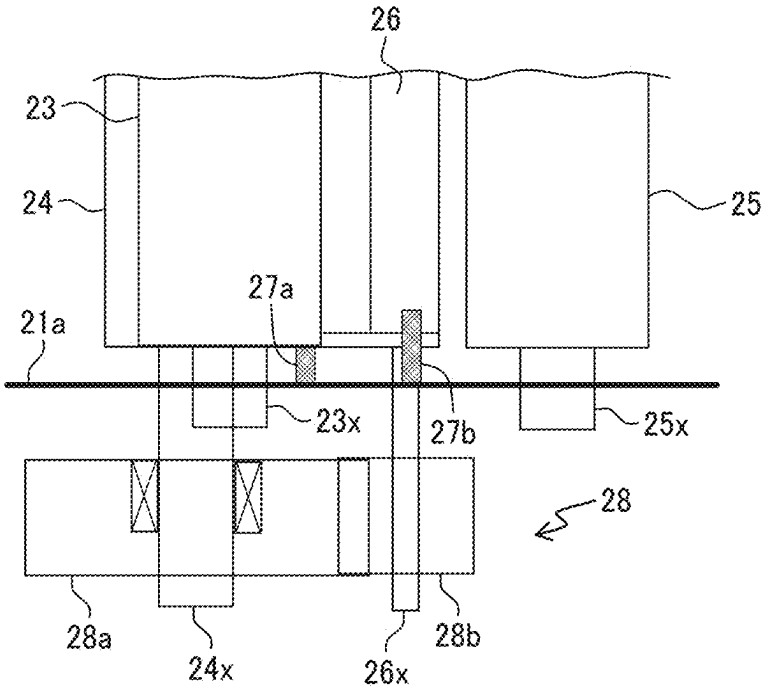

26
23
24
25
27a
21a
23x
27b
25x
28
28a
24x
26x
28b

FIG. 3B

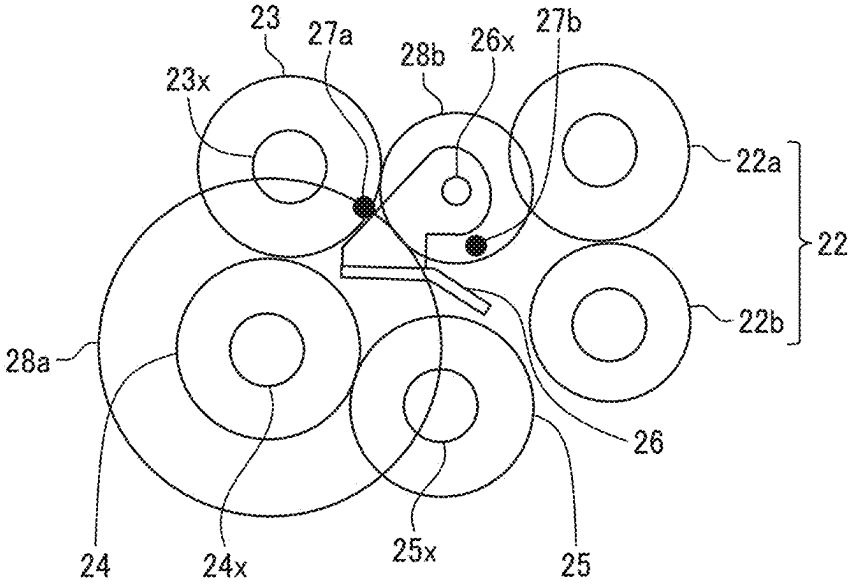

23
27a
28b
26x
27b
23x
22a
22
22b
28a
26
24
24x
25x
25

FIG. 4

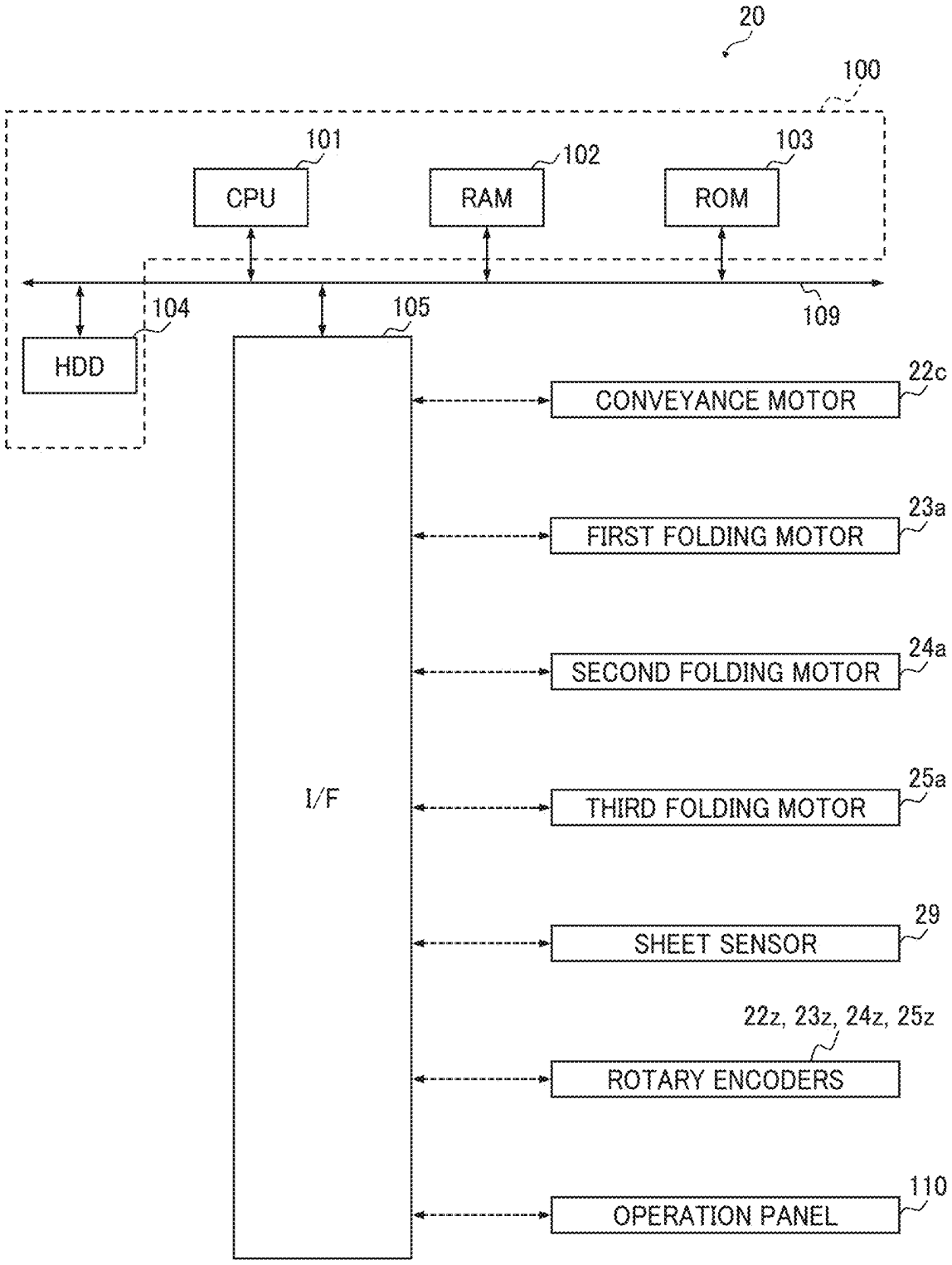

20
100
101
CPU
102
RAM
103
ROM
104
HDD
105
109
I/F
22c
CONVEYANCE MOTOR
23a
FIRST FOLDING MOTOR
24a
SECOND FOLDING MOTOR
25a
THIRD FOLDING MOTOR
29
SHEET SENSOR
22z, 23z, 24z, 25z
ROTARY ENCODERS
110
OPERATION PANEL

FIG. 5A

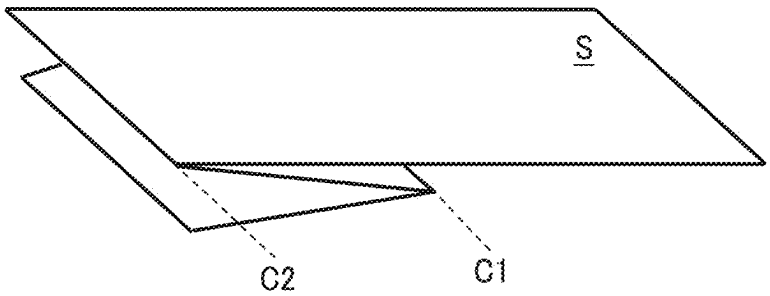


FIG. 5B

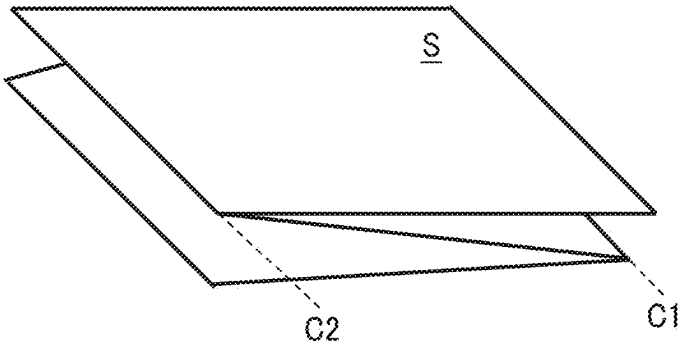


FIG. 5C

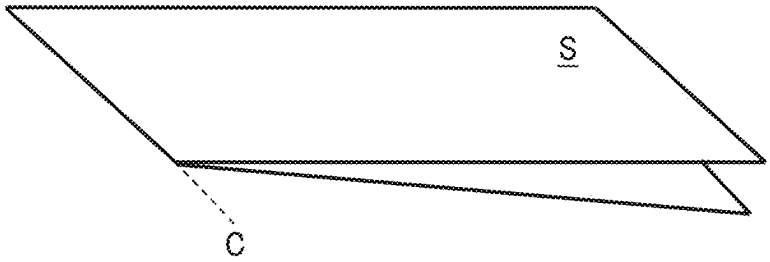


FIG. 6

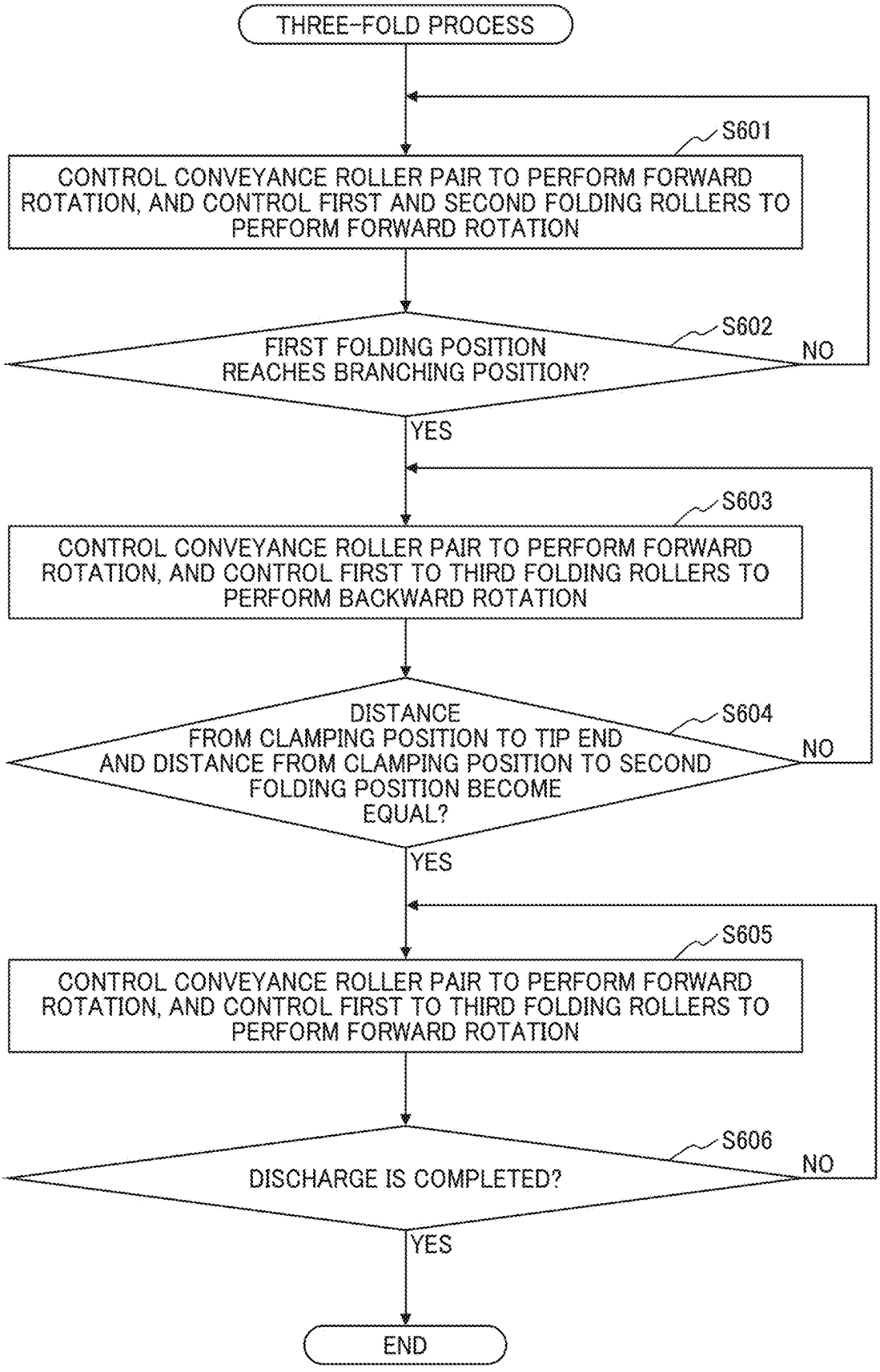

THREE-FOLD PROCESS
S601
CONTROL CONVEYANCE ROLLER PAIR TO PERFORM FORWARD ROTATION, AND CONTROL FIRST AND SECOND FOLDING ROLLERS TO PERFORM FORWARD ROTATION
S602
FIRST FOLDING POSITION REACHES BRANCHING POSITION?
NO
YES
S603
CONTROL CONVEYANCE ROLLER PAIR TO PERFORM FORWARD ROTATION, AND CONTROL FIRST TO THIRD FOLDING ROLLERS TO PERFORM BACKWARD ROTATION
S604
DISTANCE FROM CLAMPING POSITION TO TIP END AND DISTANCE FROM CLAMPING POSITION TO SECOND FOLDING POSITION BECOME EQUAL?
NO
YES
S605
CONTROL CONVEYANCE ROLLER PAIR TO PERFORM FORWARD ROTATION, AND CONTROL FIRST TO THIRD FOLDING ROLLERS TO PERFORM FORWARD ROTATION
S606
DISCHARGE IS COMPLETED?
NO
YES
END

FIG. 7B

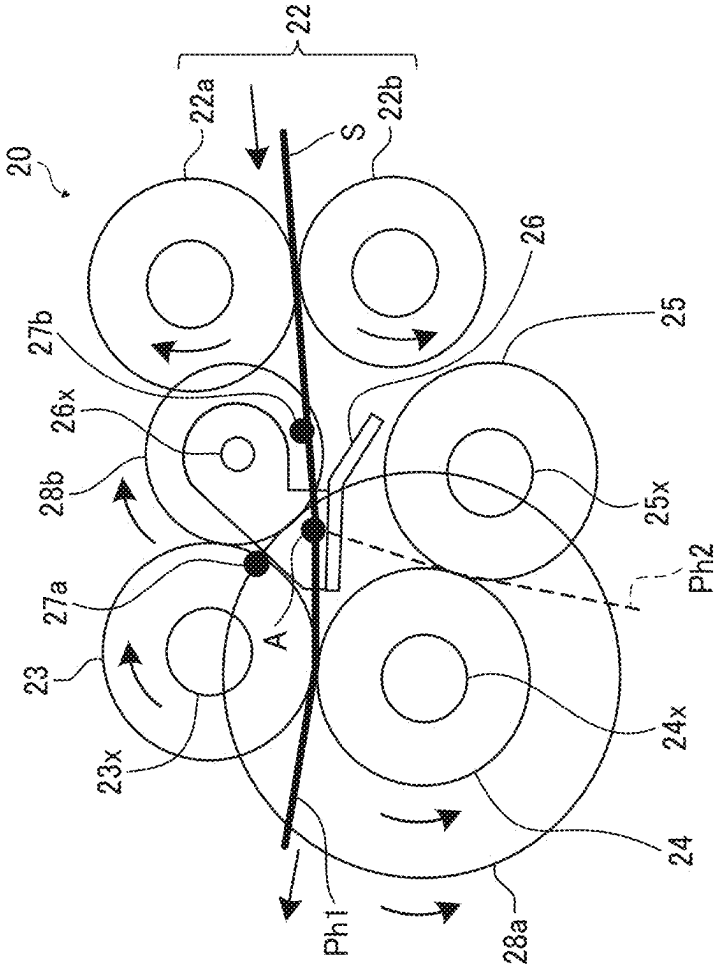

20
22
22a
22b
S
26
25
27b
26x
28b
25x
Ph2
27a
A
23
24x
23x
24
Ph1
28a

FIG. 7A

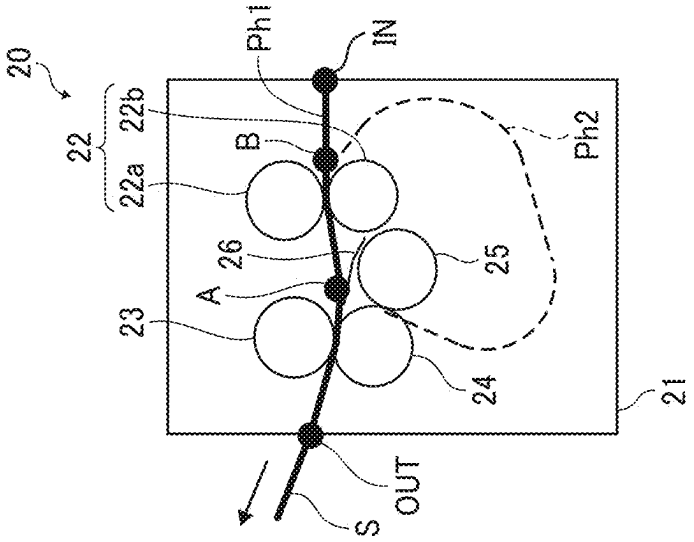

20
Phi
IN
22
22b
B
Ph2
22a
26
25
A
23
24
21
OUT
S

FIG. 8B

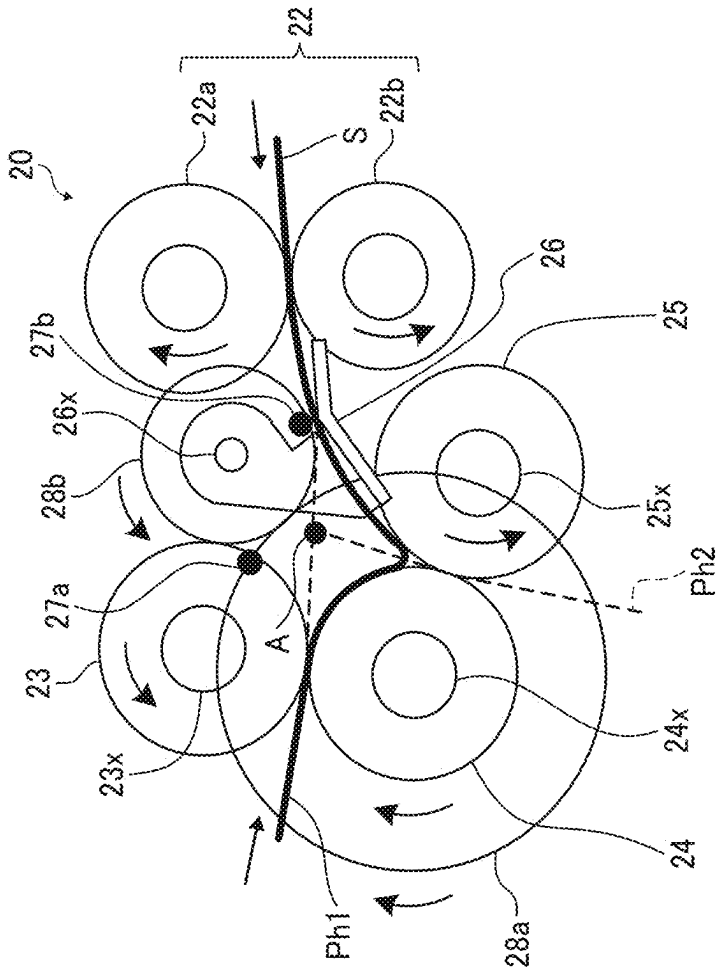

20
22
22a
22b
S
26
25
27b
26x
28b
25x
Ph2
27a
A
23
24x
23x
24
Ph1
28a

FIG. 8A

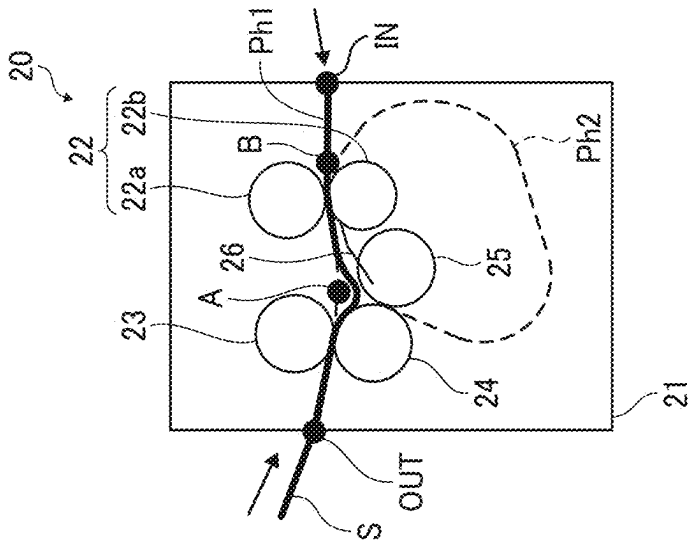

20
Ph1
IN
22
22b
B
Ph2
22a
26
25
A
23
24
21
OUT
S

FIG. 9B

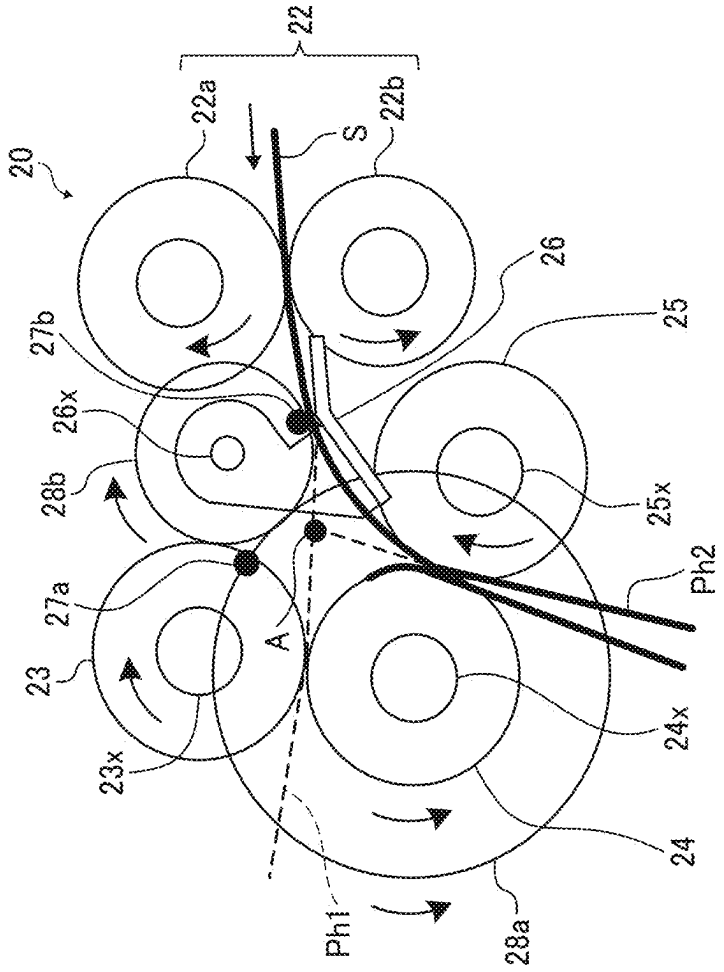

22
22a
22b
S
20
26
25
27b
26x
28b
25x
Ph2
27a
A
23
24x
23x
24
Ph1
28a

FIG. 9A

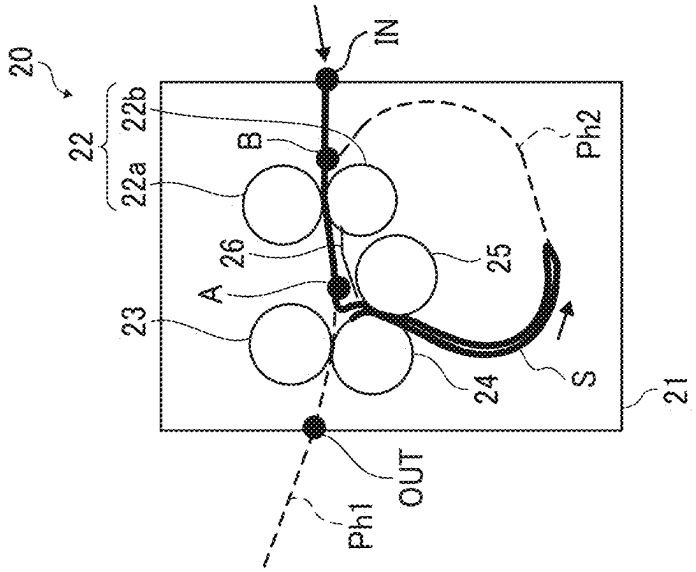

20
IN
22
22b
B
Ph2
22a
26
25
A
23
24
S
21
Ph1
OUT

FIG. 10B

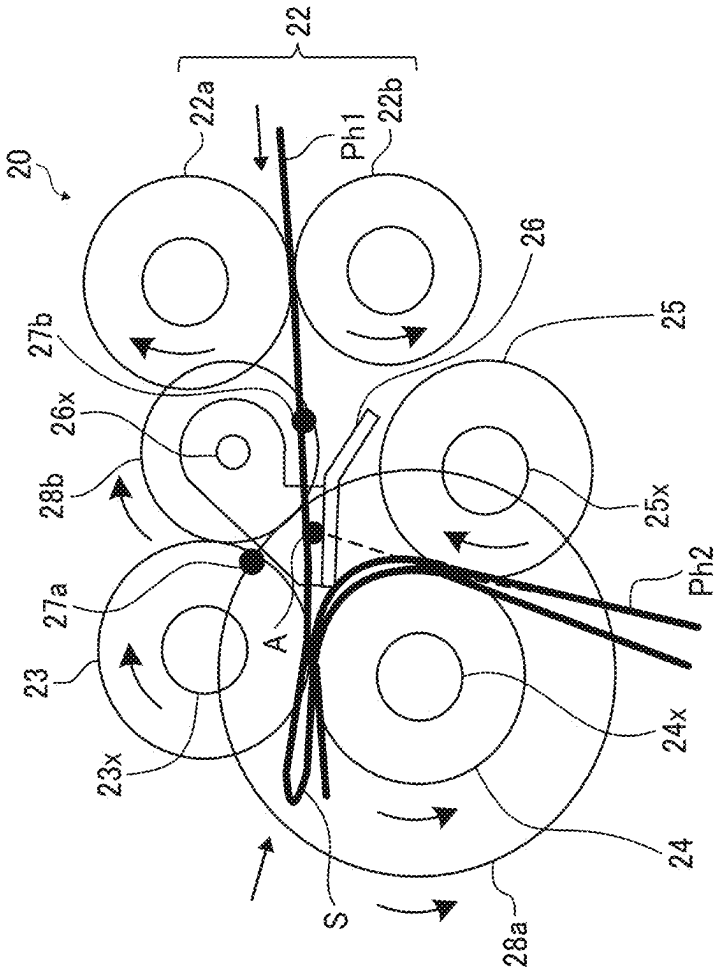


FIG. 10A

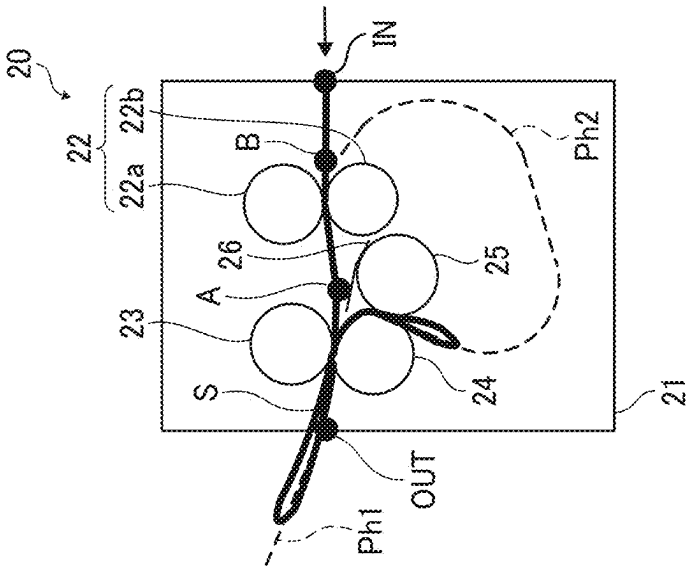


FIG. 11

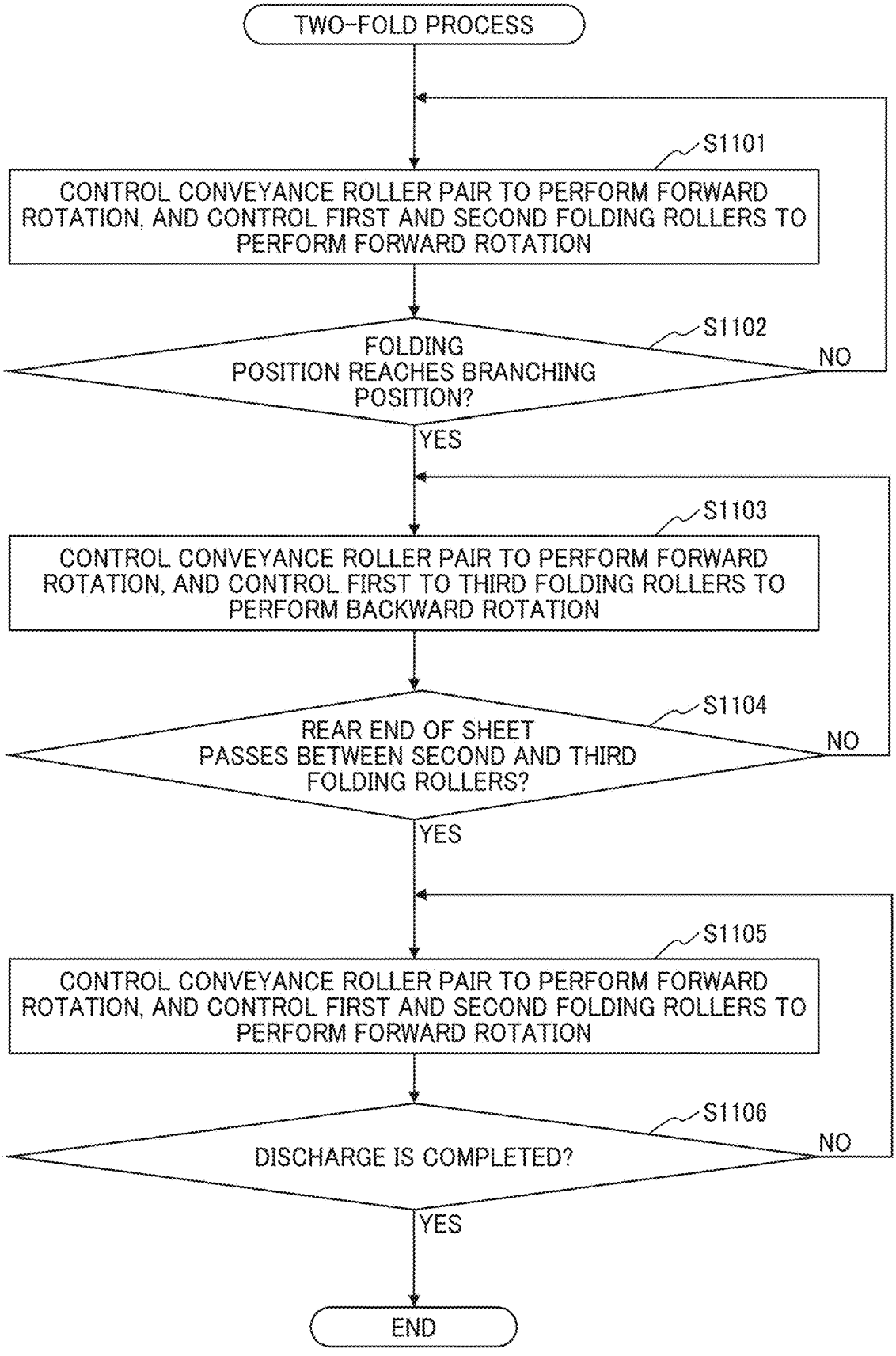

TWO-FOLD PROCESS
S1101
CONTROL CONVEYANCE ROLLER PAIR TO PERFORM FORWARD ROTATION, AND CONTROL FIRST AND SECOND FOLDING ROLLERS TO PERFORM FORWARD ROTATION
S1102
FOLDING POSITION REACHES BRANCHING POSITION?
NO
YES
S1103
CONTROL CONVEYANCE ROLLER PAIR TO PERFORM FORWARD ROTATION, AND CONTROL FIRST TO THIRD FOLDING ROLLERS TO PERFORM BACKWARD ROTATION
S1104
REAR END OF SHEET PASSES BETWEEN SECOND AND THIRD FOLDING ROLLERS?
NO
YES
S1105
CONTROL CONVEYANCE ROLLER PAIR TO PERFORM FORWARD ROTATION, AND CONTROL FIRST AND SECOND FOLDING ROLLERS TO PERFORM FORWARD ROTATION
S1106
DISCHARGE IS COMPLETED?
NO
YES
END

FIG. 12A

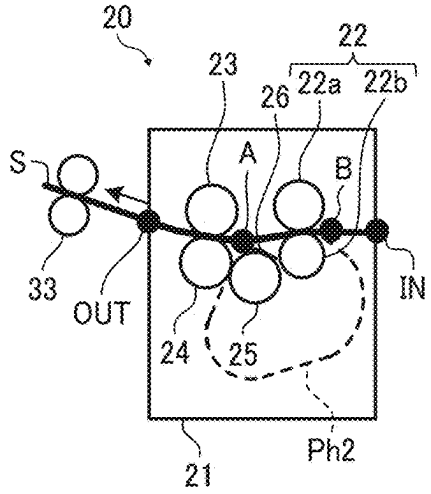


FIG. 12B

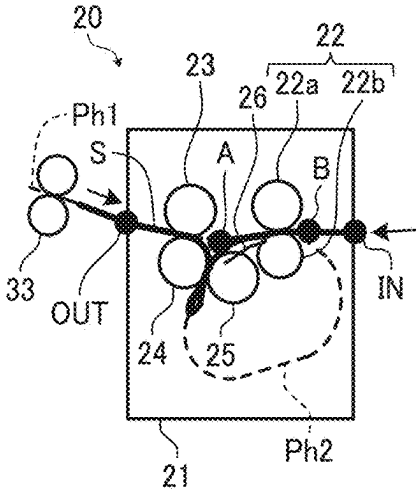


FIG. 12C

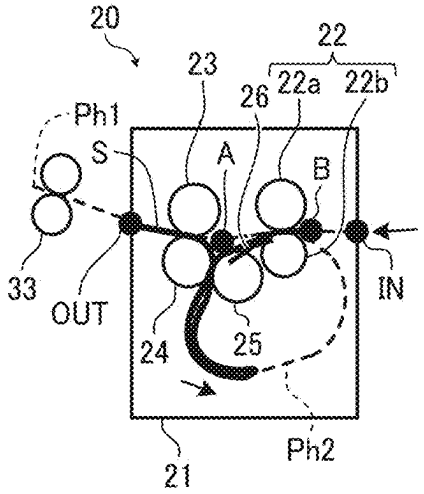


FIG. 12D

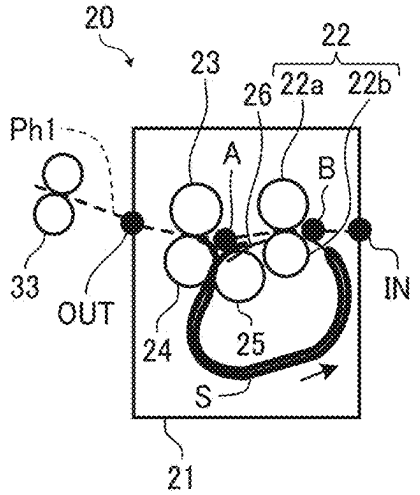


FIG. 12E

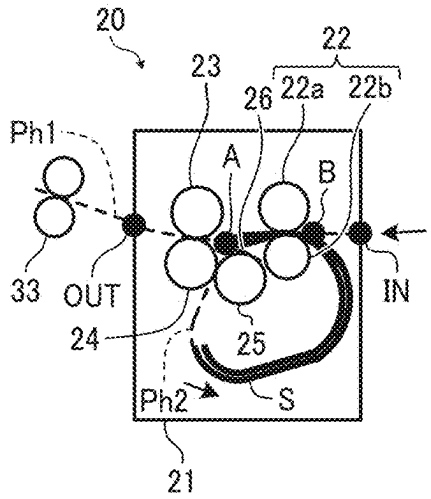
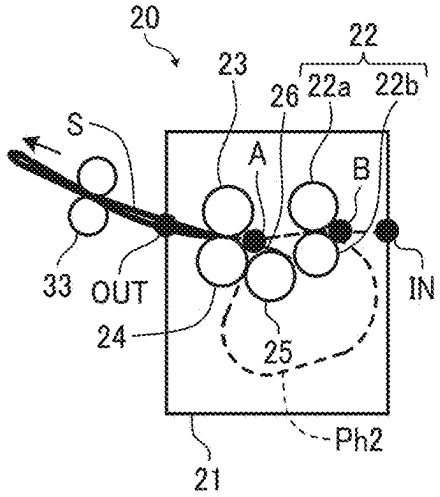


FIG. 12F



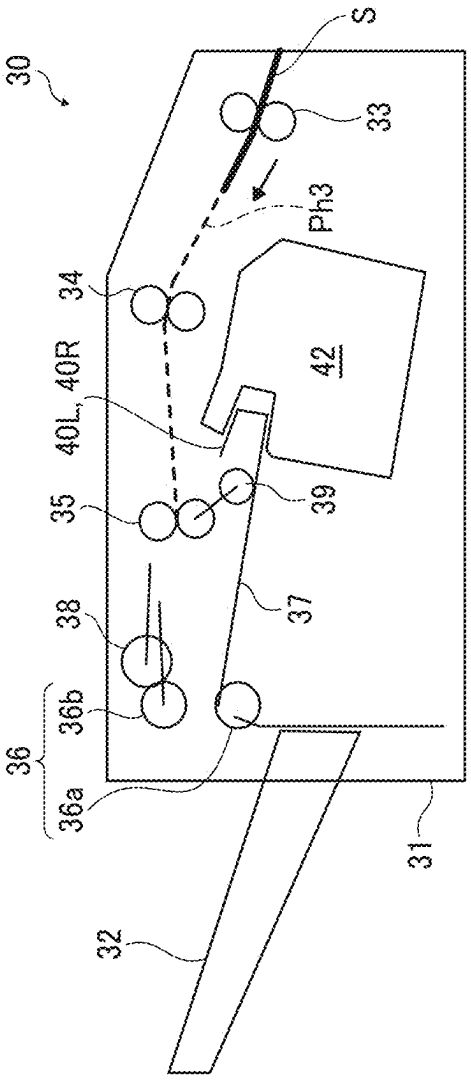


FIG. 13A

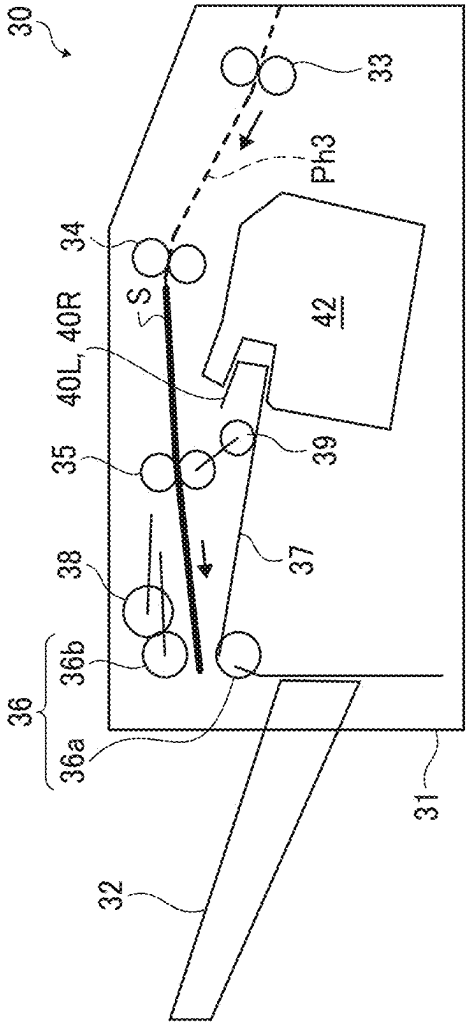


FIG. 13B

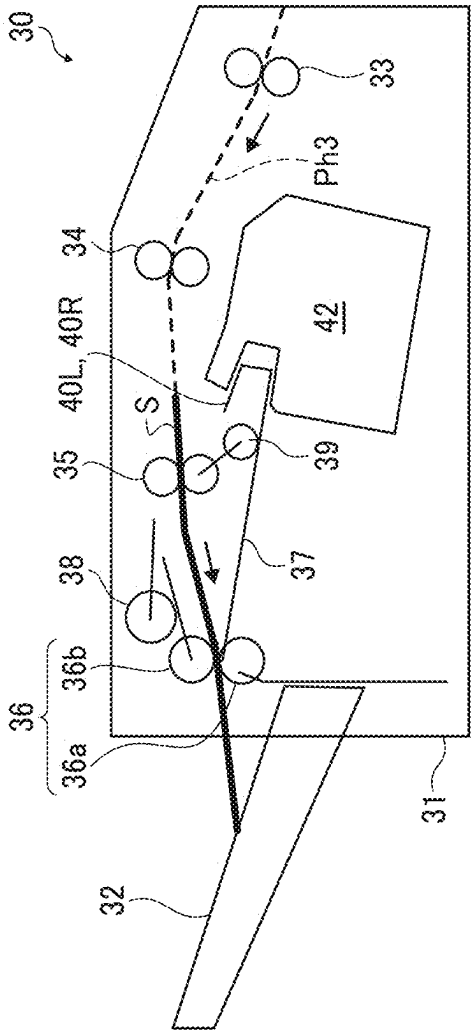


FIG. 14A

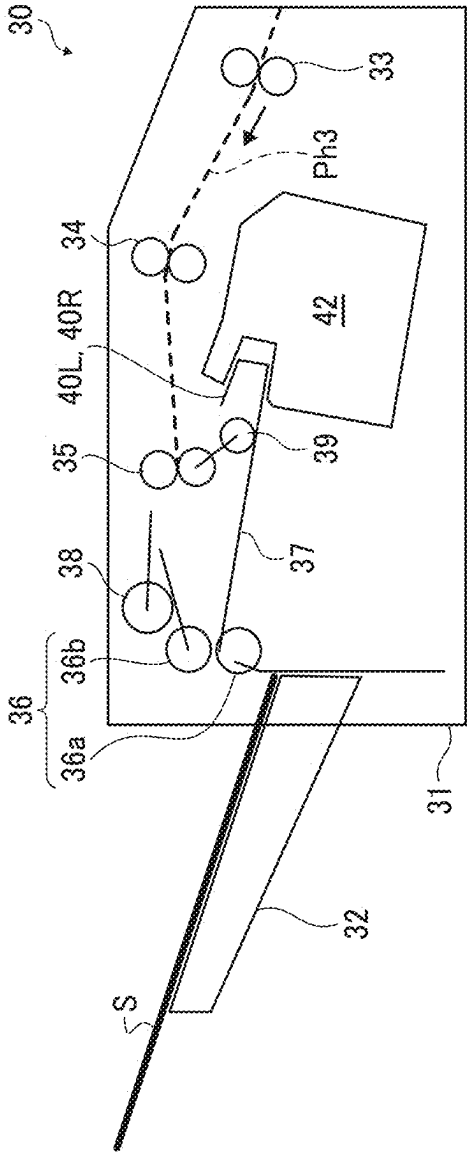


FIG. 14B

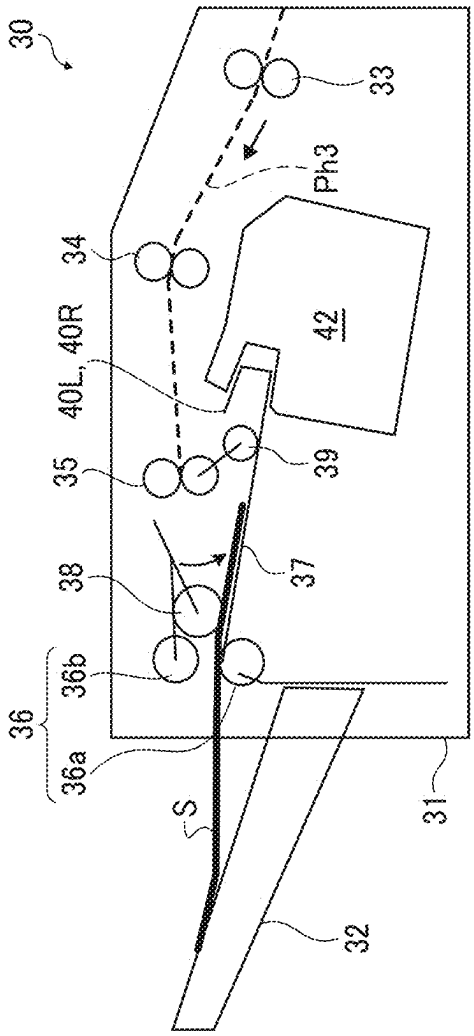


FIG. 15A

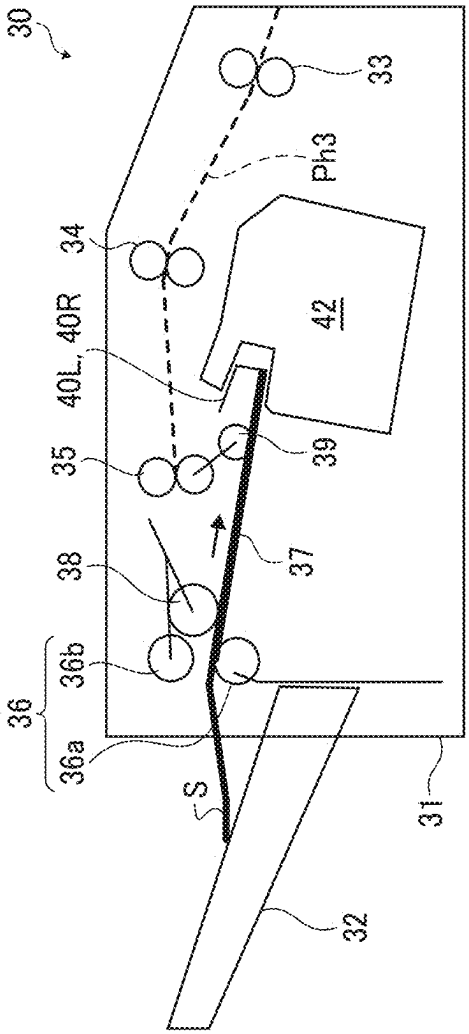
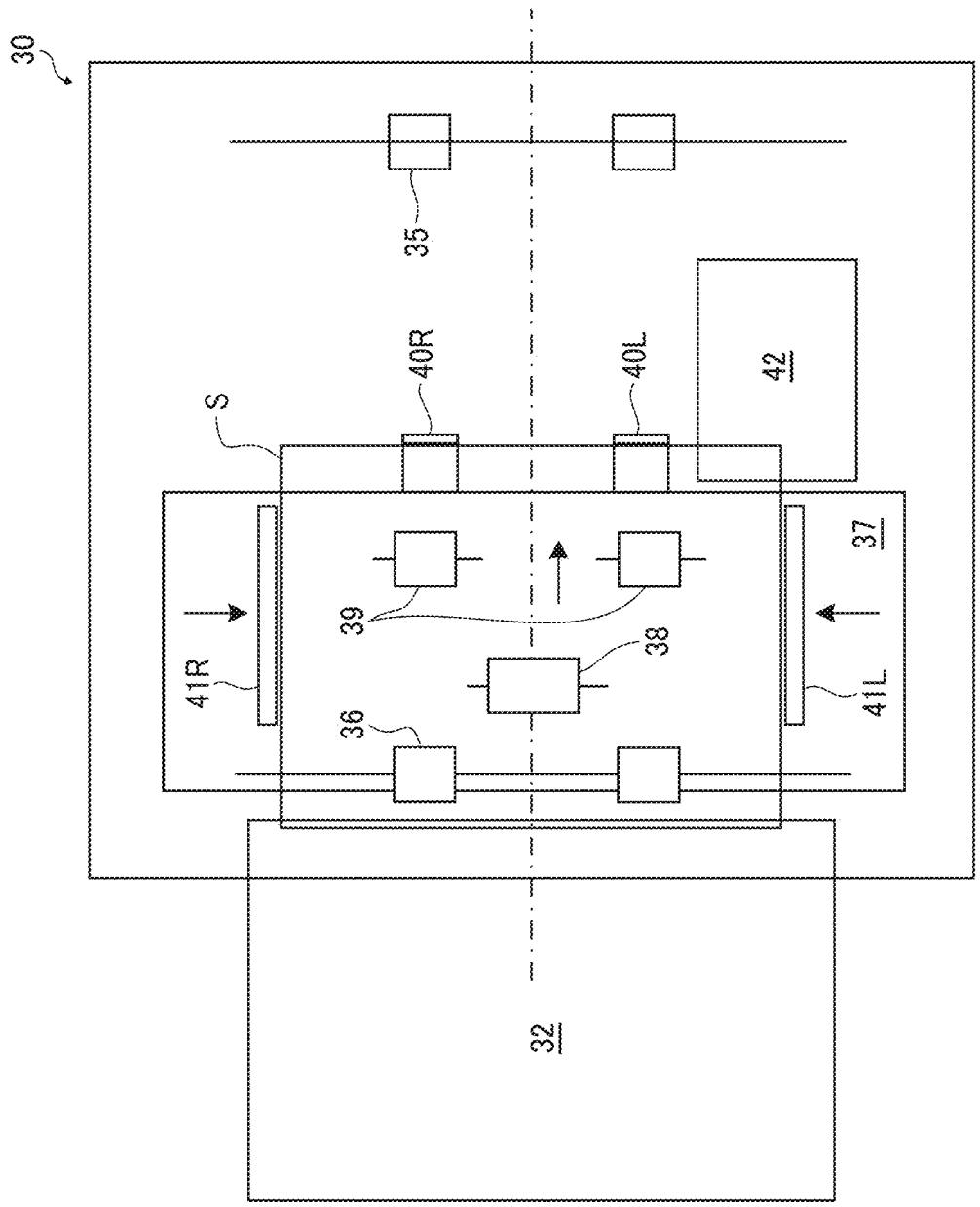


FIG. 15B

FIG. 16



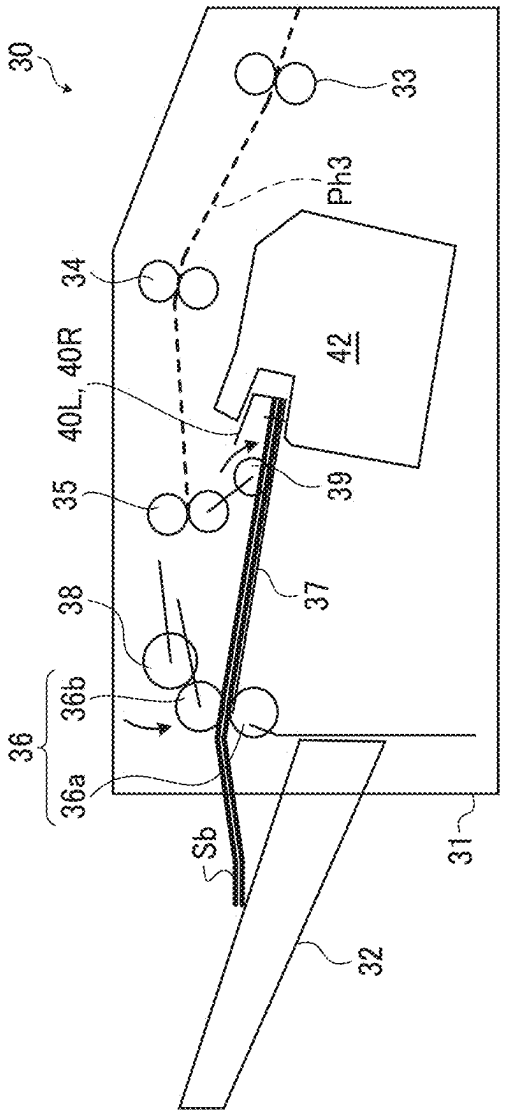


FIG. 17A

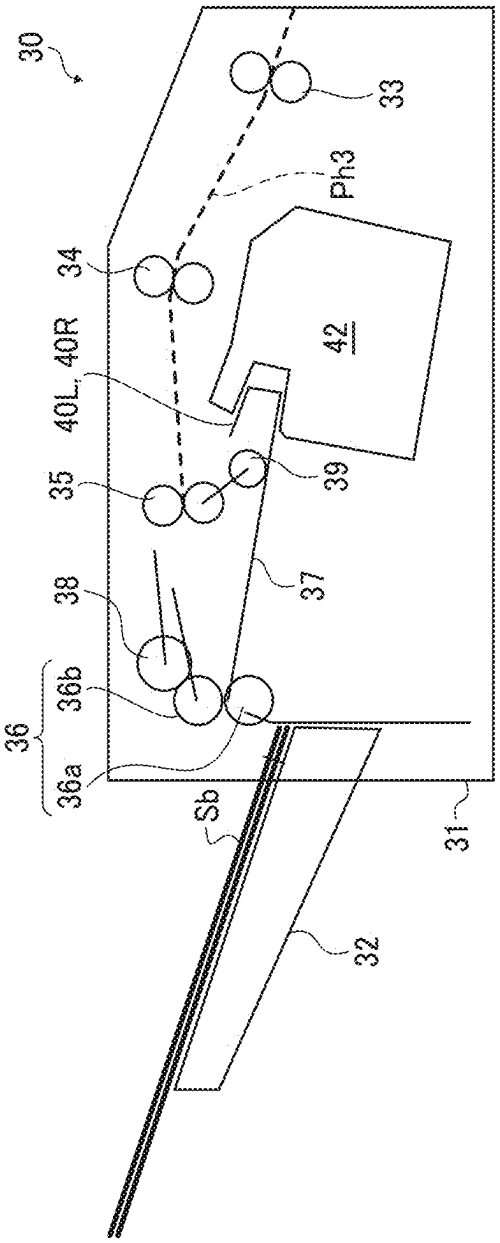


FIG. 17B

FIG. 18A

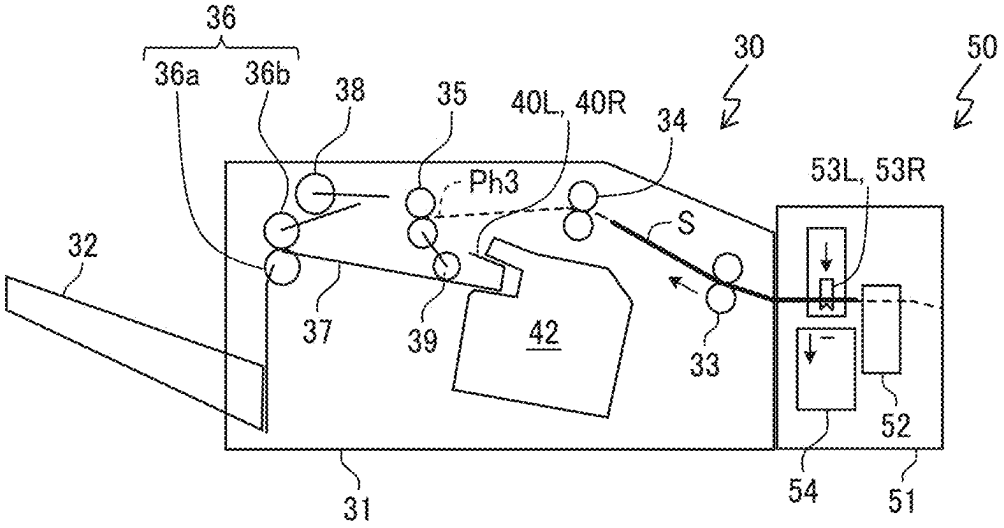


FIG. 18B

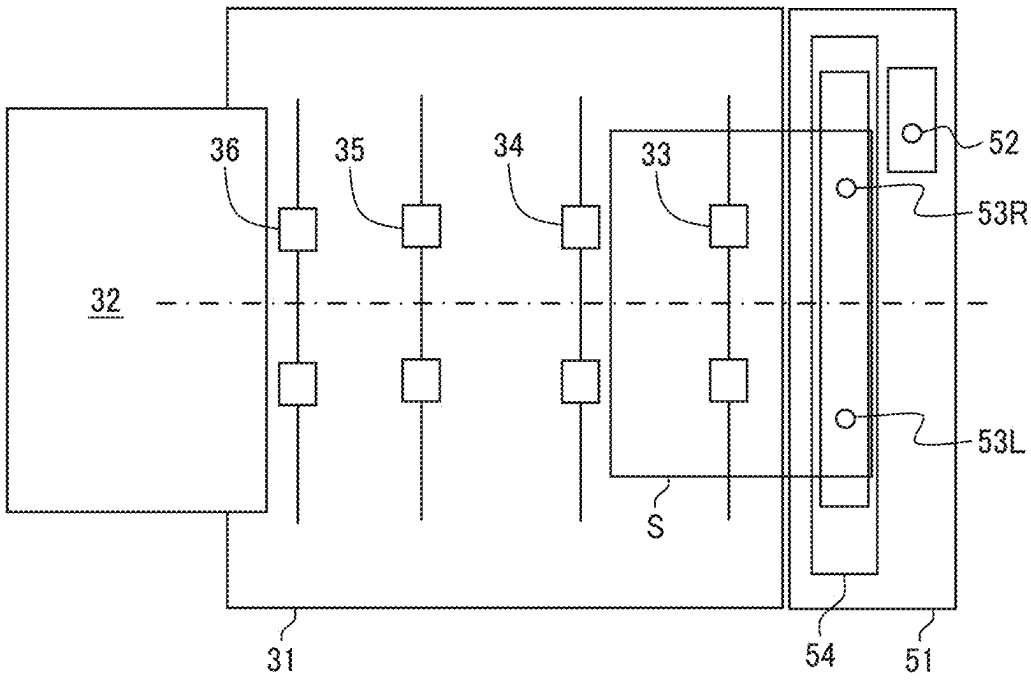
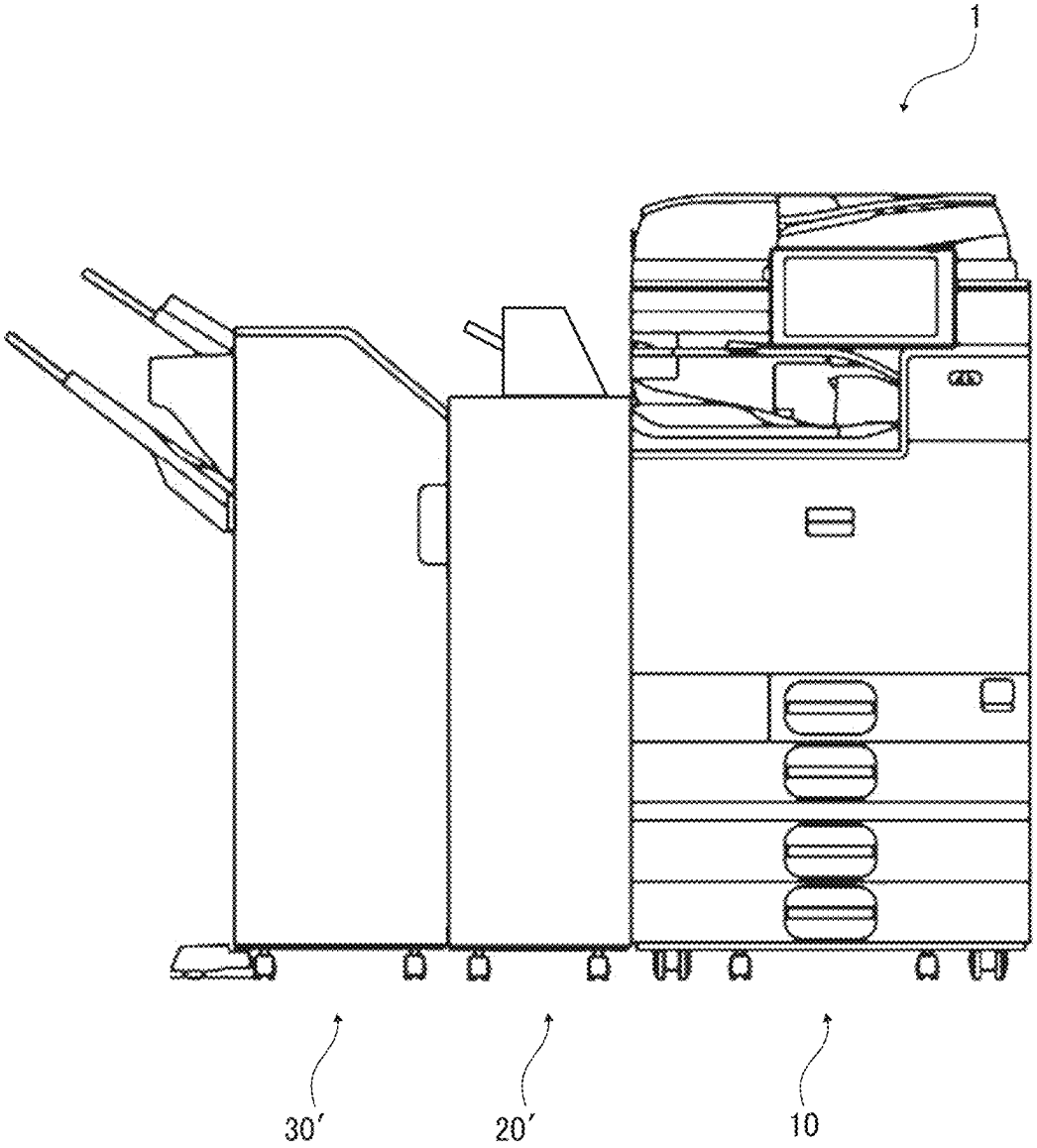


FIG. 19



SHEET FOLDING APPARATUS, IMAGE FORMING APPARATUS, AND IMAGE FORMING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

This patent application is based on and claims priority pursuant to 35 U.S.C. § 119(a) to Japanese Patent Application No. 2022-195096, filed on Dec. 6, 2022, in the Japan Patent Office, the entire disclosure of which is hereby incorporated by reference herein.

TECHNICAL FIELD

Embodiments of the present disclosure relate to a sheet folding apparatus, an image forming apparatus, and an image forming system.

RELATED ART

A sheet folding apparatus that folds a sheet on which an image is formed by an image forming apparatus into a predetermined shape (for example, Z-fold, outer three-fold, and two-fold) has been known. Here, when an image forming system is configured by connecting a sheet folding apparatus to an existing image forming apparatus, there is a problem that the entire system is enlarged.

In order to solve such a problem, for example, a sheet folding apparatus has been proposed that can be mounted in a body of an image forming apparatus and is suitable for alternately folding inward and outward in the sheet conveying direction to perform a so-called Z-fold.

SUMMARY

According to an embodiment of the present disclosure, a sheet folding apparatus includes a conveyor, a first folding roller, a second folding roller, a third folding roller, a guide, a motor, and a driving force transmission mechanism. The conveyor conveys a sheet along a main conveying path in a conveying direction. The first folding roller and the second folding roller are disposed opposite to each other with the main conveying path interposed between the first folding roller and the second folding roller. The third folding roller is disposed opposite to the second folding roller with a reflux conveying path interposed between the third folding roller and the second folding roller. The reflux conveying path branches off from the main conveying path at a branching position upstream from the first folding roller in the conveying direction and joins the main conveying path at a joining position upstream from the branching position in the conveying direction. The guide switches between a first posture and a second posture. The guide in the first posture prevents the sheet conveyed on the main conveying path in the conveying direction from entering the reflux conveying path through the branching position. The guide in the second posture allows the sheet to be conveyed from one of the main conveying path and the reflux conveying path to the other of the main conveying path and the reflux conveying path through the branching position. The motor causes the second folding roller to perform either forward rotation in which the second folding roller rotates to convey the sheet on the main conveying path in the conveying direction and to convey the sheet on the reflux conveying path from the joining position toward the branching position or backward rotation in which the second folding roller rotates in a direction opposite to the forward rotation. The driving force transmission mechanism rotates the guide from the second posture toward the first posture in conjunction with the forward rotation of the second folding roller and rotates the guide from the first posture toward the second posture in conjunction with the backward rotation of the second folding roller.

According to another embodiment of the present disclosure, an image forming apparatus includes a housing, an image former, and the sheet folding apparatus. The image former is housed in the housing to form an image on a sheet. The sheet folding apparatus is detachably supported by the housing, to fold the sheet on which the image is formed by the image former.

According to still another embodiment of the present disclosure, an image forming system includes an image forming apparatus to form an image on a sheet and the sheet folding apparatus that is connected to the image forming apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

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:

FIG. **1** is an external view of an image forming apparatus;

FIG. **2** is a diagram illustrating an internal configuration of a sheet folding unit and a sheet binding unit;

FIGS. **3**A and **3**B are views of the sheet folding unit as viewed from a direction (A) orthogonal to a sheet on a main conveying path and a width direction (B) of the sheet;

FIG. **4** is a hardware configuration diagram of the sheet folding unit;

FIGS. **5**A to **5**C are views for describing variations of a folding method that are implemented by the sheet folding unit;

FIG. **6** is a flowchart of a three-fold process;

FIGS. **7**A to **7**B are views illustrating a state of the sheet folding unit before a sheet is folded at a first folding position;

FIGS. **8**A to **8**B are views illustrating a state of the sheet folding unit when the sheet is folded at the first folding position;

FIGS. **9**A to **9**B are views illustrating a state of the sheet folding unit before the sheet is folded at a second folding position;

FIGS. **10**A to **10**B are views illustrating a state of the sheet folding unit after the sheet is folded at the second folding position;

FIG. **11** is a flowchart of a two-fold process;

FIGS. **12**A to **12**F are views illustrating a state of the sheet folding unit during the two-fold process;

FIGS. **13**A to **13**B are views illustrating a state of the sheet binding unit until the sheet reaches a conveyance roller pair;

FIGS. **14**A to **14**B are views illustrating a state of the sheet binding unit in a case where the sheet is ejected to an ejection tray without performing a binding process;

FIGS. **15**A to **15**B are views illustrating a state of the sheet binding unit that performs the binding process;

FIG. **16** is a view of the sheet binding unit in FIG. **15**B as viewed from the thickness direction of the sheet;

FIGS. **17**A to **17**B are views illustrating a state of the sheet binding unit in a case where a sheet bundle subjected to a binding process is ejected to the ejection tray;

FIGS. **18**A to **18**B are diagrams illustrating an internal configuration of a hole punch unit; and

FIG. **19** is an external view of the image forming system.

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 OF EMBODIMENTS

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.

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.

Hereinafter, an image forming apparatus **10** according to an embodiment of the present disclosure will be described with reference to the drawings. FIG. **1** is an external view of the image forming apparatus **10**. The image forming apparatus **10** is an apparatus that forms an image on a sheet S (typically, a sheet of paper). As illustrated in FIG. **1**, the image forming apparatus **10** includes a housing **11** and an image former **12**.

The housing **11** has a box shape in which an internal space for accommodating components of the image forming apparatus **10** is formed. The housing **11** has an in-body space **13** accessible from the outside of the image forming apparatus **10**. The in-body space **13** is located, for example, slightly above the center of the housing **11** in the vertical direction. The in-body space **13** is exposed to the outside by cutting out the outer wall of the housing **11**. Further, the in-body space **13** has a sheet folding unit **20** (serving as a sheet folding apparatus), a sheet binding unit **30** (serving as a post-processing device), and a hole punch unit **50** (see FIGS. **18**A to **18**B) to be described later.

The image former **12** forms an image on the sheet S stored in the tray, and ejects the sheet S on which the image is formed to the sheet folding unit **20**, the sheet binding unit **30**, or the hole punch unit **50**. The image former **12** may be an inkjet image forming device that forms an image with ink or an electrophotographic image forming device that forms an image with toner. Since the configuration of the image former **12** is already known, a detailed description thereof will be omitted.

The sheet folding unit **20** is attached to the in-body space **13** of the image forming apparatus **10** on the downstream side of the image former **12** and on the upstream side of the sheet binding unit **30** in the conveying path of the sheet S from the image former **12** to the sheet binding unit **30** (the path indicated by the dashed arrow in FIG. **1**). That is, the sheet S on which an image is formed by the image former **12** is first delivered to the sheet folding unit and subjected to a folding process to be described later, and then delivered to the sheet binding unit **30** and subjected to a binding process to be described later.

The sheet folding unit **20** is detachably attached to the image forming apparatus **10**. When the sheet folding unit **20** is removed, the sheet S on which an image is formed by the image former **12** is directly delivered to the sheet binding unit **30** and subjected to the binding process. Further, the hole punch unit **50** is detachably attached to a position where the sheet folding unit **20** is removed in the in-body space **13**. When the hole punch unit **50** is attached, the sheet S on which an image is formed by the image former **12** is first delivered to the hole punch unit **50** and subjected to a punching process to be described later, and then delivered to the sheet binding unit **30** and subjected to a binding process. At the position where the sheet folding unit **20** is removed in the in-body space **13**, a unit that performs an arbitrary process on the sheet S can be attached without being limited to the hole punch unit.

FIG. **2** is a diagram illustrating an internal configuration of the sheet folding unit **20** and the sheet binding unit **30**. Each of the sheet folding unit **20** and the sheet binding unit **30** is unitized, and an input/output interface of the sheet S can be connected thereto. That is, the input interface IN of the sheet folding unit **20** is connected to the output interface of the image former **12**. The input interface of the sheet binding unit **30** is connected to the output interface of the image former **12** and the output interface OUT of the sheet folding unit **20**.

The sheet folding unit **20** executes a folding process of folding the sheet S on which an image is formed by the image former **12** into a predetermined shape (for example, Z-fold, outer three-fold, and two-fold). As illustrated in FIG. **2**, the sheet folding unit **20** includes a housing **21**, a conveyance roller pair **22** (serving as a conveyor), a first folding roller **23**, a second folding roller **24**, a third folding roller **25**, a guide plate **26** (serving as a guide), a first stopper **27***a* and a second stopper **27***b* (see FIGS. **3**A to **3**B), and a driving force transmission mechanism **28** (see FIGS. **3**A to **3**B).

The housing **21** has a box shape in which an internal space for accommodating components of the sheet folding unit **20** is formed. The internal space of the housing **21** includes a main conveying path Ph1 and a reflux conveying path Ph2, which are spaces through which the sheet S passes. The main conveying path Ph1 is a conveying path from the input interface IN connected to the image former **12** to the output interface OUT connected to the sheet binding unit **30**. Hereinafter, a direction from the input interface IN to the output interface OUT on the main conveying path PHI is referred to as a "conveying direction". The reflux conveying path Ph2 is an annular conveying path that branches from the main conveying path PHI at a branching position A and joins the main conveying path Ph1 at a joining position B. The joining position B is located on the upstream side of the branching position A in the conveying direction.

The conveyance roller pair **22** conveys the sheet S in the conveying direction along the main conveying path Ph1. The conveyance roller pair **22** includes a driving roller **22***a* and a driven roller **22***b* arranged to face each other with the main conveying path Ph1 interposed therebetween on the upstream side in the conveying direction of the branching position A and on the downstream side in the conveying direction of the joining position B (that is, between the branching position A and the joining position B). The driving roller **22***a* and the driven roller **22***b* are rotatably supported by the housing **21**. The driving roller **22***a*, to which the driving force of a conveyance motor **22***c* (see FIG. **4**) is transmitted, rotates forward in the direction of conveying the sheet S in the conveying direction (clockwise in FIG. **2**). The driven roller **22***b* is arranged to face the driving roller **22***a* with the main conveying path Ph1 interposed therebe-

tween, and is driven with the rotation of the driving roller **22***a*. Then, when the conveyance motor **22***c* is driven in a state where the driving roller **22***a* and the driven roller **22***b* clamp the sheet S, the sheet S is conveyed in the conveying direction along the main conveying path Ph1.

The first folding roller **23** is rotatably supported by the housing **21** at a position facing the main conveying path Ph1. The second folding roller **24** is rotatably supported by the housing **21** at a position facing both the main conveying path Ph1 and the reflux conveying path Ph2. The third folding roller **25** is rotatably supported by the housing **21** at a position facing the reflux conveying path Ph2. The first folding roller **23** and the second folding roller **24** are arranged to face each other with the main conveying path Ph1 interposed therebetween on the downstream side in the conveying direction of the branching position A. Further, the second folding roller **24** and the third folding roller **25** are arranged to face each other with the reflux conveying path Ph2 interposed therebetween between at the branching position A and the joining position B.

The first folding roller **23** rotates forward and backward when the driving force of the first folding motor **23***a* (see FIG. **4**) is transmitted. The forward rotation of the first folding roller **23** is rotation in a direction conveying the sheet S on the main conveying path Ph1 in the conveying direction. The backward rotation of the first folding roller **23** is a rotation in a direction opposite to the forward rotation. The first folding motor **23***a* can perform forward rotation of forward rotating the first folding roller **23** and backward rotation of backward rotating the first folding roller **23**.

The second folding roller **24** rotates forward and backward when the driving force of the second folding motor **24***a* (see FIG. **4**) is transmitted. The forward rotation of the second folding roller **24** is rotation in a direction of conveying the sheet S on the main conveying path Ph1 in the conveying direction and conveying the sheet S on the reflux conveying path Ph2 from the joining position B toward the branching position A. The backward rotation of the second folding roller **24** is a rotation in a direction opposite to the forward rotation. The second folding motor **24***a* (motor) can perform forward rotation of forward rotating the second folding roller **24** and backward rotation of backward rotating the second folding roller **24**.

The third folding roller **25** is rotated forward and backward by the transmission of the driving force of the third folding motor **25***a* (see FIG. **4**). The forward rotation of the third folding roller **25** is rotation in a direction of conveying the sheet S on the reflux conveying path Ph2 from the joining position B toward the branching position A. The backward rotation of the third folding roller **25** is a rotation in a direction opposite to the forward rotation. The third folding motor **25***a* can perform forward rotation of forward rotating the third folding roller **25** and backward rotation of backward rotating the third folding roller **25**.

The guide plate **26** is rotatably supported by the housing **21** in the vicinity of the branching position A. The guide plate **26** rotates between a first posture illustrated in FIGS. **7**B and **10**B and a second posture illustrated in FIGS. **8**B and **9**B. The first posture is a posture of the guide plate **26** that allows the sheet S to be conveyed on the main conveying path Ph1 in the conveying direction and prevents the sheet S conveyed on the main conveying path Ph1 in the conveying direction from entering the reflux conveying path Ph2 through the branching position A. On the other hand, the guide plate **26** in the first posture allows the sheet S on the reflux conveying path Ph2 to enter the main conveying path Ph1 through the branching position A. The second posture is a posture of the guide plate **26** that allows the sheet S to be conveyed from one of the main conveying path Ph1 and the reflux conveying path Ph2 to the other through the branching position A.

As illustrated in FIGS. **7**B and **10**B, the first stopper **27***a* abuts on the guide plate **26** in the first posture to prevent the guide plate **26** from rotating in a direction away from the second posture (clockwise in FIGS. **7**B and **10**B). As illustrated in FIGS. **8**B and **9**B, the second stopper **27***b* abuts on the guide plate **26** in the second posture to prevent the guide plate **26** from rotating in a direction away from the first posture (counterclockwise in FIGS. **8**B and **9**B). As a result, the guide plate **26** rotates between the first posture and the second posture (in other words, between the first stopper **27***a* and the second stopper **27***b*). In other words, the first stopper **27***a* and the second stopper **27***b* restrict the rotation range of the guide plate **26**.

FIGS. **3**A to **3**B are views of the sheet folding unit **20** viewed from a direction (A) orthogonal to the sheet S and a width direction (B) of the sheet S on the main conveying path Ph1. As illustrated in FIGS. **3**A to **3**B, rotation shafts **23***x*, **24***x*, **25***x*, and **26***x* of the first folding roller **23**, the second folding roller **24**, the third folding roller **25**, and the guide plate **26** extend in the width direction of the sheet S. The rotation shafts **23***x*, **24***x*, **25***x*, and **26***x* pass through a partition wall **21***a* provided inside the housing **21**. The driving force transmission mechanism **28** is disposed on the side opposite to the first folding roller **23**, the second folding roller **24**, the third folding roller **25**, and the guide plate **26** with the partition wall **21***a* interposed therebetween.

The driving force transmission mechanism **28** distributes the driving force of the second folding motor **24***a* to the second folding roller **24** and the guide plate **26** to drive the second folding roller **24** and the guide plate **26** in conjunction with each other. More particularly, the driving force transmission mechanism **28** rotates the guide plate **26** from the second posture toward the first posture in conjunction with the forward rotation of the second folding roller **24**. The driving force transmission mechanism **28** rotates the guide plate **26** from the first posture toward the second posture in conjunction with the backward rotation of the second folding roller **24**. As illustrated in FIGS. **3**A to **3**B, the driving force transmission mechanism **28** includes, for example, a torque limiter **28***a* and a driven gear **28***b*.

An output shaft of the second folding motor **24***a* is connected to the rotation shaft **24***x* of the second folding roller **24**. The torque limiter **28***a* is attached to the rotation shaft **24***x* of the second folding roller **24** and rotates integrally with the second folding roller **24**. The driven gear **28***b* is attached to the rotation shaft **26***x* of the guide plate **26** and rotates integrally with the guide plate **26**. The torque limiter **28***a* and the driven gear **28***b* are meshed with each other.

Thus, the driving force of the second folding motor **24***a* is transmitted to the second folding roller **24**, and is also transmitted to the guide plate **26** through the torque limiter **28***a* and the driven gear **28***b*. More particularly, when the second folding motor **24***a* rotates forward, the second folding roller **24** rotates forward, and the guide plate **26** rotates from the second posture toward the first posture. On the other hand, when the second folding motor **24***a* rotates backward, the second folding roller **24** rotates backward, and the guide plate **26** rotates from the first posture toward the second posture.

The torque limiter **28***a* transmits the driving force of the second folding motor **24***a* to the driven gear **28***b* (in other words, the guide plate **26**) when the rotational torque is less than the threshold (that is, the guide plate **26** is separated

from the first stopper **27***a* and the second stopper **27***b*). On the other hand, the torque limiter **28***a* releases (that is, idling) the transmission of the driving force from the second folding motor **24***a* to the driven gear **28***b* (in other words, the guide plate **26**) when the rotational torque is equal to or greater than the threshold (that is, the guide plate **26** abuts on the first stopper **27***a* and the second stopper **27***b*). Since the configuration of the torque limiter **28***a* for switching transmission and transmission release of the driving force is already known, a detailed description thereof will be omitted.

Furthermore, the number of teeth Z1 of the torque limiter **28***a* is larger than the number of teeth Z2 of the driven gear **28***b* (Z1>Z2). As a result, the driving force transmission mechanism **28** accelerates the rotation of the second folding motor **24***a* and transmits the accelerated rotation to the guide plate **26**. More particularly, when the second folding motor **24***a* makes one rotation, the second folding roller **24** rotates by the first rotation speed (for example, one rotation), whereas the guide plate **26** rotates by the second rotation speed (for example, Z1/Z2) larger than the first rotation speed. As a result, the posture of the guide plate **26** can be quickly changed.

The sheet folding unit **20** includes a sheet sensor **29** (see FIG. **4**) that detects that the sheet S has reached a predetermined position on the main conveying path Ph1 or the reflux conveying path Ph2, and rotary encoders **22***z*, **23***z*, **24***z*, and **25***z* (see FIG. **4**) that detect the rotation speeds of the rollers **22***a*, **23**, **24**, and **25**. A controller **100** to be described later can grasp the position of the sheet S on the main conveying path Ph1 and the reflux conveying path Ph2 based on the detection results of the sheet sensor **29** and the rotary encoders **22***z*, **23***z*, **24***z*, and **25***z*.

More particularly, the controller **100** grasps the position of the sheet S based on the number of pulse signals output from the rotary encoders **22***z*, **23***z*, **24***z*, and **25***z* after the sheet S is detected by the sheet sensor **29**. Thus, the timing of steps S**602**, S**604**, S**606**, S**1102**, S**1104**, and S**1106** to be described later is detected. Note that the installation position of the sheet sensor **29** is not limited to one position, and may be a plurality of positions.

The sheet binding unit **30** performs a binding process (post-process) of binding a plurality of sheets S (hereinafter, referred to as a "sheet bundle Sb") on which an image is formed by the image former **12**. In the present embodiment, the sheet binding unit **30** will be described as an example of the post-processing device, but a specific example of the post-processing device (or post-process) is not limited thereto. As illustrated in FIG. **2**, the sheet binding unit **30** includes a housing **31**, an ejection tray **32**, a plurality of conveyance roller pairs **33**, **34**, **35**, and **36**, an inner tray **37**, a tapping roller **38**, a return roller **39**, end fences **40**L and **40**R, side fences **41**L and **41**R (see FIG. **16**), and a binding processor **42**.

The housing **31** has a box shape in which an internal space for accommodating components of the sheet binding unit **30** is formed. The internal space of the housing **31** includes a conveying path Ph3, which is a space through which the sheet S passes. The ejection tray **32** is supported by an outer surface of the housing **31**. The ejection tray **32** supports the sheet S or the sheet bundle Sb conveyed by the conveyance roller pairs **33** to **36**.

The conveyance roller pairs **33** to **36** are disposed on the conveying path Ph3 at a predetermined interval. The conveyance roller pairs **33** to **36** convey the sheet S along the conveying path Ph3. A basic configuration of the conveyance roller pairs **33** to **36** is common to the conveyance roller pair **22** of the sheet folding unit **20**. However, the conveyance roller pair **36** includes a driving roller **36***a* and a driven roller **36***b* that can come into and out of contact with the driving roller **36***a*. Further, the conveyance roller pair **35** may slide in the width direction in order to implement a sorting process of shifting the sheet S in the width direction and ejecting the sheet S to the ejection tray **32**.

The inner tray **37** temporarily supports (stacks) the plurality of sheets S sequentially conveyed on the conveying path Ph3. The tapping roller **38** is supported at a tip end of a rotation arm above the inner tray **37**. The tapping roller **38** rotates the rotation arm to supply the sheet S clamped by the conveyance roller pair **36** to the inner tray **37**. The return roller **39** abuts on the top surface of the sheet S supported by the inner tray **37** and rotates to guide the sheet S toward the end fences **40**L and **40**R.

The end fences **40**L and **40**R abut on the end portion on the downstream side in the conveying direction of the sheet S supported by the inner tray **37** to align the position of the sheet S in the conveying direction. The side fences **41**L and **41**R abut on both end portions in the width direction of the sheet S supported by the inner tray **37** to align the position of the sheet S in the width direction. The binding processor **42** executes a binding process of binding the sheet bundle Sb supported by the inner tray **37**. The binding process executed by the binding processor **42** may be a needle binding process of inserting a binding needle into the sheet bundle Sb and binding the sheet bundle Sb, or may be a crimp binding process of pressure-deforming and binding the sheet bundle Sb. Further, the sheet binding unit **30** may include a needle binding processor that executes a needle binding process and a crimp binding processor that executes a crimping process, the needle binding processor and the crimp binding processor being operated independently of each other at positions separated in the width direction.

In addition, a manual staple slit may be provided at a position facing the binding processor **42** of the housing **31**. Then, the user may insert the sheet bundle into the binding processor **42** through the manual staple slit and press a manual staple button of an operation panel **110** to be described later so that the binding processor **42** can execute the binding process.

FIG. **4** is a hardware configuration diagram of the sheet folding unit **20**. As illustrated in FIG. **4**, the sheet folding unit **20** has a configuration in which a central processing unit (CPU) **101**, a random access memory (RAM) **102**, a read only memory (ROM) **103**, a hard disk drive (HDD) **104**, and an interface (I/F) **105** are connected via a common bus **109**.

The CPU **101** is a calculation unit, and controls the entire operation of the sheet folding unit **20**. The RAM **102** is a volatile storage medium that allows data to be read and written at high speed. The CPU **101** uses the RAM **102** as a working area for data processing. The ROM **103** is a read-only non-volatile storage medium that stores programs such as firmware. The HDD **104** is a non-volatile storage medium that allows data to be read and written and has a relatively large storage capacity. The HDD **104** stores, for example, an operating system (OS), various control programs, and application programs.

The sheet folding unit **20** processes a control program stored in the ROM **103**, an information processing program (application program) loaded from a storage medium such as the HDD **104** to the RAM **102**, and the like by an arithmetic function of the CPU **101**. Through the process, a software controller including various functional modules of the sheet folding unit **20** is configured. The combination of the software controller configured as described above and hard-

ware resources mounted on the sheet folding unit **20** constitutes a functional block that implements the function of the sheet folding unit **20**. That is, the CPU **101**, the RAM **102**, the ROM **103**, and the HDD **104** constitute a controller **100** that controls the operation of the sheet folding unit **20**.

The I/F **105** is an interface that connects the conveyance motor **22***c*, the first folding motor **23***a*, the second folding motor **24***a*, the third folding motor **25***a*, the sheet sensor **29**, the rotary encoders **22***z*, **23***z*, **24***z*, and **25***z*, and the operation panel **110** to the common bus **10**). The controller **100** acquires information from the sheet sensor **29**, the rotary encoders **22***z*, **23***z*, **24***z*, and **25***z*, and the operation panel **110** through the I/F **105**, and operates the conveyance motor **22***c*, the first folding motor **23***a*, the second folding motor **24***a*, and the third folding motor **25***a*.

Note that although only the components of the sheet folding unit **20** are illustrated in FIG. **4**, the controller **100** may also control the operations of the image former **12** and the sheet binding unit **30**. Further, the controller **100** may communicate with a controller that controls the operation of the image former **12** and a controller that controls the operation of the sheet binding unit **30** to operate the sheet folding unit **20** in conjunction with the image former **12** and the sheet binding unit **30**.

The operation panel **110** includes an operation device that receives instructions from a user and a display serving as an indicator that notifies the user of information. The operation device includes, for example, physical input buttons and a touch panel overlaid on a display. The operation panel **110** acquires information from the operator through the operation device and provides the operator with information through the display. Examples of the indicator are not limited to the display and may be, for example, a light emitting diode (LED) lamp or a speaker.

FIGS. **5**A to **5**C are views for describing variations of a folding method that are implemented by the sheet folding unit **20**. FIG. **5**A is a view in which the sheet S having the total length L in the conveying direction is folded in opposite directions at a first folding position C1 of L/4 from the front end and a second folding position C2 of L/2 (that is, the upstream side of the first folding position in the conveying direction) from the front end to form the so-called "Z-fold". FIG. **5**B is a view in which the sheet S having the total length L in the conveying direction is folded in opposite directions at a first folding position C1 of L/3 from the front end and a second folding position C2 of 2 L/3 (that is, the upstream side of the first folding position in the conveying direction) from the front end to form the so-called "outer three-fold". FIG. **5**C is a view in which the sheet S having the total length L in the conveying direction is folded at a folding position C of L/2 from the front end to form the so-called "two-fold".

Next, a three-fold process of folding the sheet S in three will be described with reference to FIGS. **6** to **10**. FIG. **6** is a flowchart of a three-fold process. FIGS. **7**A to **7**B are views illustrating a state of the sheet folding unit **20** before the sheet S is folded at the first folding position C1. FIGS. **8**A to **8**B are views illustrating a state of the sheet folding unit **20** when the sheet S is folded at the first folding position C1. FIGS. **9**A to **9**B are views illustrating a state of the sheet folding unit **20** before the sheet S is folded at the second folding position C2. FIGS. **10**A to **10**B are views illustrating a state of the sheet folding unit after the sheet S is folded at the second folding position C2.

The controller **100** starts the three-fold process illustrated in FIG. **6** in response to the sheet S being supplied from the image former **12** through the input interface IN. Note that how to fold the sheet S (in other words, the locations of the folding positions C1 and C2 in the conveying direction) may be instructed by the user through the operation panel **110** or may be instructed from an external apparatus through a communication network. That is, when the folding positions C1 and C2 are shifted in the conveying direction, both the Z-fold illustrated in FIG. **5**A and the outer three-fold illustrated in FIG. **5**B are implemented.

First, the controller **100** controls the conveyance roller pair **22**, the first folding roller **23**, and the second folding roller **24** to perform the forward rotation (S**601**). As a result, as illustrated in FIGS. **7**A to **7**B, the posture of the guide plate **26** changes to the first posture. The sheet S supplied through the input interface IN is conveyed in the conveying direction along the main conveying path Ph1. Then, the controller **100** continues the process of step S**601** until the first folding position C1 reaches the branching position A (S**602**: No).

Next, at the timing when the first folding position C1 reaches the branching position A (S**602**: Yes), the controller **100** controls the conveyance roller pair **22** to perform the forward rotation, and the first folding roller **23**, the second folding roller **24**, and the third folding roller **25** to perform the backward rotation (S**603**). As a result, as illustrated in FIGS. **8**A to **8**B, the posture of the guide plate **26** changes to the second posture. Further, the sheet S enters the reflux conveying path Ph2 with the first folding position C1 as a head, and is clamped by the second folding roller **24** and the third folding roller **25**. As a result, the sheet S is folded at the first folding position C1. Then, as illustrated in FIGS. **9**A to **9**B, the controller **100** continues the process of step S**603** until the distance D**1** from the clamping position between the first folding roller **23** and the second folding roller **24** to the front end of the sheet S and the distance D**2** from the clamping position to the second folding position C2 become equal (S**604**: No).

Next, the controller **100** controls, at a timing when the distances D**1** and D**2** become equal (S**605**: Yes), the conveyance roller pair **22**, the first folding roller **23**, and the second folding roller **24** to perform the forward rotation (S**605**). As a result, as illustrated in FIGS. **10**A to **10**B, the posture of the guide plate **26** changes to the first posture. Further, the sheet S enters the clamping position between the first folding roller **23** and the second folding roller **24** with the front end and the second folding position C2 of the sheet S as the head. As a result, the sheet S is folded at the second folding position C2, and the Z-fold is completed.

Then, the controller **100** continues the process of step S**605** until the rear end of the sheet S passes through the clamping position between the first folding roller **23** and the second folding roller **24** in the conveying direction (S**606**: No), that is, until the ejection of the sheet S three-folded is completed. Furthermore, at a timing when the rear end of the sheet S passes through the clamping position between the first folding roller **23** and the second folding roller **24** in the conveying direction (S**606**: Yes), the controller **100** stops the conveyance roller pair **22**, the first folding roller **23**, and the second folding roller **24**, and ends the three-fold process.

Next, a two-fold process of folding the sheet S in two will be described with reference to FIGS. **11** and **12**A to **12**F. FIG. **11** is a flowchart of a two-fold process, FIGS. **12**A to **12**F are views illustrating a state of the sheet folding unit **20** during the two-fold process. Note that detailed description of points in common with the three-fold process will be omitted, and differences will be mainly described.

First, the controller **100** controls the conveyance roller pair **22**, the first folding roller **23**, and the second folding roller **24** to perform the forward rotation (S**1101**). As a

result, as illustrated in FIG. **12**A, the posture of the guide plate **26** changes to the first posture, and the sheet S is conveyed in the conveying direction along the main conveying path Ph1. Then, the controller **100** continues the process of step S**1101** until the folding position C reaches the branching position A (S**1102**: No).

Next, the controller **100** controls, at a timing when the folding position C reaches the branching position A (S**1102**: Yes), the conveyance roller pair **22** to perform the forward rotation, and the first folding roller **23**, the second folding roller **24**, and the third folding roller **25** to perform the backward rotation (S**1103**). As a result, as illustrated in FIGS. **12**B to **12**D, the posture of the guide plate **26** changes to the second posture, and the sheet S enters the reflux conveying path Ph2 with the folding position C as the head. Then, the sheet S is two-folded at the folding position C by being clamped by the second folding roller **24** and the third folding roller **25**. Then, the controller **100** continues the processing of step S**1103** until the rear end of the sheet S passes through the clamping position between the second folding roller **24** and the third folding roller **25** (S**1104**: No).

Next, the controller **100** controls, at a timing when the rear end of the sheet S passes through the clamping position between the second folding roller **24** and the third folding roller (S**1104**: Yes), the first folding roller **23** and the second folding roller **24** to perform the forward rotation (S**1105**). The controller **100** continues the forward rotation of the conveyance roller pair **22**. As a result, as illustrated in FIGS. **12**E and **12**F, the posture of the guide plate **26** changes to the first posture, and the sheet S passes through the clamping position between the first folding roller **23** and the second folding roller **24** with the folding position C as the head.

Then, the controller **100** continues the process of step S**1105** until the rear end of the sheet S passes through the clamping position between the first folding roller **23** and the second folding roller **24** in the conveying direction (S**1106**: No), that is, until the ejection of the sheet S two-folded is completed. Furthermore, at a timing when the rear end of the sheet S passes through the clamping position between the first folding roller **23** and the second folding roller **24** in the conveying direction (S**1106**: Yes), the controller **100** stops the conveyance roller pair **22**, the first folding roller **23**, and the second folding roller **24**, and ends the two-fold process.

Note that the controller **100** is not necessary to execute the three-fold process or the two-fold process on all the sheets S on which an image is formed by the image former **12**. When the sheet S is ejected without being folded, the controller **100** may control the conveyance roller pair **22**, the first folding roller **23**, and the second folding roller **24** to perform the forward rotation in response to the sheet S supplied from the image former **12** through the input interface IN until the rear end of the sheet S passes through the clamping position between the first folding roller **23** and the second folding roller **24** in the conveying direction.

The control of the controller **100** that folds the sheet S on which an image is formed by the image former **12** by the sheet folding unit **20** and then delivers the sheet S to the sheet binding unit **30** is an example of "first control". On the other hand, the control of the controller **100** that delivers the sheet S on which an image is formed by the image former **12** to the sheet binding unit **30** without folding the sheet S by the sheet folding unit **20** is an example of "second control". Then, the controller **100** may switch between the first control and the second control on the basis of an instruction from the user through the operation panel **110** or an instruction from an external apparatus through the communication network.

Next, an operation of the sheet binding unit **30** will be described with reference to FIGS. **13**A to **17**B. FIGS. **13**A to **13**B are views illustrating a state of the sheet binding unit until the sheet S reaches the conveyance roller pair **36**. FIGS. **14**A to **14**B are views illustrating a state of the sheet binding unit **30** in a case where the sheet S is ejected to the ejection tray **32** without performing the binding process. FIGS. **15**A to **15**B are views illustrating a state of the sheet binding unit **30** that performs the binding process. FIG. **16** is a view of the sheet binding unit **30** in FIG. **15**B as viewed from the thickness direction of the sheet S. FIGS. **17**A to **17**B are views illustrating a state of the sheet binding unit **30** when the sheet bundle Sb subjected to the binding process is ejected to the ejection tray **32**.

First, as illustrated in FIGS. **13**A to **13**B, the sheet binding unit **30** causes the conveyance roller pairs **33** to **35** to perform the forward rotation to convey the sheet S supplied from the sheet folding unit **20** in the conveying direction along the conveying path Ph3. At this time, in the conveyance roller pair **36**, the driving roller **36***a* and the driven roller **36***b* are separated from each other.

Next, in a case where the binding process is not performed on the sheet S, as illustrated in FIG. **14**A, the sheet binding unit **30** causes the driving roller **36***a* and the driven roller **36***b* to clamp the sheet S. Then, as illustrated in FIG. **14**B, the sheet binding unit **30** causes the conveyance roller pair **36** to perform the forward rotation to eject the sheet S to the ejection tray **32**.

On the other hand, in a case where the binding process is performed on the sheet S, as illustrated in FIGS. **15**A to **15**B, the sheet binding unit **30** brings the tapping roller **38** and the return roller **39** to abut on the sheet S having passed through the conveyance roller pair **35** and rotates the tapping roller **38** and the return roller **39** to store the sheet S in the inner tray **37**. As illustrated in FIG. **16**, the sheet binding unit **30** moves the side fences **41**L and **41**R in the width direction to align the position in the width direction of the sheet S stored in the inner tray **37**. Then, the sheet binding unit **30** repeats the process illustrated in FIGS. **13**A to **13**B, **15**A to **15**B, and **16** to form the sheet bundle Sb on the inner tray **37**.

Next, the sheet binding unit **30** drives the binding processor **42** to bind the sheet bundle Sb supported by the inner tray **37**. Next, as illustrated in FIG. **17**A, the sheet binding unit **30** causes the driving roller **36***a* and the driven roller **36***b* to clamp the sheet bundle Sb. Then, as illustrated in FIG. **14**B, the sheet binding unit **30** causes the conveyance roller pair **36** and the return roller **39** to perform the forward rotation to eject the sheet bundle Sb to the ejection tray **32**.

According to the above-described embodiment, the following operational effects, for example, are achieved.

According to the above embodiment, various types of folding methods are implemented by combining the forward rotation and the backward rotation of three of the folding rollers **23**, **24**, and **25**. By switching the posture of the guide plate **26**, the sheet S can be appropriately conveyed in a desired direction. Furthermore, by rotating the second folding roller **24** and the guide plate **26** in conjunction with each other by the driving force transmission mechanism **28**, a driving source for rotating the guide plate **26** can be omitted. As a result, the sheet folding unit **20** that can deal with various folding types with a simple configuration is implemented.

According to the above embodiment, by making the second rotation speed of the guide plate **26** larger than the first rotation speed of the second folding roller **24**, the posture of the guide plate **26** can be quickly changed. As a result, an unintended behavior such as bending of the sheet

S can be prevented, and the stability and accuracy of the folding process can be improved.

According to the above embodiment, the moving range of the guide plate **26** is limited by the stoppers **27***a* and **27***b*, and the torque limiter **28***a* is included in the driving force transmission mechanism **28**, so that the second folding roller **24** and the guide plate **26** can be rotated in conjunction with each other with a simple configuration. Accordingly, the sheet folding unit **20** can be further downsized.

According to the above embodiment, the folding rollers **23** to **25**, the guide plate **26**, and the driving force transmission mechanism **28** are disposed on the opposite side with the partition wall **21***a* interposed therebetween, so that the sheet S can be prevented from being contaminated by dust emitted from the driving force transmission mechanism **28**. Further, dust emitted from the sheet S can be prevented from clogging the driving force transmission mechanism **28** and inhibiting smooth transmission of the driving force.

Further, the sheet folding unit **20** according to the above embodiment has a particularly advantageous effect by being attached to the in-body space **13** of the image forming apparatus **10** having a limited space. However, what is attached to the in-body space **13** is not limited to the sheet folding unit **20**. The attachment position of the sheet folding unit is not limited to the in-body space **13**.

A first variation is described below.

FIGS. **18**A to **18**B are diagrams illustrating an internal configuration of the hole punch unit **50** (serving as a hole punch). The hole punch unit **50** illustrated in FIGS. **18**A to **18**B is detachably attached to a position where the sheet folding unit **20** is removed in the in-body space **13**. That is, the image forming apparatus **10** allows the sheet folding unit **20** and the hole punch unit **50** to be interchanged according to the application. Since the configuration of the hole punch unit **50** is already known, detailed description thereof is omitted, but for example, the following configuration may be adopted.

As illustrated in FIGS. **18**A to **18**B, the hole punch unit **50** includes a housing **51**, a sheet sensor **52**, punching pins **53***a* and **53***b*, and a punch waste hopper **54**. The housing **51** includes an internal space for accommodating components of the hole punch unit **50**. The internal space of the housing **51** has a conveyance path through which the sheet passes on which an image is formed by the image former **12**. The sheet sensor **52** detects that the sheet S supplied from the image former **12** has reached a predetermined position. The punching pins **53***a* and **53***b* punch holes in the sheet S detected by the sheet sensor **52**. Punch waste dropped from the sheet S falls into a punch waste hopper **54**. As a result, a punching process of punching holes in the sheet S is implemented.

Next, a second variation is described below.

FIG. **19** is an external view of the image forming system **1**. As illustrated in FIG. **19**, the image forming system **1** includes an image forming apparatus **10**, a sheet folding apparatus **20'**, and a sheet binding apparatus **30'**. The image forming apparatus **10**, the sheet folding apparatus **20'**, and the sheet binding apparatus **30'** are each independently operated and are mutually connected. Further, the configuration of the sheet folding apparatus **20'** is common to the above-described sheet folding unit **20**, and the configuration of the sheet binding apparatus **30'** is common to the above-described sheet binding unit **30**.

Note that the embodiments of the present disclosure are not limited to the above-described embodiments, and various modifications can be made without departing from the technical gist thereof, and all technical matters included in the technical idea described in the claims are the subject of the present invention. It is therefore to be understood that the above-described embodiments of the present disclosure may be practiced otherwise by those skilled in the art than as specifically described herein. Such embodiments and variations thereof are included in the scope and gist of the embodiments of the present disclosure and are included in the embodiments described in claims and the equivalent scope thereof.

Aspects of the present disclosure are, for example, as follows.

First Aspect

According to a first aspect, a sheet folding apparatus includes a conveyor, a first folding roller and a second folding roller, a third folding roller, a guide, a motor, and a driving force transmission mechanism. The conveyor conveys a sheet along a main conveying path in a conveying direction. The first folding roller and a second folding roller are disposed opposite to each other with the main conveying path interposed between the first folding roller and the second folding roller. The third folding roller is disposed opposite to the second folding roller with a reflux conveying path interposed between the third folding roller and the second folding roller. The reflux conveying path branches off from the main conveying path at a branching position upstream from the first folding roller in the conveying direction, and joins the main conveying path at a joining position upstream from the branching position in the conveying direction. The guide switches between a first posture and a second posture. The guide in the first posture prevents the sheet conveyed on the main conveying path in the conveying direction from entering the reflux conveying path through the branching position. The guide in the second posture allows the sheet to be conveyed from one of the main conveying path and the reflux conveying path to the other of the main conveying path and the reflux conveying path through the branching position. The motor causes the second folding roller to perform either forward rotation in which the second folding roller rotates to convey the sheet on the main conveying path in the conveying direction and to convey the sheet on the reflux conveying path from the joining position toward the branching position or backward rotation that the second folding roller rotates in a direction opposite to the forward rotation. The driving force transmission mechanism rotates the guide from the second posture toward the first posture in conjunction with the forward rotation of the second folding roller and rotates the guide from the first posture toward the second posture in conjunction with the backward rotation of the second folding roller.

Second Aspect

In the sheet folding apparatus according to the first aspect, the driving force transmission mechanism transmits a driving force of the motor to the guide such that the guide rotates at a rotation speed larger than a rotation speed of the second folding roller.

Third Aspect

The sheet folding apparatus according to the second aspect further includes a first stopper and a second stopper. The first stopper abuts on the guide in the first posture and prevents the guide from rotating in a direction away from the second posture. The second stopper abuts on the guide in the second posture and prevents the guide from rotating in a

direction away from the first posture. The driving force transmission mechanism includes a torque limiter to release transmission of a driving force from the motor to the guide when the guide abuts on the first stopper or the second stopper and a rotational torque becomes equal to or larger than a threshold.

Fourth Aspect

The sheet folding apparatus according to the third aspect further includes a partition wall through which a rotation shaft of the second folding roller and a rotation shaft of the guide pass. The torque limiter is disposed on a side opposite to the second folding roller and the guide across the partition wall.

Fifth Aspect

The sheet folding apparatus according to any one of the first to fourth aspects further includes a controller to control rotation of the first folding roller, the second folding roller, and the third folding roller. The first folding roller performs forward rotation of conveying the sheet on the main conveying path in the conveying direction and performs backward rotation in which the first folding roller rotates in a direction opposite to the forward rotation. The third folding roller performs forward rotation of conveying the sheet on the reflux conveying path from the joining position toward the branching position and performs backward rotation in which the third folding roller rotates in a direction opposite to the forward rotation. The controller causes the first folding roller and the second folding roller to perform the forward rotation until a first folding position of the sheet reaches the branching position, causes the first folding roller, the second folding roller, and the third folding roller to perform the backward rotation at a timing when the first folding position reaches the branching position, until a distance from a clamping position between the first folding roller and the second folding roller to a front end of the sheet on the reflux conveying path and a distance from the clamping position to a second folding position upstream the first folding position in the conveying direction become equal; and causes the first folding roller, the second folding roller, and the third folding roller to perform the forward rotation at a timing when a distance from the clamping position to the front end of the sheet and a distance from the clamping position to the second folding position become equal, until a rear end of the sheet passes through the clamping position in the conveying direction.

Sixth Aspect

The sheet folding apparatus according to any one of the first to fourth aspects further includes a controller to control a rotation of the first folding roller, the second folding roller, and the third folding roller. The first folding roller performs forward rotation of conveying the sheet on the main conveying path in the conveying direction and performs backward rotation in which the first folding roller rotates in a direction opposite to the forward rotation. The third folding roller performs forward rotation of conveying the sheet on the reflux conveying path from the joining position toward the branching position and performs backward rotation in which the third folding roller rotates in a direction opposite to the forward rotation. The controller causes the first folding roller and the second folding roller to perform the forward rotation until a folding position of the sheet reaches the branching position; and causes the first folding roller, the second folding roller and the third folding roller to perform the backward rotation at a timing when the folding position of the sheet reaches the branching position, until a rear end of the sheet passes a clamping position between the second folding roller and the third folding roller.

Seventh Aspect

An image forming apparatus includes a housing, an image former, and the sheet folding apparatus according to any one of the first to sixth aspects. The image former is housed in the housing and forms an image on a sheet. The sheet folding apparatus is detachably supported by the housing, to fold the sheet on which the image is formed by the image former.

Eighth Aspect

The image forming apparatus according to the seventh aspect further includes a post-processing device. The post-processing device is supported by the housing and performs post-processing on the sheet on which an image is formed by the image former. The sheet folding apparatus is detachably attached to the housing at a position downstream from the image former and upstream from the post-processing device in a conveying path of the sheet from the image former to the post-processing device.

Ninth Aspect

In the image forming apparatus according the eighth aspect, the post-processing is a binding process of bundling and binding a plurality of sheets on which an image is formed by the image former.

Tenth Aspect

The image forming apparatus according to the eighth or ninth aspect further includes a controller to switch between a first control of folding the sheet on which the image is formed by the image former by the sheet folding apparatus and delivering the sheet folded to the post-processing device and a second control of delivering the sheet to the post-processing device without folding the sheet by the sheet folding apparatus.

Eleventh Aspect

The image forming apparatus according to any one of seventh to tenth aspects further includes a hole punch to punch a hole in the sheet on which the image is formed by the image former. The hole punch is detachably attached to a position at which the sheet folding apparatus is removed from the housing.

Twelfth Aspect

An image forming system includes an image forming apparatus to forms an image on a sheet and the sheet folding apparatus according to any one of the first to eighth aspects. The sheet folding apparatus is connected to the image forming apparatus.

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.

Each of the functions of the described embodiments may be implemented by one or more processing circuits or circuitry. Processing circuitry includes a programmed processor, as a processor includes circuitry. A processing circuit also includes devices such as an application specific integrated circuit (ASIC), digital signal processor (DSP), field programmable gate array (FPGA), and conventional circuit components arranged to perform the recited functions.

The invention claimed is:

1. A sheet folding apparatus, comprising:

a conveyor to convey a sheet along a main conveying path in a conveying direction;

a first folding roller and a second folding roller disposed opposite to each other with the main conveying path interposed between the first folding roller and the second folding roller;

a third folding roller disposed opposite to the second folding roller with a reflux conveying path interposed between the third folding roller and the second folding roller, the reflux conveying path branching off from the main conveying path at a branching position upstream from the first folding roller in the conveying direction and joining the main conveying path at a joining position upstream from the branching position in the conveying direction;

a guide to switch between a first posture and a second posture, the guide in the first posture preventing the sheet conveyed on the main conveying path in the conveying direction from entering the reflux conveying path through the branching position, the guide in the second posture allowing the sheet to be conveyed from one of the main conveying path and the reflux conveying path to the other of the main conveying path and the reflux conveying path through the branching position;

a motor to cause the second folding roller to perform either forward rotation in which the second folding roller rotates to convey the sheet on the main conveying path in the conveying direction and to convey the sheet on the reflux conveying path from the joining position toward the branching position or backward rotation in which the second folding roller rotates in a direction opposite to the forward rotation; and

a driving force transmission mechanism to rotate the guide from the second posture toward the first posture in conjunction with the forward rotation of the second folding roller and rotate the guide from the first posture toward the second posture in conjunction with the backward rotation of the second folding roller.

2. The sheet folding apparatus according to claim **1**,

wherein the driving force transmission mechanism transmits a driving force of the motor to the guide such that the guide rotates at a rotation speed larger than a rotation speed of the second folding roller.

3. The sheet folding apparatus according to claim **2**, further comprising:

a first stopper to abut on the guide in the first posture and prevent the guide from rotating in a direction away from the second posture; and

a second stopper to abut on the guide in the second posture and prevent the guide from rotating in a direction away from the first posture,

wherein the driving force transmission mechanism includes a torque limiter to release transmission of a driving force from the motor to the guide when the guide abuts on the first stopper or the second stopper and a rotational torque becomes equal to or larger than a threshold.

4. The sheet folding apparatus according to claim **3**, further comprising:

a partition wall through which a rotation shaft of the second folding roller and a rotation shaft of the guide pass,

wherein the torque limiter is disposed on a side opposite to the second folding roller and the guide across the partition wall.

5. The sheet folding apparatus according to claim **1**, further comprising:

a controller to control rotation of the first folding roller, the second folding roller, and the third folding roller,

wherein the first folding roller performs forward rotation of conveying the sheet on the main conveying path in the conveying direction and performs backward rotation in which the first folding roller rotates in a direction opposite to the forward rotation,

the third folding roller performs forward rotation of conveying the sheet on the reflux conveying path from the joining position toward the branching position and performs backward rotation in which the third folding roller rotates in a direction opposite to the forward rotation, and

the controller

causes the first folding roller and the second folding roller to perform the forward rotation until a first folding position of the sheet reaches the branching position,

causes the first folding roller, the second folding roller, and the third folding roller to perform the backward rotation at a timing when the first folding position reaches the branching position, until a distance from a clamping position between the first folding roller and the second folding roller to a front end of the sheet on the reflux conveying path and a distance from the clamping position to a second folding position upstream from the first folding position in the conveying direction become equal, and

causes the first folding roller, the second folding roller, and the third folding roller to perform the forward rotation at a timing when a distance from the clamping position to the front end of the sheet and a distance from the clamping position to the second folding position become equal, until a rear end of the sheet passes through the clamping position in the conveying direction.

6. The sheet folding apparatus according to claim **1**, further comprising:

a controller to control rotation of the first folding roller, the second folding roller, and the third folding roller,

wherein the first folding roller performs forward rotation of conveying the sheet on the main conveying path in the conveying direction and performs backward rotation in which the first folding roller rotates in a direction opposite to the forward rotation,

the third folding roller performs forward rotation of conveying the sheet on the reflux conveying path from the joining position toward the branching position and performs backward rotation in which the third folding roller rotates in a direction opposite to the forward rotation, and

the controller

causes the first folding roller and the second folding roller to perform the forward rotation until a folding position of the sheet reaches the branching position, and

causes the first folding roller, the second folding roller and the third folding roller to perform the backward rotation at a timing when the folding position of the sheet reaches the branching position, until a rear end of the sheet passes a clamping position between the second folding roller and the third folding roller.

7. An image forming apparatus, comprising:

a housing;

an image former housed in the housing to form an image on a sheet; and

the sheet folding apparatus according to claim **1**,

wherein the sheet folding apparatus is detachably supported by the housing, to fold the sheet on which the image is formed by the image former.

8. The image forming apparatus according to claim **7**, further comprising:

a post-processing device supported by the housing to perform post-processing on the sheet on which the image is formed by the image former,

wherein the sheet folding apparatus is detachably attached to the housing at a position downstream from the image former and upstream from the post-processing device in a conveying path of the sheet from the image former to the post-processing device.

9. The image forming apparatus according to claim **8**,

wherein the post-processing is a binding process of bundling and binding a plurality of sheets on which an image is formed by the image former.

10. The image forming apparatus according to claim **8**, further comprising a controller to switch between a first control of folding the sheet on which the image is formed by the image former by the sheet folding apparatus and delivering the sheet folded to the post-processing device and a second control of delivering the sheet to the post-processing device without folding the sheet by the sheet folding apparatus.

11. The image forming apparatus according to claim **7**, further comprising a hole punch to punch a hole in the sheet on which the image is formed by the image former,

wherein the hole punch is detachably attached to a position at which the sheet folding apparatus is removed from of the housing.

12. An image forming system comprising:

an image forming apparatus to form an image on a sheet; and

the sheet folding apparatus according to claim **1** that is connected to the image forming apparatus.

* * * * *