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(54) **DETERMINING DEVICE, CONVEYING DEVICE, IMAGE READING DEVICE, AND IMAGE FORMING APPARATUS**

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(57) **ABSTRACT**

A determining device includes an acquisition processing portion and a determination processing portion. The acquisition processing portion acquires a signal based on an ultrasonic wave emitted toward an object conveyed in a specific direction. The determination processing portion determines whether or not a first time period is equal to or larger than a predetermined first time threshold, wherein the first time period is a time period during which a level of the signal changes from a predetermined first level threshold to a second level threshold that is smaller than the first level threshold.

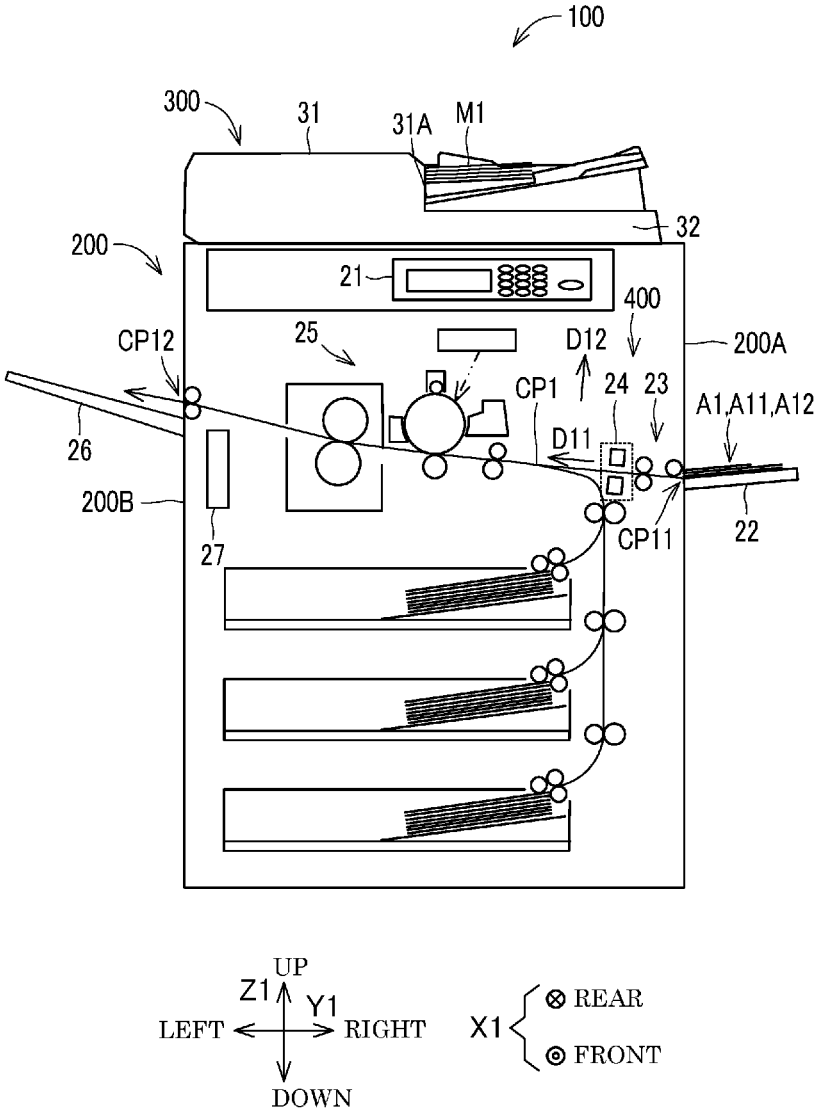


FIG. 1

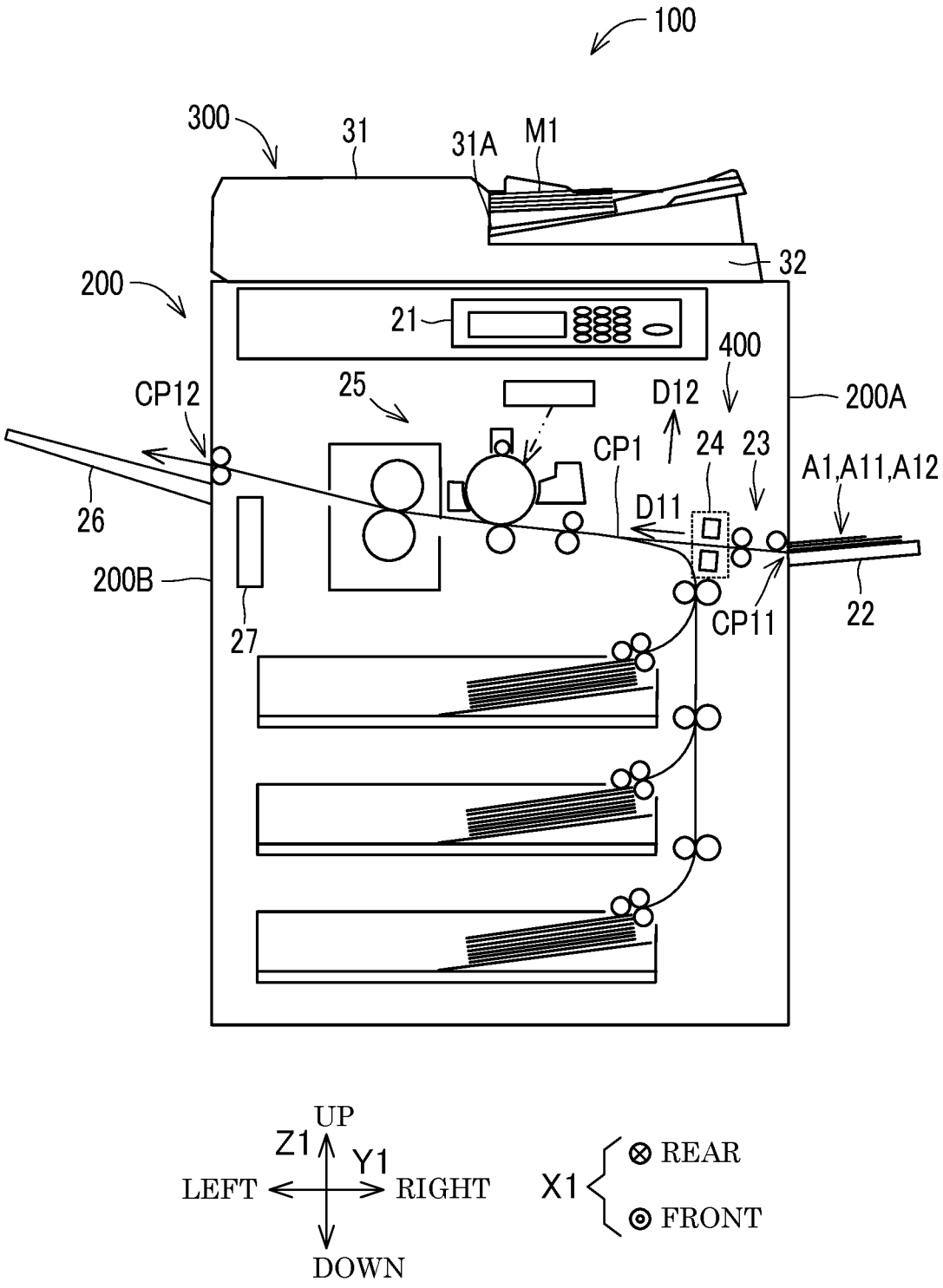

100
300
31
31A
M1
32
200
21
400
CP12
25
D12
200A
CP1
24
23
A1,A11,A12
26
D11
200B
27
CP11
22
UP
Z1
Y1
LEFT
RIGHT
DOWN
X1
REAR
FRONT

FIG. 2A

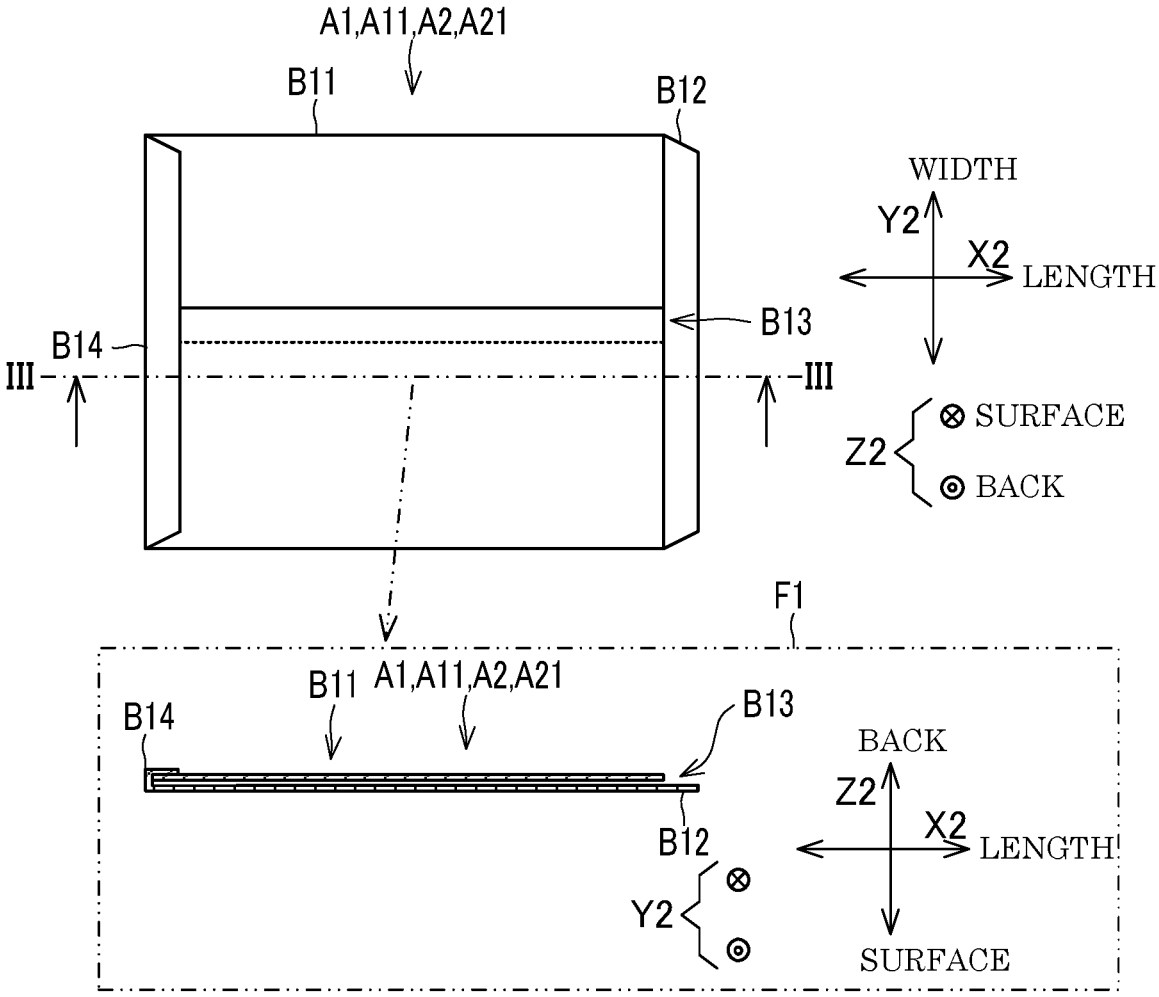

A1,A11,A2,A21
B11
B12
WIDTH
Y2
X2
LENGTH
B14
B13
III
III
SURFACE
Z2
BACK
F1
B11
A1,A11,A2,A21
B14
B13
BACK
Z2
X2
LENGTH
B12
Y2
SURFACE

FIG. 2B

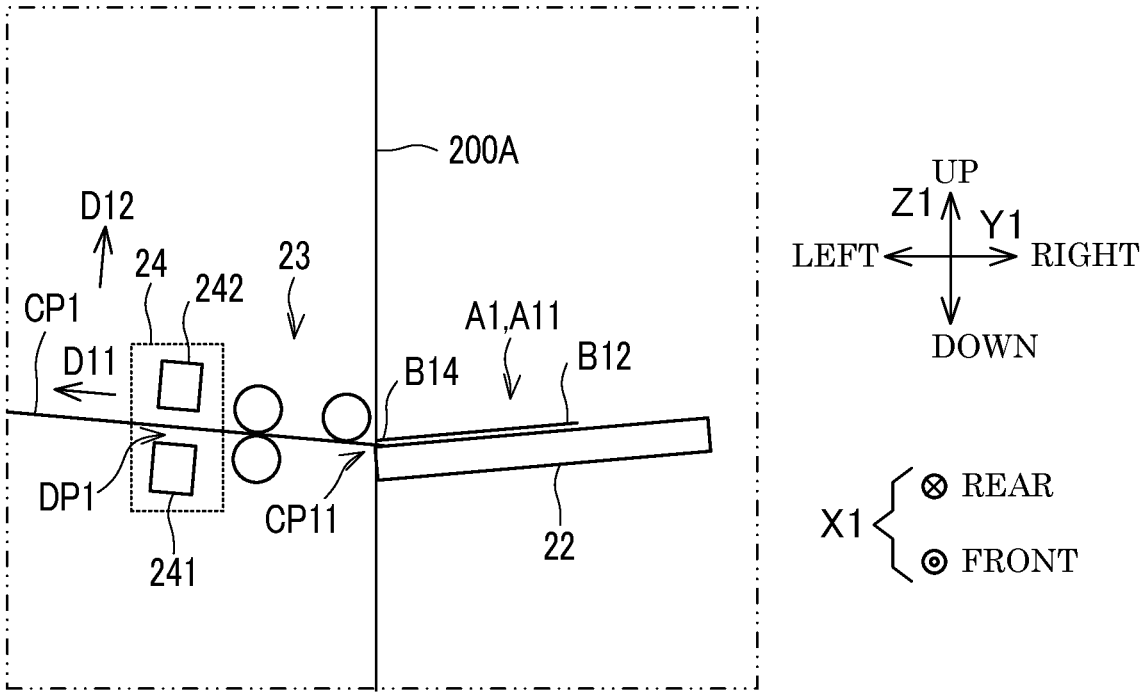

200A
D12
24
242
23
CP1
D11
A1,A11
B14
B12
DP1
CP11
22
241
UP
Z1
Y1
LEFT
RIGHT
DOWN
X1
REAR
FRONT

FIG. 3

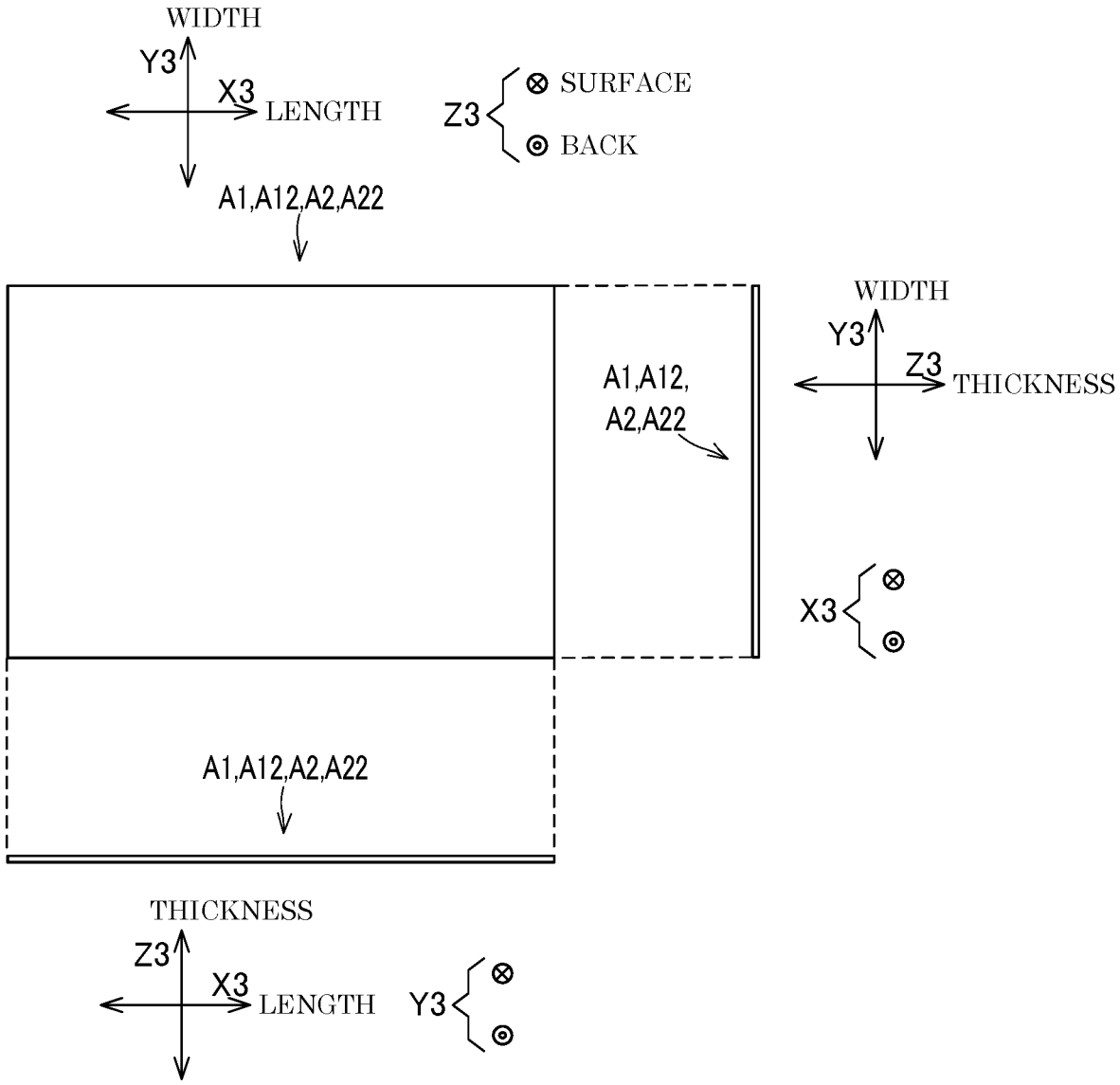

WIDTH
Y3
X3
LENGTH
Z3
SURFACE
BACK
A1,A12,A2,A22
WIDTH
Y3
Z3
THICKNESS
A1,A12,
A2,A22
X3
A1,A12,A2,A22
THICKNESS
Z3
X3
LENGTH
Y3

FIG. 4A

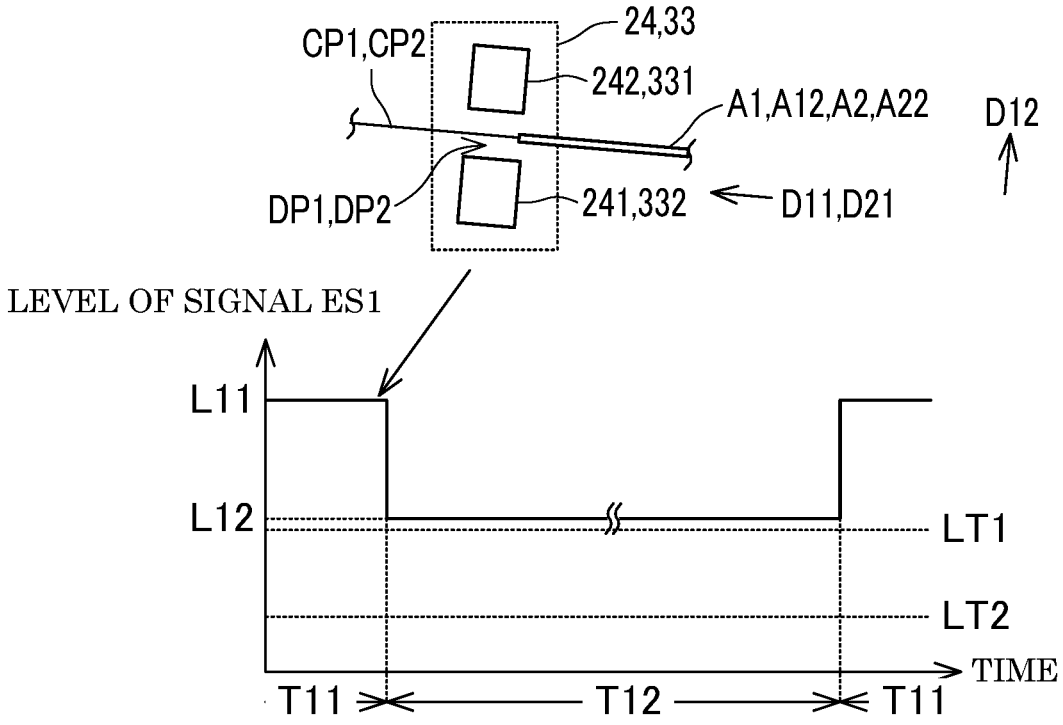

CP1,CP2
24,33
242,331
A1,A12,A2,A22
D12
DP1,DP2
241,332
D11,D21
LEVEL OF SIGNAL ES1
L11
L12
LT1
LT2
TIME
T11
T12
T11

FIG. 4B

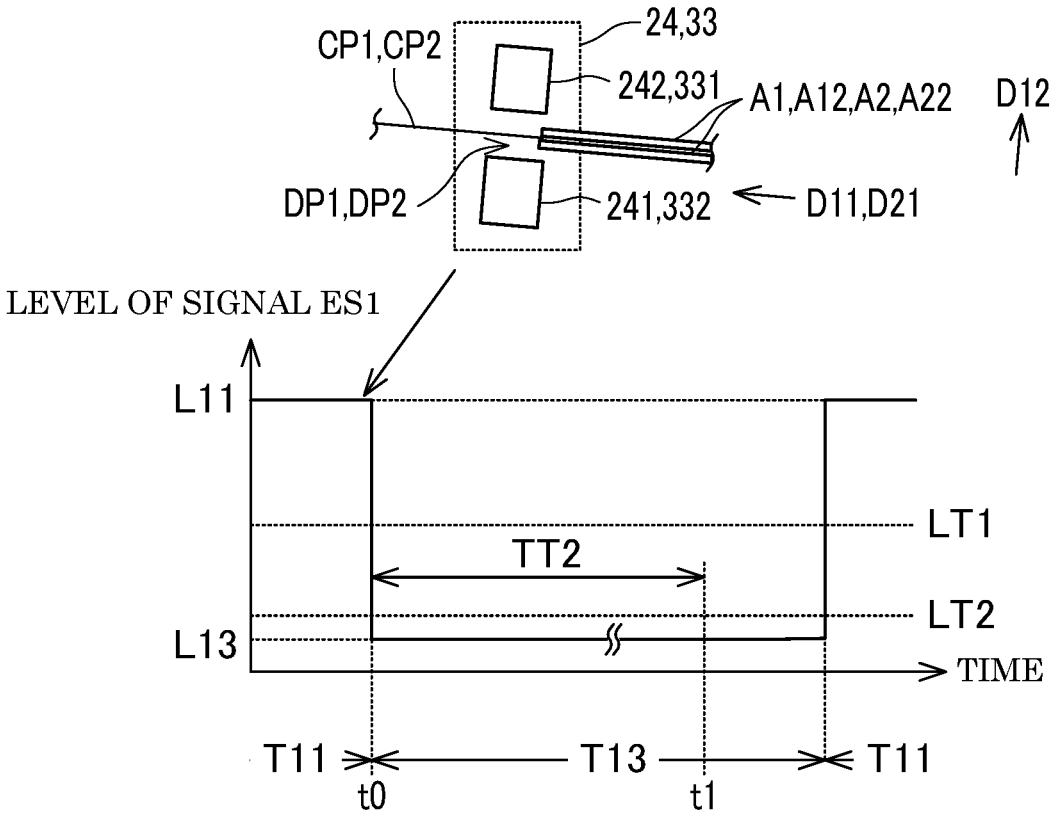
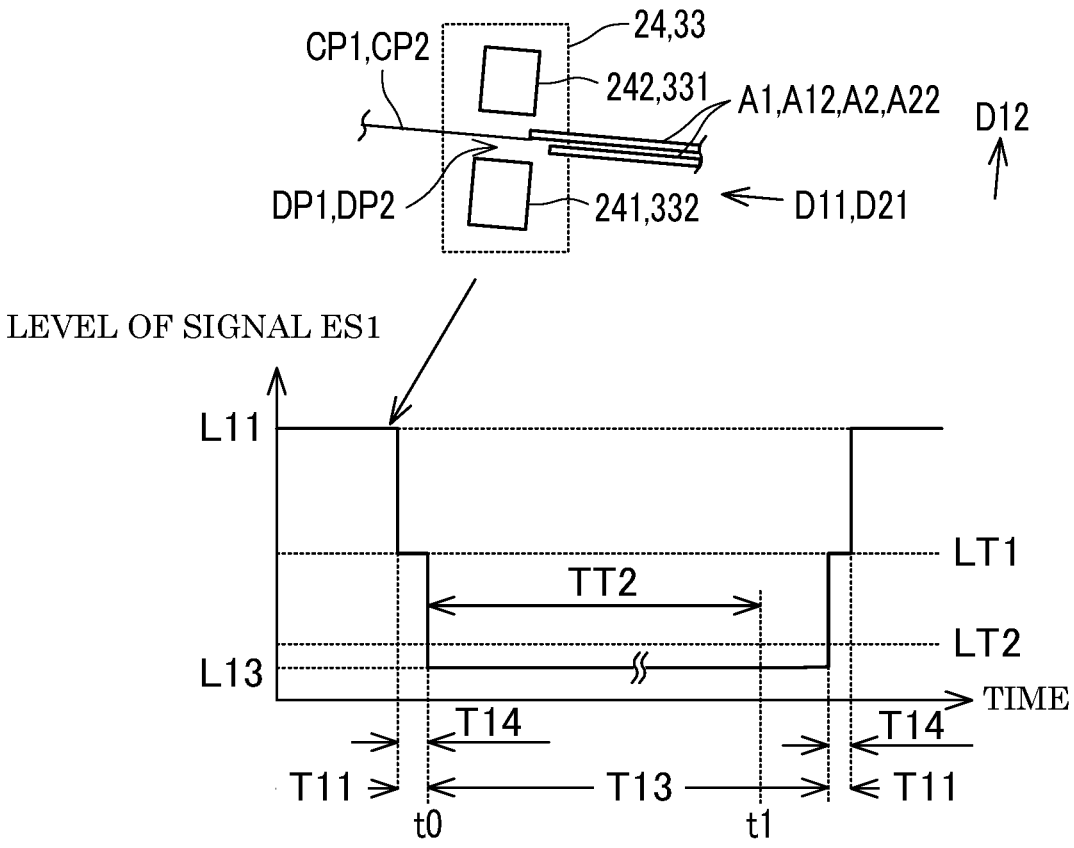

24,33
CP1,CP2
242,331
A1,A12,A2,A22
D12
DP1,DP2
241,332
D11,D21
LEVEL OF SIGNAL ES1
L11
LT1
TT2
LT2
L13
TIME
T11
T13
T11
t0
t1

FIG. 4C


CP1,CP2
24,33
242,331
A1,A12,A2,A22
D12
DP1,DP2
241,332
D11,D21
LEVEL OF SIGNAL ES1
L11
LT1
TT2
LT2
L13
TIME
T14
T14
T11
T13
T11
t0
t1

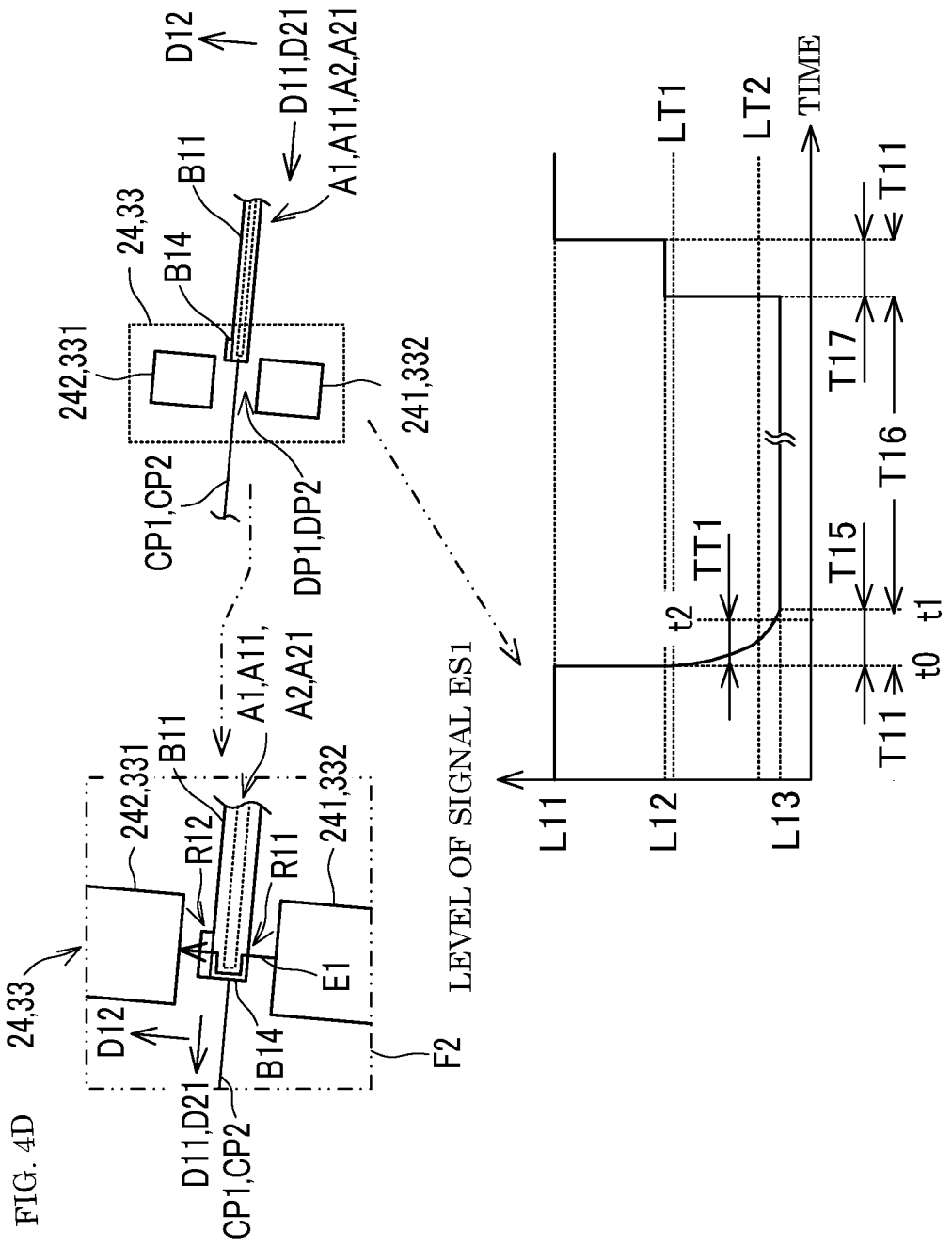

24,33
D12
D11,D21
CP1,CP2
B14
F2
242,331
B11
R12
R11
E1
241,332
A1,A11,
A2,A21
DP1,DP2
LEVEL OF SIGNAL ES1
L11
L12
L13
LT1
LT2
TIME
TT1
t2
t0
t1
T11
T15
T16
T17

FIG. 4D

FIG. 5

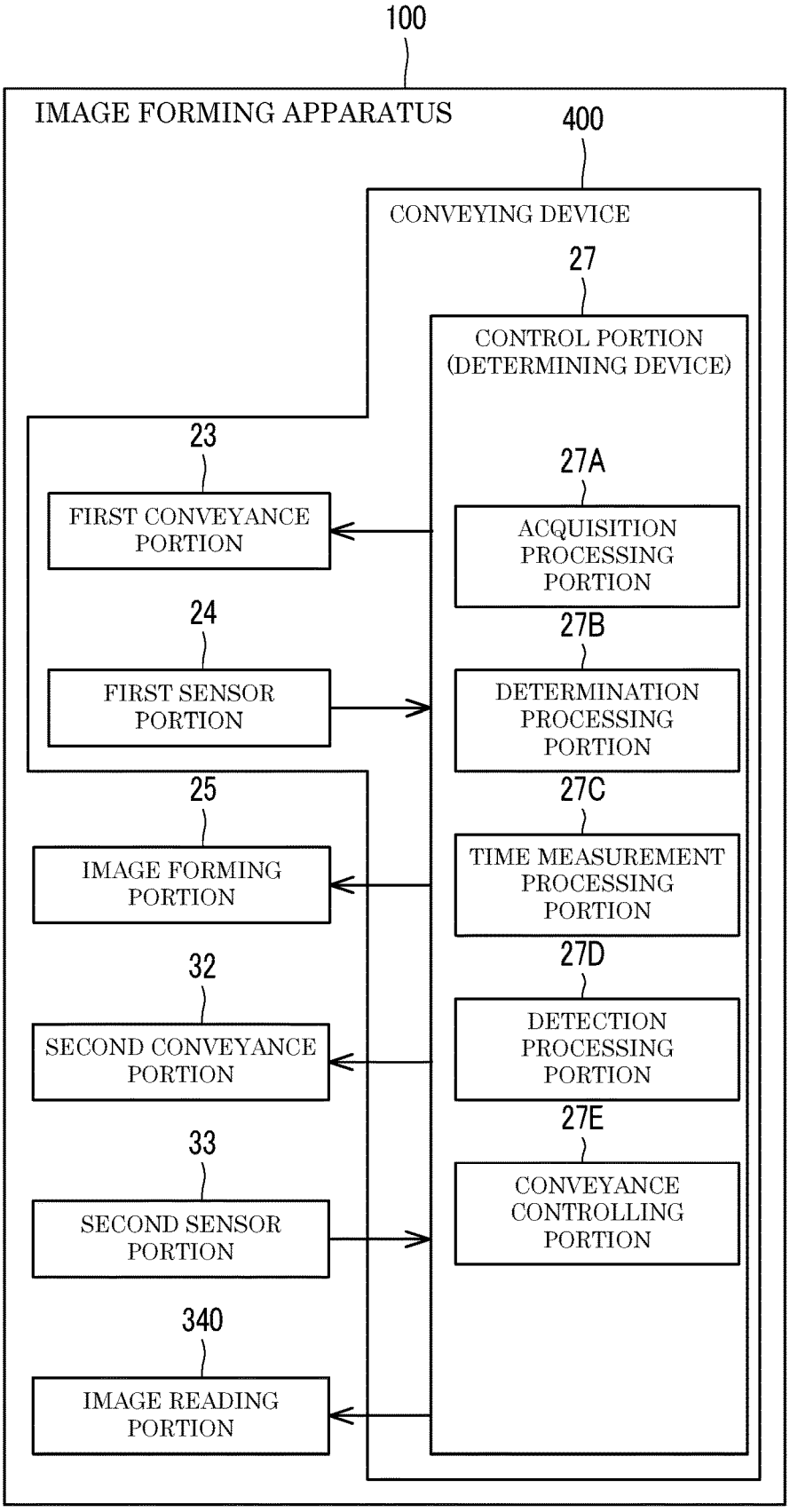

100
IMAGE FORMING APPARATUS
400
CONVEYING DEVICE
27
CONTROL PORTION
(DETERMINING DEVICE)
23
FIRST CONVEYANCE PORTION
24
FIRST SENSOR PORTION
25
IMAGE FORMING PORTION
32
SECOND CONVEYANCE PORTION
33
SECOND SENSOR PORTION
340
IMAGE READING PORTION
27A
ACQUISITION PROCESSING PORTION
27B
DETERMINATION PROCESSING PORTION
27C
TIME MEASUREMENT PROCESSING PORTION
27D
DETECTION PROCESSING PORTION
27E
CONVEYANCE CONTROLLING PORTION

FIG. 6A

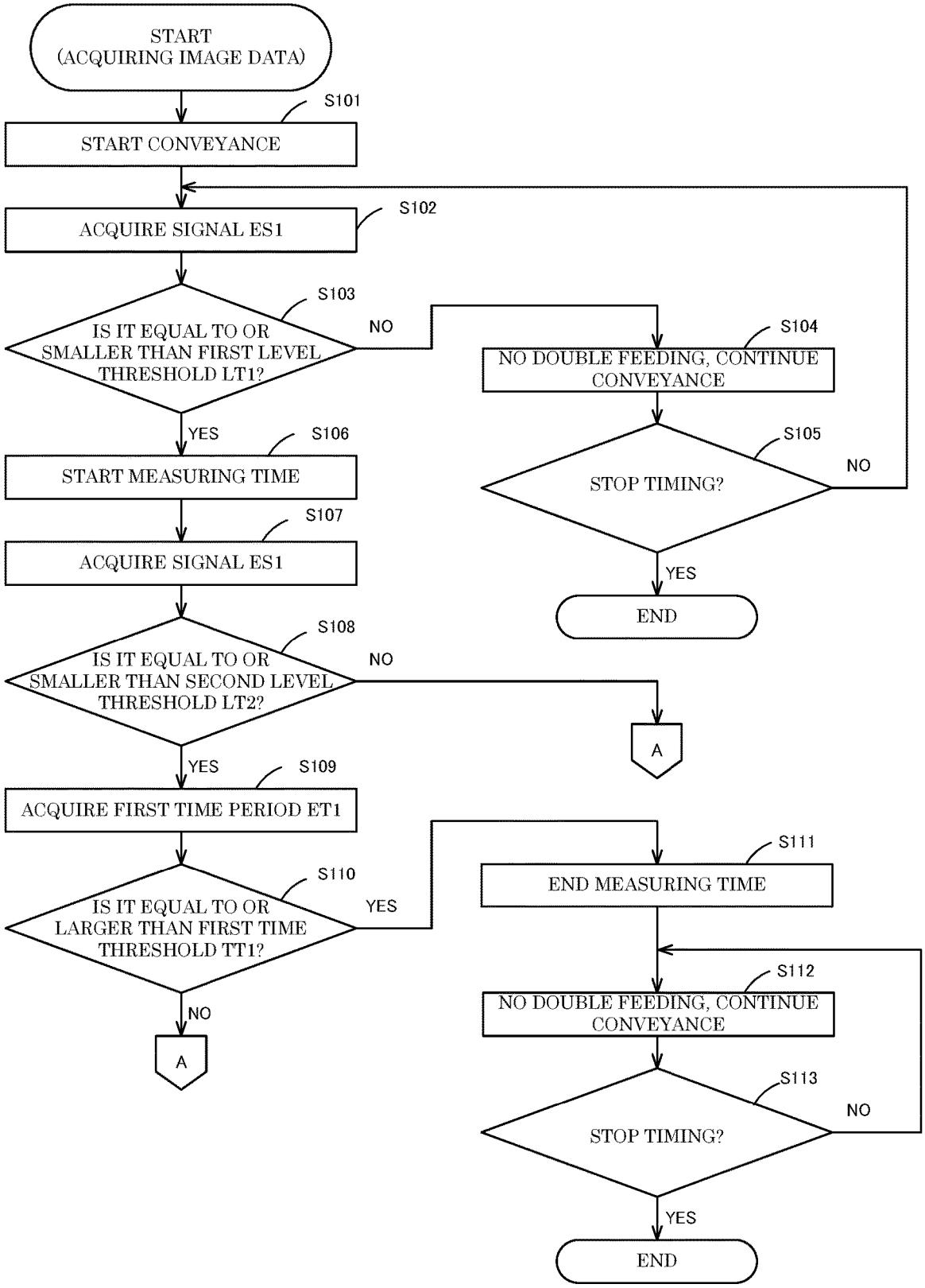

START
(ACQUIRING IMAGE DATA)
S101
START CONVEYANCE
S102
ACQUIRE SIGNAL ES1
S103
IS IT EQUAL TO OR SMALLER THAN FIRST LEVEL THRESHOLD LT1?
NO
S104
NO DOUBLE FEEDING, CONTINUE CONVEYANCE
S105
STOP TIMING?
NO
YES
END
YES
S106
START MEASURING TIME
S107
ACQUIRE SIGNAL ES1
S108
IS IT EQUAL TO OR SMALLER THAN SECOND LEVEL THRESHOLD LT2?
NO
A
YES
S109
ACQUIRE FIRST TIME PERIOD ET1
S110
IS IT EQUAL TO OR LARGER THAN FIRST TIME THRESHOLD TT1?
YES
S111
END MEASURING TIME
S112
NO DOUBLE FEEDING, CONTINUE CONVEYANCE
S113
STOP TIMING?
NO
YES
END
NO
A

FIG. 6B

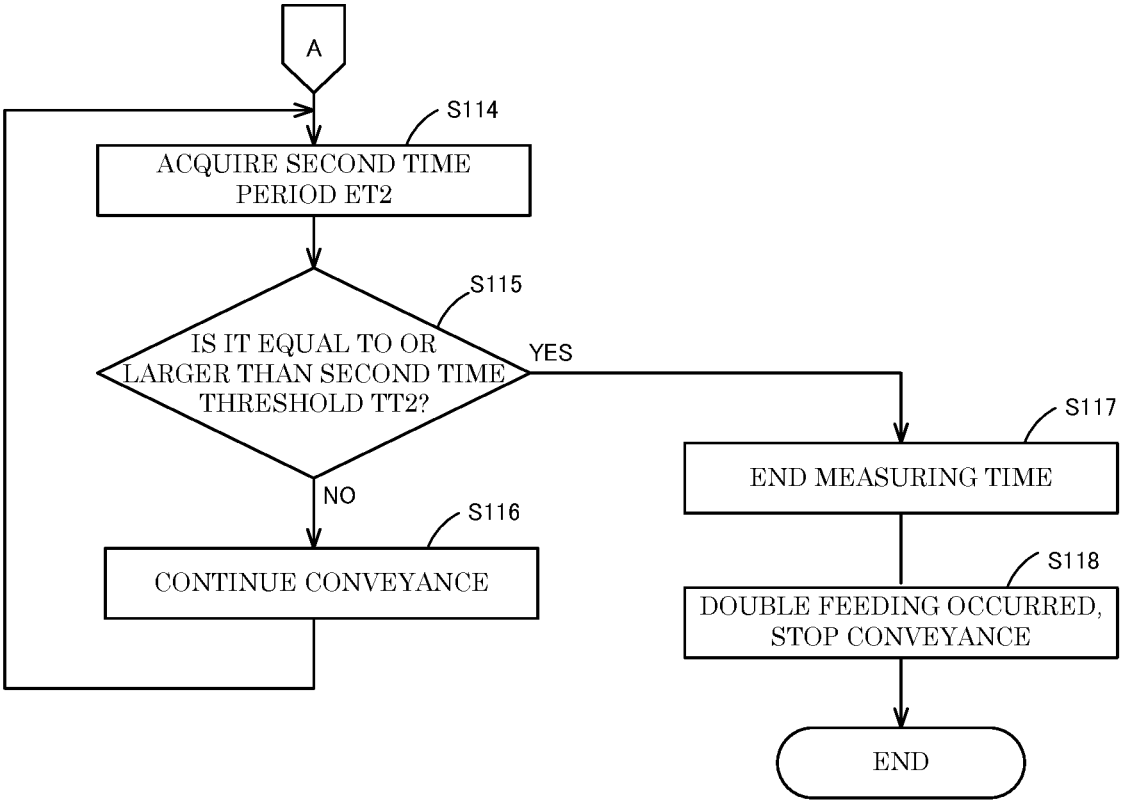
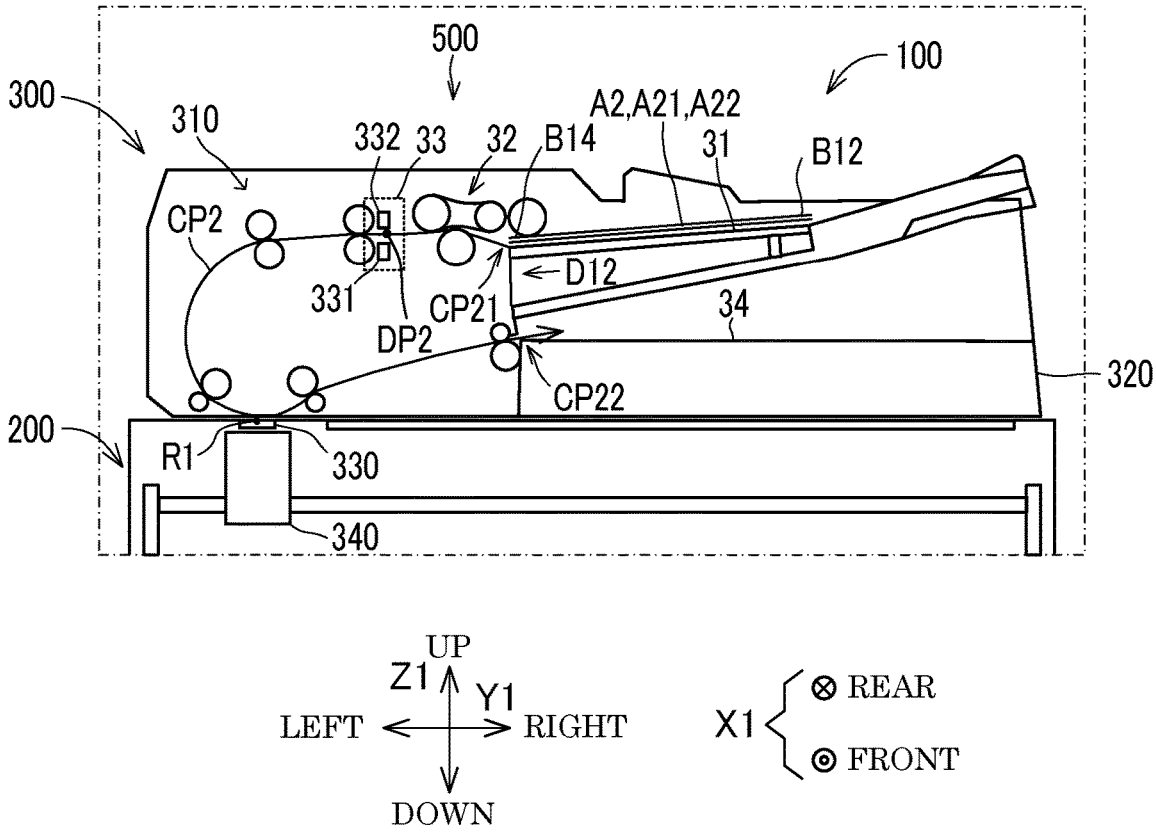

A
S114
ACQUIRE SECOND TIME PERIOD ET2
S115
IS IT EQUAL TO OR LARGER THAN SECOND TIME THRESHOLD TT2?
YES
NO
S116
CONTINUE CONVEYANCE
S117
END MEASURING TIME
S118
DOUBLE FEEDING OCCURRED, STOP CONVEYANCE
END

FIG. 7


500
100
300
310
332
33
32
B14
A2,A21,A22
31
B12
CP2
331
DP2
CP21
D12
34
320
CP22
200
R1
330
340
UP
Z1
Y1
LEFT
RIGHT
DOWN
X1
REAR
FRONT

DETERMINING DEVICE, CONVEYING DEVICE, IMAGE READING DEVICE, AND IMAGE FORMING APPARATUS

INCORPORATION BY REFERENCE

[0001] This application is based upon and claims the benefit of priority from the corresponding Japanese Patent Application No. 2019-009520 filed on Jan. 23, 2019, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0002] The present disclosure relates to a determining device, a conveying device, an image reading device, and an image forming apparatus.

[0003] An image reading device or an image forming apparatus may have a function to determine whether or not a double feeding has occurred in a conveyance path. The double feeding is a phenomenon where a plurality of sheet-like objects are conveyed in the conveyance path in a state of overlapping with each other.

[0004] In an image forming apparatus of a related technology, a type of the object (for example, envelope or paper) is set based on a user operation. The image forming apparatus includes an ultrasonic sensor that emits an ultrasonic wave toward the object that is conveyed in the conveyance path, and outputs a signal having a level that changes according to an incident wave from the object. Furthermore, in the image forming apparatus, when the envelope is set as the type of the object, and if a change of the signal in lapse of time does not satisfy a first specific condition that has been determined for the envelope, it is determined that the double feeding has occurred, and a conveyance of the plurality of envelopes is stopped. In addition, when the paper is set as the type of the object, and if a change of the signal in lapse of time does not satisfy a second specific condition that is different from the first specific condition, it is determined that the double feeding has occurred, and a conveyance of the plurality of sheets of paper is stopped.

SUMMARY

[0005] A determining device according to an aspect of the present disclosure includes an acquisition processing portion and a determination processing portion. The acquisition processing portion acquires a signal based on an ultrasonic wave emitted toward an object conveyed in a specific direction. The determination processing portion determines whether or not a first time period is equal to or larger than a predetermined first time threshold, wherein the first time period is a time period during which a level of the signal changes from a predetermined first level threshold to a second level threshold that is smaller than the first level threshold.

[0006] A conveying device according to another aspect of the present disclosure includes a sensor portion and the determining device. The sensor portion emits an ultrasonic wave toward the object, and outputs the signal having a level that changes according to an incident wave from the object.

[0007] An image reading device according to a further aspect of the present disclosure includes the determining device or the conveying device.

[0008] An image forming apparatus according to a still further aspect of the present disclosure includes the determining device or the conveying device.

[0009] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description with reference where appropriate to the accompanying drawings. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Furthermore, the claimed subject matter is not limited to implementations that solve any or all disadvantages noted in any part of this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a schematic diagram showing a configuration of an image forming apparatus according to an embodiment of the present disclosure.

[0011] FIG. **2**A is a schematic diagram showing a first object viewed from a back side, with a cross section of the first object taken along a two-dot chain line III-III and viewed from a width direction of the first object.

[0012] FIG. **2**B is a schematic diagram showing the first object placed on a first set portion shown in FIG. **1**.

[0013] FIG. **3** is a schematic diagram showing a second object viewed from a surface side.

[0014] FIG. **4**A is a diagram showing a change of a signal in lapse of time when one second object is conveyed in a first conveyance path shown in FIG. **1**.

[0015] FIG. **4**B is a diagram showing a change of a signal in lapse of time when two second objects are conveyed in the first conveyance path shown in FIG. **1** without being deviated in a first direction.

[0016] FIG. **4**C is a diagram showing a change of a signal in lapse of time when two second objects are conveyed in the first conveyance path shown in FIG. **1** in a state of being deviated in the first direction.

[0017] FIG. **4**D is a diagram showing a change of a signal in lapse of time when one first object is conveyed in the first conveyance path shown in FIG. **1**.

[0018] FIG. **5** is a diagram showing a block configuration of the image forming apparatus shown in FIG. **1**.

[0019] FIG. **6**A is a flowchart showing a first part of a processing procedure of a control portion shown in FIG. **5**.

[0020] FIG. **6**B is a flowchart showing a second part of a processing procedure of the control portion shown in FIG. **5**.

[0021] FIG. **7** is a schematic diagram showing a detailed configuration of an image reading device shown in FIG. **1**.

DETAILED DESCRIPTION

[0022] The following describes an embodiment of the present disclosure with reference to the accompanying drawings for the understanding of the present disclosure. It should be noted that the following embodiment is an example of a specific embodiment of the present disclosure and should not limit the technical scope of the present disclosure.

[0023] In FIG. **1**, arrows **X1**, **Y1** and **Z1** respectively indicate a front-rear direction, a left-right direction, and an up-down direction of an image forming apparatus **100**.

[0024] The image forming apparatus **100** is, for example, a copier, a printer, a facsimile, or a multifunction peripheral. The multifunction peripheral includes a plurality of func-

tions such as a copy function, a print function, and a facsimile function. The image forming apparatus **100** includes a main body device **200** and an image reading device **300**. It is noted that the image forming apparatus **100** may not include the image reading device **300**.

[0025] The main body device **200** includes a first set portion **22**, a first conveyance portion **23**, a first sensor portion **24**, an image forming portion **25**, a first discharge portion **26**, a control portion (namely, determining device) **27**. In the main body device **200**, a conveying device **400** includes at least the first conveyance portion **23**, the first sensor portion **24**, and the control portion **27**.

[0026] A first conveyance path CP**1** in which objects A**1** are conveyed is provided in the main body device **200**. The first conveyance path CP**1** extends from a first upstream end CP**11** to a first downstream end CP**12**. Specifically, the first upstream end CP**11** and the first downstream end CP**12** are provided at predetermined positions in the up-down direction on a right side portion **200**A and a left side portion **200**B of the main body device **200**.

[0027] The first set portion **22** is a manual feed tray, and extends diagonally upward right from a position slightly below the first upstream end CP**11** on the right side portion **200**A. The first set portion **22** is configured such that a plurality of types of objects A**1** can be placed thereon. The plurality of types of objects A**1** include a first object A**11** (see FIG. **2**A) and a second object A**12** (see FIG. **3**).

[0028] In FIG. **2**A, arrows X**2**, Y**2** and Z**2** respectively indicate a length direction, a width direction, and a thickness direction of the first object A**11**. A frame F**1** of FIG. **2**A shows a cross section of the first object A**11** taken along the two-dot chain line III-III parallel to the length direction, and viewed from one side in the width direction.

[0029] The first object A**11** is, for example, an unused envelope, and includes a body portion B**11** and a flap portion B**12**. The body portion B**11** has a shape of an approximate rectangle when viewed in the thickness direction. The body portion B**11** further has a shape of a bag where a plurality of sheets overlap in the thickness direction. Specifically, as shown in the frame F**1**, one side of the body portion B**11** in the length direction is opened, and forms an opening B**13**. In addition, as shown in the frame F**1**, the other side of the body portion B**11** in the length direction is closed, and forms a closed portion B**14**. The flap portion B**12** extends from the other side of the body portion B**11**, and closes the opening B**13** by being folded. As shown in FIG. **2**B, the first object A**11** is placed on the first set portion **22** such that the closed portion B**14** is along the first upstream end CP**11**.

[0030] In FIG. **3**, arrows X**3**, Y**3** and Z**3** respectively indicate a length direction, a width direction, and a thickness direction of the second object A**12**. The second object A**12** is, for example, an unused sheet of paper or an OHP sheet, and has a constant thickness over the entire region in the length direction and the width direction. It is noted that the image forming apparatus **100** is configured to form images on a plurality of types of second objects A**12** that are different from each other in thickness.

[0031] Referring to FIG. **1**, the first conveyance portion **23** includes a pickup roller and a pair of conveyance rollers, and feeds an object A**1** from the first upstream end CP**11** into the first conveyance path CP**1**. Thereafter, the first conveyance portion **23** conveys the object A**1** along the first conveyance path CP**1** in a first direction D**11** at a predetermined velocity V**1**. The first direction D**11** is directed toward the downstream in the first conveyance path CP**1**, and is a first example of a specific direction of the present disclosure. In addition, the velocity V**1** is a first example of a specific velocity of the present disclosure.

[0032] The first sensor portion **24** is a first example of a sensor portion of the present disclosure, and is a transmission-type ultrasonic sensor. As shown in FIG. **2**B, the first sensor portion **24** includes a sending portion **241** and a receiving portion **242**.

[0033] The sending portion **241** sends an ultrasonic wave (hereinafter referred to as a measurement wave) toward a detection position DP**1**, a position in the first conveyance path CP**1** that is set to be immediately on the downstream side of the first conveyance portion **23**. The amplitude level of the measurement wave is predetermined.

[0034] The receiving portion **242** is disposed to face the sending portion **241** across the detection position DP**1**. The receiving portion **242** outputs, to the control portion **27**, a signal ES**1** that is generated based on the measurement wave emitted toward an object A**1** that is passing the detection position DP**1**. Specifically, the signal ES**1** has a level (namely, a voltage value) that changes according to the ultrasonic wave (hereinafter referred to as an incident wave) that is incident on the receiving portion **242** based on the measurement wave. The level of the signal ES**1** is related to a total thickness of the object A**1** that is passing the detection position DP**1**. More specifically, the level of the signal ES**1** is related to the type and number of the objects A**1**.

[0035] The type and number of the objects A**1** are roughly divided into cases: (1) one second object A**12** is passing the detection position DP**1** (see FIG. **4**A); (2) two or more second objects A**12** aligned in the first direction D**11** are passing the detection position DP**1** (see FIG. **4**B); (3) two or more second objects A**12** deviated from each other in the first direction D**11** are passing the detection position DP**1** (see FIG. **4**C); and (4) one first object A**11** is passing the detection position DP**1** (see FIG. **4**D).

[0036] In the case (1), as shown in FIG. **4**A, in a first time section T**11** in which the one second object A**12** is not passing the detection position DP**1**, the signal ES**1** represents a first level L**11**. It is noted that the signal ES**1** represents the first level L**11** in the first time section T**11** in which neither the two or more second objects A**12** (see FIG. **4**B, **4**C) nor the one first object A**11** (see FIG. **4**D) is passing the detection position DP**1**. In the case (1), in a second time section T**12** in which the one second object A**12** is passing the detection position DP**1**, the signal ES**1** represents a second level L**12** that is smaller than the first level L**11**.

[0037] In the case (2), as shown in FIG. **4**B, in a third time section T**13**, the signal ES**1** represents a level that is smaller than the second level L**12**. It is noted that FIG. **4**B shows an example case where the signal ES**1** represents a third level L**13** in the third time section T**13**. In the third time section T**13**, two second objects A**12** in a state of overlapping each other are passing the detection position DP**1**. It is noted that when three or more second objects A**12** are passing the detection position DP**1**, the level of the signal ES**1** changes with time in a similar manner to FIG. **4**B.

[0038] In the case (3), as shown in FIG. **4**C, in the third time section T**13**, the signal ES**1** represents a level (for example, the third level L**13**) that is smaller than the second level L**12**, and in a fourth time section T**14**, the signal ES**1**

represents the second level L12. In the fourth time section T14, only one of two second objects A12 is passing the detection position DP1.

[0039] The case (4) is the same as the case (2) in that the body portion B11 of the first object A11 is composed of a plurality of sheets overlapping each other, but the case (4) is different from the case (2) in that the plurality of sheets are connected to each other by the closed portion B14 or the like. As a result, in a fifth time section T15 from the time when the body portion B11 starts passing the detection position DP1 until a specific time period elapses, the level of the signal ES1 reduces with time and finally reaches the third level L13. The reason is as follows.

[0040] As indicated by an arrow E1 in a frame F2 of FIG. 4D, when the measurement wave collides with a first region R11 of the body portion B11, a vibration generated by the collision is transmitted from the first region R11 to a second region R12 of the body portion B11 via the closed portion B14 without being largely attenuated. The first region R11 is a region close to the closed portion B14 of a sheet passing on the sending portion 241 side among the plurality of sheets. The second region R12 is a region close to the closed portion B14 of a sheet passing on the receiving portion 242 side among the plurality of sheets. The vibration transmitted to the second region R12 is transmitted to the receiving portion 242 via the air. In addition, since the first object A11 is conveyed in the first direction D11, as the time elapses, the transmission distance from the first region R11 to the closed portion B14 increases. As a result, the vibration transmitted to the second region R12 reduces with time. Accordingly, as shown in FIG. 4D, the level of the signal ES1 reduces with time and reaches the third level L13. It is noted that the length of the fifth time section T15 is determined by the material and thickness of the first object A11, the velocity V1, and a distance from the closed portion B14 in a reverse direction of the first direction D11.

[0041] In addition, in the case (4), as shown in FIG. 4D, in a sixth time section T16, the signal ES1 represents the third level L13, and in a seventh time section T17, the signal ES1 represents the second level L12. The sixth time section T16 is a time section that follows the fifth time section T15, in a time section in which the body portion B11 is passing the detection position DP1. In the seventh time section T17, the flap portion B12 of the first object A11 is passing the detection position DP1 (see FIG. 2A).

[0042] Referring to FIG. 1, the image forming portion 25 forms an image on an object A1 conveyed in the first conveyance path CP1, at a position on the downstream side of the first sensor portion 24 in the first conveyance path CP1, based on image data transmitted from the control portion 27. The image forming portion 25 discharges the object A1 with the image formed thereon onto the first discharge portion 26 that is, for example, a discharge tray. It is noted that the image forming portion 25 forms the image by an electrophotographic method or an inkjet method.

[0043] The control portion 27 serves as a determination device 27. The control portion 27 includes a processor, a program storage portion that is a ROM or the like, and a working area that is a RAM or the like. The processor executes, by using the working area, a program that is preliminarily stored in the program storage portion. This allows the control portion 27 to control the components of the image forming apparatus 100 comprehensively. It is noted that the control portion 27 may be an electronic circuit such as an ASIC (Application Specific Integrated Circuit) or a DSP (Digital Signal Processor). It is noted that when the image forming apparatus 100 includes the image reading device 300, the control portion 27 may be provided in the image reading device 300.

[0044] An image forming apparatus according to a related technology detects whether or not a double feeding has occurred, based on a condition that differs among a plurality of types of objects that may be conveyed in a conveyance path. As a result, in a case where a plurality of types of objects are conveyed in sequence in the conveyance path, the related technology cannot detect correctly whether or not a double feeding has occurred, with regard to at least one of the plurality of types of objects. On the other hand, the image forming apparatus 100 is configured to detect, for each of a plurality of types of objects, whether or not a double feeding has occurred, even in a case where a plurality of types of objects are conveyed in sequence in a conveyance path.

[0045] As shown in FIG. 5, in the image forming apparatus 100, the control portion 27 includes an acquisition processing portion 27A, a determination processing portion 27B, a time measurement processing portion 27C, a detection processing portion 27D, and a conveyance controlling portion 27E. When the processor executes the program, the control portion 27 functions as the acquisition processing portion 27A, the determination processing portion 27B, the time measurement processing portion 27C, the detection processing portion 27D, and the conveyance controlling portion 27E.

[0046] The acquisition processing portion 27A acquires the signal ES1 from the first sensor portion 24.

[0047] The determination processing portion 27B determines whether or not a first time period ET1 (see FIG. 6A) is equal to or larger than a first time threshold TT1 (see FIG. 4D), wherein the first time period ET1 is a time period during which the level of the signal ES1 changes from a first level threshold LT1 (see FIG. 4A to FIG. 4D) to a second level threshold LT2.

[0048] The first level threshold LT1, the second level threshold LT2, and the first time threshold TT1 are preliminarily determined in the design and development stage of the image forming apparatus 100 through an experiment or a simulation, and are written in the program.

[0049] The first level threshold LT1 and the second level threshold LT2 are determined based on the thickness of the object A1 in a second direction D12 that intersects the first direction D11. The second direction D12 is a first example of an intersecting direction of the present disclosure, and specifically, extends in the up-down direction. As shown in FIG. 4B, the first level threshold LT1 has a value that is between the second level L12 and the third level L13, and is close to the second level L12. The second level threshold LT2 is smaller than the first level threshold LT1, and has a value that is between the second level L12 and the third level L13, and is close to the third level L13. More specifically, as shown in FIG. 4A, the first level threshold LT1 is set such that when one second object A12 is passing the detection position DP1, the level of the signal ES1 exceeds the second level L12. Furthermore, as shown in FIG. 4B, the first level threshold LT1 is set such that when the first object A11 or a plurality of second objects A12 are passing the detection

position DP1, the level of the signal ES1 is equal to or smaller than the second level L12 and equal to or smaller than the third level L13.

[0050] The first time threshold TT1 shown in FIG. 4D is determined based on the velocity V1 and a distance from an end of the object A1 on the first direction D11 side in the reverse direction of the first direction D11. Here, timings at which the level of the signal ES1 becomes the second level L12 and the third level L13, are referred to as a start time t0 and an end time t1 of the fifth time section T15. The first time threshold TT1 is a time period from the start time t0 of the fifth time section T15 to a time t2 that is close to the end time t1 of the fifth time section T15. More specifically, in the distance from the end on the first direction D11 side in the reverse direction, a distance D31 where the level of the signal ES1 changes from larger than the third level L13 to equal to or smaller than the third level L13, is preliminarily determined through the experiment or the simulation. In this case, the first time threshold TT1 is preliminarily determined to be equal to or smaller than a value that is obtained by dividing the distance D31 by the velocity V1.

[0051] The time measurement processing portion 27C measures an elapsed time from the time when the determination processing portion 27B determined that the level of the signal ES1 was equal to or smaller than the first level threshold LT1. The elapsed time is used as the first time period ET1 and a second time period ET2 by the determination processing portion 27B.

[0052] The determination processing portion 27B is configured to, after it determines that the first time period ET1 is not equal to or larger than the first time threshold TT1 (namely, is smaller than the first time threshold TT1), determine whether or not a double feeding of the object has occurred, based on the level of the signal ES1 acquired by the acquisition processing portion 27A. Specifically, when it determines whether or not a double feeding of the object has occurred, the determination processing portion 27B determines whether or not the second time period ET2 is equal to or larger than a second time threshold TT2, wherein the second time period ET2 is a time period in which the level of the signal ES1 is equal to or smaller than the first level threshold LT1 (see FIG. 6B), and the second time threshold TT2 (see FIG. 4C) is longer than the first time threshold TT1 (see FIG. 4D).

[0053] The second time threshold TT2 is preliminarily determined based on the velocity V1 and a length of a specific object A1 in the first direction D11. The specific object A1 is a second object A12 having the smallest length in the first direction D11 among second objects A12 on which images can be formed by the image forming apparatus 100. The second time threshold TT2 is a time period that is obtained by dividing the length of the specific object A1 by the velocity V1.

[0054] The detection processing portion 27D detects whether or not a double feeding of the object A1 has occurred, based on the determination result of the determination processing portion 27B. Specifically, when the determination processing portion 27B determines that the first time period ET1 is equal to or larger than the first time threshold TT1, the detection processing portion 27D detects that a double feeding has not occurred. In this case, the conveyance controlling portion 27E further conveys the object A1 toward the downstream in the first direction D11. When the determination processing portion 27B determines that the first time period ET1 is not equal to or larger (is smaller) than the first time threshold TT1, the detection processing portion 27D detects that a double feeding has occurred. In this case, the conveyance controlling portion 27E stops conveying the object A1 in the first direction D11.

[0055] Next, a detailed description is given of the process and control of the control portion 27 in the image forming apparatus 100.

[0056] First, the user stacks a plurality of objects A1 on the first set portion 22 (see FIG. 1). The plurality of objects A1 include a first object A11 and a second object A12. In addition, the control portion 27 acquires image data that represents an image to be formed. Specifically, the control portion 27 receives the image data from an information processing apparatus (not shown) that is communicably connected with the image forming apparatus 100 via a network. In a case where the image forming apparatus 100 includes the image reading device 300, the control portion 27 may receive the image data from the image reading device 300. Upon receiving the image data, the control portion 27 repeatedly executes the processes shown in FIG. 6A to FIG. 6C as many times as necessary for one object A1, thereby forming the image represented by the image data on as many objects A1 as necessary. It is noted here that since a double feeding may occur in the first conveyance path CP1, the processes shown in FIG. 6A to FIG. 6C include a double feeding detection process.

[0057] In step S101 of FIG. 6, the control portion 27 functions as the conveyance controlling portion 27E. The conveyance controlling portion 27E starts conveying an object A1 on the first set portion 22 by controlling the first conveyance portion 23.

[0058] Next, in step S102, the control portion 27 functions as the acquisition processing portion 27A, and acquires a signal ES1 from the first sensor portion 24. Next, in step S103, the control portion 27 functions as the determination processing portion 27B. In order to determine whether or not a double feeding has occurred at the current time, the determination processing portion 27B determines whether or not the level of the signal ES1 is equal to or smaller than the first level threshold LT1 (see FIG. 4A or the like). Upon determining that the level is not equal to or smaller (is larger) than the first level threshold LT1, the determination processing portion 27B determines that a double feeding has not occurred at the current time, and moves the process to step S104; and upon determining that the level is equal to or smaller than the first level threshold LT1, the determination processing portion 27B moves the process to step S106.

[0059] In step S104, the control portion 27 functions as the detection processing portion 27D and the conveyance controlling portion 27E. The detection processing portion 27D detects that a double feeding has not occurred in the first conveyance path CP1. In this case, the conveyance controlling portion 27E continues the conveyance of the object A1 by controlling the first conveyance portion 23.

[0060] Next, in step S105, the conveyance controlling portion 27E determines whether or not it is a stop timing to stop the pickup roller of the first conveyance portion 23. The stop timing is a timing immediately after a rear end of the object A1 in the first direction D11 has passed the pickup roller. Specifically, the conveyance controlling portion 27E determines whether or not it is the stop timing based on an output signal of an optical sensor or the like provided near the first upstream end CP11. Upon determining that it is the

stop timing, the conveyance controlling portion **27**E stops the pickup roller, ends the processes of FIG. **6**A to FIG. **6**C, and waits for a next object A**1** to be conveyed. In addition, upon determining that it is not the stop timing, the conveyance controlling portion **27**E returns the process to step S**102**.

[0061] When one second object A**12** is conveyed in the first conveyance path CP**1** (see FIG. **4**A), a process loop that is composed of steps S**102** to S**105** executed in the stated order, is repeated. In this case, the image forming portion **25** forms the image on the second object A**12** that is being conveyed. Thereafter, the second object A**12** with the image formed thereon is discharged onto the first discharge portion **26**.

[0062] In step S**106**, the control portion **27** functions as the time measurement processing portion **27**C, and starts measuring an elapsed time from the time when the execution of step S**106** was started. Next, in step S**107**, the control portion **27** functions as the acquisition processing portion **27**A and acquires a signal ES**1** from the first sensor portion **24**. Next, in step S**108**, the control portion **27** functions as the determination processing portion **27**B, and determines whether or not a double feeding has occurred in the first conveyance path CP**1**, by determining whether or not the level of the signal ES**1** is equal to or smaller than the second level threshold LT**2** (see FIG. **4**B to FIG. **4**D). Upon determining that the level is equal to or smaller than the second level threshold LT**2**, the determination processing portion **27**B determines that one first object A**11** (see FIG. **4**D) or a plurality of second objects A**12** (see FIG. **4**B, FIG. **4**C) are conveyed in the first conveyance path CP**1**, and moves the process to step S**109**. Upon determining that the level is not equal to or smaller (is larger) than the second level threshold LT**2**, the determination processing portion **27**B determines that not one first object A**11** but a plurality of second objects A**12** are conveyed in the first conveyance path CP**1**, and moves the process to step S**114** of FIG. **6**B.

[0063] In a case where the process is returned to step S**107**, the acquisition processing portion **27**A acquires the signal ES**1** a plurality of times with a time interval therebetween. Here, the time interval is denoted as ΔT, and ΔT is a time period smaller than the first time threshold TT**1**. The image forming apparatus **100** is designed such that the acquisition processing portion **27**A acquires the signals ES**1** with the time interval ΔT.

[0064] The control portion **27** functions as the determination processing portion **27**B and executes steps S**109** and S**110** in sequence. In step S**109**, the determination processing portion **27**B acquires an elapsed time as the first time period ET**1** from the time measurement processing portion **27**C, and in step S**110**, the determination processing portion **27**B determines whether or not the first time period ET**1** is equal to or larger than the first time threshold TT**1**. Based on the result of step S**110**, the determination processing portion **27**B determines whether or not a double feeding has occurred in the first conveyance path CP**1**. Upon determining that the first time period ET**1** is equal to or larger than the first time threshold TT**1**, the determination processing portion **27**B moves the process to step S**111**. Upon determining that the first time period ET**1** is not equal to or larger (is smaller) than the first time threshold TT**1**, the determination processing portion **27**B determines that a plurality of second objects A**12** are conveyed in the first conveyance path CP**1** (see FIG. **4**B, FIG. **4**C), and that a double feeding has occurred, and moves the process to step S**114** of FIG. **6**B.

[0065] In step S**111**, the control portion **27** functions as the time measurement processing portion **27**C, and ends the measurement of time, and then moves the process to step S**112**. In step S**112**, the control portion **27** functions as the detection processing portion **27**D, determines that the object A**1** that is being conveyed is one first object A**11** (see FIG. **4**D), and detects that a double feeding has not occurred in the first conveyance path CP**1**. Furthermore, in step S**112**, the control portion **27** functions as the conveyance controlling portion **27**E, and conveys the one first object A**11** further toward the downstream side in the first direction D**11**. Step S**112** is repeated until the conveyance controlling portion **27**E determines in step S**113** that it is the stop timing.

[0066] According to the processes of FIG. **6**A to FIG. **6**C, in steps S**105** to S**110**, the detection processing portion **27**D detects that one first object A**11** is passing the detection position DP**1** and that a double feeding has not occurred, when it is detected that the first time period ET**1** (see FIG. **6**A) is equal to or larger than the first time threshold TT**1** (see FIG. **4**D), wherein the first time period ET**1** is a time period during which the level of the signal ES**1** changes from the first level threshold LT**1** (see FIG. **4**A) to the second level threshold LT**2**. That is, the control portion **27** can automatically determine that the object A**1** that is being conveyed in the first conveyance path CP**1** is the first object A**11**, even if the user does not set the type of the object A**1** (namely, the first object A**11** or the second object A**12**). Thereafter, a process loop composed of steps S**112** and S**113** is repeated. The image forming portion **25** forms the image on the object A**1** that is being conveyed. Subsequently, the first object A**11** with the image formed thereon is discharged onto the first discharge portion **26**.

[0067] In steps S**114** and S**115**, the control portion **27** functions as the determination processing portion **27**B. In step S**114**, the determination processing portion **27**B acquires an elapsed time as the second time period ET**2** from the time measurement processing portion **27**C. The determination processing portion **27**B determines whether or not the second time period ET**2** is equal to or larger than the second time threshold TT**2**. Upon determining that the second time period ET**2** is not equal to or larger (is smaller) than the second time threshold TT**2**, the determination processing portion **27**B moves the process to step S**116**; and upon determining that the second time period ET**2** is equal to or larger than the second time threshold TT**2**, the determination processing portion **27**B moves the process to step S**117**.

[0068] In step S**116**, the control portion **27** functions as the conveyance controlling portion **27**E, and continues to convey the plurality of second objects A**12** in the first conveyance path CP**1**.

[0069] In step S**117**, the control portion **27** functions as the time measurement processing portion **27**C, and ends the measurement of time. Subsequently, in step S**118**, the control portion **27** functions as the detection processing portion **27**D, determines that a plurality of second objects A**12** are passing the detection position DP**1** in the first conveyance path CP**1** (see FIG. **4**B, FIG. **4**C), and detects that a double feeding has occurred. Furthermore, in step S**114**, the control portion **27** functions as the conveyance controlling portion **27**E, and stops conveyance of the plurality of second objects

A12 in the first direction D11. Specifically, the conveyance controlling portion 27E controls the first conveyance portion 23 to convey the plurality of second objects A12 in a reverse direction of the first direction D11 in the first conveyance path CP1, and discharge the plurality of second objects A12 from the first upstream end CP11 onto the first set portion 22.

[0070] The processes of FIG. 6A to FIG. 6C make it possible to provide the determining device 27, the conveying device 400, and the image forming apparatus 100 that can determine whether or not a double feeding has occurred for each of a plurality of types of objects A1 even when the plurality of types of objects A1 (the first object A11 and the second object A12) are stacked on the first set portion 22, and the plurality of types of objects A1 are conveyed in sequence in the first conveyance path CP1.

[0071] It is noted that after it is determined in step S108 that the level of the signal ES1 is not equal to or smaller (is larger) than the second level threshold LT2, and before it is determined in step S115 that the second time period ET2 is equal to or larger than the second time threshold TT2, the control portion 27 may determine whether or not the level of each of the signals ES1 acquired with the time interval ΔT is the first level threshold LT1.

[0072] In addition, upon determining in step S110 that the first time period ET1 is not equal to or larger (is smaller) than the first time threshold TT1, the control portion 27 may execute steps S117 and S118 without executing steps S114 to S116.

[0073] Referring to FIG. 7, the image reading device 300 is provided above the main body device 200. It is noted that the image reading device 300 may be a scanner or the like that is provided independent of the image forming apparatus 100.

[0074] The image reading device 300, including an ADF (Automatic Document Feeder) 310, a cover 320, a contact portion 330, and an image reading portion 340, generates image data by optically reading an image of an object A2 that is conveyed, and outputs the image data to the control portion 27 (see FIG. 1, FIG. 5).

[0075] The ADF 310 is a document feeding device, and is integrally provided with the cover 320 on an upper surface of the main body device 200. The ADF 310 includes a second set portion 31, a second conveyance portion 32, a second sensor portion 33, and a second discharge portion 34. In addition, in the image forming apparatus 100, the conveying device 400 is provided in the image reading device 300, and includes at least the second conveyance portion 32, the second sensor portion 33, and the control portion 27 (see FIG. 1, FIG. 5).

[0076] In addition, a second conveyance path CP2 in which objects A2 are conveyed is provided in the ADF 310. The second conveyance path CP2 extends from a second upstream end CP21 to a second downstream end CP22. Specifically, the second upstream end CP21 is provided at an upper position close to a center in the left-right direction of the ADF 310. The second downstream end CP22 is provided below the second upstream end CP21 in the ADF 310. In the second conveyance path CP2, its upstream portion extends from the second upstream end CP21 leftward, and its intermediate portion, between its upstream portion and its downstream portion, goes downward while bending. The downstream portion extends diagonally upward right from the intermediate portion to the second downstream end CP22.

[0077] The second set portion 31 is a supply tray, and provided at an upper-right portion of the image reading device 300. The second set portion 31 is configured such that a plurality of types of objects A2 can be placed thereon. The plurality of types of objects A2 include a first object A21 and a second object A22. The first object A21 is different from the first object A11 only in that it is a used envelope on which an address or the like has been written. The second object A22 is different from the second object A12 only in that it is a sheet of paper or an OHP sheet on which an image or the like has been recorded. As a result, in the following description, the components common to the first object A21 and the second object A22 are assigned the same reference signs, description thereof is omitted, and FIG. 2A and FIG. 3 are used for the explanation. As shown in FIG. 7, the first object A21 is placed on the second set portion 31 such that the closed portion B14 is along the second upstream end CP21.

[0078] The second conveyance portion 32 includes a pickup roller and a pair of conveyance rollers, and feeds an object A2 from the second upstream end CP21 into the second conveyance path CP2. Thereafter, the second conveyance portion 32 conveys the object A2 along the second conveyance path CP2 in a third direction D21 at a predetermined velocity V2. The third direction D21 is directed toward the downstream in the second conveyance path CP2, and is a second example of the specific direction of the present disclosure.

[0079] The second sensor portion 33 is a second example of the sensor portion of the present disclosure, and is a transmission-type ultrasonic sensor. The second sensor portion 33 includes a sending portion 331 and a receiving portion 332 that face each other across a predetermined detection position DP2. The detection position DP2 is located immediately on the downstream side of the second conveyance portion 32 in the second conveyance path CP2. The second sensor portion 33 is configured to cause the sending portion 331 to emit a measurement wave having a predetermined amplitude level toward the detection position DP2. The second sensor portion 33 causes the receiving portion 332 to output, to the control portion 27, a signal ES2 that is generated based on the measurement wave. The level of the signal ES2 is related to the type and number of the objects A2 that are passing the detection position DP2 (see FIG. 4A to FIG. 4D).

[0080] The second discharge portion 34 is a discharge tray, and is provided on the right side of the second downstream end CP22. Objects A2 discharged from the second downstream end CP22 are stacked on the second discharge portion 34.

[0081] The contact portion 330 is a translucent, plate-like member such as a glass plate or a resin plate. The contact portion 330 is provided close to a left end on an upper surface of the main body device 200. The contact portion 330 is attached to the upper surface of the main body device 200 so as to be along a lowest end portion of the second conveyance path CP2. A reading region R1 is preliminarily determined on the contact portion 330. The object A2 conveyed in the second conveyance path CP2 passes over the reading region R1.

[0082] The image reading portion 340 is a CIS (Contact Image Sensor). The image reading portion 340 is provided in the main body device 200 at a position close to an upper surface thereof. The image reading portion 340 emits light

from below the contact portion **330** toward the reading region R**1**. The image reading portion **340** generates image data representing an image of the object A**2** by photoelectrically converting reflected light from the object A**2** that passes the reading region R**1**, and outputs the image data to the control portion **27**.

[0083] The acquisition processing portion **27**A may acquire the signal ES**2** from the second sensor portion **33** instead of the first sensor portion **24**. In this case, the determination processing portion **27**B and the time measurement processing portion **27**C execute the processes shown in FIG. **6**A to FIG. **6**C based on the signal ES**2** instead of the signal ES**1**. The detection processing portion **27**D detects whether or not a double feeding of the object A**2** has occurred in the second conveyance path CP**2**, based on the determination result of the determination processing portion **27**B. The conveyance controlling portion **27**E controls the conveyance of the object A**2** by the second conveyance portion **32**, based on the detection result of the detection processing portion **27**D.

[0084] It is to be understood that the embodiments herein are illustrative and not restrictive, since the scope of the disclosure is defined by the appended claims rather than by the description preceding them, and all changes that fall within metes and bounds of the claims, or equivalence of such metes and bounds thereof are therefore intended to be embraced by the claims.

1. A determining device comprising:

an acquisition processing portion configured to acquire a signal based on an ultrasonic wave emitted toward an object conveyed in a specific direction; and

a determination processing portion configured to determine whether or not a first time period is equal to or larger than a predetermined first time threshold, wherein the first time period is a time period during which a level of the signal changes from a predetermined first level threshold to a second level threshold that is smaller than the first level threshold.

2. The determining device according to claim **1**, wherein

the first time threshold is determined based on: a velocity at which the object is conveyed in the specific direction; and a distance from an end of the object on the first direction side in a reverse direction of the specific direction.

3. The determining device according to claim **1**, wherein

the first level threshold and the second level threshold are determined based on a thickness of the object in an intersecting direction that intersects the specific direction.

4. The determining device according to claim **1**, wherein

upon determining that the first time period is not equal to or larger than the first time threshold, the determination processing portion further determines whether or not a second time period is equal to or larger than a second time threshold, wherein the second time period is a time period in which the level of the signal is equal to or smaller than the first level threshold, and the second time threshold is longer than the first time threshold.

5. The determining device according to claim **4**, wherein

the second time threshold is determined based on: a velocity at which the object is conveyed in the specific direction; and a length of the object in the specific direction.

6. A conveying device comprising:

a sensor portion configured to emit an ultrasonic wave toward the object, and output the signal having a level that changes according to an incident wave from the object; and

the determining device according to claim **1**.

7. The conveying device according to claim **6**, further comprising:

a detection processing portion configured to detect whether or not a double feeding of the object has occurred, based on a determination result of the determining device.

8. The conveying device according to claim **7**, wherein

when the determination processing portion determines that the first time period is equal to or larger than the first time threshold, the detection processing portion detects that a double feeding has not occurred,

the conveying device further comprising:

a conveyance controlling portion configured to, when the detection processing portion detects that a double feeding has not occurred, further convey the object toward a downstream in the specific direction.

9. The conveying device according to claim **8**, wherein

when the determination processing portion determines that the first time period is not equal to or larger than the first time threshold, the detection processing portion detects that a double feeding has occurred, and

when the detection processing portion detects that a double feeding has occurred, the conveyance controlling portion stops conveying the object in the specific direction.

10. An image reading device comprising:

the determining device according to claim **1**.

11. An image reading device comprising:

the conveying device according to claim **6**.

12. An image forming apparatus comprising:

the determining device according to claim **1**.

13. An image forming apparatus comprising:

the conveying device according to claim **6**.

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