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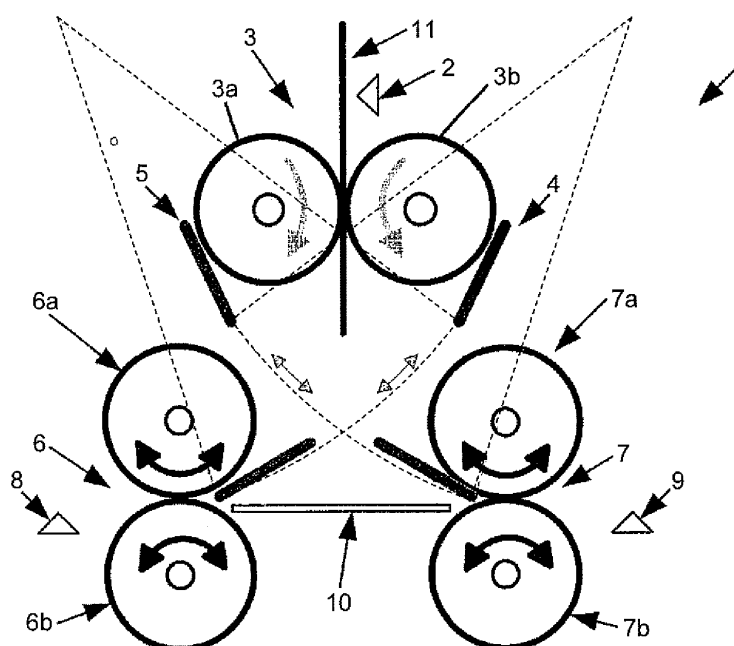
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(54) **Sheet folding apparatus, image forming system and sheet folding method**

(57) A sheet folding apparatus (1) folds a sheet in parallel a plurality of times. The sheet folding apparatus includes a transport roller pair (3) that transports the sheet; first and second folding roller pairs (6, 7) that are provided with a predetermined gap therebetween and alternately fold the sheet transported from the transport roller pair (3); and first and second sheet detecting units

(8, 9) that are provided outside the first and second folding roller pairs (6, 7) so as to face the first and second folding roller pairs (6, 7), respectively. Second and subsequent folding positions of the sheet are set based on an amount of transport of the sheet that is determined on the basis of an end of the sheet (F0) or a first folding end (F1).

FIG.1



Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to and incorporates by reference the entire contents of Japanese Patent Application No. 2010-132338 filed in Japan on June 9, 2010.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to a sheet folding apparatus having a function of folding a sheet-shaped recording medium, such as a sheet of paper, a plurality of times, an image forming system including the sheet folding apparatus and an image forming apparatus, such as a copier, a printer, a facsimile, or a digital multi-function peripheral, and a sheet folding method.

2. Description of the Related Art

[0003] In general, in a copier that copies a large size document, such as a drawing document, copying is performed, in many cases, on a large copying sheet, such as an A0, A1, or A2 sheet. When the large copying sheet is stored or handled without reducing the size thereof, a large storage space is needed, or it is difficult to handle the copying sheet. Therefore, in general, the sheet is folded and stored.

[0004] However, when the large copying sheet is manually folded, it takes a long time to fold the sheet and the time required to fold the sheet is several times longer than the time required for copying. For this reason, a sheet folding machine having a function of folding, for example, an A0 sheet into an A4 sheet is provided on the discharge path of the copier and is used.

[0005] The sheet folding machine includes, for example, two folding roller pairs that fold the sheet, a transport roller pair that feeds the sheet to one of the two folding roller pairs, and a deflection unit that changes the folding direction of the sheet to the one folding roller pair. The sheet folding machine can alternately change the folding direction of the sheet and continuously fold the sheet a plurality of times.

[0006] Fig. 1 is a diagram schematically illustrating the structure of a sheet folding apparatus that performs the above-mentioned folding method according to the related art. In Fig. 1, a sheet folding apparatus 1 includes an inlet sensor 2, a transport roller pair 3 (3a and 3b), a first folding roller pair 6 (6a and 6b) and a second folding roller pair 7 (7a and 7b) which are provided on the lower left and right sides of the transport roller pair 3 so as to face each other, first and second sheet guide members 4 and 5 that selectively guide a sheet 11 transported from the transport roller pair 3 to the first and second folding roller pairs 6 and 7, respectively, first and second sensors 8

and 9 that are respectively provided outside the first and second folding roller pairs 6 and 7, and a sheet lower surface guide 10 that guides the lower surface of the sheet 11.

[0007] The sheet 11 is transported by the transport roller pair 3 and is selectively guided to the first folding roller pair 6 or the second folding roller pair 7 by the operation of the first sheet guide member 4 or the second sheet guide member 5. Then, when the first folding roller pair 6 and the second folding roller pair 7 are repeatedly rotated forward and backward, the sheet 11 is repeatedly transported between the first folding roller pair 6 and the second folding roller pair 7 by the operation of the first or second sheet guide member 4 or 5 while sliding on the lower surface of the sheet lower surface guide 10. This operation is repeatedly performed to fold the sheet a predetermined number of times.

[0008] The first sheet guide member 4 and the second sheet guide member 5 are operated as follows. When the sheet 11 is transported to the first folding roller pair 6, the first sheet guide member 4 is operated. When the sheet 11 is transported to the second folding roller pair 7, the second sheet guide member 5 is operated.

[0009] In the sheet folding apparatus, a pressing mechanism (not shown) presses the pressing rollers 6a and 7a against the folding rollers 6b and 7b in the first and second folding roller pairs 6 and 7 such that a predetermined nip pressure is obtained between the pressing roller 6a and the folding roller 6b and between the pressing roller 7a and the folding roller 7b. Therefore, the gap between the pressing roller 6a and the folding roller 6b varies depending on the thickness of the folded sheet 11. For the folding roller pair 7, similarly, the gap between the pressing roller 7a and the folding roller 7b varies depending on the thickness of the folded sheet 11.

[0010] Fig. 2 is a block diagram illustrating the control structure of the sheet folding apparatus. The control structure of the sheet folding apparatus includes a control unit 30 as a main unit. An instruction to designate a folding size and a folding method is input to the control unit 30 through a folding size designating unit 31 and a folding method designating unit 32. In the sheet folding apparatus 1, detection results 34 of the first and second sensors 8 and 9 are input to the control unit 30. The control unit 30 receives the information, determines the transport distance and transport direction of the sheet after the leading end of the sheet is detected, and outputs an instruction to an electric component control unit 36 that controls the driving of, for example, a motor and a solenoid. The electric component control unit 36 controls electric components in response to the instruction.

[0011] That is, the first sensor 8 and the second sensor 9 provided outside the first folding roller pair 6 and the second folding roller pair 7 detect the end of the sheet transported by the first folding roller pair 6 and the second folding roller pair 7. The control unit 30 controls the transport direction and transport distance of the sheet on the basis of the detection result. The first sensor 8 and the

second sensor 9 detect the ends of the sheet as follows. The first sensor 8 detects the end of the sheet 11 close to the first folding roller pair 6 and the second sensor 9 detects the end of the sheet 11 close to the second folding roller pair 7.

[0012] The control unit 30 includes a CPU, a ROM, and a RAM (which are not shown). The ROM stores program codes executed by the CPU. The CPU expands the program code read from the ROM on the RAM and performs a control operation defined by the program code while using the RAM as a work area and a data buffer.

[0013] In the sheet folding apparatus, as in the finished state of the folding of the sheet shown in Fig. 3, the width of the folding surface is gradually reduced from the front side such that the relationship $L1 > L2 \geq L3 \geq \dots \geq Ln$ is satisfied. Even when it is difficult to detect the folding end of the sheet using the first sensor 8 or the second sensor 9 immediately after the sheet is folded, the stopping of the folding roller pair is controlled on the basis of the stop position of the previous folding operation. L1 indicates the length (hereinafter, referred to as the "length of a first folding surface") of a first folding portion of the sheet and is from a sheet end F0 to a first folding end F1, L2 indicates the length (hereinafter, referred to as the "length of a second folding surface") of a second folding portion of the sheet and is from the first folding end F1 to a second folding end F2, and L3 indicates the length (hereinafter, referred to as the "length of a third folding surface") of a third folding portion of the sheet and is from the second folding end F2 to a third folding end F3. Similarly, Ln indicates the length (hereinafter, referred to as the "length of an L-th folding surface") of an n-th (n is a positive integer) folding portion of the sheet and is from an (Ln-1)-th folding end Fn-1 to an Ln-th folding end Fn.

[0014] That is, when the stop position of the folding roller is set after the sheet is folded at the second folding end F2 shown in Fig. 3, the sheet end F0 protrudes from the second folding end F2. Therefore, it is difficult to detect the second folding end F2 with the first sensor 8. Therefore, the stopping of the folding roller pairs 6 and 7 is controlled based on a stop position after the first folding end F1 which is at the stop position on the front side of the second folding end F2 is detected by the second sensor 9. In this way, even in a folding method in which the folding end of the sheet cannot be detected by the first sensor 8 or the second sensor 9, the folding operation can be controlled. This sheet folding apparatus is disclosed in, for example, Japanese Patent No. 3911091.

[0015] However, in the sheet folding apparatus disclosed in Japanese Patent No. 3911091, the transport direction and the amount of transport of the first and second folding roller pairs 6 and 7 are controlled on the basis of the detection of the end or folding end of the sheet by the first sensor 8 or the second sensor 9. The position of the first sensor 8 or the second sensor 9 relative to the first folding roller pair 6 and the second folding roller pair 7 has an effect on the minimum value of the length of a

folding surface.

[0016] In order to reduce the length of the folding surface, it is necessary to reduce the distance between (a nip portion of) the first folding roller pair 6 and the first sensor 8 and the distance between (a nip portion of) the second folding roller pair 7 and the second sensor 9. However, on the layout including, for example, the diameters of the rollers 6a, 6b, 7a, and 7b, the distance between the folding roller pairs 6 and 7, and the sizes of the first and second sensors 8 and 9, the limit of the distance between the components is determined, and it is difficult to set the length of the folding surface to a desired value or a target value.

[0017] In folding a sheet, to which a large size document, such as a drawing document is copied, there are folding methods other than the folding method described in JIS (Z8311: Technical drawings - Sizes and layout of drawing sheets (for reference): a standard method of folding a drawing sheet). That is, there are various kinds of folding methods that are different depending on the field of business. Therefore, for example, when there is a folding surface with a small length, it is difficult to respond to a desired folding length due to the positional relationship between the components of the sheet folding apparatus.

[0018] For example, in the folding finished state of the sheet shown in Fig. 3, as in the related art, the stop position for folding the sheet at the second or subsequent folding end is controlled based on the stop position that is determined on the basis of the detection position of the first folding end F1 by the second sensor 9. As such, as long as an operation for stopping the sheet is performed using the sensor detection, the stop position is affected by the detection position by the sensor and is certainly affected by the layout.

[0019] Fig. 4 is a diagram illustrating the positional relationship between the components that restrict the minimum value of the folding length. The minimum length of the folding surface is calculated in the case where the gap (distance between nip portions) between the first folding roller pair 6 and the second folding roller pair 7 is 80 mm, the gap between (a nip portion of) the first folding roller pair 6 and the first sensor 8 is 30 mm, the gap between (a nip portion of) the second folding roller pair 7 and the second sensor 9 is 30 mm, and a transport distance (free running distance) from the detection of the end of the sheet or the folding end of the sheet by the first sensor 8 and the second sensor 9 to the stopping of the first folding roller pair 6 and the second folding roller pair 7 is 20 mm. The transport distance H1 of the first folding roller pair 6 and the second folding roller pair 7 from the detection of the first folding end by the second sensor 9 shown in the state (a) of Fig. 4 to the folding of the sheet at the second folding end shown in the state (b) of Fig. 4 is a value obtained by subtracting the transport distance h1 of the transport roller pair 3 from the gap, 80 mm, between the first folding roller pair 6 and the second folding roller pair 7. That is, the following ex-

pression is established:

$H1 = 80\text{mm} - h1$.

[0020] When the transport distance $h2$ of the first folding roller pair 6 and the second folding roller pair 7 is equal to the transport distance $h1$ of the transport roller pair 3, the transport distance $h2$ of the first folding roller pair 6 and the second folding roller pair 7 from the state (a) of Fig. 4 to the state (b) of Fig. 4 is 40 mm.

[0021] Therefore, as shown in the state (c) of Fig. 4, the minimum length H_{min} of the folding surface is 90 mm which is the sum of 80 mm, which is the gap between the first folding roller pair 6 and the second folding roller pair 7, and 10 mm, which is the length of the sheet protruding from the second folding roller pair 7.

[0022] In the actual operation, the first folding roller pair 6 and the second folding roller pair 7 are rotated forward, stopped, and rotated backward, but the transport roller pair 3 continuously transports the sheet without being stopped and rotated backward. Therefore, the transport distance $h2$ of the first folding roller pair 6 and the second folding roller pair 7 is not equal to the transport distance $h1$ of the transport roller pair 3. Since the transport distance $h2$ of the first folding roller pair 6 and the second folding roller pair 7 is less than the transport distance $h1$, the minimum length H_{min} of the folding surface increases.

SUMMARY OF THE INVENTION

[0023] An object of the invention is to provide a technique capable of folding a sheet while reducing the minimum length of a folding surface, regardless of mechanical positional relationships, such as the diameter of a folding roller, the distance between the folding roller pairs, and the position of a sensor, and a size.

[0024] According to an aspect of the present invention, there is provided a sheet folding apparatus folds a sheet in parallel a plurality of times. The sheet folding apparatus includes a transport roller pair that transports the sheet; first and second folding roller pairs that are provided with a predetermined gap therebetween and alternately fold the sheet transported from the transport roller pair; and first and second sheet detecting units that are provided outside the first and second folding roller pairs so as to face the first and second folding roller pairs, respectively. Second and subsequent folding positions of the sheet are set based on an amount of transport of the sheet that is determined on the basis of an end of the sheet or a first folding end.

[0025] According to another aspect of the present invention, there is provided an image forming system that includes the sheet folding apparatus above; and an image forming apparatus that forms an image on a sheet.

[0026] According to still another aspect of the present invention, there is provided a sheet folding method that folds a sheet in parallel a plurality of times and is performed in a sheet folding apparatus including a transport roller pair that transports the sheet, first and second fold-

ing roller pairs that are provided with a predetermined gap therebetween and alternately fold the sheet transported from the transport roller pair, and first and second sheet detecting units that are provided outside the first and second folding roller pairs so as to face the first and second folding roller pairs, respectively. The method includes setting second and subsequent folding positions of the sheet based on an amount of transport of the sheet that is determined on the basis of an end of the sheet or a first folding end; and alternately folding the sheet using the first and second folding roller pairs.

[0027] In the following embodiments, the sheet corresponds to reference numeral 11, the transport roller pair corresponds to reference numeral 3 or reference numeral 100, the first and second folding roller pairs correspond to first and second folding roller pairs 6 and 7, the first and second sheet detecting units correspond to first and second sensors 8 and 9, the third sheet detecting unit corresponds to an inlet sensor 2, the folding method designating unit corresponds to a folding method designating unit 32, the first and second sheet guide members correspond to first and second sheet guide members 4 and 5, the DC motor corresponds to reference numeral 101, the clutch corresponds to reference numeral 104, the stepping motor corresponds to reference numeral 110, and the image forming apparatus corresponds to reference numeral 50.

[0028] The above and other objects, features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

Fig. 1 is a diagram schematically illustrating the structure of a sheet folding unit according to the related art;

Fig. 2 is a block diagram illustrating the control structure of the sheet folding apparatus;

Fig. 3 is a diagram illustrating the finished state of the folding of a sheet according to the related art;

Fig. 4 is a diagram illustrating the positional relationship between components restricting the minimum length of a folding length according to the related art;

Fig. 5 is a block diagram schematically illustrating the structure for controlling a folding roller pair included in a sheet folding apparatus according to a first embodiment;

Fig. 6 is an explanatory diagram for explaining transport control when the end and folding end of a folding surface of the sheet are not detected;

Fig. 2C is an explanatory diagram for explaining the patch image used for determining the parameters of an approximation formula;

Fig. 7 is a diagram illustrating a sheet folding operation according to the first embodiment;
 Fig. 8 is a diagram illustrating another sheet folding operation according to the first embodiment;
 Fig. 9 is a diagram illustrating a sheet folding operation according to a second embodiment;
 Fig. 10 is a diagram illustrating the finished state of the folding of a sheet according to a third embodiment;
 Fig. 11 is a block diagram illustrating a control structure according to a fourth embodiment;
 Fig. 12 is a diagram illustrating a sheet folding operation according to a fifth embodiment;
 Figs. 13A to 13C are diagrams illustrating a sheet folding operation according to an eighth embodiment;
 Figs. 14A to 14C are diagrams illustrating a sheet folding operation according to an eleventh embodiment;
 Figs. 15A and 15B are diagrams illustrating the structure of a sheet folding apparatus according to a twelfth embodiment; and
 Fig. 16 is a perspective view schematically illustrating the structure of an image forming system according to a thirteenth embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0030] The invention has been made with the intention to be able to fold a sheet a plurality of times by making the minimum length of a folding surface smaller without being affected by a mechanical element. Next, exemplary embodiments of the invention will be described with reference to the accompanying drawings.

[0031] In the embodiments, a sheet folding apparatus 1 has the same structure as that according to the related art shown in Fig. 1 and includes a transport roller pair 3, first and second folding roller pairs 6 and 7 that are provided on the lower left and right sides of the transport roller pair 3 so as to face each other, first and second sheet guide members 4 and 5 that selectively guide a sheet 11 transported from the transport roller pair 3 to each folding roller pair, and a sheet lower surface guide 10 that guides the lower surface of the sheet. The first sheet guide member 4 and the second sheet guide member 5 need not to be provided in some of the following embodiments. However, the folding apparatus provided with the members 4 and 5 is shown in Fig. 1 as a substantial structure.

[0032] The sheet 11 is transported by the transport roller pair 3 and is selectively guided to the first folding roller pair 6 or the second folding roller pair 7 by the operation of the first sheet guide member 4 or the second sheet guide member 5. When the first folding roller pair 6 and the second folding roller pair 7 are repeatedly rotated forward and backward, the sheet 11 is transported between folding rollers of the first folding roller pair 6 or

between folding rollers of the second folding roller pair 7 by the operation of the first sheet guide member 4 or the second sheet guide member 5 while sliding on the upper surface of the sheet lower surface guide 10, and is then subjected to folding process a given number of times. The details of the folding process are as described above.

[0033] The structure and operation of the folding apparatus are the same as those in the related art described with reference to Figs. 1 to 4 except for the control of a folding method.

[0034] Fig. 5 is a block diagram schematically illustrating the structure for controlling the folding roller pair 6 included in the sheet folding apparatus 1 according to the first embodiment. In Fig. 5, the control structure of the sheet folding apparatus includes a transport amount calculating unit 33 serving as a main unit, a folding size designating unit 31, a folding method designating unit 32, the first and second sensors 8 and 9, an electric component control unit, and the sheet folding unit 1.

[0035] The transport amount calculating unit 33 transports the sheet 11 by a distance corresponding to the length of the folding surface designated by the folding size designating unit 31 and the folding method designating unit 32 and stops the first folding roller pair 6. That is, the detection result of the end or the folding end of the sheet 11 by the first sensor 8 and the second sensor 9 of the sheet folding apparatus 1 is input as first and second sensor detection results 34 to the transport amount calculating unit 33, and the amount of transport based on the information from the folding size designating unit 31 and the folding method designating unit 32 is calculated. The calculated amount of transport is transmitted as transport distance and transport direction data 35 to the electric component control unit 36. The sheet folding apparatus 1 is controlled based on the data 35.

[0036] The transport amount calculating unit 33 includes a CPU, a ROM, and a RAM (which are not shown), similar to the control unit 30 shown in Fig. 2. The ROM stores program codes executed by the CPU 30. The CPU 30 expands the program code read from the ROM on the RAM and performs a control operation defined by the program code while using the RAM as a work area and a data buffer.

[0037] The transport amount calculating unit 33 is provided in the sheet folding apparatus 1. However, the transport amount calculating unit 33 may be provided as a controller in a control unit of an image forming apparatus 50 in an image forming system, which will be described below. The folding size designating unit 31 may be provided in an operation panel (not shown) of the image forming apparatus 50.

[0038] In the case of the image forming system, the transport control unit shown in Fig. 5 can communicate with the control unit of the image forming apparatus 50 through an interface and control the overall operation of the image forming system.

[0039] Next, exemplary embodiments will be described in detail.

First Embodiment

[0040] In a first embodiment, the transport direction and transport distance of a sheet are controlled without detecting the end and folding end of a target surface of the sheet with a first sensor 8 or a second sensor 9, or without using the detection result, and the sheet is folded while being transported by the first folding roller pair 6 and the second folding roller pair 7 at the transport timing of the sheet by the first folding roller pair 6 and the second folding roller pair 7 and the operation timing of the sheet guide members. In the first embodiment, the first sheet guide member 4 or the second sheet guide member 5 is not used in the folding operation.

[0041] Fig. 6 is an explanatory diagram for explaining transport control when the end and the folding end of a target surface of the sheet are not detected.

[0042] As shown in Fig. 6, when the sheet is folded such that the length L1 of a first folding surface is the largest and a sheet end F0 and a first folding end F1 are convex, a second folding end F2 and the subsequent folding ends are concealed behind the sheet end F0 and the first folding end F1 and cannot be detected by the first sensor 8 and the second sensor 9. Therefore, transport control on the length L3 of the third folding surface and the subsequent lengths after the second and subsequent folding operations is not performed. In this case, in the related art shown in Fig. 3, the length L3 of the third folding surface is controlled on the basis of the first folding end F1, not on the second folding end F2.

[0043] In contrast, in this embodiment, the lengths L3 and L5 of the third and fifth folding surfaces are controlled on the basis of the sheet end F0, and the lengths L2 and L4 of the second and fourth folding surfaces are controlled on the basis of the first folding end F1. In this way, it is possible to stop the transport of the sheet with the amount of transport less than that in the transport control according to the related art and reduce the length of the folding surface. In addition, since folding position is close to the previous folding end, it is possible to reduce a variation in the length of the folding surface due to a transport variation.

[0044] In addition, by performing the following operation if necessary, a folding length close to a length of the gap between the folding roller pairs 6 and 7 can be obtained.

[0045] The sheet folding apparatus is operated as shown in Fig. 4 and the transport distance of the first folding roller pair 6 and the second folding roller pair 7 is equal to the transport distance of the transport roller pair 3. When the transport distance of the first folding roller pair 6 and the second folding roller pair 7 shown in the states (a) and (b) in Fig. 4 is 40 mm, the sheet is folded at the first folding end F1 shown in the state (a) of Fig. 4 and is then stopped. Then, the sheet is transported 40 mm to the first folding roller pair 6 and is folded at the second folding end F2 shown in the state (b) of Fig. 4. In this case, as shown in the state (c) of Fig. 4, the minimum

length of the folding surface is 90 mm.

[0046] That is, the stop of the sheet, after the folding at the first folding end F1 shown in the state (a) of Fig. 4 is performed, is achieved with a way of stop position control which does not depend on the detection result of the first folding end F1 by the second sensor 9. With such a control, the sheet stops before the second sensor 9. In this way, it is possible to reduce the minimum length of the folding surface.

[0047] Fig. 7 is a diagram illustrating the above-mentioned operation. The state (a) of Fig. 7 shows a state after the end of the sheet 11 enters the first folding roller pair 6, and the sheet 11 is stopped so as to be folded at the first folding end. In this state, the sheet 11 is transported 40 mm to the second folding roller pair 7 and is folded at the first folding end F1. After the folding operation, the sheet 11 is stopped at the position where it is controlled to be folded at the second folding end F2.

[0048] The state (b) of Fig. 7 shows a stop position when the distance L2 between the first folding end F1 and the second folding end F2 is set to 85 mm. When the sheet is stopped at the position shown in the state (b) of Fig. 7, the transport direction is changed, and the sheet is transported 40 mm and is then folded at the next folding end. In this way, the amount of protrusion of the sheet from the second folding roller pair 7 to the outside is obtained by subtracting 40 mm from the designated length of the folding surface. The stop control is performed from the stop position shown in the state (a) of Fig. 4 to set the position that is 85 mm, which is the distance L2 between the first folding end F1 and the second folding end F2, apart from the stop position shown in the state (a) of Fig. 4A as the stop position shown in the state (b) of Fig. 7, without using the detection results of the sheet end F0 or the folding ends F1, ..., Fn of the sheet 11 detected by the first sensor 8 and the second sensor 9.

[0049] The state (c) of Fig. 7 shows a state in which the sheet 11 is transported 40 mm to the first folding roller pair 6 from the state (b) of Fig. 7. As can be seen from the state (c) of Fig. 7, when the sheet is transported 40 mm, the amount of protrusion of the sheet from the second folding roller pair 7 to the outside is 5 mm, and the folding length of the sheet is 85 mm, which is a set value of the distance L2 between the first folding end F1 and the second folding end F2.

[0050] In this embodiment, in the structure for controlling the folding roller shown in Fig. 5, the amount of transport by the first and second folding roller pairs 6 and 7 is input as a roller transport amount detection result 37 to the transport amount calculating unit 33, and the amount of transport based on the information from the folding size designating unit 31 and the folding method designating unit 32 is calculated. The calculated amount of transport is transmitted as the transport distance and transport direction data 35 to the electric component control unit 36. The sheet folding apparatus 1 is controlled based on the data 35.

[0051] In the actual control operation, the first folding

roller pair 6 and the second folding roller pair 7 are rotated forward, stopped, and rotated backward, whereas the transport roller pair 3 is not stopped and rotated backward, thereby continuously transporting the sheet. In this way, the transport distance of the first folding roller pair 6 and the second folding roller pair 7 is not equal to that of the transport roller pair 3, but the transport distance of the first folding roller pair 6 and the second folding roller pair 7 is less than that of the transport roller pair 3. Therefore, in the stop control of the first and second folding roller pairs 6 and 7, it is necessary to determine the stop position, taking the difference between the transport distances into consideration.

[0052] The folding operation will be described with reference to Fig. 7 and Fig. 8 in the case where the difference between the transport distance of the first folding roller pair 6 and the second folding roller pair 7 and the transport distance of the transport roller pair 3 is 25 mm (the transport distance of the transport roller pair 3 is 25 mm more than that of the first folding roller pair 6 and the second folding roller pair 7).

[0053] The state (b) of Fig. 7 shows a stopped state before the sheet is folded at the second folding end F2 and shows a stop position when the transport distance of the first folding roller pair 6 and the second folding roller pair 7 is equal to the transport distance of the transport roller pair 3. The state (c) of Fig. 7 shows a state in which the sheet is transported 40 mm to the first folding roller pair 6 from the state shown in the state (b) of Fig. 7. In this case, the amount of protrusion of the sheet from the second folding roller pair 7 to the outside is 5 mm and the length L2 of the folding surface is 85 mm. When the difference between the transport distance of the first folding roller pair 6 and the second folding roller pair 7 and the transport distance of the transport roller pair 3 is 25 mm, the stopped state of the sheet before the sheet is folded at the second folding end F2 is the same as that shown in the state (b) of Fig. 7. When the sheet is transported to the first folding roller pair 6, as shown in the state (a) of Fig. 8, the sheet is folded at the second folding end F2 that is 12.5 mm ($= 25 \text{ mm} \times 1/2$) apart from the end F0 of the sheet in terms of the transport distance of the first folding roller pair 6 and the second folding roller pair 7 since the transport distance of the transport roller pair 3 is 25 mm more than that of the first folding roller pair 6 and the second folding roller pair 7. In this case, since the amount of protrusion of the sheet from the second folding roller pair 7 to the outside is 17.5 mm, the length L2 of the folding surface is 97.5 mm. The state (b) of Fig. 8 shows a stop position to which the length of the folding surface is reflected. The state (b) of Fig. 8 shows a state in which the stop position is shifted 12.5 mm ($= 25 \text{ mm}$, which is the difference between the transport distance of the first folding roller pair 6 and the second folding roller pair 7 and the transport distance of the transport roller pair 3, $\times 1/2$) to the second folding roller pair 7. The state (c) of Fig. 8 shows a state in which the sheet is transported 27.5 mm ($= 40 \text{ mm} - 25 \text{ mm} \times 1/2$) to the

first folding roller pair 6 from the state shown in the state (b) of Fig. 8. In the state (c) of Fig. 8, the amount of protrusion of the sheet from the second folding roller pair 7 to the outside is 5 mm and the distance between the first folding end F1 and the second folding end F2 is 85 mm, which is a set value of the length L2 of the folding surface.

[0054] As described above, according to the first embodiment, the detection of the end of the sheet is not performed with the first sensor 8 or the second sensor 9. That is, it is possible to stop the transport of the sheet before the first or second sensor 8 or 9 detects the end of the sheet, by controlling the transport direction and transport distance of the sheet. As a result, it is possible to reduce the set value of the control of the transport distance and reduce the length of the folding surface.

Second Embodiment

[0055] In the first embodiment, in the structure shown in Fig. 5, the amount of transport of the first and second folding roller pairs 6 and 7 is input as the roller transport amount detection result 37 to the transport amount calculating unit 33, and the amount of transport based on the information from the folding size designating unit 31 and the folding method designating unit 32 is transmitted as the transport distance and transport direction data 35 to the electric component control unit 36 to control the sheet folding apparatus 1. In a second embodiment, the time elapsed from the detection of the end of the sheet by an inlet sensor 2 is measured, the amount of transport of the transport roller pair 3 is calculated, and the transport direction and transport distance of the sheet are controlled based on the calculated amount of transport and a designated folding direction. The difference between the second embodiment and the first embodiment will be described below. In the second embodiment, a description of the same components as those in the first embodiment will not be repeated.

[0056] In the second embodiment, the stopping of the first folding roller pair 6 and the second folding roller pair 7 is controlled by the inlet sensor 2. The basic structure of a sheet folding apparatus is the same as that of the sheet folding apparatus shown in Fig. 1.

[0057] A sheet 11 transported from a copier body to the sheet folding apparatus 1 is detected by the inlet sensor 2 and is transported by the transport roller pair 3. Then, the sheet 11 is guided to the first folding roller pair 6 or the second folding roller pair 7 by the first sheet guide member 4 or the second sheet guide member 5. The sheet is stopped at the stop position where the sheet is folded at the first folding end F1 based on the amount of transport from the inlet sensor 2, the transport direction of the first folding roller pair 6 and the second folding roller pair 7 is changed, and the sheet is folded at the first folding end F1. Then, the sheet is stopped at the stop position where the sheet is folded at the second folding end F2 based on the amount of transport from the inlet sensor 2. Then, the transport direction of the first folding

roller pair 6 and the second folding roller pair 7 is changed, and the sheet is folded at the second folding end F2. Then, the sheet is stopped at the stop position where the sheet is folded at the third folding end F3 based on the amount of transport from the inlet sensor 2. This operation is repeatedly performed to fold the sheet such that the folding surface has a designated length.

[0058] Fig. 9 is a diagram illustrating a folding operation according to the second embodiment. In Fig. 9, the following case will be described in which a target folding length is 85 mm, the distance from the inlet sensor 2 to a nip portion of the first folding roller pair 6 or the second folding roller pair 7 is 130 mm, the amount of transport from the stopped state of the first folding roller pair 6 or the second folding roller pair 7 to a folding position is equal to the transport distance of the first folding roller pair 6 and the second folding roller pair 7 and the transport distance of the transport roller pair 3, and folding is performed at a transport distance of 40 mm.

[0059] The state (a) in Fig. 9 shows a stopped state before the sheet is folded at the first folding end F1. The target value of the length L1 of the first folding surface is 85 mm, the amount of protrusion of the sheet from the second folding roller pair 7 to the outside is 45 mm, and the distance from the inlet sensor 2 to a nip portion of the first folding roller pair 6 or the second folding roller pair 7 is 130 mm. Therefore, stop control is performed at a transport distance of 175 mm (= 130 mm + 45 mm) from the inlet sensor 2.

[0060] The state (b) of Fig. 9 shows a stopped state before the sheet is folded at the second folding end F2. The target value of the length L2 of the second folding surface is 85 mm, the amount of protrusion of the sheet from the second folding roller pair to the outside is 45 mm, and the transport distance from the state (a) of Fig. 9 is 85 mm obtained by adding a transport distance of 40 mm to the folding position to the amount of protrusion of 45 mm from the roller pair to the outside. Therefore, the transport distance from the inlet sensor 2 is 260 mm (= 175 mm + 85 mm), which is the sum of the amount of transport shown in the state (a) of Fig. 9 and the transport distance from the state (a) of Fig. 9 to the state (b) of Fig. 9. Stop control is performed at the transport distance.

[0061] As described above, according to the second embodiment, the transport direction and transport distance of the sheet are controlled based on the transport distance of the transport roller pair 3. Therefore, it is possible to reduce the length of the folding surface to be less than the length L1 of the first folding surface. In addition, since the transport distance is calculated based on the transport roller 3 and the transport distance is calculated based on the amount of transport of the first and second folding roller pairs 6 and 7, it is possible to prevent, for example, the influence of the slip of the sheet and accurately fold the sheet.

Third Embodiment

[0062] A third embodiment is an example in which control based on the detection of the end of the sheet by the first sensor 8 or the second sensor 9 is not performed, but the transport direction and transport distance of the sheet are controlled only for a specific portion in the designated sheet folding method. The third embodiment is the same as the first or second embodiment except for a characteristic control operation and thus a description of the same components as those in the first or second embodiment will be repeated.

[0063] In the third embodiment, when the component layout and operation conditions of the sheet folding apparatus 1 are the same as those of the sheet folding apparatus according to the first and second embodiments, the minimum value of the length of the folding surface is 90 mm in the sheet folding apparatus 1 according to the related art. When the folding of the sheet is finished as shown in Fig. 10, the lengths L2 and L3 of the second and third folding surfaces are 88 mm which is not compatible with the related art since the minimum length Hmin of the folding surface is 90 mm as shown in the state (c) of Fig. 4 in the related art. The lengths L4 and L5 of the fourth and fifth folding surfaces are 104 mm which is not compatible with those in the related art. Therefore, it is possible to implement the first or second embodiment without using a sensor.

[0064] Therefore, in the third embodiment, a folding process that requires the detection of the end of the sheet or the folding end of the sheet 11 by the first sensor 8 and the second sensor 9 is performed only on a portion in which the lengths L2 and L3 of the second and third folding surfaces are 88 mm. The folding process according to the related art which is based on the detection of the end of the sheet or the folding end of the sheet 11 by the first sensor 8 and the second sensor 9 is performed on a portion in which the lengths L4 and L5 of the fourth and fifth folding surfaces are 104 mm. In Fig. 10, FF indicates the last end of the sheet.

[0065] As such, according to the third embodiment, a control process of setting the length of the folding surface using the first and second sensors 8 and 9 is not applied to a portion with a length less than the minimum length of the folding surface, but a process of detecting the end of the sheet using the first or second sensor 8 or 9 and controlling the transport direction and transport distance of the sheet on the basis of the detection result is performed on the other portions. Therefore, it is possible to reduce the length of the folding surface with high accuracy.

Fourth Embodiment

[0066] A fourth embodiment is an example in which a process of controlling the transport direction and transport distance of the sheet regardless of the detection of the end of the sheet is performed only on a portion cor-

responding to control conditions regardless of the detection of the sensor in the designated sheet folding method. The fourth embodiment is the same as the first to third embodiments except for a characteristic control operation and a description of the same components as those in the first to third embodiments will not be repeated.

[0067] In this embodiment, the determination result of a folding roller stop determining unit 38 is transmitted to the transport amount calculating unit 33 shown in Fig. 5 in the first embodiment. Fig. 11 is a block diagram illustrating a control structure according to this embodiment. As can be seen from Fig. 11, the control structure according to this embodiment is the same as that of the first embodiment except that the folding roller stop determining unit 38 is provided between the folding size designating unit 31 and the folding method designating unit 32, and the transport amount calculating unit 33 in the control structure shown in Fig. 5.

[0068] According to this structure, the data from the folding size designating unit 31 and the folding method designating unit 32, which is data in the finished state of the folding of the sheet, is transmitted to the folding roller stop determining unit 38. The folding roller stop determining unit 38 determines, by referring to the data, whether to perform a control process based on the detection of the end of the sheet or the folding end of the sheet 11 by the first sensor 8 and the second sensor 9 and transmits the determination result to the transport amount calculating unit 33. The subsequent control process is the same as that in the first embodiment shown in Fig. 5.

[0069] As described above, according to the fourth embodiment, for example, even when the designated sheet folding method is changed by a user adjustment function, the folding roller stop determining unit performs a process of controlling the transport direction and transport distance of the sheet regardless of the detection of the end of the sheet only on a portion corresponding to control conditions regardless of the detection of the sensor. Therefore, it is possible to reduce the length of the folding surface with high accuracy, without being affected by the adjustment value of the user adjustment function.

Fifth Embodiment

[0070] A fifth embodiment is an example in which, when a sheet is transported after the transport direction of the sheet is changed, a transport roller pair is stopped and the sheet is transported only by a folding roller pair. The fifth embodiment has the same structure as the first embodiment except for a characteristic control operation and thus a description of the same components as those in the first embodiment will not be repeated.

[0071] That is, in the fifth embodiment, the component layout of a sheet folding apparatus is the same as that of the sheet folding apparatus according to the first to fourth embodiments except that, when a sheet is transported after a transport direction of the first folding roller pair 6 and the second folding roller pair 7 is changed, the

transport roller pair 3 is stopped and the sheet 11 is transported only by the first folding roller pair 6 and the second folding roller pair 7.

[0072] The operation of the sheet folding apparatus up to folding will be described with reference to Fig. 12 while being compared with that shown in Fig. 7. Fig. 7 shows the sheet folding apparatus according to the first embodiment and is a diagram illustrating the operation of the sheet folding apparatus when the transport distance of the first folding roller pair 6 and the second folding roller pair 7 is equal to the transport distance of the transport roller pair 3.

[0073] The state of Fig. 7 shows the stop position before the sheet is folded at the second folding end F2. In the state (b) Fig. 7, after the sheet is folded at the first folding end F1, the sheet is transported 45 mm. The state (c) of Fig. 7 shows a state in which the first folding roller pair 6, the second folding roller pair 7, and the transport roller pair 3 transport the sheet toward the folding roller pair 6 by 40 mm from the state shown in the state (b) of Fig. 7 to the folding position of the second folding end F2. In the state (c) of Fig. 7, the total necessary amount of transport to the first folding roller pair 6 is 80 mm.

[0074] In contrast, Fig. 12 is a diagram illustrating the operation of this embodiment. The state (a) of Fig. 12 shows a stopped state before the sheet is folded at the second folding end F2, similar to the state (b) of Fig. 7. The fifth embodiment differs from the first embodiment in that the transport roller pair 3 is stopped at the same time as that the transport operation of the first folding roller pair 6 and the second folding roller pair 7 is stopped. In the fifth embodiment, the first folding roller pair 6 and the second folding roller pair 7 are driven to transport the sheet toward the first folding roller pair 6 from the state (a) of Fig. 12 to the state (b) of Fig. 12, with the transport roller pair 3 being stopped. Then, the transport operation of the transport roller pair 3 is resumed.

[0075] The necessary amount of transport is the same as the case where the sheet is transported from the state (b) of Fig. 7 to the state (c) of Fig. 7. The first folding roller pair 6 and the second folding roller pair 7 transport the sheet by 80 mm to the first folding roller pair 6. Therefore, a necessary transport distance is 80 mm, which is the amount of transport of the first folding roller pair 6 and the second folding roller pair 7.

[0076] In the first embodiment shown in Fig. 7, since the amount of transport of the first folding roller pair 6 and the second folding roller pair 7 is 40 mm, the sheet is transported 40 mm and is then folded at the second folding end F2, similar to the first folding end F1. Therefore, the length of the folding surface is 85 mm. In contrast, in Fig. 12, the sheet is transported 80 mm, which is a necessary amount of transport, only by the first folding roller pair 6 and the second folding roller pair 7. Therefore, the first folding end F1 is transported 80 mm and then the sheet is folded at the second folding end F2. As a result, the length of the folding surface is 45 mm.

[0077] As described above, according to the fifth em-

bodiment, since the folding roller pairs 6 and 7 are stopped, it is possible to reduce the amount of transport until folding and reduce the length of the folding surface.

Sixth Embodiment

[0078] A sixth embodiment is an example in which the driving of a transport roller pair 3 is resumed before a folding portion of a sheet enters a first or second folding roller pairs 6 and 7 in the fifth embodiment. That is, in the fifth embodiment, the transport operation of the transport roller pair 3 is stopped until the sheet enters the state (b) of Fig. 12. However, in the sixth embodiment, before the sheet is folded at the second folding end F2, the transport operation of the transport roller pair 3 is resumed. When the sheet is folded at the second folding end F2, the transport roller pair 3, the first folding roller pair 6, and the second folding roller pair 7 transport the sheet. The sixth embodiment is the same as the fifth embodiment except for a characteristic control operation and a description of the same components as those in the fifth embodiment will not be repeated.

[0079] According to this embodiment, since the driving of a transport roller pair 3 is resumed before a folding portion of the sheet enters folding roller pairs 6 and 7, it is possible to reduce the length of a folding surface. In addition, when a folding portion of the sheet enters the folding roller pairs 6 and 7, the transport roller pair 3 is being driven. Therefore, it is possible to prevent positional deviation when the folding portion of the sheet enters the folding roller pair. As a result, it is possible to reduce the length of the folding surface with high accuracy while preventing the occurrence of wrinkles.

Seventh Embodiment

[0080] A seventh embodiment is an example in which, before a folding portion of a sheet enters a first or second folding roller pair 6 or 7, the start-up of a transport roller pair 3 ends, the transport roller pair 3 is driven at a constant speed, which is the same speed as the first and second folding roller pairs 6 and 7 in the sixth embodiment. The seventh embodiment is the same as the sixth embodiment except for a characteristic control operation and a description of the same components as those in the sixth embodiment will not be repeated.

[0081] That is, in the sixth embodiment, before the sheet becomes the state (b) of Fig. 12 (the folding of the sheet at the second folding end F2 is completed), the transport operation of the transport roller pair 3 is resumed. When the sheet is folded at the second folding end F2, the transport roller pair 3 and the first and second folding roller pairs 6 and 7 transport the sheet. In contrast, in the seventh embodiment, before the sheet is folded at the second folding end F2, the start-up of the transport roller pair 3 ends and the transport roller pair 3 is driven at a constant speed. When the sheet is folded at the second folding end F2, the transport roller pair 3 and the

first and second folding roller pairs 6 and 7 are the same in sheet transport speed.

[0082] According to this embodiment, when the sheet is folded at the second folding end F2, the transport roller pair 3 and the first and second folding roller pairs 6 and 7 are the same in sheet transport speed. Therefore, the folding of the sheet is not affected by a variation in the speed of the transport roller pair 3 and the difference between the speed of the transport roller pair 3 and the speeds of the folding roller pairs 6 and 7. As a result, it is possible to reduce the length of the folding surface with high accuracy.

Eighth Embodiment

[0083] An eighth embodiment is an example in which the first and second folding roller pairs 6 and 7 are stopped before a folding portion of a sheet enters the first or second folding roller pair 6 or 7 so that the sheet enters the first or second folding roller pair 6 or 7 after the posture of the sheet is stabilized in the fifth, sixth, and seventh embodiments. The eighth embodiment is the same as the fifth, sixth, and seventh embodiments except for a characteristic control operation and a description of the same components as those in the fifth, sixth, and seventh embodiments will not be repeated.

[0084] Figs. 13A to 13C are diagrams illustrating a sheet folding operation according to the eighth embodiment. The basic operation of the eighth embodiment is the same as that of the fifth embodiment. That is, Fig. 13A shows a stopped state before the sheet is folded at the second folding end F2, similar to the state (a) of Fig. 12. In this state, the transport roller pair 3 is stopped at the same time as the transport operation of the first folding roller pair 6 and the second folding roller pair 7 is stopped. In this state, the sheet is folded at the second folding end F2 by the transport operation of the first folding roller pair 6 and the second folding roller pair 7 toward the folding roller pair 6, with the transport roller pair 3 being stopped. This state is shown in Fig. 13C and is the same as that shown in the state (b) of Fig. 12. During a transport operation from the state shown in Fig. 13A to the state shown in Fig. 13C, the transport operation of the first folding roller pair 6 and the second folding roller pair 7 is stopped once. Fig. 13B shows this state. In this embodiment, as shown in Fig. 13B, the transport operation of the first folding roller pair 6 and the second folding roller pair 7 is stopped once to stabilize the behavior of a portion of the sheet that is folded at the second folding end F2. Then, the transport operation of the first folding roller pair 6 and the second folding roller pair 7 is resumed to transport the sheet again.

[0085] Of course, the stopping of the transport operation before the folding of the sheet at the second folding end F2, is performed before the sheet is folded at the second folding end F2. In this embodiment, as shown in Fig. 13B, the sheet is stopped at a position that is 60 mm away from the position shown in Fig. 13A (the position

where the amount of protrusion of the first folding end F1 is the maximum).

[0086] According to this embodiment, the first and second folding roller pairs 6 and 7 are stopped once. Therefore, when the transport direction of the sheet is changed, it is possible to prevent the second folding end F2 from entering a nip portion between the first folding rollers 6 during the period for which the speed is unstable and thus to stabilize, for example, the kind of sheet, an environment, and a sheet transport speed. As a result, during the folding of the sheet, the posture of a folding portion of the sheet is stabilized when the folding portion enters the folding roller pair, and it is possible to reduce the length of the folding surface with high accuracy.

Ninth Embodiment

[0087] A ninth embodiment is an example in which the transport roller pair 3 is driven in synchronization with the re-driving of the first and second folding roller pairs 6 and 7, and the transport roller pair 3 and the folding roller pairs 6 and 7 are driven at the same speed in the eighth embodiment. The ninth embodiment is the same as the eighth embodiment except for a characteristic control operation and a description of the same components as those in the eighth embodiment will not be repeated.

[0088] In this embodiment, when the first folding roller pair 6 and the second folding roller pair 7 that are in a stopped state immediately before the sheet is folded at the second folding end as shown in Fig. 13B in the eighth embodiment are driven again to transmit the sheet again, the transport roller pair 3 is driven in synchronization with the re-driving of the first folding roller pair 6 and the second folding roller pair 7. In this way, when the sheet is transported again, the first and second folding roller pairs 6 and 7 and the transport roller pair 3 are synchronously driven at the same speed.

[0089] Since the first folding roller pair 6, the second folding roller pair 7, and the transport roller pair 3 are synchronously driven again, the transport roller pair 3, the first folding roller pair 6, and the second folding roller pair 7 are the same in sheet transport speed when the sheet is folded at the second folding end shown in Fig. 13C.

[0090] According to this embodiment, since the driving of the first and second folding roller pairs 6 and 7 and the transport roller pair 3 starts at the same time, the amount of transport of the transport roller pair 3 is equal to that of the folding roller pair, and it is possible to make a folding portion of the sheet enter the folding roller pair, while maintaining the posture of the sheet to be stable when the first and second folding roller pairs 6 and 7 and the transport roller pair 3 are stopped. As a result, it is possible to reduce the length of a folding surface with high accuracy.

Tenth Embodiment

[0091] A tenth embodiment is an example in which the stop position of the folding roller pair before a folding portion of the sheet enters the first or second folding roller pair 6 or 7, is set to a position that is away from the nip position of the folding roller pair by a sufficient acceleration distance to make the rotational speed of the folding roller pair reach a target speed before the folding portion of the sheet enters the folding roller pair in the ninth embodiment. The tenth embodiment is the same as the ninth embodiment except for a characteristic control operation and a description of the same components as those in the ninth embodiment will not be repeated.

[0092] In this embodiment, for the ninth embodiment, the stop position before the folding of the sheet at the second folding end shown in Fig. 13B is set on the upstream side in the transport direction from the folding position of the second folding end F2 shown in Fig. 13C by a distance required for acceleration during the start-up of a folding roller driving unit (not shown). In this way, when the sheet is folded at the second folding end F2, the start-up of the transport roller pair 3 and the first and second folding roller pairs 6 and 7 ends and the sheet is transported at a constant speed.

[0093] According to this embodiment, when a folding portion of the sheet enters the folding roller pair, the rotational speed of the folding roller pair reaches a target value. Therefore, it is possible to prevent a variation in the rotational speed of the folding roller due to a variation in load when the folding portion, the folding end, and the end of the sheet enter the folding roller pair. As a result, the sheet is accurately transported by the folding roller pairs 6 and 7 and it is possible to reduce the length of a folding surface with high accuracy.

Eleventh Embodiment

[0094] An eleventh embodiment is an example in which, when the folding roller pair is stopped before a folding portion of the sheet enters the folding roller pair, the inside of the folding portion of the sheet is guided by a sheet guide member and the folding portion of the sheet is guided to the folding roller pair, with the posture of the sheet being stable, in the tenth embodiment. The eleventh embodiment is the same as the tenth embodiment and the related art shown in Fig. 1 except for a characteristic control operation and a description of the same components as those in the tenth embodiment and the related art will not be repeated.

[0095] Figs. 14A to 14C are diagrams illustrating a sheet folding operation according to this embodiment. The operation shown in Figs. 14A to 14C is the same as that according to the tenth embodiment shown in Figs. 13A to 13C except that the first and second sheet guide members 4 and 5 are provided, come into contact with the inside of the sheet, and guide the sheet, thereby folding the sheet. That is, this embodiment is different from

the tenth embodiment in that, in the stopped state immediately before the folding of the sheet at the second folding end F2 shown in Fig. 13B, the first sheet guide member 4 guides a portion of the sheet 11 that is folded at the second folding end F2 from the inside of the sheet 11.

[0096] The guide timing of a portion of the sheet 11 that is folded at the second folding end F2 by the first sheet guide member 4 is set such that the first sheet guide member 4 reaches the lower end point from the stopped state immediately before the folding of the sheet at the second folding end F2 shown in Fig. 13B to the re-driving of the transport roller pair 3 and the first and second folding roller pairs 6 and 7.

[0097] According to this embodiment, the sheet 11 is guided to the folding roller pairs 6 and 7 by the sheet guide members 4 and 5. Therefore, it is possible to stabilize the posture of the sheet and improve the entrance property of a folding portion of the sheet to the folding roller pair. As a result, it is possible to accurately guide the folding portion of the sheet to the folding roller pair and reduce the length of a folding surface with high accuracy.

Twelfth Embodiment

[0098] A twelfth embodiment is an example in which the first and second folding rollers 6 and 7 and the transport roller 3 are driven by a DC motor and a clutch is turned on or off to drive or stop the rollers in the ninth embodiment.

[0099] Figs. 15A and 15B are diagrams illustrating the structure of a sheet folding apparatus 1 according to the twelfth embodiment 2. Fig. 15A shows a driving unit of the transport roller pair 3 and Fig. 15B shows another example of the driving unit of the transport roller pair.

[0100] In the twelfth embodiment, the structure of each component and the basic operation are the same as those of the ninth embodiment in which the transport roller pair 3 is driven in synchronization with the re-driving of the first and second folding roller pairs 6 and 7 and the transport roller pair 3 and the folding roller pairs 6 and 7 are operated at a constant speed except that the driving unit of each roller has the structure shown in Fig. 15A.

[0101] The driving unit shown in Fig. 15A drives the transport roller pair 3 (which is shown as a general transport roller 100 in Fig. 15) to rotate the transport roller forward and backward and stop the transport roller. The driving unit includes the transport roller 100, a DC motor 101, a clutch 102, a forward/reverse rotation switching mechanism 103, an encoder 104, a brake 105, and a driving belt 106.

[0102] The power of the DC motor 101 is transmitted to the clutch 102, the forward/reverse rotation switching mechanism 103, and the transport roller 100 through the driving belt 106. The clutch 102 selects whether to transmit the power of the DC motor 101 and drives or stops the transport roller 100. The forward/reverse rotation switching mechanism 103 has a function of changing the

rotation direction of the transport roller 100. The encoder 104 measures the amount of transport of the sheet by the transport roller 100 and prevents overrun when the rotation of the transport roller 100 is stopped by the brake 105.

[0103] When the first and second folding roller pairs 6 and 7 are driven, the first and second folding roller pairs 6 and 7 are driven at the same time by the driving force of the DC motor 101. For example, when the driving belt 106 at the last stage is provided in parallel and is wound around the driven pulleys of the first and second folding roller pairs 6 and 7, the first and second folding roller pairs 6 and 7 are controlled to be synchronously driven.

[0104] Therefore, when the transport roller pair 3 and the first and second folding roller pairs 6 and 7 are driven, the transport amount calculating unit (control unit) 33 controls the driving of each DC motor 101 to synchronize the three rollers, or divides the rollers into two driving systems, such as one driving system including the transport roller pair 3 and the other driving system including the first and second folding roller pairs 6 and 7, and independently controls the driving of the two driving systems.

[0105] When a stepping motor 110 is used as the DC motor 101, as shown in Fig. 15B, control elements, such as the encoder 104 and the brake 105, and a driving element, such as the forward/reverse rotation switching mechanism 103, may be replaced with a speed reducer 111. Therefore, it is possible to simplify a structure and a control process.

[0106] That is, in the example shown in Fig. 15B, the power of the DC motor 101 is transmitted to the speed reducer 111 and the transport roller 100 through the driving belt 106 to drive the transport roller 100. In this case, the transport roller 100 may be replaced with the transport roller pair 3 or the first and second folding roller pairs 6 and 7. The speed reducer 111 is a mechanism that converts the power of the stepping motor 110 into power required for the transport roller 100 and is set to a speed reduction ratio which is determined by the characteristics of the stepping motor 110 and necessary characteristics of the transport roller 100.

[0107] As such, when the stepping motor 110 is used as the DC motor, it is possible to control the amount of transport of the sheet using the characteristics of the stepping motor 110, without using, for example, the encoder 104 and the brake 105.

[0108] According to this embodiment, it is possible to accurately perform the driving and stopping of the first and second folding rollers 6 and 7 and the transport roller pair 3. Therefore, it is possible to improve the transport accuracy of the sheet and reduce the length of a folding surface with high accuracy.

[0109] When the stepping motor 110 capable of performing position control is used, it is possible to improve positional accuracy and finely adjust the driving and stopping of the rollers.

Thirteenth Embodiment

[0110] The sheet folding apparatus according to the first to twelfth embodiments is combined with, for example, an image forming apparatus to form an image forming system.

[0111] Fig. 16 is a perspective view illustrating the outline of the structure of the image forming system. In the image forming system, the sheet folding apparatus 1 is provided on the rear side of the image forming apparatus 50, as viewed from the operation side of the user. The sheet folding apparatus 1 is provided as a folding means of a bellows folding unit 53 for folding the sheet in a bellows shape, which will be described below.

[0112] In Fig. 16, a rolled sheet 11 is set in the image forming apparatus 50 and is transported when copying starts, and an image is formed on the sheet 11 by an image forming unit 51 which is not shown in detail (portion "1" shown as a number in a circle in Fig. 16, which is the same as that in the following description). The sheet 11 having the image formed thereon is guided from an outlet of the image forming apparatus 50 to an inlet of the sheet folding apparatus 1 and the corner of the sheet is folded by a corner folding unit 52 (portion "2"). Then, the bellows folding unit 53 folds the sheet in a direction perpendicular to the transport direction of the sheet (portion "3"). The sheet folding apparatus according to each of the first to twelfth embodiments corresponds to the bellows folding unit 53.

[0113] The transport direction of the sheet 11 folded in a bellows shape is changed by a transport direction switching unit 54 that changes the transport direction of the sheet (portion "4"). At the same time, punch holes for a file are formed in the sheet 11 by a punch 55 (portion "5"). Then, the sheet is transported to a cross folding unit 56 and is then folded in a direction perpendicular to the transport direction of the sheet (portion "6"). The sheet 11 is reversed by a reversing portion 57 (portion "7") and the leading end and the rear end of the sheet 11 are reversed by a rotating unit 58 (portion "8"). Information indicating, for example, a copy date, a shipment date, and a company name, is printed on the sheet by a stamp unit 59 (portion "9"), and the folded sheet 11 is discharged to a stack unit 60 in a correct (intended) order and direction (portion "10").

[0114] The corner folding of the sheet by the corner folding unit 52, the formation of the punch holes by the punch 55, and the stamping by the stamp unit 59 can be selected by, for example, an operation unit of the copier. The absence or presence of an operation is selected, if necessary. In addition, the absence or presence of the operation of the reversing portion 57 and the rotating portion 58 is automatically determined by information, such as the size, direction, and folding direction of the sheet such that the folded sheet can be correctly stacked on the stack unit 60 in a designated order and direction.

[0115] According to this embodiment, it is possible to fold a sheet immediately after an image is formed, using

a series of operations. For example, a copied document can be directly folded, a printed sheet can be directly folded, and a facsimile sheet can be folded. Therefore, it is possible to reduce the length of a folding surface with high accuracy.

[0116] According to the above-mentioned embodiments of the invention, the second and subsequent folding positions of the sheet are set based on the amount of transport of the sheet that is determined on the basis of the end or first folding end of the sheet. Therefore, even when the end and folding end of the sheet cannot be detected by the first and second sheet detecting units, it is possible to fold the sheet while reducing the minimum length of a folding surface, regardless of mechanical positional relationships, such as the diameter of a folding roller, the distance between the folding roller pairs, and the position of a sensor, and a size.

[0117] It is appreciated that various features of the invention that are, for clarity, described in the contexts of separate embodiments may also be provided in combination in a single embodiment. Conversely, various features of the invention that are, for brevity, described in the context of a single embodiment may also be provided separately or in any suitable sub-combination.

[0118] Although the invention has been described with respect to specific embodiments for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

Claims

1. A sheet folding apparatus (1) that folds a sheet in parallel a plurality of times, comprising:

a transport roller pair (3) that transports the sheet;

first and second folding roller pairs (6, 7) that are provided with a predetermined gap therebetween and alternately fold the sheet transported from the transport roller pair (3); and

first and second sheet detecting units (8, 9) that are provided outside the first and second folding roller pairs (6, 7) so as to face the first and second folding roller pairs (6, 7), respectively, wherein second and subsequent folding positions of the sheet are set based on an amount of transport of the sheet that is determined on the basis of an end of the sheet (F0) or a first folding end (F1).

2. The sheet folding apparatus (1) according to claim 1, further comprising:

a third sheet detecting unit (2) that detects an

- end of the sheet carried into the apparatus (1);
and
a measuring unit that measures a transport time
on the basis of the detection timing of the end
of the sheet by the third sheet detecting unit (2),
wherein the transport direction and transport
distance of the sheet is determined based on an
amount of transport of the sheet calculated from
the transport time measured by the measuring
unit and a folding method which is designated.
3. The sheet folding apparatus (1) according to claim 2,
wherein the determination of the transport direction
and transport distance of the sheet is performed on
a specific portion in the designated folding method.
4. The sheet folding apparatus (1) according to claim 3,
wherein the determination is performed when the
specific portion corresponds to the second or sub-
sequent folding position that cannot be detected due
to the first folding end (F0).
5. The sheet folding apparatus (1) according to any one
of claims 2 to 4, further comprising:

a folding method designating unit (32) that des-
ignates the folding method.
6. The sheet folding apparatus (1) according to any one
of claims 1 to 5,
wherein, when the sheet is transported after the
transport direction of the sheet is changed, the trans-
port roller pair (3) is stopped and the sheet is trans-
ported only by the first and second folding roller pairs
(6, 7).
7. The sheet folding apparatus (1) according to claim 6,
wherein the transport roller pair (3) starts to be driven
again before a folding portion of the sheet enters one
of the first and second folding roller pairs (6, 7).
8. The sheet folding apparatus (1) according to claim 7,
wherein, before the folding portion of the sheet en-
ters one of the first and second folding roller pairs
(6, 7), start-up of the transport roller pair (3) ends
and the transport roller pair (3) is driven at a constant
speed, which is the same speed as the first and sec-
ond folding roller pairs (6, 7).
9. The sheet folding apparatus (1) according to any one
of claims 6 to 8,
wherein the first and second folding roller pairs (6,
7) are stopped before the folding portion of the sheet
enters one of the first and second folding roller pairs
(6, 7) so that the sheet enters the folding roller pair
(6, 7) after a posture of the sheet is stabilized.
10. The sheet folding apparatus (1) according to claim 9,

wherein the transport roller pair (3) is driven in syn-
chronization with re-driving of the first and second
folding roller pairs (6, 7),
when the sheet enters one of the first and second
folding roller pairs, the transport roller pair (3) and
the first and second folding roller pairs (6, 7) are driv-
en at the same speed.
11. The sheet folding apparatus (1) according to claim
10,
wherein the stop position of one of the first and sec-
ond folding roller pairs (6, 7) before the folding portion
of the sheet enters the folding roller pair (6, 7) is away
from a nip portion of the folding roller pair (6, 7) by
a sufficient acceleration distance to make rotational
speed of the folding roller pair (6, 7) reach a target
speed before the folding portion of the sheet enters
the folding roller pair (6, 7).
12. The sheet folding apparatus (1) according to claim
11, further comprising:

first and second sheet guide members (4, 5) that
guide the sheet to one of the first and second
folding roller pairs (6, 7) from the inside of the
folding portion of the sheet,
wherein, when one of the first and second folding
roller pairs (6, 7) is stopped before the folding
portion of the sheet enters the folding roller pair
(6, 7), the sheet guide member (4, 5) that is pro-
vided so as to correspond to the folding roller
pair (6, 7) guides the folding portion of the sheet
to the folding roller pair (6, 7), with the posture
of the sheet being stable.
13. The sheet folding apparatus (1) according to claim
10,
wherein the first and second folding rollers (6, 7) and
the transport roller (3) are driven by a DC motor
(101), and a clutch (102) is turned on or off to drive
or stop the first and second folding rollers (6, 7) and
the transport roller(3).
14. An image forming system comprising:

the sheet folding apparatus (1) according to any
one of claims 1 to 13; and
an image forming apparatus (50) that forms an
image on a sheet.
15. A sheet folding method that folds a sheet in parallel
a plurality of times and is performed in a sheet folding
apparatus (1) including a transport roller pair (3) that
transports the sheet, first and second folding roller
pairs (6, 7) that are provided with a predetermined
gap therebetween and alternately fold the sheet
transported from the transport roller pair (3), and first
and second sheet detecting units (8, 9) that are pro-

vided outside the first and second folding roller pairs (6, 7) so as to face the first and second folding roller pairs (6, 7), respectively, the method comprising:

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setting second and subsequent folding positions of the sheet based on an amount of transport of the sheet that is determined on the basis of an end of the sheet (F0) or a first folding end (F1); and

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alternately folding the sheet using the first and second folding roller pairs (6, 7).

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FIG.1

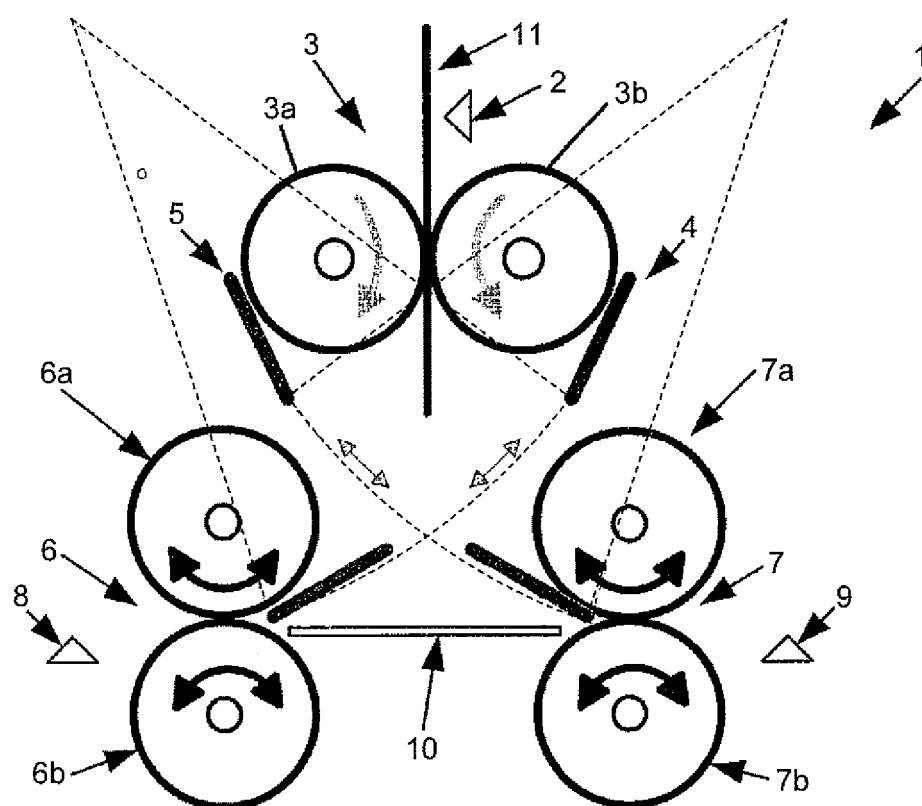


FIG.2

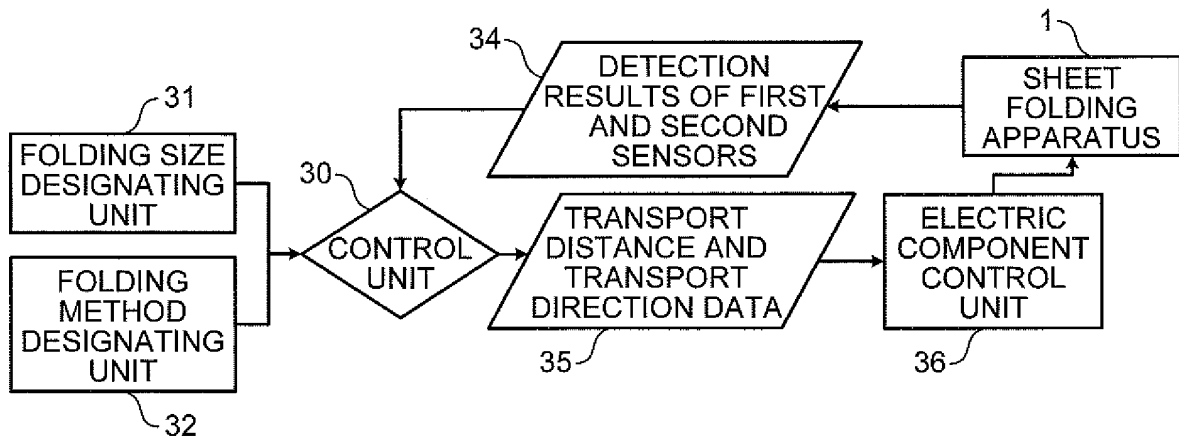
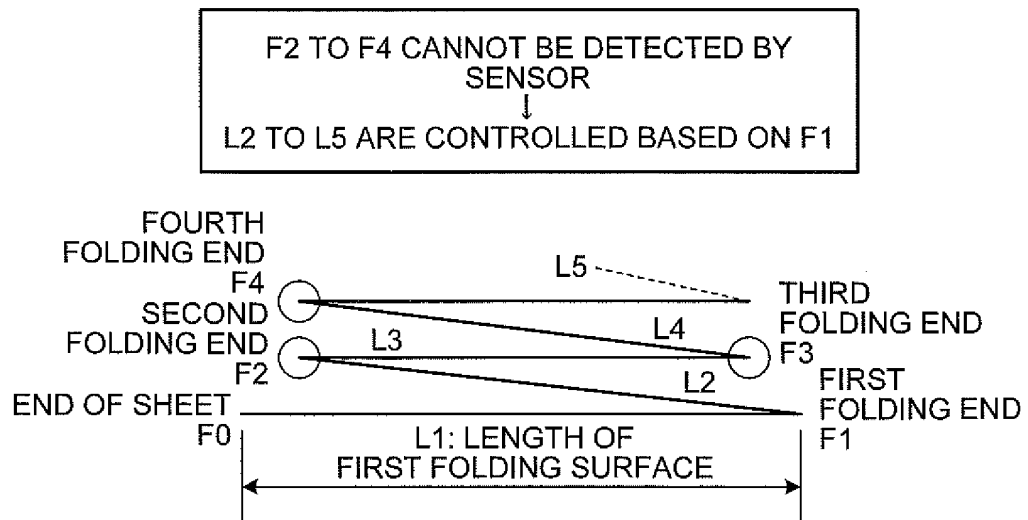


FIG.3



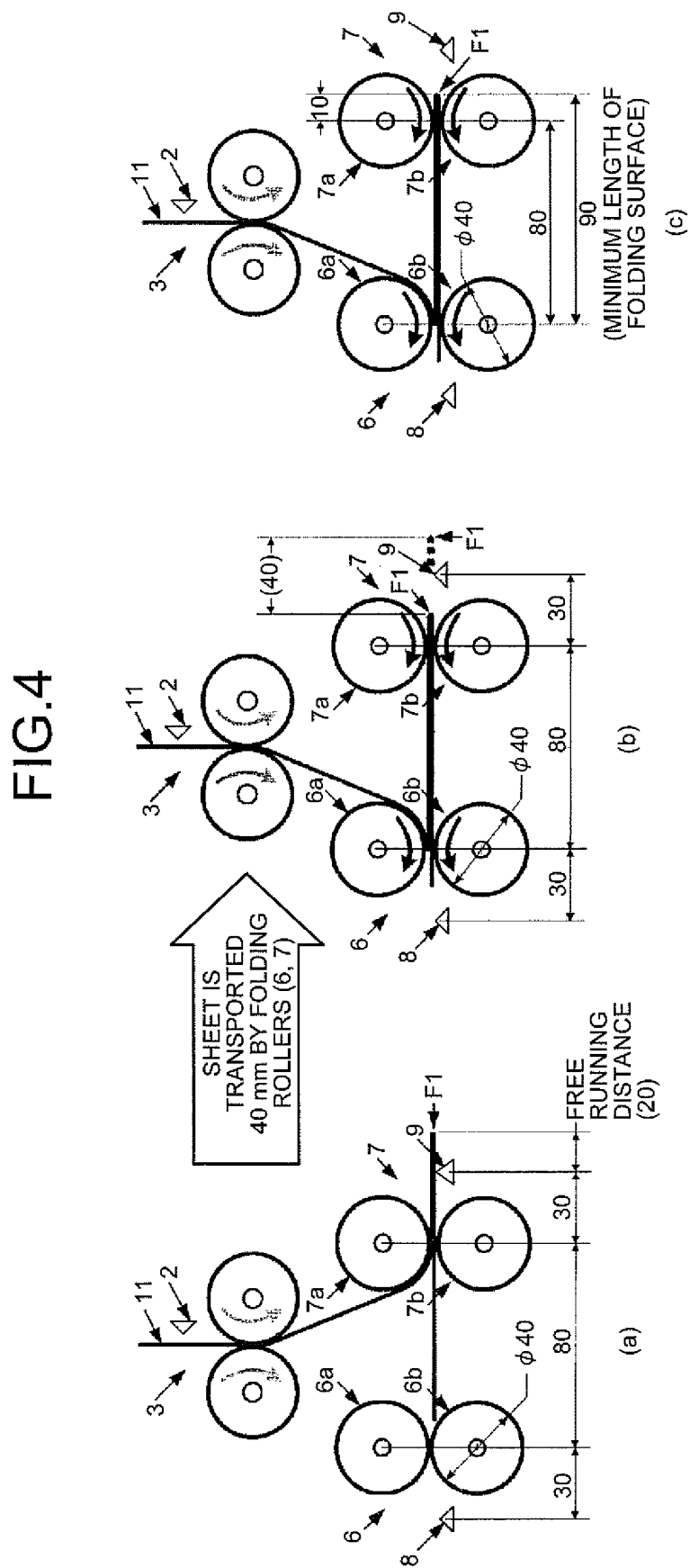


FIG. 5

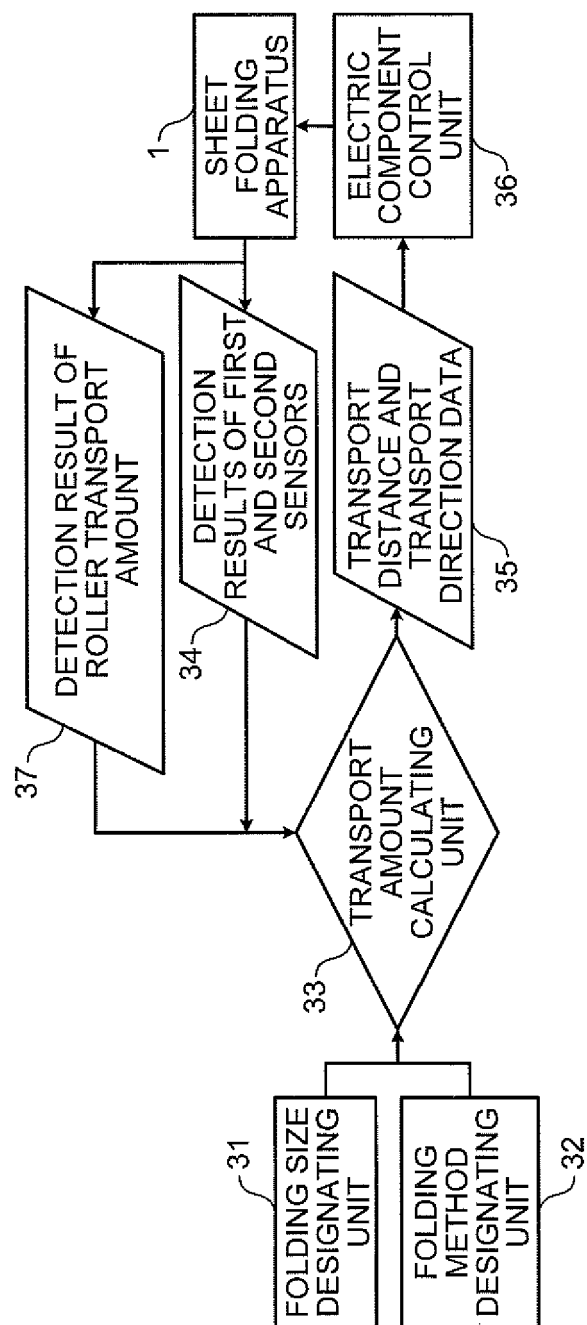


FIG.6

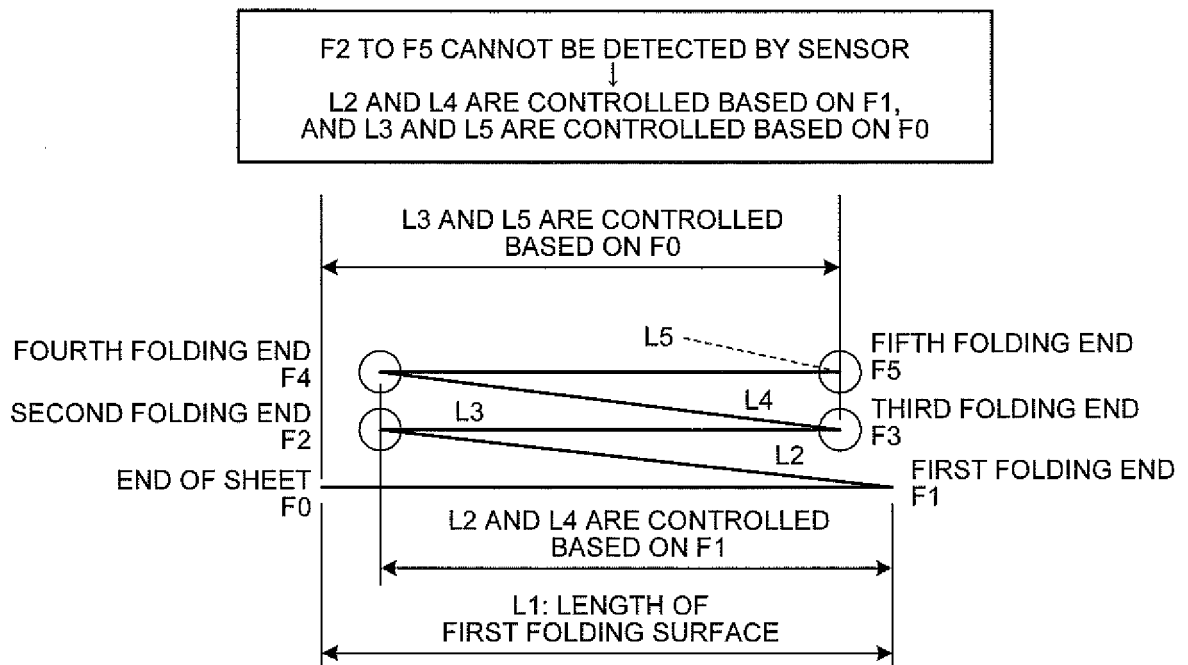


FIG. 7

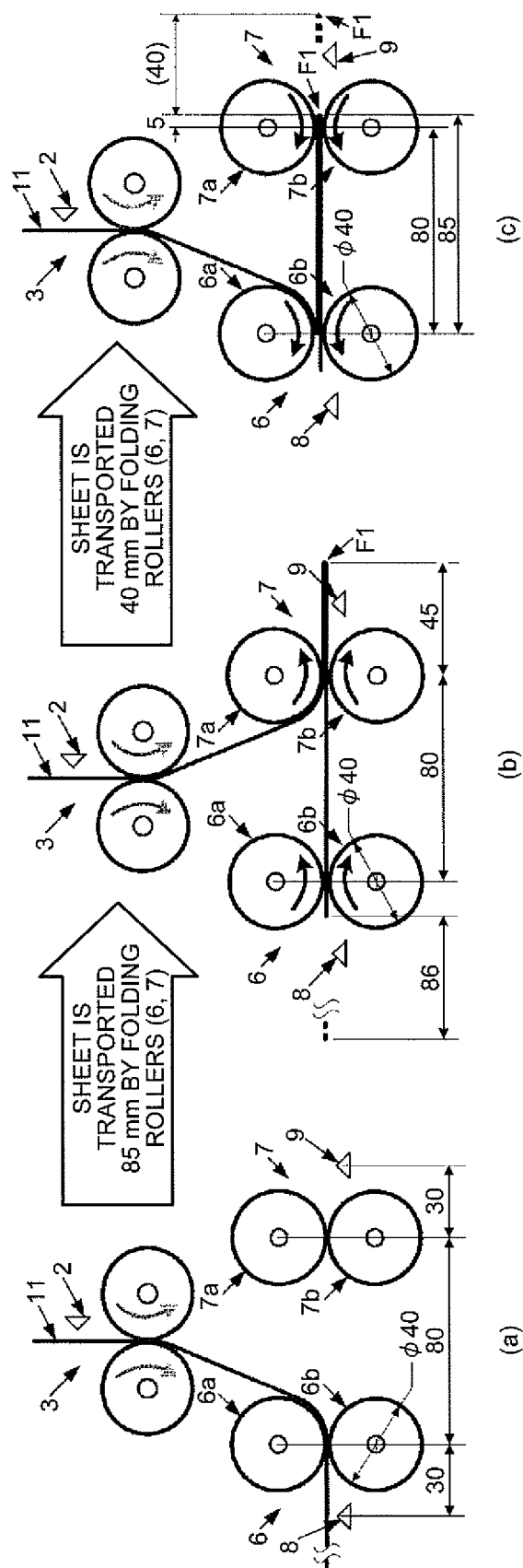


FIG. 8

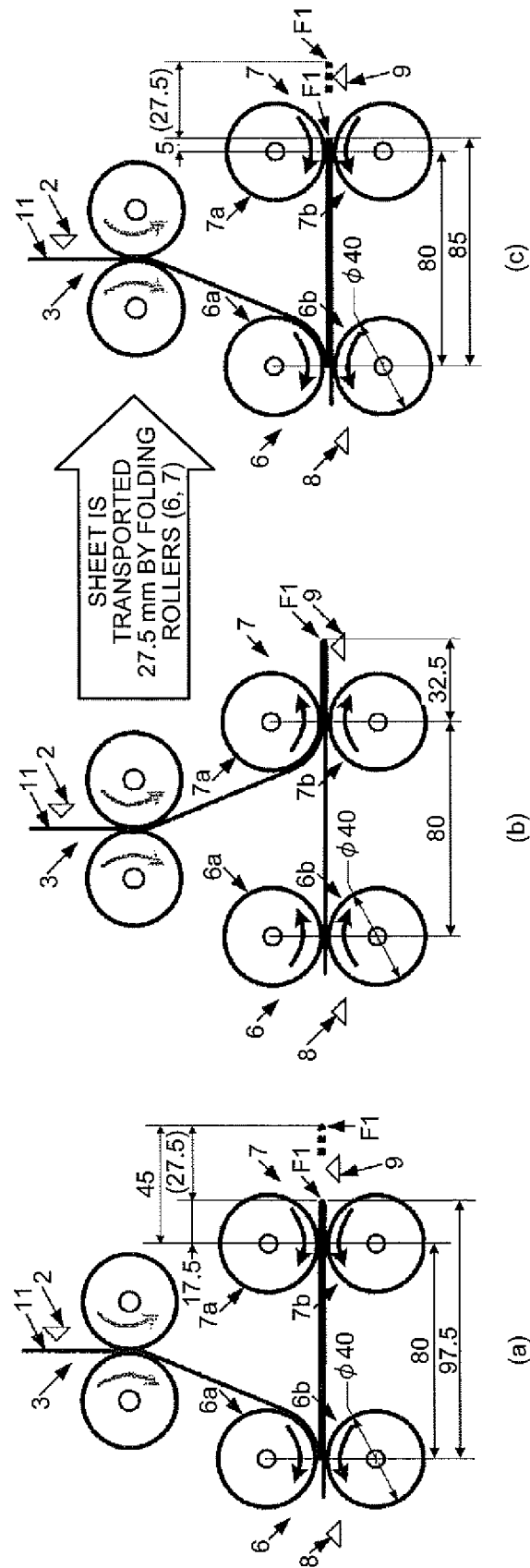


FIG.9

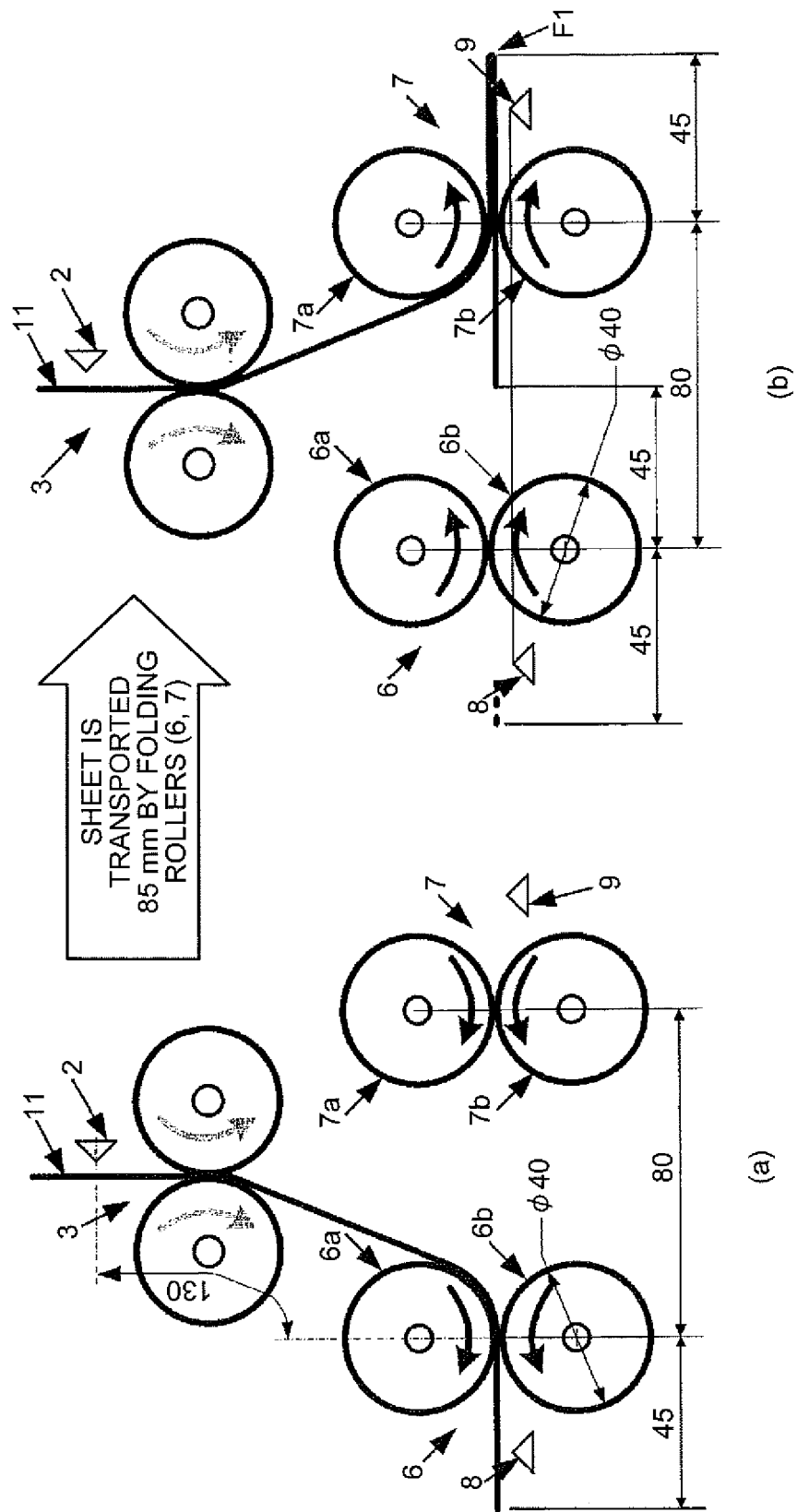


FIG.10

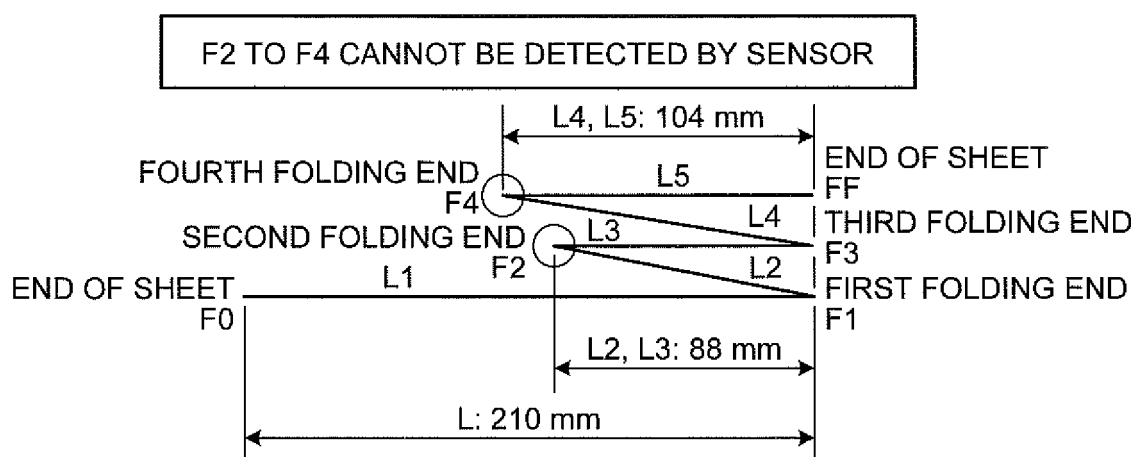


FIG.11

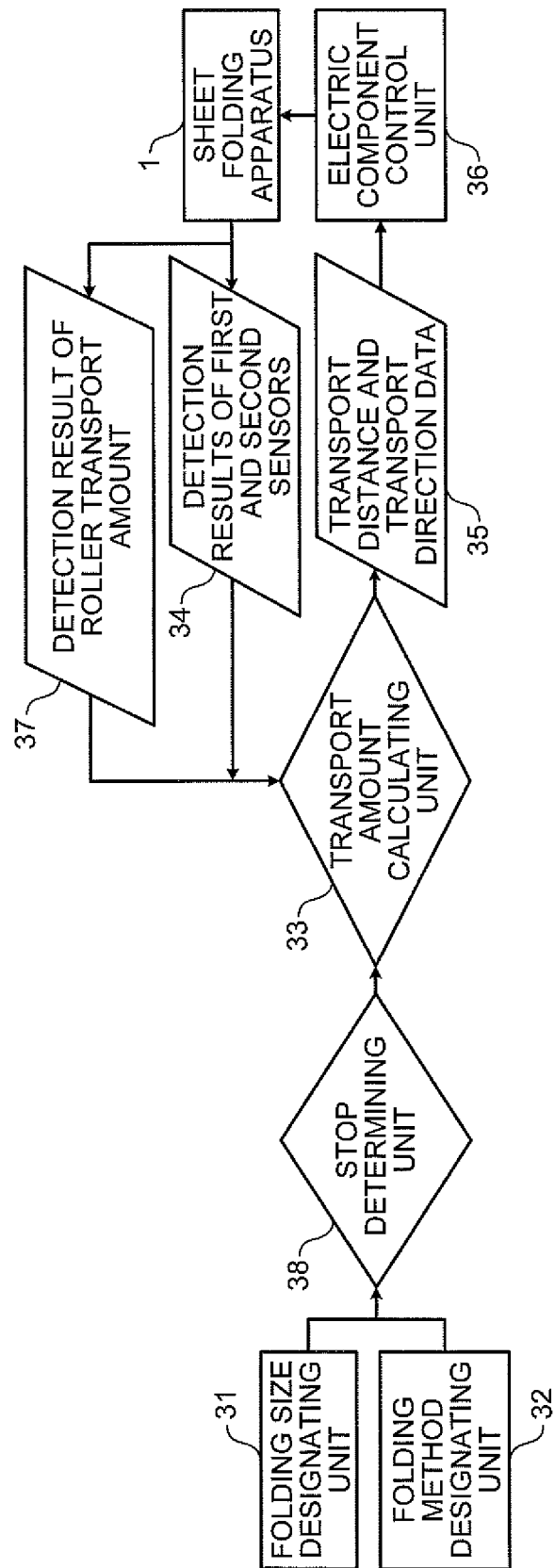


FIG.12

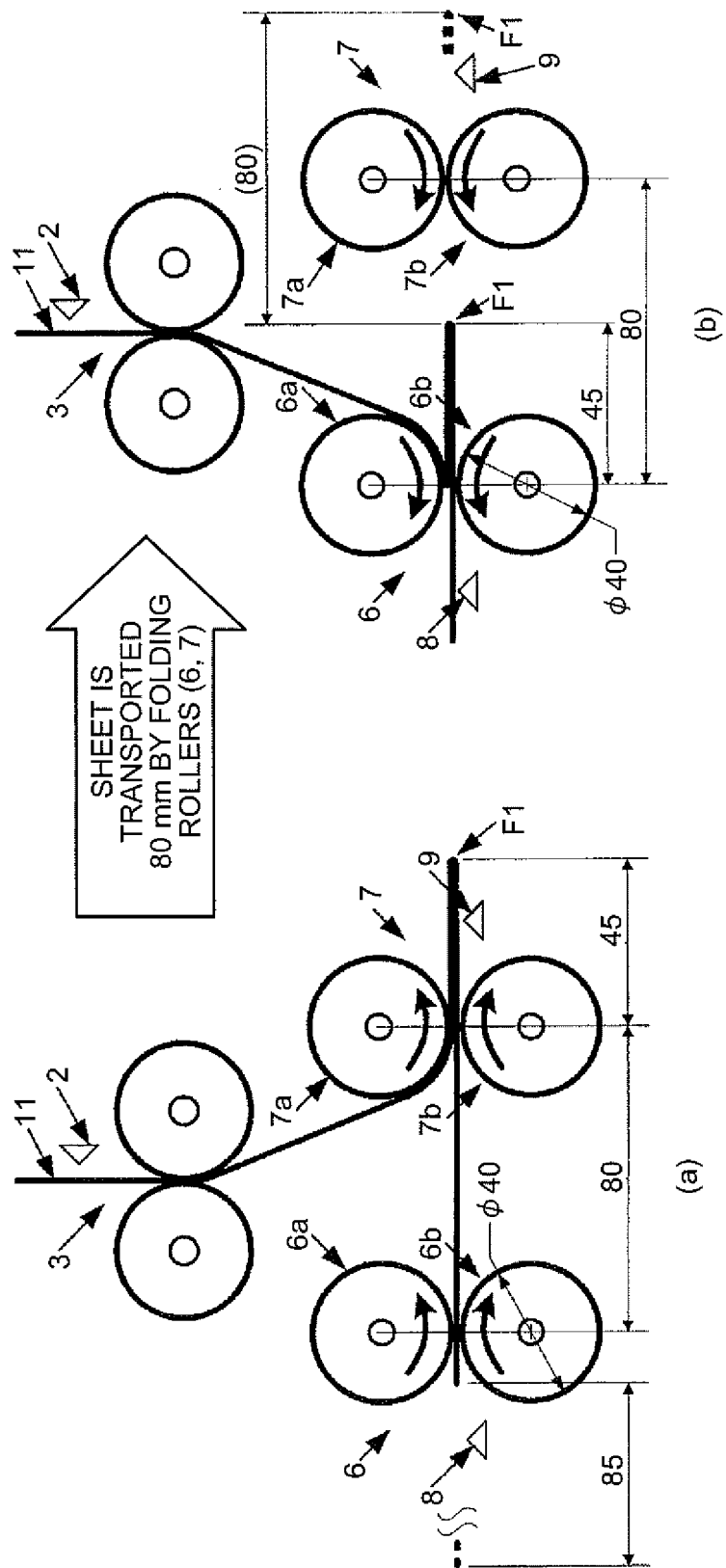


FIG. 13C

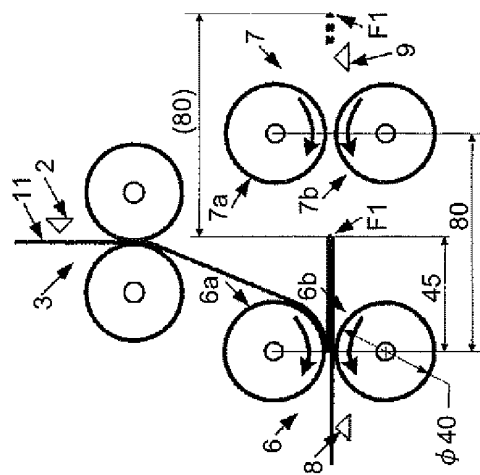


FIG. 13B

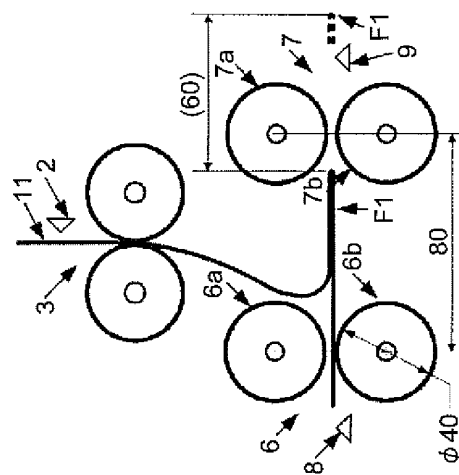


FIG. 13A

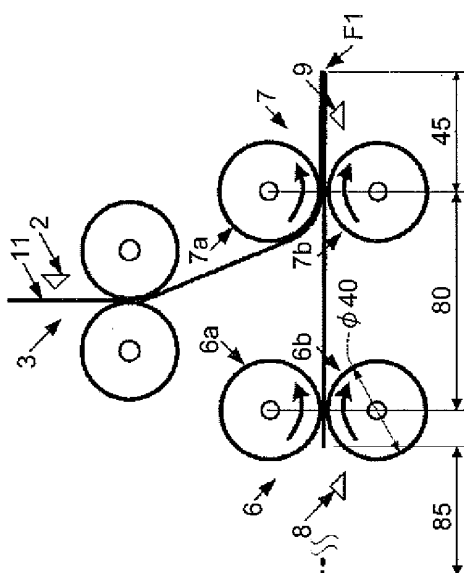


FIG. 14C

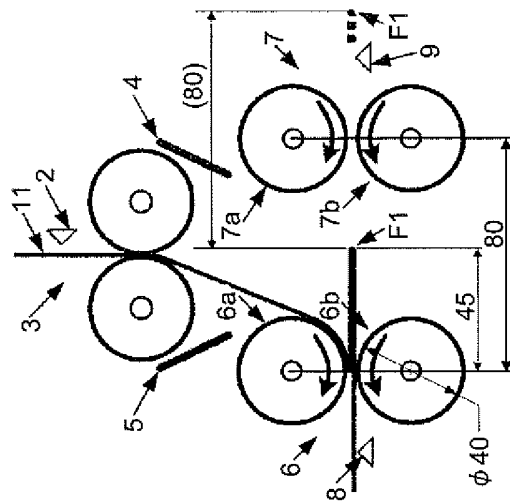


FIG. 14B

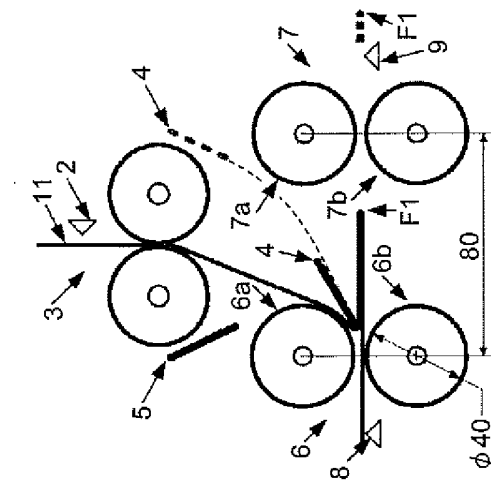


FIG. 14A

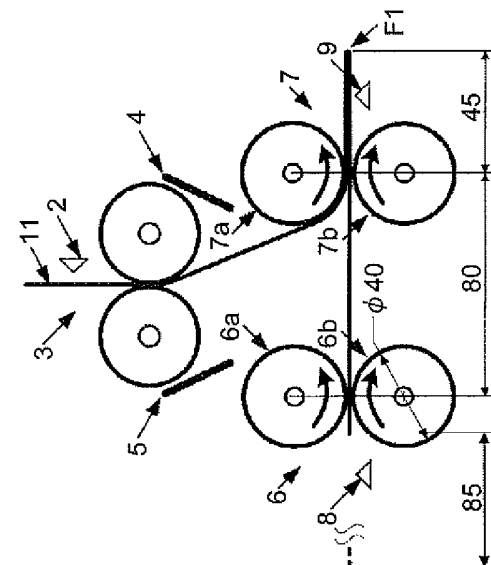


FIG.15A

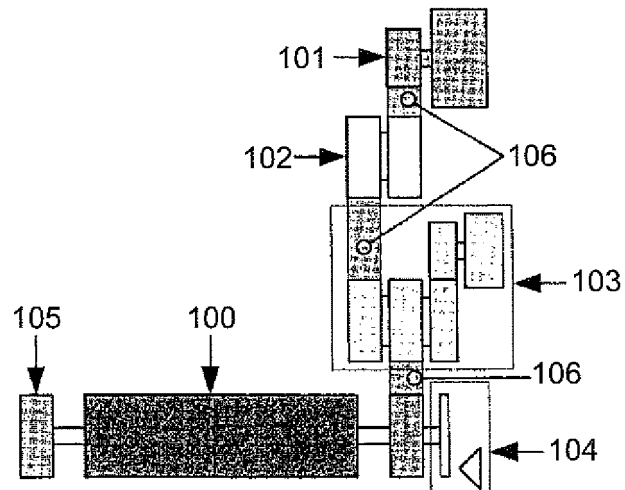


FIG.15B

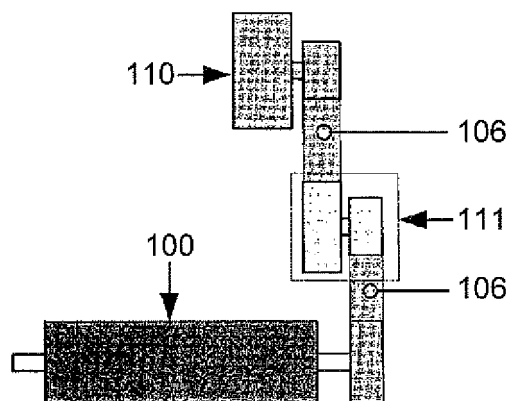
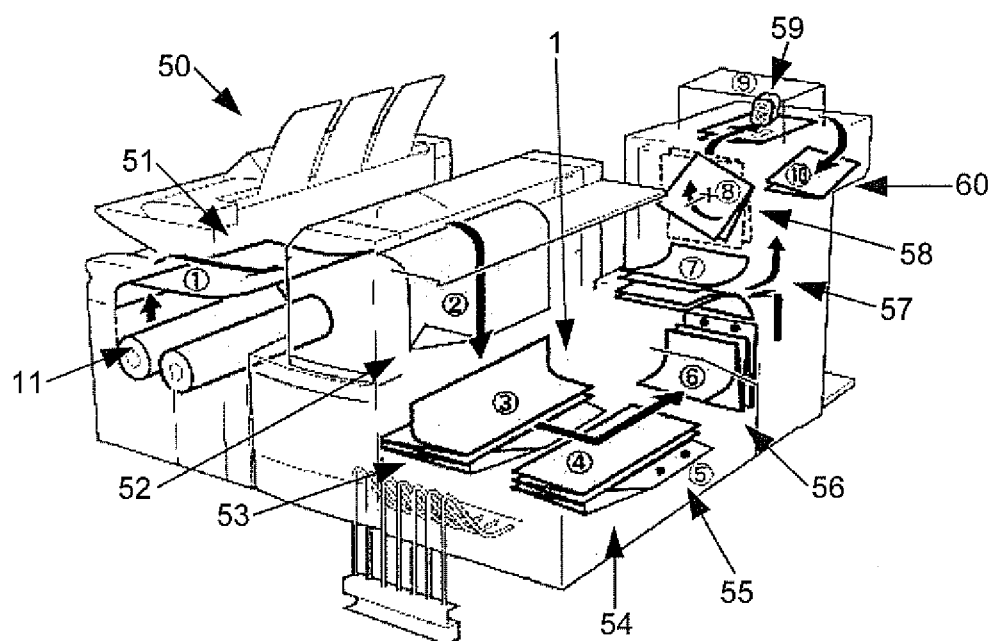


FIG.16





EUROPEAN SEARCH REPORT

Application Number
EP 11 16 9158

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2008/174061 A1 (KURITA WATARU [JP]) 24 July 2008 (2008-07-24) * the whole document *	1-15	INV. B65H45/20
X	US 2006/205580 A1 (SEKINE NORIAKI [JP] ET AL) 14 September 2006 (2006-09-14) * the whole document *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			B65H
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 6 September 2011	Examiner Jezierski, Krzysztof
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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ON EUROPEAN PATENT APPLICATION NO.**

EP 11 16 9158

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06-09-2011

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008174061 A1	24-07-2008	JP 2008168964 A	24-07-2008
US 2006205580 A1	14-09-2006	NONE	

REFERENCES CITED IN THE DESCRIPTION

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- JP 3911091 B [0014] [0015]