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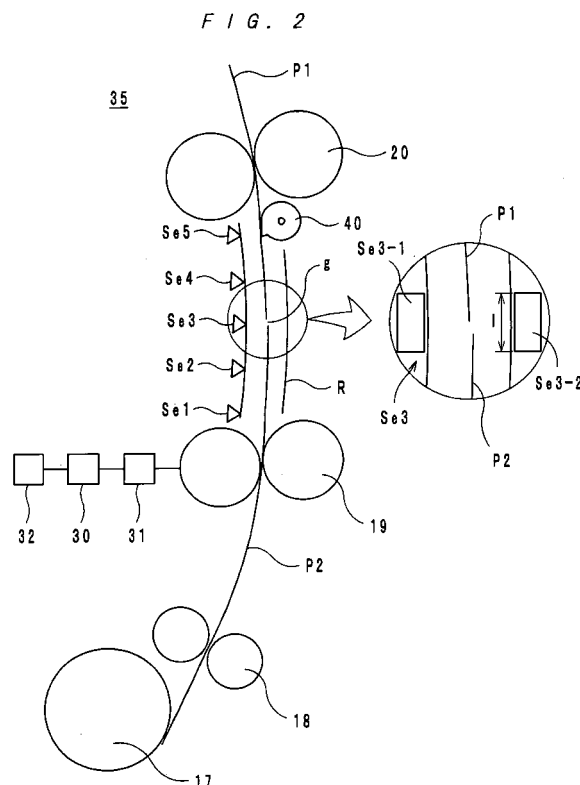
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(54) **Sheet feeding device and image forming apparatus provided with the sheet feeding device**

(57) A sheet feeding device (35) that is suited to be employed in an image forming apparatus having a printing section (2) for printing an image on a sheet. The sheet feeding device has feed rollers (19) for feeding a sheet at a speed "Va" and timing rollers (20) for feeding a sheet fed by the feed rollers (19) to the printing section at a speed "Vb". Sensors (Se1-Se5) are provided between the feed rollers (19) and the timing rollers (20), so that the gap between a foregoing sheet and a following sheet can be detected at a plurality of detection points while the foregoing sheet is being fed by the timing rollers (20) and the following sheet is being fed by the feed rollers (19). When one of the sensors (Se1-Se5) detects that there is a gap between the sheets, a control unit controls the feed rollers such that the speed "Va" will be higher than the speed "Vb".



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Description

Technical Field

[0001] The present invention relates to a sheet feeding device and an image forming apparatus provided with the sheet feeding device, and more particularly to a sheet feeding device for feeding sheets of printed medium successively and an image forming apparatus provided with the sheet feeding device.

Background of the Invention

[0002] When a sheet feeding device feeds a plurality of sheets successively, it is preferred that the sheets are fed with no gaps among the sheets for the reasons below. If there are gaps among sheets, feed rollers and a transfer belt will rotate even while the gaps are passing thereby. Therefore, in this case, the drive distance of the feed rollers and the transfer belt is large, compared with the case wherein there are no gaps among sheets. Accordingly, when there are gaps among sheets, the feed rollers and the transfer belt are abraded shortly. Also, when there are gaps among sheets, the productivity becomes lower, compared with the case wherein there are no gaps among sheets. For these reasons, sheets are fed successively preferably with no gaps among the sheets.

[0003] As a conventional sheet feeding device, for example, a sheet feeding device as disclosed by Japanese Patent Laid-Open Publication No. 2006-232475 (Reference 1) is well known. In this sheet feeding device, when a detector detects that the gap between two sheets (a foregoing sheet and a following sheet) that are successively fed is lower than a specified value, a control unit controls a feed-out means to slow down the speed of the following sheet. With this control, it is possible to feed a plurality of sheets successively while keeping constant gaps among the sheets.

[0004] Thus, in the sheet feeding device disclosed by Reference 1, the gaps among sheets are kept constant. However, Reference 1 is silent about controlling the gaps closer to zero.

Disclosure of the Invention

[0005] An object of the present invention is to provide a sheet feeding device wherein the gaps among sheets successively fed can be made closer to zero and an image forming apparatus provided with the sheet feeding device.

[0006] An embodiment of the present invention is a sheet feeding device that is suited to be used in an image forming apparatus comprising a printing section for printing an image on a sheet, and the sheet feeding device comprises: a first feeder for feeding the sheet at a first speed; a second feeder for feeding the sheet fed by the first feeder to the printing section at a second speed; a detector, which is located between the first feeder and the second feeder, for detecting a gap between a first sheet and a second sheet at a plurality of detection points while the first sheet is being fed by the second feeder and the second sheet is being fed by the first feeder; and a controller for controlling the first feeder or the second feeder, and when the detector detects that there is a gap between the first sheet and the second sheet, the controller controls the first feeder or the second feeder such that the first speed will be higher than the second speed.

[0007] Another embodiment of the present invention is an image forming apparatus, and the image forming apparatus comprises the above-described sheet feeding device.

Brief Description of the Drawings

[0008]

Fig. 1 is a schematic view showing the general structure of an image forming apparatus according to an embodiment of the present invention.

Fig. 2 is an enlarged view of a sheet feeding device employed in the apparatus shown by Fig. 1.

Figs. 3a-3c are illustrations showing operation of an overlap correction mechanism.

Fig. 4 is a flowchart showing a procedure that is carried out by a control unit while the sheet feeding device is feeding sheets successively.

Fig. 5 is a graph showing waveforms of signals outputted from sensors.

Figs. 6a-6d are illustrations showing passing of two sheets by a light receiving element.

Figs. 7a-7d are illustrations showing passing of two sheets by a light receiving element.

Figs. 8a-8c are illustrations showing passing of two sheets by a light receiving element.

Figs. 9a-9c show modifications of the sensors provided for the sheet feeding device.

Fig. 10 shows a modification of the overlap correction mechanism.

Best Mode for Carrying out the Invention

[0009] A sheet feeding device and an image forming apparatus according to an embodiment of the present invention are hereinafter described.

Structure of Image Forming Apparatus

[0010] Referring to Fig. 1, an image forming apparatus 1 provided with a sheet feeding device according to an embodiment of the present invention is described.

[0011] The image forming apparatus 1 is an electrophotographic color printer and forms a color image by combining four color (Y: yellow, M: magenta, C: cyan and K: black) images in a tandem method. The image forming apparatus 1 is to form an image on a sheet of paper P in accordance with image data, and comprises a printing section 2, a feeding section 15, a sheet feeding device 35, a fixing device 22 and a printed-sheet tray 23.

[0012] The feeding section 15 is to supply sheets P one by one, and comprises a sheet tray 16, a feed-out roller 17 and separation rollers 18. A plurality of sheets to be subjected to printing is stacked in the sheet tray 16. The feed-out roller 17 is to pick the sheets P out of the tray 16 one by one. The separation rollers 18 separate two or more sheets possibly picked out by the feed-out roller 17 and feed surely one sheet P forward.

[0013] As Fig. 2 shows, the sheet feeding device 35 comprises feed rollers 19, timing rollers 20, a control unit 30, a driver 31, a storage 32, an overlap correction mechanism 40, a route R and sensors Se1 to Se5. The feed rollers 19 are rotated by the driver 31 to feed the sheet P at a speed "Va". The driver 31 is, for example, a motor. The feed rollers 19 and the driver 31 form a feeder. The timing rollers 20 are rotated by another driver (not shown) to feed the sheet P fed thereto by the feed rollers 19 further to a printing section 2 at a speed "Vb". The timing rollers 20 and the driver form another feeder. The route R is formed between the feed rollers 19 and the timing rollers 20, and the sheet P travels therein.

[0014] The sensors Se1 to Se5 are provided along the route R. When two sheets P1 and P2 are fed successively as shown by Fig. 2, the sensors Se1 to Se5 detect the gap between the sheets P1 and P2. More specifically, while the sheet P1 is being fed by the timing rollers 20 and while the sheet P2 is being fed by the feed rollers 19, the gap "g" between the trailing edge of the sheet P1 and the leading edge of the sheet P2 (which is hereinafter referred to as the gap "g" between the sheets P1 and P2) is detected by the plural sensors Se1 to Se5 provided along the route R. Each of the sensors Se1 to Se5 comprises a light source Se1-1 (Se2-1, Se3-1, Se4-1 or Se5-1) and a light receiving element Se1-2 (Se2-2, Se3-2, Se4-2 or Se5-2). The light source Se3-1 and the light receiving element Se3-2 are shown in the magnified view in Fig. 2. The light sources Se1-1 to Se5-1 emit light. The light receiving elements Se1-2 to Se5-2 define detection points. The light receiving elements Se1-2 to Se5-2 receive the light emitted from the light sources Se1-1 to Se5-1 and send the control unit 30 output signals Sig1 to Sig 5 in accordance with the quantities of received light. Specifically, when the light receiving elements Se1-2 to Se5-2 receive relatively large quantities of light, the elements Se1-2 to Se5-2 send output signals Sig1 to Sig5 of relatively high voltages, and when the light receiving elements Se1-2 to Se5-2 receive relatively small quantities of light, the elements Se1-2 to Se5-2 send output signals Sig1 to Sig5 of relatively low voltages. As shown in the magnified view in Fig. 2, the light receiving elements Se1-2 to Se5-2 have a dimension (length) "1" in the sheet feeding direction. In this embodiment, the sensors Se1 to Se5 are arranged at intervals larger than the initial gap "g" between the sheets P1 and P2, so that the gap "g" will never be detected by two or more sensors concurrently.

[0015] The control unit 30 controls the driver 31 and the feed rollers 19 in accordance with the detection results of the sensors Se1 to Se5. The storage 32 is, for example, a hard disk or a memory, and stores a table as shown by Table 1. The table shows the relationship between the size "L" of the gap "g" and the speed "Va".

Table 1

Size "L" of Gap "g"	Speed "Va"
0	V1
$0 < L \leq L1$	V2
$L1 < L \leq L2$	V3
$L2 < L \leq L3$	V4
$L3 < L$	V5

[0016] The control unit 30 recognizes the size "L" of the gap "g" based on the output signals Sig1 to Sig5 from the sensors Se1 to Se5 and determines the speed "Va" with reference to the table. In Table 1, the values meet the conditions

$L1 < L2 < L3$, $V1 < V2 < V3 < V4$ and $V1 = Vb$. That is, the speed "Va" is equal to or greater than the speed "Vb" at all times. Thereby, when there is a gap between the sheets P1 and P2 ($L > 0$), the control unit 30 controls the driver 31 and the feed rollers 19 such that the gap "g" detected by a more downstream sensor of the sensors Se1 to Se5 will be smaller than the gap "g" detected by a more upstream sensor of the sensors Se1 to Se5. On the other hand, when one of the sensors "Sen" detects no gap between the sheets P1 and P2 ($L = 0$), the control unit 30 controls the driver 31 and the feed rollers 19 such that the speed "Va" will be $V1$ that is equal to the speed "Vb".

[0017] The overlap correction mechanism 40 is to correct an overlap of the sheets P1 and P2. Specifically, as shown in Figs. 1 and 2, the overlap correction mechanism 40 is provided in a downstream position in the route R (near the timing rollers 20), and is a roller that has a cross section of a circle having a protrusion. If the sheets P1 and P2 reach the overlap correction mechanism 40 while overlapping with each other, the leading edge of the sheet P2 is hooked by the protrusion of the overlap correction mechanism 40 as shown by Fig. 3a. Then, as shown by Fig. 3b, the sheet P2 is pushed up by the force of the feed rollers 19, and accordingly, the overlap correction mechanism 40 is rotated. When the overlap correction mechanism 40 rotates by a specified amount, as shown by Fig. 3c, the leading edge of the sheet P2 is released from the protrusion of the overlap correction mechanism 40, and the sheet P2 is fed upward. Thereafter, the overlap correction mechanism 40 rotates further and returns to a state as shown by Fig. 3a. In this way, the sheet P2 slows down. Meanwhile, during the period from Fig. 3a to Fig. 3c, the sheet P1 is fed upward without slowing down. Thereby, the overlap of the sheets P1 and P2 is corrected.

[0018] The printing section 2 is to form a toner image on a sheet P fed from the timing rollers 20. As shown in Fig. 1, the printing section 2 comprises image forming units 24Y, 24M, 24C and 24K, first transfer rollers 8Y, 8M, 8C and 8K, an intermediate transfer belt 11, a driving roller 12, a driven roller 13, a second transfer roller 14, and a cleaning device 21. The image forming units 24Y, 24M, 24C and 24K comprise photosensitive drums 4Y, 4M, 4C and 4K, electric chargers 5Y, 5M, 5C and 5K, exposure devices 6Y, 6M, 6C and 6K, developing devices 7Y, 7M, 7C and 7K, and cleaners 9Y, 9M, 9C and 9K, respectively. In the following description, when the photosensitive drums, the electric chargers, the exposure devices, the developing devices, the first transfer rollers, the cleaners and the image forming units are discussed generally, they are indicated as the photosensitive drum(s) 4, the electric charger(s) 5, the exposure device(s) 6, the developing device(s) 7, the first transfer roller(s) 8, the cleaner(s) 9 and the image forming unit(s) 24. When the photosensitive drums, the electric chargers, the exposure devices, the developing devices, the first transfer rollers, the cleaners and the image forming units are discussed individually, they are indicated as the photosensitive drums 4Y, 4M, 4C and 4K, the electric chargers 5Y, 5M, 5C and 5K, the exposure devices 6Y, 6M, 6C and 6K, the developing devices 7Y, 7M, 7C and 7K, the first transfer rollers 8Y, 8M, 8C and 8K, the cleaners 9Y, 9M, 9C and 9K, and the image forming units 24Y, 24M, 24C and 24K.

[0019] The electric chargers 5 charge the circumferential surfaces of the photosensitive drums 4. The exposure devices 6 emit lasers controlled by an exposure control unit (not shown in the drawings). Thereby, electrostatic latent images are formed on the circumferential surfaces of the photosensitive drums 4. Thus, the electric chargers 5 and the exposure devices 6 serve as a unit for forming electrostatic latent images on the circumferential surfaces of the photosensitive drums 4.

[0020] The developing devices 7 are to supply toner to the photosensitive drums 4 so as to form toner images on the circumferential surfaces of the photosensitive drums 4. More specifically, the developing devices 7 store toner therein and charge the toner into the negative polarity by stirring the toner or the like. Developing rollers provided in the respective developing device 7 feed the toner toward the photosensitive drums 4. At this time, the negative charged toner moves from the developing rollers to the photosensitive drums 4 influenced by the electric fields of the electrostatic latent images on the photosensitive drums 4. In this way, toner images are formed on the circumferential surfaces of the photosensitive drums 4.

[0021] The intermediate transfer belt 11 is laid between the driving roller 12 and the driven roller 13, and the toner images formed on the photosensitive drums 4 are transferred onto the intermediate transfer belt 11 such that the transferred images will be laid on one another to be combined into a full-color image (first transfer). The first transfer rollers 8 are located in contact with the inner surface of the intermediate transfer belt 11. A first transfer voltage is applied from a voltage source (not shown in the drawings) to the first transfer rollers 8, whereby the toner images formed on the photosensitive drums 4 are transferred onto the intermediate transfer belt 11. The cleaners 9 are to collect residual toner remained on the photosensitive drums 4 after the first transfer. The driving roller 12 is rotated by an intermediate transfer belt driver (not shown in the drawings), whereby the intermediate transfer belt 11 is driven. Then, the intermediate transfer belt 11 carries the full-color toner image to the second transfer roller 14.

[0022] The second transfer roller 14 is located opposite the intermediate transfer belt 11, and a nip portion N is formed between the second transfer roller 14 and the intermediate transfer belt 11. While a sheet P fed from the timing rollers 20 is passing through the nip portion N, the second transfer roller 14 transfers the toner image carried by the intermediate transfer belt 11 onto the sheet P (second transfer). After the second transfer, the cleaning device 21 removes residual toner from the intermediate transfer belt 11.

[0023] The sheet P that has been subjected to the second transfer is fed to the fixing device 22. The fixing device 22

applies a heating treatment and a pressing treatment to the sheet P so as to fix the toner image on the sheet P. The printed sheet P is ejected onto the printed-sheet tray 23.

Operation of Image Forming Apparatus

[0024] The operation of the image forming apparatus 1 provided with the sheet feeding device 35 is hereinafter described with reference to the drawings.

[0025] First, referring to Figs. 5 to 8, the operation of the image forming apparatus 1 is generally described. When the light receiving elements Se1-2 to Se5-2 receive relatively large quantities of light, the light receiving elements Se1-2 to Se5-2 output signals Sig1 to Sig5 of relatively high voltages. When the light receiving elements Se1-2 to Se5-2 receive relatively small quantities of light, the light receiving elements Se1-2 to Se5-2 output signals Sig1 to Sig5 of relatively low voltages. Therefore, referring to Fig. 5, while the output signals Sig1 to Sig5 are high (during the periods between time "0" to time "t3"), the gap "g" between the sheets P1 and P2 are passing in front of the light receiving elements Se1-2 to Se5-2, respectively. That is, the size "L" of the gap "g" can be judged from the length of the period when the voltage of the output signal Sig1 to Sig5 is high. The control unit 30 times the period and calculates the size "L" of the gap "g" between the sheets P1 and P2, and in accordance with the calculation result, the control unit 30 controls the speed "Va".

[0026] As shown in Fig. 5, the waveforms of the output signals Sig1 to Sig5 can be classified into three types. More specifically, the waveforms of the output signals Sig1 and Sig2 are trapezoidal. The waveform of the output signal Sig3 is four-cornered with the upper side slanting. The waveform of the output signal Sig4 is triangle. The output signal Sig5 is constant and flat, which indicates that the gap "g" between the sheets P1 and P2 is zero.

[0027] The reason why the output signals Sig1 to Sig5 have different waveforms is that the size "L" of the gap "g" is changeable. Specifically, as shown by Figs. 6a to 6d, when the size "L" of the gap "g" is greater than the length "1" of the light receiving element Sen-2, the output signal "Sign" has such a waveform as those of the output signals Sig1 and Sig2. As shown by Figs. 7a to 7d, when the size "L" of the gap "g" is smaller than the size of the light receiving element Sen-2, the output signal "Sign" has such a waveform as that of the output signal Sig3. As shown by Fig. 8a to 8c, when the gap "g" becomes zero while passing in front of the light receiving element Sen-2, the output signal "Sign" has such a waveform as that of the output signal Sig4. This is described in more details below.

[0028] Referring to Figs. 6a to 6d, a case wherein the gap "g" is larger than the length "1" of the light receiving element Sen-2 is described. While the trailing edge of the sheet P1 is passing in front the light receiving element Sen-2 (during the period from Fig. 6a to Fig. 6b), the area of the light receiving element Sen-2 covered by the sheet P1 is decreasing. Accordingly, the voltage of the output signal "Sign" is increasing like the output signals Sig1 and Sig 2 in the periods from "0" to "t1" shown in Fig. 5. Next, when and after the trailing edge of the sheet P1 has completed passing by the light receiving element Sen-2 (during the period from Fig. 6b to Fig. 6c), the light receiving element Sen-2 is covered neither by the sheet P1 nor by the sheet P2. Accordingly, the voltage of the output signal "Sign" is fixed at a relatively high level like the output signals Sig1 and Sig2 in the periods from "t1" to "t2" shown in Fig. 5. Next, while the leading edge of the sheet P2 is passing in front of the light receiving element Sen-2 (during the period from Fig. 6c to Fig. 6d), the area of the light receiving element Sen-2 covered by the sheet P2 is increasing. Accordingly, the voltage of the output signal "Sign" is decreasing like the output signals Sig1 and Sig2 in the periods from "t2" to "t3" shown in Fig. 5. Finally, when and after the leading edge of the sheet P2 has completed passing by the light receiving element Sen-2 (after Fig. 6d), the light receiving element Sen-2 is entirely covered by the sheet P2. Accordingly, the voltage of the output signal "Sign" is fixed at a relatively low level like the signals Sig1 and Sig2 after "t3" shown in Fig. 5.

[0029] Next, referring to Figs. 7a to 7d, a case wherein the gap "g" is smaller than the length "1" of the light receiving element Sen-2 is described. In a first part of the period when the trailing edge of the sheet P1 is passing in front of the light receiving element Sen-2 (during the period from Fig. 7a to Fig. 7b), the area of the light receiving element Sen-2 covered by the sheet P1 is decreasing. Accordingly, the voltage of the output signal "Sign" is increasing like the output signal Sig3 in the period from "0" to "t1" shown in Fig. 5. Thereafter, as shown by Fig. 7b, the leading edge of the sheet P2 comes to the light receiving element Sen-2 while the trailing edge of the sheet P1 is still passing in front of the light receiving element "Sen-2". In this moment, because the speed "Va" is higher than the speed "Vb", the covered area of the light receiving element Sen-2 covered by the sheets P1 and P2 is gradually increasing. Accordingly, the voltage of the output signal "Sign" is gradually decreasing like the output signal Sig3 in the period from "t1" to "t2" shown in Fig. 5. Next, when and after the trailing edge of the sheet P1 has completed passing by the light receiving element Sen-2 (after Fig. 7c), only the leading edge of the sheet P2 passes in front of the light receiving element Sen-2, and accordingly, the voltage of the output signal "Sign" is steeply decreasing like the signal Sig3 in the period from "t2" to "t3" shown in Fig. 5. Finally, when and after the leading edge of the sheet P2 has completed passing by the light receiving element "Sen-2" (after Fig. 7d), the light receiving element Sen-2 is entirely covered by the sheet P2. Accordingly, the voltage of the output signal "Sign" is fixed at a relatively low level like the signal Sig3 after "t3" shown in Fig. 5. Thus, when the gap "g" is smaller than the length "1" of the light receiving element "Sen-2", the leading edge of the sheet P2 starts passing in front of the light receiving element Sen-2 before the trailing edge of the sheet P1 completes passing in front

of the light receiving element Sen-2. Therefore, during the period "t1" to "t2", the voltage of the output signal "Sign" is not fixed but is gradually decreasing.

[0030] Next, referring to Figs. 8a to 8c, a case wherein the gap "g" becomes zero while the gap "g" is passing in front of the light receiving element Sen-2 is described. In a first part of the period when the trailing edge of the sheet P1 is passing in front of the light receiving element Sen-2 (during the period from Fig. 8a to Fig. 8b), the area of the light receiving element Sen-2 covered by the sheet P1 is decreasing. Accordingly, the voltage of the output signal "Sign" is increasing like the output signal Sig5 in the period from "0" to "t1" shown in Fig. 5. Thereafter, as shown by Fig. 8b, the leading edge of the sheet P2 comes to the light receiving element Sen-2 while the trailing edge of the sheet P1 is still passing in front of the light receiving element Sen-2. In this moment, because the speed "Va" is higher than the speed "Vb", the covered area of the light receiving element Sen-2 is gradually increasing. Accordingly, the voltage of the output signal "Sign" is gradually decreasing like the output signal Sig5 in the period from "t1" to "t3" shown in Fig. 5. Next, the leading edge of the sheet P2 catches up with the trailing edge of the sheet P1 as shown by Fig. 8c, and thereafter, the light receiving element Sen-2 is entirely covered by the sheets P1 and P2. Accordingly, the voltage of the output signal "Sign" is fixed at a relatively low level like the output signal Sig4 after "t3" shown in Fig. 5.

[0031] As described above, the timings of the passing of the trailing edge of the sheet P1 and the passing of the leading edge of the sheet P2 in front of the light receiving element Sen-2 depend on the size "L" of the gap "g". The control unit 30 recognizes the passing of the trailing edge of the sheet P1 and the passing of the leading edge of the sheet P2, based on the waveform of the output signal "Sign" from the light receiving element Sen-2. Referring to Fig. 4, the operation of the image forming apparatus 1 is hereinafter described, focusing on this point.

[0032] The control unit 30 sets N to 1 at step S1. This step S1 is carried out, for example, based on the time when the leading edge of the sheet P1 is detected by the sensor Se5 located the most downstream in the route R.

[0033] Next, in order to judge the presence or non-presence of a gap "g" between the sheets P1 and P2, the control unit 30 judges whether the sensor "Sen" (n: integer from 1 to 5) detects the trailing edge of the sheet P1 during a period when the trailing edge of the sheet P1 is expected to come thereto (step S2). While the trailing edge of the sheet P1 is passing in front of the light receiving element Sen-2, the covered area of the light receiving element Sen-2 is decreasing, and the quantity of light received by the light receiving element Sen-2 is increasing. Accordingly, the voltage of the output signal "Sign" from the light receiving element Sen-2 is increasing. Therefore, the control unit 30 judges the up-edge of the output signal "Sign" as the time when the sensor "Sen" starts detecting the trailing edge of the sheet P1. Thereafter, the processing goes to step S4. On the other hand, when the trailing edge of the sheet P1 is not detected, the control unit 30 judges that there is no gap between the sheets P1 and P2. Then, the processing goes to step S3.

[0034] When the trailing edge of the sheet P1 is not detected, the control unit 30 sets the speed "Va" to V1 at step S3. In this procedure, when the control unit 30 judges that there is no gap between the sheets P1 and P2, the control unit 30 judges that adjustment of the speed "Va" is not necessary. Therefore, the control unit 30 sets the speed "Va" to V1 that is equal to the speed "Vb". Thereafter, the processing goes to step S18.

[0035] When the trailing edge of the sheet P1 is detected, the control unit 30 starts a timer (step S4). As shown by Fig. 5, the control unit 30 starts timing with the time of the up-edge of the output signal "Sign" defined to be $t=0$. Next, the control unit 30 judges whether the increase in the voltage of the output signal "Sign" has stopped (step S5). As shown by Fig. 6b, when the trailing edge of the sheet P1 has completed passing by the light receiving element "Sen-2", the sheet P1 stops covering the light receiving element "Sen-2", and the quantity of light received by the light receiving element "Sen-2" stops increasing. Accordingly, the increase in the voltage of the output signal "Sign" stops. As shown by Figs. 7b and 8b, when the leading edge of the sheet P2 has reached the light receiving element "Sen-2", the light receiving element "Sen-2" starts to be covered by the sheet P2. Therefore, at this time, also, the quantity of light received by the light receiving element "Sen-2" stops increasing, and accordingly, the increase in the voltage of the output signal "Sign" stops. At step S5, however, the control unit 30 cannot judge whether the stop of the increase in the voltage of the output signal "Sign" is due to the completion of the passing of the trailing edge of the sheet P1 by the light receiving element "Sen-2" or due to the arrival of the leading edge of the sheet P2 at the light receiving element "Sen-2". This judgment is made at step S7 that will be described later. When the increase in the voltage of the output signal "Sign" stops, the processing goes to step S6. Unless the increase in the voltage of the output signal "Sign" stops, the processing returns to step S5. Until the increase in the voltage of the output signal "Sign" stops, the process at step S5 is repeated.

[0036] At step S6, the control unit 30 takes in a value of the time "t1" (see Fig. 5) when the increase in the voltage of the output signal "Sign" stops.

[0037] Next, the control unit 30 judges whether the value "t1" is equal to a value "ta" (step S7). The value "ta" is obtained by dividing the length "l" of the light receiving element "Sen-2" by the speed "Vb", and therefore, the value "ta" indicates the time that is necessary for the trailing edge of the sheet P1 to complete passing by the light receiving element "Sen-2". The speed "Vb" is a fixed value known to the control unit 30. Thus, at step S7, by judging whether the value "t1" is equal to the value "ta", the control unit 30 judges whether the stop of the increase in the voltage of the output signal "Sign" is due to the completion of the passing of the trailing edge of the sheet P1 by the light receiving element "Sen-2" as shown by Fig. 6b or due to the arrival of the leading edge of the sheet P2 at the light receiving element "Sen-

2" as shown by Figs. 7b and 8b. In other words, the control unit 30 judges which waveform of the output signals Sig1 to Sig4 shown in Fig. 5 the output signal "Sign" has. When the value "t1" is equal to the value "ta", the control unit 30 judges that the stop of the increase in the voltage of the output signal "Sign" is due to the completion of the passing of the trailing edge of the sheet P1 by the light receiving element "Sen-2" (see the waveforms of the signals Sig1 and Sig2 in Fig. 5). Thereafter, the processing goes to step S8. On the other hand, when the value "t1" is not equal to the value "ta", the control unit 30 judges that the stop of the increase in the voltage of the output signal "Sign" is due to the arrival of the leading edge of the sheet P2 at the light receiving element "Sen-2" (see the waveforms of signals Sig3 and Sig4 in Fig. 5). Thereafter, the processing goes to step S10.

[0038] When it is judged that the time "t1" is equal to the time "ta", the control unit 30 judges at step S8 whether the sensor "Sen" has detected the leading edge of the sheet P2. As shown by Figs. 6c and 6d, while the leading edge of the sheet P2 is passing by the light receiving element "Sen-2", the area of the light receiving element "Sen-2" covered by the sheet P2 is increasing. Accordingly, the quantity of light received by the light receiving element "Sen-2" is decreasing, and the voltage of the output signal "Sign" from the light receiving element "Sen-2" is decreasing like the output signals Sig1 and Sig2 for the periods from "t2" to "t3". The control unit 30 judges the down-edge of the output signal "Sign" as the time when the leading edge of the sheet P2 has reached the light receiving element "Sen-2". The process at step S8 is repeated until the sensor "Sen" starts detecting the leading edge of the sheet P2. Then, when the control unit 30 judges that the leading edge of the sheet P2 has reached the light receiving element "Sen-2", the processing goes to step S9.

[0039] When it is judged at step S7 that the time "t1" is not equal to "ta", the control unit 30 subsequently judges whether the time "t1" is smaller than "ta" (step S10). The time "ta" is a time that is necessary for the trailing edge of the sheet P1 to complete passing by the light receiving element "Sen-2". Therefore, in the normal state, the time "t1" is equal to or smaller than "ta", and it never happens that the time "t1" is greater than "ta". Accordingly, when it is judged that the time "t1" is greater than "ta" ("NO" at step S10), the control unit 30 judges that an error has occurred. Then, the processing is terminated. On the other hand, when the time "t1" is smaller than "ta", the processing goes to step S11.

[0040] At step S11, the control unit 30 judges whether the trailing edge of the sheet P1 has completed passing by the light receiving element "Sen-2". When and after the trailing edge of the sheet P1 has completed passing by the light receiving element "Sen-2", the light receiving element "Sen-2" is covered by only the sheet P2 as shown by Fig. 7c. Because the sheet P2 travels in such a direction as to cover more part of the light receiving element "Sen-2", the voltage of the output signal "Sign" is steeply decreasing like the output signal Sig3 in the period from "t2" to "t3" shown in Fig. 5. Thus, the control unit 30 judges whether the trailing edge of the sheet P1 has completed passing by the light receiving element "Sen-2" by judging whether the decreasing speed in the voltage of the output signal "Sign" is accelerated. When the completion of the passing of the trailing edge of the sheet P1 by the light receiving element "Sen-2" is judged at step S11, the processing goes to step S9. When the completion of the passing of the trailing edge of the sheet P1 is not judged at step S11, the processing goes to step S12.

[0041] At step S12, the control unit 30 judges whether the voltage of the output signal "Sign" is zero. In other words, at step S12, the control unit 30 judges whether the leading edge of the sheet P2 has caught up with the trailing edge of the sheet P1 while the light receiving element "Sen-2" is detecting the trailing edge of the sheet P1 and the leading edge of the sheet P2 as shown by the output signal Sig4 in Fig. 5 and Figs. 8a-8c. When the voltage of the output signal "Sign" is zero at step S12, the control unit 30 judges that the leading edge of the sheet P2 has caught up with the trailing edge of the sheet P1. Thereafter, the processing goes to step S13. On the other hand, when the voltage of the output signal "Sign" is not zero at step S12, the control unit 30 judges that the leading edge of the sheet P2 has not caught up with the trailing edge of the sheet P1. Thereafter, the processing returns to step S11.

[0042] When the voltage of the output signal "Sign" is zero, the size "L" of the gap "g" between the sheets P1 and P2 is judged to be zero (step S13). Thereafter, the processing goes to step S17.

[0043] At step S9, the control unit 30 takes in a value of the time "t2" (see Fig. 5) when the voltage of the output signal "Sign" starts decreasing due to the detection at step S8 or the detection at step S11. Thereafter, at step S14, the control unit 30 judges whether the leading edge of the sheet P2 has completed passing by the light receiving element "Sen-2". When and after the leading edge of the sheet P2 has completed passing by the light receiving element "Sen-2", the light receiving element "Sen-2" is completely covered by the sheet P2. Accordingly, the quantity of light received by the light receiving element "Sen-2" becomes zero, and the voltage of the output signal "Sign" becomes zero. Therefore, the control unit 30 judges whether the leading edge of the sheet P2 has completed passing by the light receiving element "Sen-2" by judging whether the voltage of the output signal "Sign" has become zero. When the completion of the passing of the leading edge of the sheet P2 by the light receiving element "Sen-2" is judged at step S14, the processing goes to step S15. The process at step S14 is repeated until it is judged that the leading edge of the sheet P2 has completed passing by the light receiving element "Sen-2".

[0044] At step S15, the control unit 30 takes in a value of the time "t3" (see Fig. 5) when the leading edge of the sheet P2 has completed passing by the light receiving element "Sen-2".

[0045] Then, the control unit 30 calculates the size "L" of the gap "g" between the sheets P1 and P2 from the length

"1" of the light receiving element "Sen-2", the speed "Vb" and the time "t3". Specifically, the control unit 30 figures out the size "L" of the gap "g", based on the following expression (1).

$$L = t3 \times Vb - l \quad \dots (1)$$

[0046] Next, at step S17, the control unit 30 controls the driver 31 and the feed rollers 19 to adjust the speed "Va" in accordance with the size "L" of the gap "g". More specifically, the control unit 30 specifies a value for the speed "Va", referring to Table 1, and the control unit 30 controls the driver 31 and the feed rollers 19 so that the sheet P2 will be fed at the specified speed "Va". Since the speeds V2, V3, V4 and V5 in Table 1 are larger than the speed "Vb", the gap "g" between the sheets P1 and P2 will be decreasing. Then, the processing goes to step S18.

[0047] At step S18, the control unit 30 judges whether N is equal to five. Step S18 is a process to judge whether the processes from step S2 to step S 17 have been carried out with regard to all the sensors Se1 to Se5. When N is equal to five, the procedure is completed. When N is not equal to five, the processing goes to step S19.

[0048] At step S19, the control unit 30 resets the timer. Subsequently, the control unit 30 makes an increment of N at step S20. Thereafter, the processing returns to step S2.

[0049] In this way, all the sensors Se1 to Se5 are subjected to the same processing. Accordingly, as shown by Fig. 5, the gap "g" detected by a more downstream sensor of the sensors Se1 to Se5 is smaller than the gap "g" detected by a more upstream sensor.

Effects

[0050] In the sheet feeding device 35 or in the image forming apparatus 1 provided with the sheet feeding device 35, the gap "g" between two sheets P1 and P2 that are sequentially fed can be made closer to zero. In the sheet feeding device 35, a plurality of sensors Se1 to Se5 are provided in the sheet route R at a plurality of locations, and the control unit 30 can adjust the speed "Va" of the sheet P2 fed by the feed rollers 19 at a plural number of times. Accordingly, the sheet feeding device 35 can control the speed "Va" more precisely, compared with the sheet feeding device disclosed by Reference 1 that detects the gap between sheets only once. In the sheet feeding device 35 and the image forming apparatus 1 provided with the sheet feeding device 35, consequently, it is possible to make the gap "g" between sheets P1 and P2 closer to zero. Thereby, the lives of the feed rollers 19 and the intermediate transfer belt 11 are prolonged, and the productivity is improved.

[0051] In the sheet feeding device 35 and in the image forming apparatus 1 provided with the sheet feeding device 35, the gap "g" between sheets P1 and P2 can be made closer to zero, and even if the speeds "Va" and "Vb" are low, the productivity can be maintained high. If the speeds "Va" and "Vb" are low, the speed of a sheet traveling in the fixing device 22 is also low, which permits the fixing temperature of the fixing device 22 to be set low. Thereby, the power consumption of the image forming apparatus 1 can be lowered.

[0052] In the sheet feeding device 35 and in the image forming apparatus 1 provided with the sheet feeding device 35, when the gap "g" between sheets is relatively large, the speed "Va" is accelerated, and when the gap "g" between sheets becomes relatively small, the speed "Va" is decelerated. When the leading edge of the sheet P2 is catching up with the trailing edge of the sheet P1, the speed "Va" is decelerated so that the sheet P1 and the sheet P2 are prevented from overlapping with each other.

[0053] Further, in the sheet feeding device 35 and the image forming apparatus 1 provided with the sheet feeding device 35, an overlap correction mechanism 40 is provided, and even if the sheets P1 and P2 overlap with each other, the overlap can be corrected by the overlap correction mechanism 40.

Modifications

[0054] The sheet feeding device 35 and the image forming apparatus 1 provided with the sheet feeding device 35 are not limited to the embodiment above. Modifications are possible within the scope of the invention. In the following, modifications of the sheet feeding device 35 and the image forming apparatus 1 provided with the sheet feeding device 35 is described.

[0055] Figs. 9a-9c show modifications of the sensors Se1 to Se5 for the sheet feeding device 35. As Fig. 9a shows, a light receiving member Se1-2 may be provided for the light sources Se1-1 to Se5-1. As Fig. 9b shows, a camera "C" may be provided instead of the sensors Se1 to Se5. In this case, the camera "C" is preferably located in a position suited to take pictures mainly around the timing rollers 20 as shown by Fig. 9c. This is because the target is that the gap "g" becomes zero before the gap "g" comes to the timing rollers 20.

[0056] In the embodiment above, the control unit 30 adjusts the speed "Va" while fixing the speed "Vb". However, the

speed "Vb" may be adjusted, while the speed "Va" may be fixed. In this case, when there is a gap "g" between sheets P1 and P2, the control unit 30 controls the timing rollers 20 and a driver for the timing rollers 20 so that the speed "Vb" will be lower than the speed "Va".

[0057] Additionally, when the most upstream sensor Se1 detects no gap between the sheets P1 and P2, the control unit 30 may control the feed rollers 19 and the driver 31 or the timing rollers 20 and the driver for the timing roller 20 so that the speed "Va" will be lower than the speed "Vb". When the sensor Se1 detects no gap between the sheets P1 and P2, there is a possibility that the sheets P1 and P2 may overlap with each other. For this reason, the control unit 30 makes a control so as to form a gap "g" between the sheets P1 and P2 once and then to close the gap "g". Thereby, the sheets P1 and P2 can be prevented from going out of the route R while overlapping with each other. Further, when any other sensors Se2 to Se5 than the sensor Se1 detect no gap between the sheets P1 and P2, the control unit 30 may control the feed rollers 19 and the driver 31 or the timing rollers 20 and the driver for the timing rollers 20 so that the speed "Va" will be lower than the speed "Vb".

[0058] The overlap correction mechanism 40 is not limited to have the structure shown by Fig. 2. Fig. 10 shows a modified overlap correction mechanism 40'. The overlap correction mechanism 40' is made by bending a guide plate that is a component of the route R. The leading edge of the sheet P2 is hooked by the guide plate, and thereby, an overlap of the sheets P1 and P2 is corrected.

[0059] Although the present invention has been described with reference to the embodiments above, it is to be noted that various changes and modifications are possible to those who are skilled in the art. Such changes and modifications are to be understood as being within the scope of the present invention.

Claims

1. A sheet feeding device that is suited to be used in an image forming apparatus comprising a printing section for printing an image on a sheet;
a first feeder for feeding the sheet at a first speed;
a second feeder for feeding the sheet fed by the first feeder to the printing section at a second speed;
a detector, which is located between the first feeder and the second feeder, for detecting a gap between a first sheet and a second sheet at a plurality of detection points while the first sheet is being fed by the second feeder and the second sheet is being fed by the first feeder; and
a controller for controlling the first feeder or the second feeder,
wherein when the detector detects that there is a gap between the first sheet and the second sheet, the controller controls the first feeder or the second feeder such that the first speed will be higher than the second speed.
2. A sheet feeding device according to claim 1, wherein the controller controls the first feeder or the second feeder such that the gap detected at a more downstream detection point of the plurality of detection points will be smaller than the gap detected at a more upstream detection point of the plurality of detection points.
3. A sheet feeding device according to claim 1 or 2, wherein when the detector detects that there is no gap between the first sheet and the second sheet, the controller controls the first feeder or the second feeder such that the first speed and the second speed will be equal to each other.
4. A sheet feeding device according to one of the preceding claims, wherein when the detector detects at the most upstream detection point that there is no gap between the first sheet and the second sheet, the controller controls the first feeder or the second feeder such that the first speed will be lower than the second speed.
5. A sheet feeding device according to one of the preceding claims,
wherein each of the detection points has a specified length;
wherein the controller calculates the first speed, the second speed and a size of the gap at each of the detection points as follows:

the controller calculates the second speed, based on a time necessary for a trailing edge of the first sheet to complete passing by the detection point and the specified length of the detection point;
the controller calculates the first speed, based on a time necessary for a leading edge of the second sheet to complete passing by the detection point and the specified length of the detection point; and
the controller calculates the size of the gap, based on the specified length of the detection point, the second speed and a time necessary for the gap to complete passing by the detection point; and

wherein the controller controls the first feeder or the second feeder in accordance with the size of the gap to adjust the first speed or the second speed.

5 **6.** A sheet feeding device according to one of the preceding claims, further comprising a corrector for correcting an overlay of the first sheet and the second sheet.

7. A sheet feeding device according to one of the preceding claims, wherein the first speed is fixed.

10 **8.** An image forming apparatus comprising:

 a sheet feeding device according to one the preceding claims.

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FIG. 1

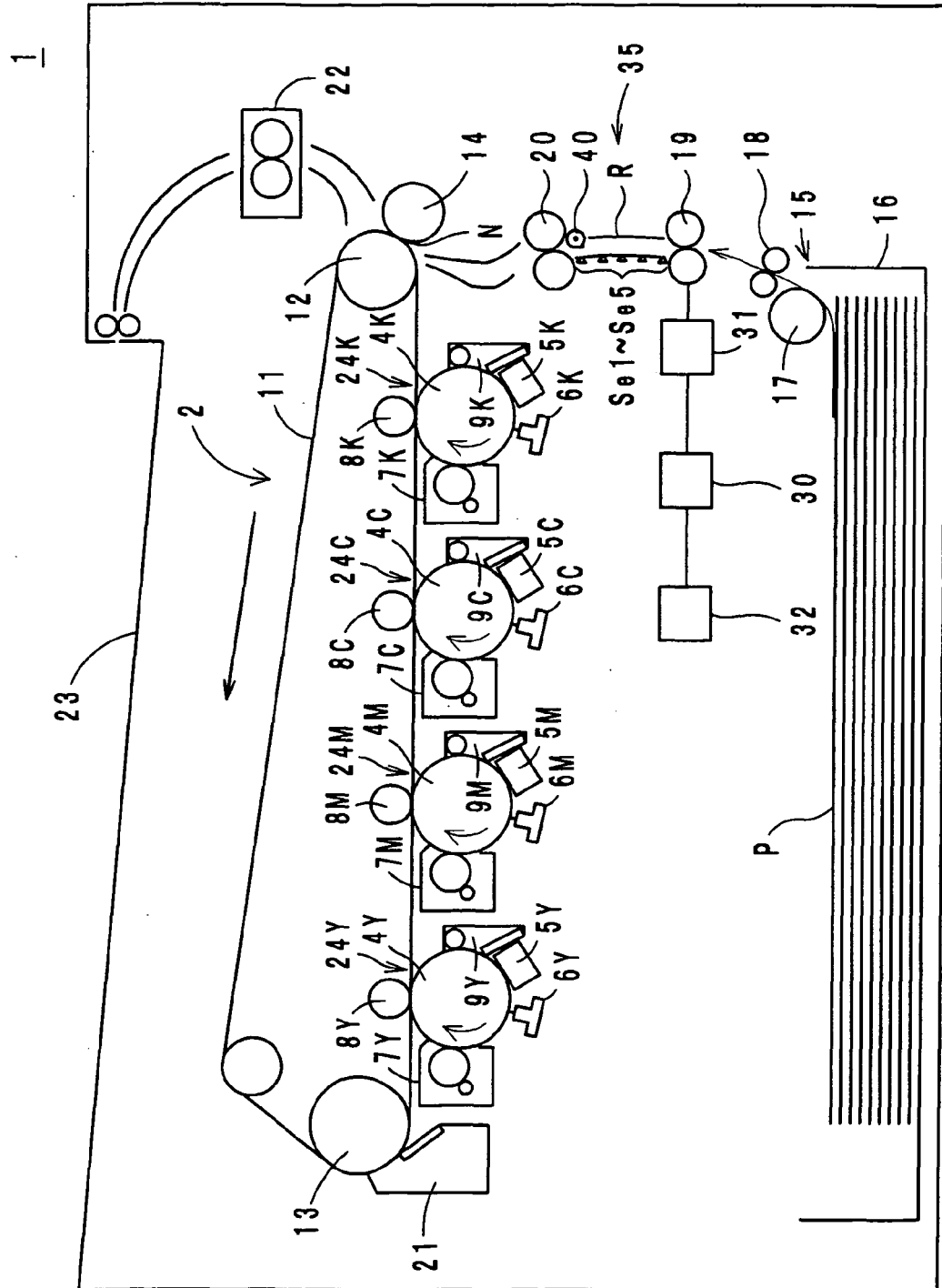
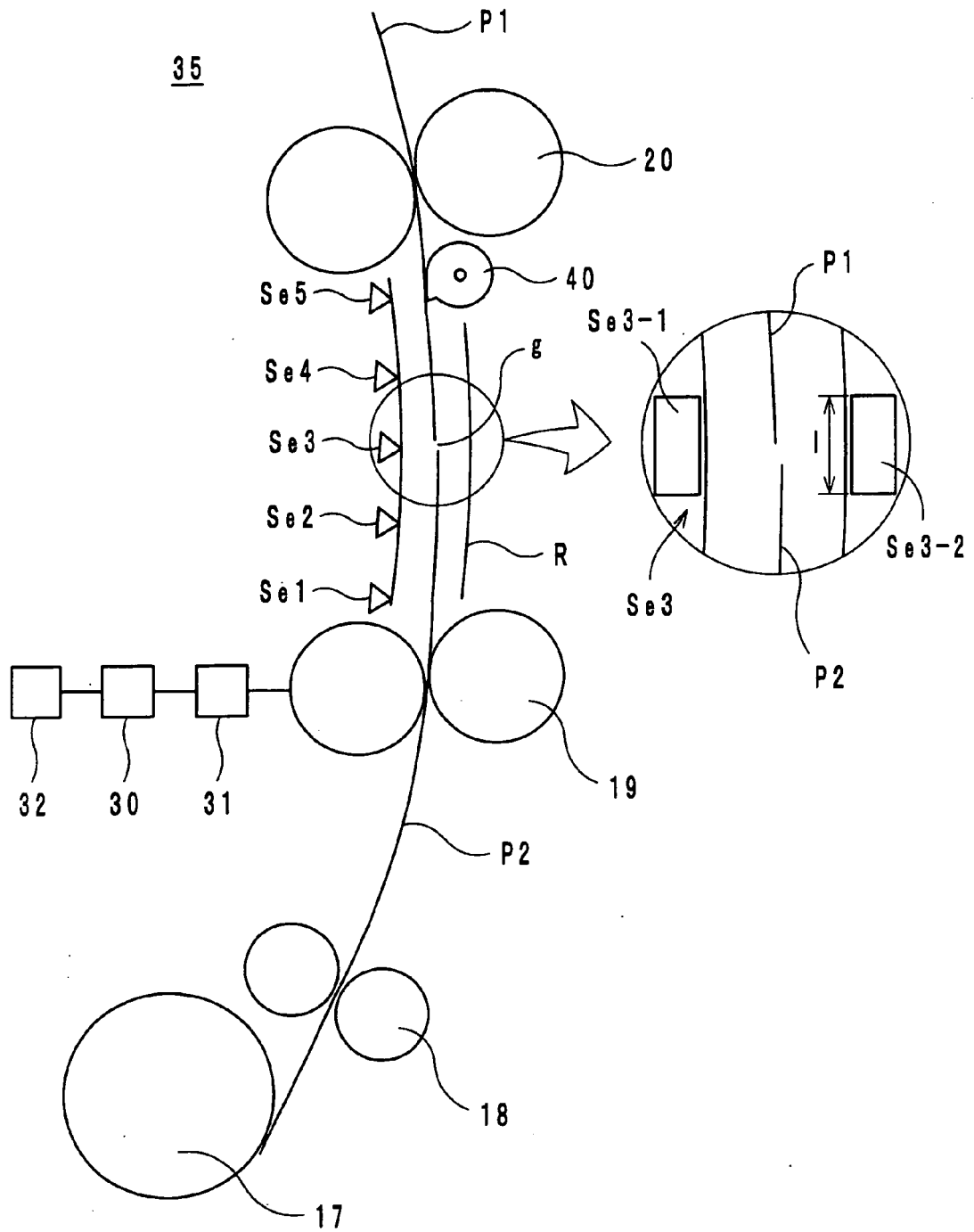
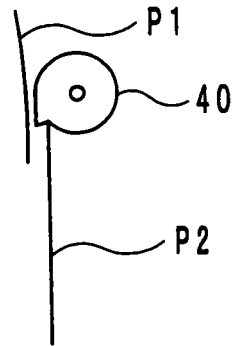


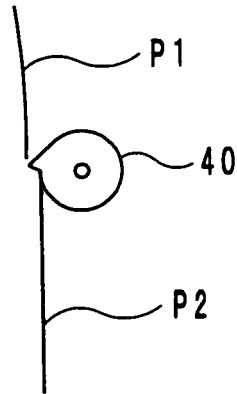
FIG. 2



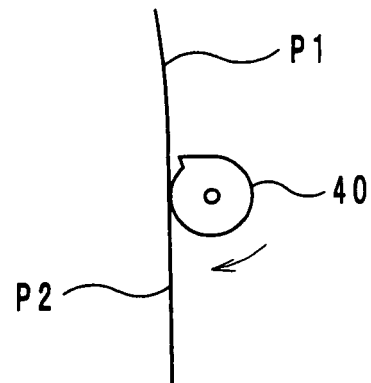
F I G . 3 a



F I G . 3 b



F I G . 3 c



F I G . 4

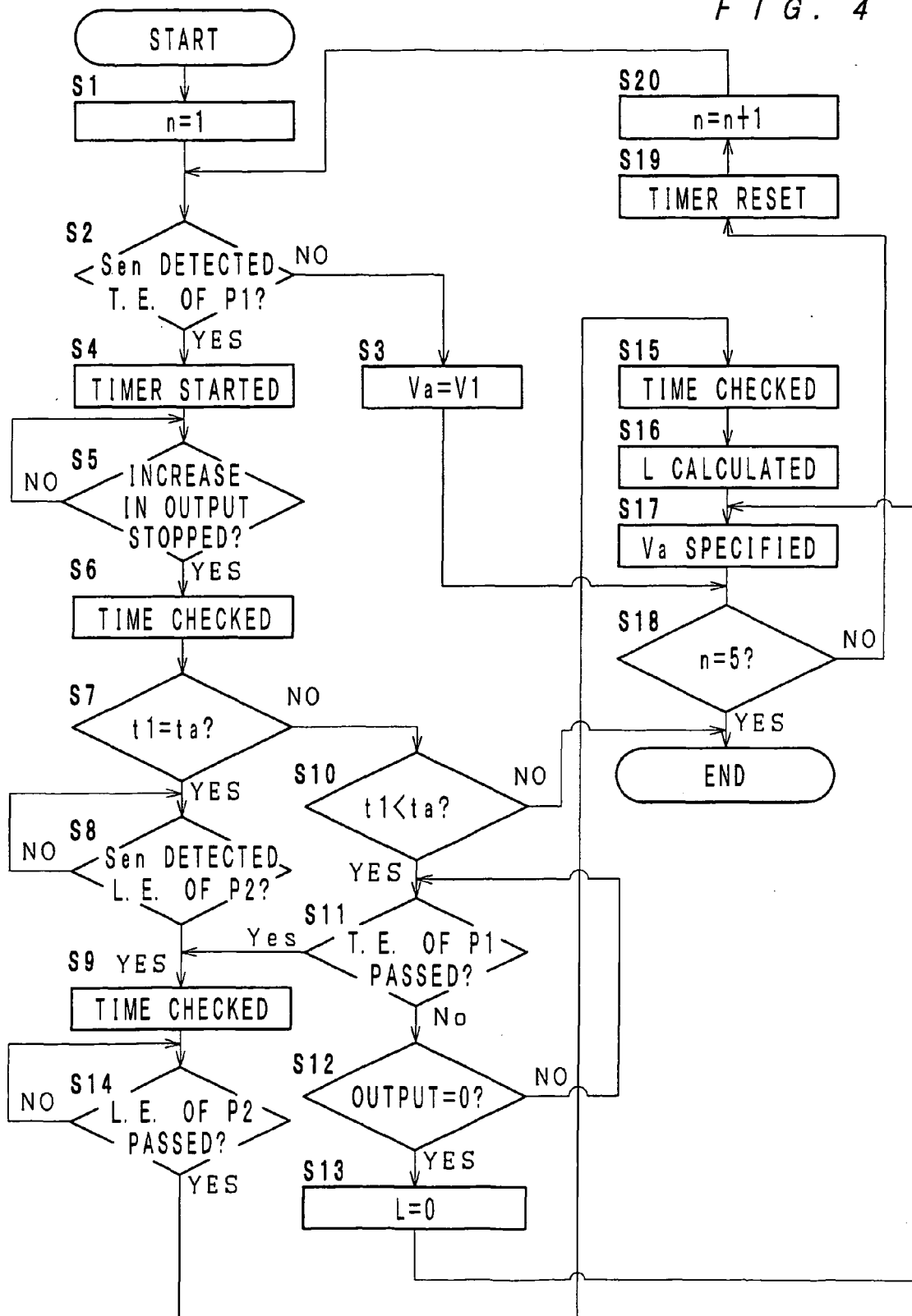
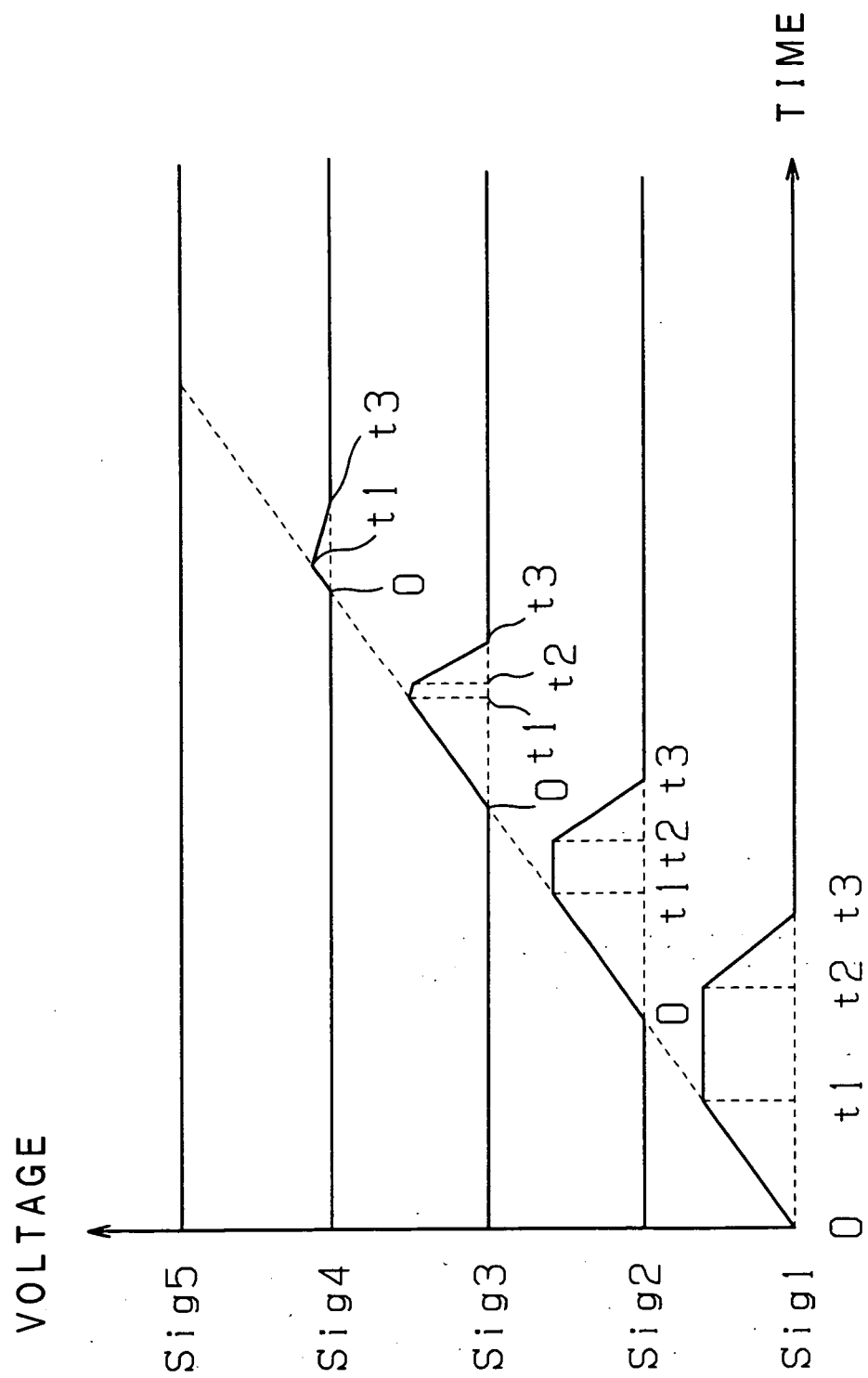
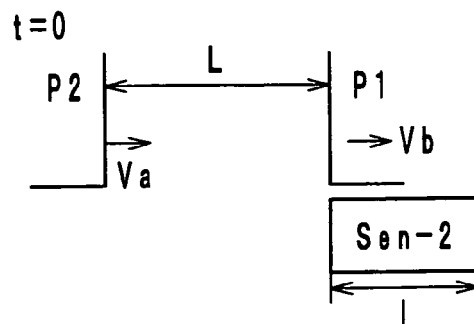


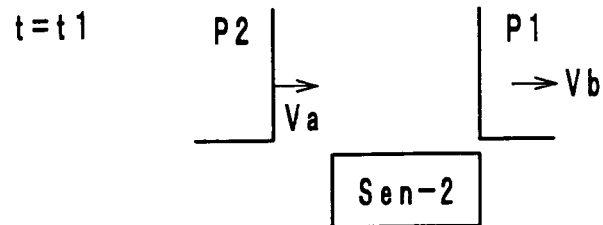
FIG. 5



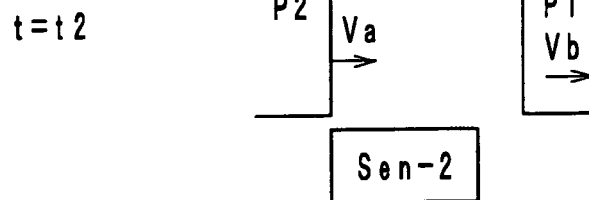
F I G . 6 a



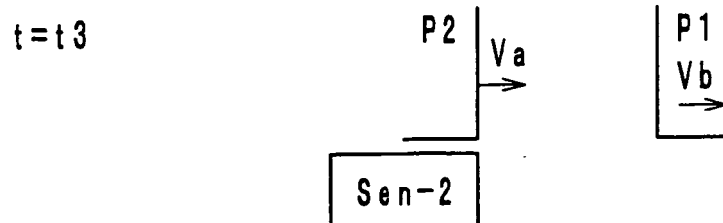
F I G . 6 b



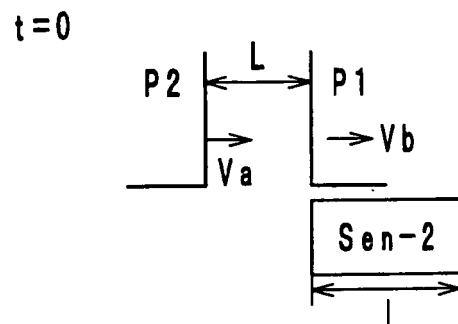
F I G . 6 c



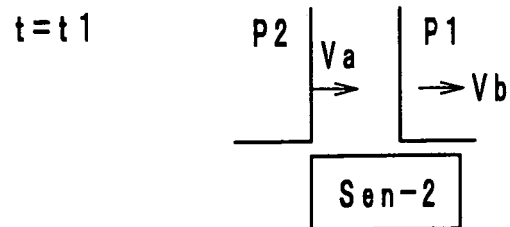
F I G . 6 d



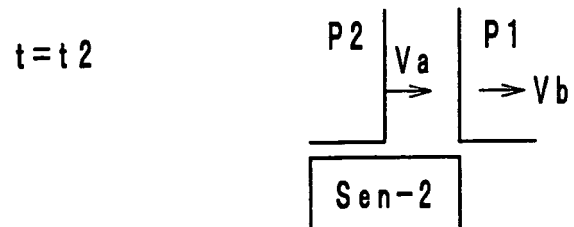
F I G . 7 a



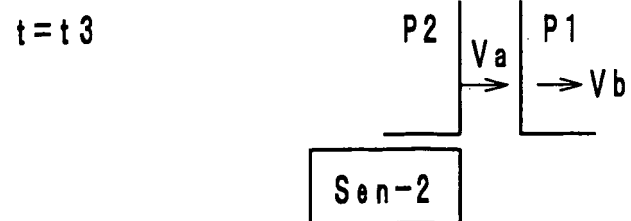
F I G . 7 b



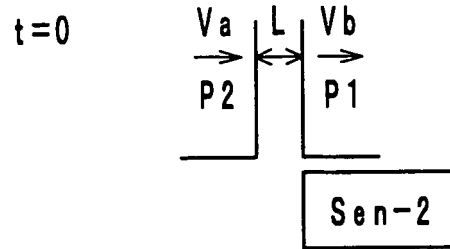
F I G . 7 c



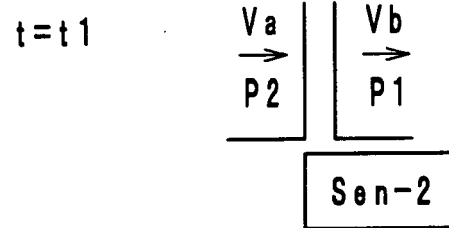
F I G . 7 d



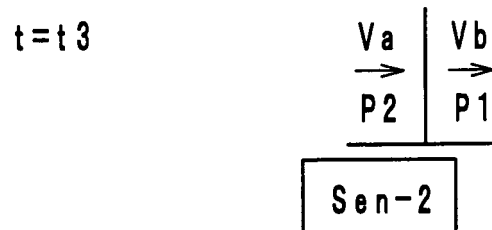
F I G . 8 a



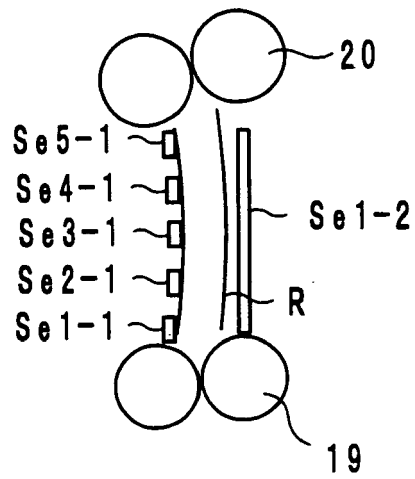
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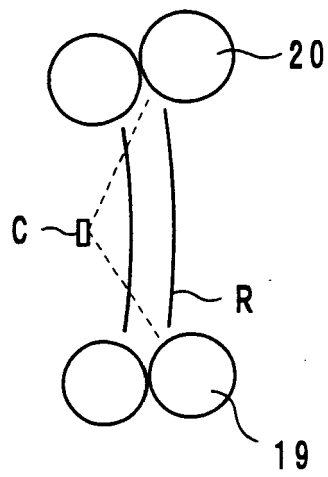
F I G . 8 c



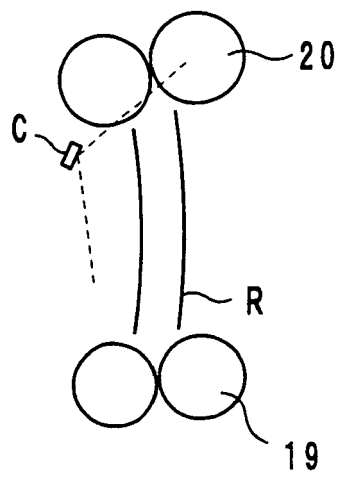
F I G . 9 a



F I G . 9 b

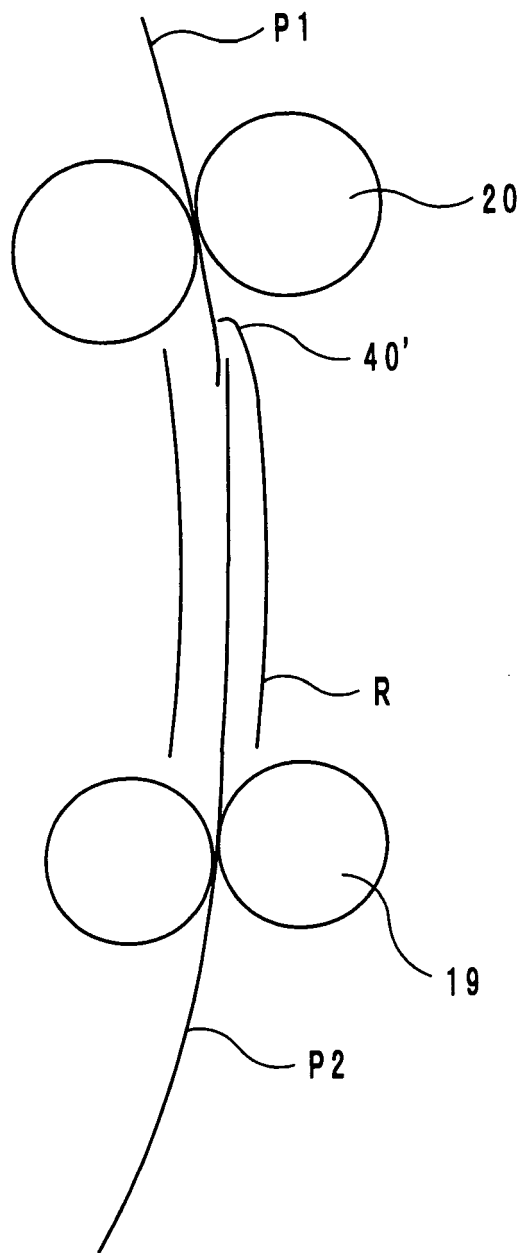


F I G . 9 c



F I G . 1 0

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REFERENCES CITED IN THE DESCRIPTION

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