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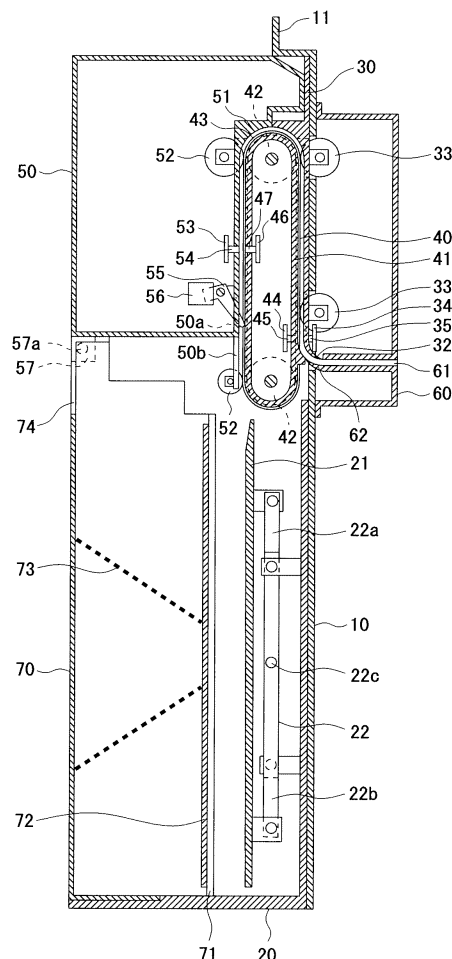
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(54) **Bill validator**

(57) The bill validator detects the intensity of light transmitted through the predetermined detecting lines (L1 and L6) on a transported bill (PM) by a photo acceptance device (45) of a first optical sensor, detects the intensity of light transmitted through the same detecting lines (L1 and L6) stated above on the transported bill (PM) by a photo acceptance device (47) of a second optical sensor, and detects the slippage of the transported bill (PM) by comparing temporal change of the first transmitted light intensity based on detecting signal of the first optical sensor with temporal change of the second transmitted light intensity based on detecting signal of the second optical sensor.

Fig. 1



Description

Background of the invention

Field of the invention

[0001] The present invention relates to a bill validator utilized in a vending machine or the like.

Description of the related art

[0002] A bill validator utilized in a vending machine or the like includes a bill transporting mechanism for transporting a bill inserted into a bill slot along a bill passageway and transport driving means for supplying power to the bill transporting mechanism. The bill transporting mechanism typically has two left and right endless belts and a plurality of rollers contacting both the endless belts. The bill passageway has a boundary face between both the endless belts and the plurality of rollers. The transport driving means has a motor as a power source and provides both the endless belts of the bill transporting mechanism with power for transporting the bill.

[0003] An authentic determination of the bill inserted into the bill slot is performed in a process before the bill reaches a predetermined position. If the bill is authentic, a bill receiving operation starts. If the bill is unauthentic (including the bill which cannot be determined), a bill re-tuning operation starts.

[0004] The bill inserted into the bill slot is transported to a predetermined position with the bill sandwiched between the two left and right endless belts and the plurality of rollers contacting both the endless belts. In general, the endless belts and rollers are made of synthetic rubber or plastic. For this reason, if the surface of the endless belts and rollers are coated with dust or oil, scratched, or deteriorated, or the pressure of the rollers decrease, contact resistance (friction resistance) between the endless belts and the bill and contact resistance (friction resistance) between the rollers and the bill lower to make an actual moving distance of the bill shorter than a rotation amount of the endless belts. So-called slippage of the bill is caused.

[0005] It is difficult to solve the problem of the slippage of a transported bill even if a routine inspection is conducted. For example, if the slippage gradually increases due to dirt on a bill inserted last, a situation may be produced in which all authentic bills are returned at some point in time (or, a situation in which the bill validator cannot be used). It is desirable to quickly detect the slippage of the transported bill to prevent such the situation. If such the detection can be performed, inspection is conducted at an appropriate timing to prevent the situation in which the bill validator cannot be used.

Brief summary of the invention

[0006] An object of the present invention is to provide

a bill validator capable of quickly detecting a slippage of a transported bill.

[0007] To achieve the object, the bill validator of the present invention comprises: a bill transporting mechanism for transporting a bill inserted into a bill slot along a bill passage; transport driving means for providing power for the bill transporting mechanism; a first optical sensor arranged on the side of the bill slot in the bill passage, the first optical sensor for detecting an intensity of light transmitted through predetermined detecting line on a transported bill; a second optical sensor arranged at the back of the first optical sensors in the bill passage, the second optical sensor for detecting an intensity of light transmitted through the same detecting line stated above on the transported bill; and slippage detecting means for detecting a slippage of the transported bill by comparing temporal change of the first transmitted light intensity based on detecting signal of the first optical sensor with temporal change of the second transmitted light intensity based on detecting signal of the second optical sensor.

[0008] This bill validator can detect the intensity of light transmitted through predetermined detecting line on the transported bill by the first optical sensor arranged on the side of the bill slot in the bill passage and the intensity of light transmitted through the same detecting line stated above on the transported bill by the second optical sensor arranged at the back of the first optical sensor in the bill passage, and then can detect the slippage of the transported bill by comparing temporal change of the first transmitted light intensity based on detecting signal of the first optical sensor with temporal change of the second transmitted light intensity based on detecting signal of the second optical sensor by the slippage detecting means. Thus, the slippage of the transported bill can be quickly detected when the slippage is caused, thereby, an inspection can be conducted at an appropriate timing and a situation that the bill validator is rendered unusable can be prevented. Thus, the bill validator capable of quickly detecting the slippage of the transported bill can be provided.

[0009] The above and other objects, features and advantages of the present invention will be apparent by the following description and appended drawings.

Brief description of several views of the drawings

[0010]

FIG. 1 is a vertical section of a bill validator illustrating one embodiment of the present invention;
FIG. 2 is an enlarged view of a principal part in FIG. 1;
FIG. 3 is a cross section taken along the line a-a of FIG. 2;
FIG. 4 is a diagram illustrating a control system related to bill transport and slippage detection;
FIG. 5 is a chart illustrating a program flow related to bill transport;
FIG. 6 is a chart illustrating a program flow related

to slippage detection;

FIG. 7 is a diagram describing an operation for transporting a bill;

FIG. 8 is a diagram illustrating arrangement lines of a first optical sensor and a second optical sensor for a transported bill and detecting lines by the optical sensors;

FIG. 9 is a chart illustrating a temporal change of an intensity of transmitted light based on the first optical sensor and the second optical sensor;

FIG. 10 is a chart illustrating a temporal change of an intensity of transmitted light observed at the time of slippage;

FIG. 11 is a partial modification of the program flow illustrated in FIG. 5; and

FIG. 12 is a partial modification of configuration of the first optical sensor.

Detailed description of the invention

[0011] FIGS. 1 to 10 illustrate one embodiment of the present invention (bill validator). FIG. 1 is a vertical section of a bill validator. FIG. 2 is an enlarged view of a principal part in FIG. 1. FIG. 3 is a cross section taken along the line a-a of FIG. 2. FIG. 4 is a diagram illustrating a control system related to bill transport and slippage detection. FIG. 5 is a chart illustrating a program flow related to bill transport. FIG. 6 is a chart illustrating a program flow related to slippage detection. FIG. 7 is a diagram describing the operation for transporting a bill. FIG. 8 is a diagram illustrating arrangement lines of a first optical sensor and a second optical sensor and detecting lines by the optical sensors. FIG. 9 is a chart illustrating a temporal change of the intensity of transmitted light based on the first optical sensor and the second optical sensor. FIG. 10 is a chart illustrating a temporal change of the intensity of transmitted light observed at the time of slippage. In the description hereinafter, the right side of FIG. 1 is called as the front, the left side is called as the rear, the near side toward you is called as the left and the far side is called as the right.

[0012] With reference to FIGS. 1 to 3, the mechanism of the bill validator will be described.

[0013] The bill validator shown in FIGS. 1 to 3 includes a main frame 10, a base box 20, a front chute 30, a bill transporting unit 40, a rear chute 50, a mask 60 and a bill receiving cassette 70.

[0014] The base box 20 is box shaped and the top and rear face thereof are opened. The front face thereof is fixed to the lower part of rear face of the main frame 10. The base box 20 has a vertically elongated rectangular bill receiving plate 21 for pushing a bill PM (refer to FIG. 7) into the bill receiving cassette 70, a link mechanism 22 for moving the bill receiving plate 21 forward and backward in parallel, a motor 105 (refer to FIG. 4), reception driving means (not shown) with a reduction gear and drive lever, and a pivot hole (not shown) for the rear chute provided at the left and the right side of the upper rear

side so that the center line of the pivot hole faces the left and the right direction.

[0015] The link mechanism 22 has a pair of a left and a right upper link 22a of which upper ends are rotatably coupled to the bill receiving plate 21 and lower ends are rotatably coupled to the base box 20, a pair of a left and a right lower link 22b of which upper ends are rotatably coupled to the base box 20 and lower ends are rotatably coupled to the bill receiving plate 21, and operation shaft 22c common to the upper and the lower link 22a and 22b. The drive lever of the reception driving means is engaged with the operation shaft 22c. The drive lever is moved forward and backward to change the form of the link mechanism 22 to move the bill receiving plate 21 forward and backward in parallel.

[0016] The front chute 30 is substantially rectangular shape. The front face thereof is fixed to the upper part of rear face of the main frame 10. The front chute 30 has an upper curved portion 31 protruding toward the rear side, a lower curved portion 32 protruding toward the front side, four rollers 33 rotatably provided at the upper, lower, left and right sides at spaced intervals such that the parts thereof are exposed to the rear side, a bill transporting unit attaching portion (not shown) and two light emitting devices 35 provided on a substrate 34 disposed on the lower front side such that the parts thereof are exposed to the rear side.

[0017] The two light emitting devices 35 and two photo acceptance devices 45 described later form a first optical sensor (no reference character is provided). The configuration of the first optical sensor will be described in detail later.

[0018] The two right rollers 33 among the four rollers 33 correspond to the upper and the lower position on the front side of the right endless belt 43 of the bill transporting unit 40, and the exposed portions thereof are brought into contact with the endless belt 43. The two left rollers 33 among the four rollers 33 correspond to the upper and the lower position on the front side of the left endless belt 43 of the bill transporting unit 40, and the exposed portions thereof are brought into contact with the endless belt 43.

[0019] The bill transporting unit 40 is substantially rectangular parallelepiped shape and detachably attached to the bill transporting unit attaching portion of the front chute 30. The bill transporting unit 40 has a unit main body 41, pulleys 42 rotatably provided on the upper left and right sides of the unit main body 41, pulleys 42 rotatably provided on the lower left and right sides of the unit main body 41 through the common rotation shaft, two endless belts 43 wound onto the two left pulleys 42 and the two right pulleys 42 to oppose both sides of the bill PM in the width direction thereof, a driven gear (not shown) coaxially coupled to the left lower pulley 42, two photo acceptance devices 45 provided on a substrate 44 disposed on the front side in the unit main body 41 such that the parts thereof are exposed to the front side and the detectors oppose the light emitting devices 35 of the

front chute 30, and six photo acceptance devices 47 provided on a substrate 46 disposed on the rear side in the unit main body 41 such that parts thereof are exposed to the rear side.

[0020] The six photo acceptance devices 47 and six light emitting devices 54 described later form a second optical sensor (no reference character is provided). The configuration of the second optical sensor will be described in detail later.

[0021] The rear chute 50 is substantially rectangular parallelepiped shape. The rear chute 50 has a curved portion 51 protruding toward the front side, four rollers 52 rotatably provided at the upper, lower, left and right sides at spaced intervals such that the parts thereof are exposed to the front side, six light emitting devices 54 provided on a substrate 53 disposed on the front side in the chute such that the parts thereof are exposed to the front side and the light emitting devices oppose the photo acceptance devices 47 of bill transporting unit 40, transport driving means (not shown) including a motor 106 (refer to FIG. 4), a reduction gear and driving gear, two bill detecting levers 55 of which common shaft 55a is rotatably supported on the front side in the rear chute and which are urged counterclockwise by a coil spring (not shown) in FIG. 2 so that the leading edges of the bill detecting levers protrude from vertical slits 50a toward the front to contact the rear face of the unit main body 41, a third optical sensor 56 detecting the movement of the bill detecting levers 55 caused by the passage of the bill, supporting pieces 57 provided on the left and the right side on the rear bottom face of the rear chute and shanks 57a provided on the supporting pieces 57 such that the center lines thereof face the left and the right direction. The rear chute 50 is attached to the base box 20 such that the left and the right shank 57a are rotatably inserted into the left and the right pivot hole of the base box 20 to enable opening and closing by rotating operation with pivotal places as a fulcrum.

[0022] The third optical sensor 56 is provided at the rear side of the one bill detecting lever 55 and includes a light emitting device 56a composed of a light emitting diode and photo acceptance device 56b composed of a photo diode or photo transistor arranged to oppose the light emitting device. When the leading edge of the transported bill PM presses the bill detecting lever 55 against an urging force of the coil spring to move the lever back, the intensity of light incident on the photo acceptance device 56b is changed by the movement (clockwise rotation) of the bill detecting lever 55. A change of the intensity of light is detected by the photo acceptance device 56b and sent to a controller 101 described later through an under-mentioned detector 104.

[0023] The two right rollers 52 among the four rollers 52 correspond to the upper and the lower position on the rear side of the endless belt 43 on the right side of the bill transporting unit 40 and the exposed portions thereof are brought into contact with the endless belt 43. The two left rollers 52 among the four rollers 52 correspond to the

upper and the lower position on the rear side of the endless belt 43 on the left side of the bill transporting unit 40 and the exposed portions thereof are brought into contact with the endless belt 43. As can be seen from FIGS. 1 and 2, the two lower left and right rollers 52 are rotatably provided on protruding pieces 50. The center lines of the rollers 52 are substantially equal in height to those of the two lower left and right pulleys 42. The rollers 52 can sandwich and hold the rear edge of the bill reaching a bill transport position described hereinunder in collaboration with the left and the right endless belt 43.

[0024] The driving gear of the transport driving means is engaged with the driven gear of the bill transporting unit 40 when the rear chute 50 is closed. That is to say, the endless belts 43 of the bill transporting unit 40 are rotated in a predetermined direction based on a rotation force transmitted from the driving gear of the transport driving means to the driven gear of the bill transporting unit 40 to transport the bill.

[0025] The mask 60 is box shaped and the rear side thereof is opened. The rear side thereof is fixed to the front face of the main frame 10. The mask 60 has a bill slot 61 which is long sideways and extends from the front to the rear face and a curved portion 62 protruding from the lower rear end of the bill slot 61 to the rear side.

[0026] The bill receiving cassette 70 is box shaped and the upper and front sides thereof are opened. The bill receiving cassette 70 is detachably fixed to the base box 20. The bill receiving cassette 70 has vertically elongated rails 71 provided on the left and the right side of the front opening of the cassette, a vertically elongated rectangular cassette plate 72 which are arranged on the rear side of both rails 71 and slightly wider than both rails 71, a truncated-cone coil spring 73 urging the cassette plate 72 forward, a hook lever (not shown) for attaching and detaching the bill receiving cassette 70 to and from the base box 20, and a notch 74 used for operating the hook lever from the rear face side.

[0027] In the aforementioned bill validator, when the rear chute 50 is in a closed position, the bill transporting unit 40 is sandwiched front and rear between the front chute 30 and the rear chute 50. An inverse U shaped bill passage BP (refer to FIG. 2) including boundaries between the endless belts 43 and the rollers 33 and 52 in addition to the upper curved portion 31 and the curved portion 51 is formed around the periphery of the bill transporting unit 40. The lower front side of the bill passage BP communicates with the rear end of the bill slot 61 through the curved portion 62.

[0028] A line indicated by reference character RL (hereinafter call as "stop line RL") in FIG. 2 (refer to FIG. 7) denotes the rear edge of the bill PM transported to the bill reception position. In other words, the bill PM transported to the bill reception position stops when the rear edge of the bill PM coincides the stop line RL.

[0029] With reference to FIG. 8, the configuration of the first and the second optical sensor will be described in detail.

[0030] The light emitting devices 35 of the first optical sensor are composed of light emitting diodes or the like. The photo acceptance devices 45 are composed of photo diodes, photo transistors or the like. In addition, the light emitting devices 54 of the second optical sensor are composed of light emitting diodes or the like. The photo acceptance devices 47 are composed of photo diodes, photo transistors or the like.

[0031] FIG. 8 shows a plan view of the transported bill PM. An arrangement line P1 of the first optical sensor and an arrangement line P2 of the second optical sensor are orthogonal to the direction in which the bill is transported. The black dots on the arrangement line P1 show positions where two pairs of light emitting devices and photo acceptance devices (35 and 45) of the first optical sensor are arranged. The black dots on the arrangement line P2 show positions where six pairs of light emitting devices and photo acceptance devices (35 and 45) of the second optical sensor are arranged. The arrangement lines P1 and P2 are apart by a distance D in the direction in which the bill PM is transported.

lines L1 to L6 in FIG. 8 are detecting lines of the transported bill PM by six pairs of light emitting devices and photo acceptance devices (54 and 47). The detecting lines L1 to L6 are parallel with the direction in which the bill PM is transported. That is to say, the photo acceptance devices 47 of the second optical sensor detect the intensities of light transmitted through the detecting lines L1 to L6 on the transported bill PM respectively. The detecting signal of the photo acceptance devices 47 of the second optical sensor are sent to the controller 101 through the detector 104.

[0032] As can be seen from FIGS. 8 and 3, two pairs of light emitting devices and photo acceptance devices (35 and 45) of the first optical sensor are arranged at intersections between the detecting lines L1 and L6 which are leftmost and rightmost in the six detecting lines L1 to L6 and the arrangement line P1 respectively. That is to say, the photo acceptance devices 45 of the first optical sensor detect the intensity of light transmitted through the detecting lines L1 to L6 on the transported bill PM. The detecting signal of the photo acceptance devices 45 of the first optical sensor are sent to the controller 101 through the detector 104.

[0033] With reference to FIG. 4, a control system related to bill transport and slippage detection in the bill validator will be described.

[0034] The control system illustrated in FIG. 4 includes a controller 101 incorporating a micro computer therein, a light emission driver 102 sending drive signal to the light emitting devices 35 of the first optical sensor, the light emitting devices 54 of the second optical sensor and the light emitting device 56a of the third optical sensor 56 based on the control signal from the controller 101, a motor driver 103 sending drive signal to the motor 105 of the reception driving means of the base box 20 and the motor 106 of the transport driving means of the rear chute 50 and a detector 104 converting the detecting

signal of the photo acceptance devices 45 of the first optical sensor, the photo acceptance devices 47 of the second optical sensor and the photo acceptance device 57b of the third optical sensor 56 into signal which can be processed by the control system 101 and sending them to the control system 101.

[0035] The memory (not shown) of the controller 101 stores a program (refer to FIG. 5) related to bill transport, data required for controlling bill transport, a program (refer to FIG. 6) related to slippage detection and data required for controlling slippage detection. The controller 101 sends a control signal to the light emission driver 102, performs a predetermined bill transport based on the signal input from the detector 104 according to the program related to bill transport and conducts a predetermined slippage detection based on the signal input from the detector 104 according to the program related to slippage detection.

[0036] With reference to FIG. 5 and FIGS. 7 to 9, operation related to bill transport of the bill validator, more specifically, operation for the case where the bill validator is used in a vending machine, will be described below.

[0037] As indicated by a dotted line in FIG. 7, when the bill PM is inserted into the bill slot 61 and the leading edge of the bill PM reaches the arrangement line P1 in FIG. 8, the intensities of light incident on the photo acceptance devices 45 of the first optical sensor decrease, and an insertion of the bill PM is determined based on decrease in the intensity of light (refer to step SS1 in FIG. 5).

[0038] If the insertion of the bill PM is determined, the motor 106 of the transport driving means of the rear chute 50 starts rotating to cause the endless belts 43 of the bill transporting unit 40 to start rotating to begin transporting the inserted bill PM (refer to step SS2 in FIG. 5).

[0039] After the bill PM has started to be transported, the photo acceptance devices 45 of the first optical sensor detect the intensities of light transmitted through the detecting lines L1 and L6 on transported bill PM and temporal change of intensities of transmitted light based on detecting signal are stored in the memory of the controller 101 (refer to step SS3 in FIG. 5). After the leading edge of the transported bill PM has reached the arrangement line P2 in FIG. 8, the photo acceptance devices 47 of the second optical sensor detect the intensities of light transmitted through the detecting lines L1 to L6 on transported bill PM and temporal change of the intensities of transmitted light based on detecting signal are stored in the memory of the controller 101 (refer to step SS4 in FIG. 5).

[0040] FIG. 9 illustrates temporal change of a first transmitted light intensity based on detecting signal of photo acceptance devices 45 of the first optical sensor corresponding to the detecting lines L1 and L6 and temporal change of a second transmitted light intensity based on detecting signal of photo acceptance devices 47 of the second optical sensor corresponding to the detecting lines L1 and L6. In FIG. 9, reference character "ta" denotes a time in a part corresponding to the length of the

bill in temporal change of the first transmitted light intensity, "tb" denotes a time in a part corresponding to the length of the bill in temporal change of the second transmitted light intensity and "tc" denotes a time difference between starting points of the times ta and tb.

[0041] Immediately before the bill PM reaches the bill reception position (position where the rear edge of the bill PM coincides with the stop line RL in FIG. 7), a determination is made as to whether the bill is authentic based on the part corresponding to the length of the bill in temporal change of the second transmitted light intensity based on detecting signal of photo acceptance devices 47 of the second optical sensor. Then, if the bill is authentic, the denomination of the bill (or, 1000-, 2000-, 5000- and 10000-yen note) is identified (refer to step SS5 in FIG. 5). If the inserted bill is determined to be authentic, data expressing not only authentication but denomination are sent from the controller 101 to other devices.

[0042] When the bill PM reaches the bill reception position, bill transport is stopped (refer to step SS6 in FIG. 5). This means that a single continuous transport causes the bill PM inserted into the bill slot 61 to reach the bill reception position. The bill PM inserted into the bill slot 61 is held with the rear edge thereof sandwiched between the two lower left and right rollers 52 and the left and the right endless belt 43, so that the bill reached the bill reception position neither drops downward from the position nor swings left and right.

[0043] In the following is described a method of stopping bill transport when the bill PM reaches the bill reception position.

[0044] When the leading edge of the bill PM being transported reaches the leading-edge position of the bill detecting levers 55 to press the bill detecting lever 55 against a urging force of the coil spring to move it back, the intensity of light incident on the photo acceptance device 56b is changed by the movement (clockwise rotation) of the bill detecting lever 55. Change in the intensity of light is detected by the photo sensor 56b. The drive signal sent to the motor 106 of the transport driving means of the rear chute 50 can be timed from this detection point of time and the authentication and denomination determination are finished before the rear edge of the bill PM approaches the stop line RL, so that if the motor 106 of the transport driving means is stopped when the timed value reaches a target time obtained by dividing the length of the bill PM whose denomination is determined by the quantity of bill transport per unit time, bill transport can be stopped at a position where the rear edge of the bill coincides with the stop line RL irrespective of the denomination of the bill PM.

[0045] When it is determined that the bill is authentic and a predetermined product purchasing operation is conducted in the vending machine, the motor 105 of the reception driving means of the base box 20 starts rotating to change the form of the link mechanism 22 to move the bill receiving plate 21 toward the left in parallel as indicated by a dotted arrow line in FIG. 7, and the bill existing

in the bill reception position moves leftward along with the bill receiving plate 21 and is squeezed into the bill receiving cassette 70 with the cassette plate 72 pressed against urging force of the coil spring 73 and moved back.

After that, the motor 105 of the reception driving means rotates, the link mechanism 22 and the bill receiving plate 21 are reset to an original position to complete a series of bill reception operation (refer to step SS7 to SS9 in FIG. 5). In the process where the bill PM moves leftward along with the bill receiving plate 21 and is squeezed into bill receiving cassette 70, the rear edge of the bill PM is pulled out of between the two lower left and right rollers 52 and the left and right endless belts 43 and restored with the rear edge curved over the two lower left and right rollers 52 and the portions on both sides are restored with the portions curved over the left and right rails 71.

[0046] On the other hand, if the bill is determined to be unauthentic (including the bill which cannot be determined), or if it is determined that a predetermined product purchasing operation is not conducted in the vending machine although the bill is determined to be authentic, the motor 106 of the transport driving means of the rear chute 50 is reversely rotated to reversely rotate the endless belt 43 of the bill transporting unit 40, the bill PM existing in the bill reception position is transported to the bill slot 61 to be returned (refer to step SS7, SS8 and SS10 in FIG. 5). The quantity of bill transport at the point of returning the bill PM is controlled by the timed value of drive signal supplied to the motor 106.

[0047] With reference to FIG. 6 and FIGS. 8 to 10, operation related to slippage detection in the bill validator will be described.

[0048] Unless the transported bill PM is slipped, the times "ta" and "tb" and the waveforms in parts corresponding to the length of the bill are equal to each other in temporal change of the first transmitted light intensity (the upper signal in FIG. 9) based on detecting signal of photo acceptance devices 45 of the first optical sensor corresponding to the detecting lines L1 and L6 in FIG. 8 and in temporal change of the second transmitted light intensity (the lower signal in FIG. 9) based on detecting signal of photo acceptance devices 47 of the second optical sensor corresponding to the detecting lines L1 and L6, although there is the time difference "tc." Accordingly, a comparison between temporal change of the first transmitted light intensity based on detecting signal of the first optical sensor and temporal change of the second transmitted light intensity based on detecting signal of the second optical sensor enables determining as to whether the bill PM is slipped at the transport process (refer to step ST1 in FIG. 6).

[0049] For example, the time difference "tc" in FIG. 9 is constant based on the distance D and the transport speed of the bill PM in FIG. 8, so that the difference will be unchanged unless the transported bill PM is slipped. If the transported bill PM is slipped, a time difference "tc1" between a starting point in a part corresponding to the length of the bill in temporal change of the first transmitted

light intensity (the upper signal in FIG. 10) and a starting point in a part corresponding to the length of the bill in temporal change of the second transmitted light intensity (the lower signal in FIG. 10) is larger than the time difference "tc" (a reference time difference). Accordingly, if the time difference "tc1" is larger than the reference time difference "tc," the slippage of the bill PM can be detected. The time difference to be compared does not always need to be a time difference between the starting points, but may be a time difference between the same points in parts corresponding to the length of the transported bill in temporal change of the first and the second transmitted light intensity. This allows detecting the slippage by comparing the time difference between the same points with the reference time difference.

[0050] The time "ta" and the time "tb" in FIG. 9 are constant based on the transport speed of the bill PM. The time values are therefore equal to each other unless the bill PM is not slipped. If the bill PM is slipped, a time "ta1" in a part corresponding to the length of the bill in temporal change of the first transmitted light intensity (the upper signal in FIG. 10) does not coincide with a time "tb1" in a part corresponding to the length of the bill in temporal change of the second transmitted light intensity (the lower signal in FIG. 10). Accordingly, if the time "ta1" does not coincide with the time "tb1," the slippage of the transported bill can be detected. Comparing the reference time without the slippage with the times in parts corresponding to the length of the bill in temporal change of the first and the second transmitted light intensity enables detecting the slippage without comparing the time "ta1" with the time "tb1."

[0051] The slippage of the transported bill PM can be accurately detected by only either one of the detection methods described above, but more accurately detected by using both the methods.

[0052] If it is determined that the transported bill PM is slipped, then a quantity of the slippage is calculated on the basis of temporal change of the first transmitted light intensity (the upper signal in FIG. 10) based on detecting signal of photo acceptance devices 45 of the first optical sensor corresponding to the detecting lines L1 and L6 in FIG. 8 and temporal change of the second transmitted light intensity (the lower signal in FIG. 10) based on detecting signal of photo acceptance devices 47 of the second optical sensor corresponding to the detecting lines L1 and L6 (refer to steps ST2 and ST3 in FIG. 6). A quantity of the slippage can be obtained from a variation in the foregoing time difference "tc1", the difference between the times "ta1" and "tb1" or the like. Time or distance obtained based on the time may be used as unit.

[0053] The quantity of the slippage is compared with a predetermined lower limit SA1 and a predetermined upper limit SA2 higher than the lower limit (refer to steps ST4 and ST5 in FIG. 6).

[0054] If the quantity of the slippage is less than the lower limit SA1, that is, when the slippage is not caused, or when the slippage is caused, however, such a situation

is not anticipated that all authentic bills are returned (or, a situation where the bill validator cannot be used), process proceeds to step ST1.

[0055] If the quantity of the slippage is not less than the lower limit SA1 and less than the upper limit SA2, that is to say, if a probability that all authentic bills are returned (or, a situation where the bill validator cannot be used) is low, a measure is taken to reduce the transport speed of the bill PM lower than an initial speed, for example, to reduce the speed to 70% of the initial speed (refer to step ST6 in FIG. 6). The slippage of the transported bill PM is not always attributed only to transport speed, however, reducing the transport speed lower than the initial speed can sufficiently suppress the slippage less than the lower limit SA1, as the case may be, the slippage can be completely eliminated.

[0056] If the quantity of the slippage is not less than the upper limit SA2, that is to say, if a probability that all authentic bills are returned (or, a situation where the bill validator cannot be used) is high, data indicating an abnormality of transport is output from the controller 101 to other devices such as an abnormality alarm to urge inspection or the like (refer to step ST7 in FIG. 6).

[0057] Thus, according to the above bill validator, the intensity of light transmitted through the predetermined detecting lines L1 and L6 on the transported bill PM is detected by the photo acceptance devices 45 of the first optical sensor and the intensity of light transmitted through the same detecting lines L1 and L6 on the transported bill PM is detected by the photo acceptance devices 47 of the second optical sensor, and then the slippage of the transported bill PM is detected by comparing temporal change of the first transmitted light intensity based on detecting signal of the first optical sensor with temporal change of the second transmitted light intensity based on detecting signal of the second optical sensor. Thus, the slippage of the transported bill PM can be quickly detected when the slippage is caused, thereby, an inspection can be conducted at an appropriate timing and a situation that the bill validator is rendered unusable can be prevented.

[0058] According to the above bill validator, the slippage is accurately detected based on the difference between the time difference and the reference time difference between the same points in a part corresponding to the length of the bill in temporal change of the first transmitted light intensity and in a part corresponding to the length of the bill in temporal change of the second transmitted light intensity, and/or based on the difference between the time in a part corresponding to the length of the bill in temporal change of the first transmitted light intensity and the time in a part corresponding to the length of the bill in temporal change of the second transmitted light intensity, thereby, the slippage of the transported bill PM can be accurately detected by a simple process.

[0059] Furthermore, according to the above bill validator, when the slippage of the transported bill PM is detected, the quantity of the slippage is calculated based

on temporal change of the first transmitted light intensity and temporal change of the second transmitted light intensity, then when the quantity of the slippage is not less than the predetermined lower limit SA1 and less than the predetermined upper limit SA2, the transport speed is reduced lower than the initial speed to enable sufficiently suppressing the slippage less than the lower limit SA1, thereby, the slippage can be completely eliminated, in some cases the slippage can be completely eliminated. Moreover, if the quantity of the slippage is not less than the predetermined upper limit SA2, data indicating the abnormality in transport is output, so that an inspection can be conducted at an appropriate timing and a situation that the bill validator is rendered unusable can be accurately prevented.

[0060] Furthermore, the first optical sensor plays a role as "a sensor obtaining a signal determining whether a bill is inserted" and the second sensor plays a role as "a sensor obtaining a signal determining whether a bill is authentic", thereby, the cost of the bill validator can be reduced and the size of the bill validator can be downsized as compared with the case where the slippage detecting sensor is separately provided in addition to the above sensors.

[0061] In the above bill validator, even if the bill inserted into the bill slot 61 is unauthentic, this bill is captured into the bill reception position and then returned. If it is provisionally determined whether the bill PM is authentic using temporal change of the first transmitted light intensity based on detecting signal of the first optical sensor, the bill PM determined to be unauthentic by this provisional determination can be quickly returned without captured into the bill reception position.

[0062] FIG. 11 illustrates a program flow for the transport of a bill stated above. The difference of this flow from that in FIG. 5 is that steps SS11 and SS12 are provided between steps SS3 and SS4.

[0063] The step SS11 in which a determination is made whether a bill PM is authentic based on a part corresponding to the length of a bill in temporal change of the first transmitted light intensity based on the detecting signal of the photo acceptance devices 45 of the first optical sensor; and the step SS12 in which the process proceeds to step SS10 if the bill PM is unauthentic (including the bill which cannot be determined) as a result of determination at the step SS11.

[0064] The use of the flow enables quickly returning the bill determined to be unauthentic by the provisional authentication determination without captured into the bill reception position to permit shortening time required for returning the bill. In addition, the authenticating determination is made again at the step SS5 to increase a determination accuracy.

[0065] Furthermore, in the above bill validator, though the first optical sensor is composed of a plurality of light emitting devices and photo acceptance devices arranged opposite to each other through the bill passage BP in the foregoing bill validator, as illustrated in FIG. 12, the light

emitting device 35 is provided on the substrate 44 of the bill transporting unit 40 such that the part thereof is exposed backward and an optical transmission device 36 transmitting light from the light emitting device 35 to photo acceptance devices 45 on the substrate 44 is provided on the side of the front chute 30, thereby simplifying works for installing and wiring the light emitting device 35 related to the first optical sensor and reducing the cost.

[0066] The light emitting device 35 is made of transparent plastic or transparent glass and includes three ports 36a, two optical transmission portions 36b connecting a central port 36a with a left and right ports 36a, a first light reflecting portion 36c provided between the central port 36a and two optical transmission portions 36b and second light reflecting portions 36d provided between the left and right ports 36a and the two optical transmission portions 36b. The optical transmission device 36 is fixed to the front chute 30 such that the ports 36a are inserted into holes provided on the front chute 30 and corresponding to the ports. The end faces of the ports 36a are exposed backward. The ports 36a are linearly arranged at spaced intervals in the direction orthogonal to a bill transport direction. Light from the light emitting device 35 is incident on the central port 36a of the optical transmission device 36 through the bill passage BP. The incident light is separated by the two first light reflecting portions 36c and transmitted by the optical transmission portions 36b. The transmitted lights are guided to the left and the right port 36a by the two left and right second light reflecting portions 36d. The transmitted lights are emitted from the left and the right ports 36a and incident on the photo acceptance devices 45 through the bill passage BP.

[0067] The optical transmission device similar to the above may be applied to the second optical sensor. The light emitting devices 54 are provided on the substrate 46 of the bill transporting unit 40 such that the parts of thereof are exposed backward and the optical transmission device transmitting light from the light emitting devices 54 to the photo acceptance devices 47 on the substrate 46 is provided on the side of the rear chute 50, thereby simplifying works for installing and wiring the light emitting device 54 related to the second optical sensor and reducing the cost as is the case with the abovementioned.

[0068] Furthermore, though the aforementioned bill validator uses two photo acceptance devices 45 as the first optical sensor and six photo acceptance devices 47 as the second optical sensor, the number of the photo acceptance devices forming their respective optical sensors may be adjusted. Only if at least one photo acceptance device of each of the first and the second optical sensor is arranged to detect light transmitted through the same detecting line on the bill PM, the same effect described above can be obtained.

[0069] The embodiments stated in the present specification are merely for the purpose of presenting examples and are not restrictive. The scope of the present

invention is defined in the appended claims. All the modifications that fall under the meaning of the claims are encompassed by the present invention.

Claims

1. A bill validator, comprising:

a bill transporting mechanism for transporting a bill (PM) inserted into a bill slot (61) along a bill passage (BP);
 transport driving means for providing power for the bill transporting mechanism;
 a first optical sensor (35, 45) arranged on the side of the bill slot in the bill passage (BP), the first optical sensor (35, 45) for detecting an intensity of light transmitted through predetermined detecting line (L1, , L6) on a transported bill (PM) ;
 a second optical sensor (54, 47) arranged at the back of the first optical sensor in the bill passage, the second optical sensor (54, 47) for detecting an intensity of light transmitted through the same detecting line stated above on the transported bill (PM); and
 slippage detecting means (101) for detecting a slippage of the transported bill (PM) by comparing temporal change of the first transmitted light intensity based on detecting signal of the first optical sensor with temporal change of the second transmitted light intensity based on detecting signal of the second optical sensor.

2. The bill validator according to claim 1, wherein:

slippage detecting means (101) detects the slippage based on a difference between a time difference between the same points in a part corresponding to the length of the bill in temporal change of the first transmitted light intensity and in a part corresponding to the length of the bill in temporal change of the second transmitted light intensity and a reference time difference.

3. The bill validator according to claim 1 or 2, wherein:

slippage detecting means (101) detects the slippage based on a difference between a time in a part corresponding to the length of the bill in temporal change of the first transmitted light intensity and a time in a part corresponding to the length of the bill in temporal change of the second transmitted light intensity.

4. The bill validator according to claim 1, further comprising:

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slippage calculating means for calculating a quantity of the slippage based on temporal change of the first transmitted light intensity and temporal change of the second transmitted light intensity when the slippage of the transported bill (PM) is detected; and
 speed reducing means for reducing a transport speed to less than an initial speed when the slippage is not less than a predetermined lower limit and less than a predetermined upper limit.

5. The bill validator according to claim 4, further comprising:

abnormality determining means for outputting data expressing abnormality in transport when the slippage is not less than the predetermined upper limit.

6. The bill validator according to claim 1, further comprising:

insertion detecting means for detecting the insertion of the bill based on change of the transmitted light intensity at a starting point in a part corresponding to the length of the bill in temporal change of the first transmitted light intensity.

7. The bill validator according to claim 1, further comprising:

authentication determining means for determining whether an inserted bill is authentic based on change of the transmitted light intensity in a part corresponding to the length of the bill in temporal change of the second transmitted light intensity.

8. The bill validator according to claim 7, further comprising:

provisional authentication determining means for determining whether the inserted bill is authentic based on change of the transmitted light intensity in a part corresponding to the length of the bill in temporal change of the first transmitted light intensity.

9. The bill validator according to any one of claims 1 to 8, wherein:

the first optical sensor has at least one photo acceptance device detecting the intensity of the transmitted light and the second optical sensor has a plurality of photo acceptance devices detecting the intensity of the transmitted light, and at least one photo acceptance device among the plurality of photo acceptance devices of the

second optical sensor and at least one photo acceptance device of the first optical sensor are arranged to enable detecting the intensity of the light transmitted through the same detecting line on the transported bill (PM).

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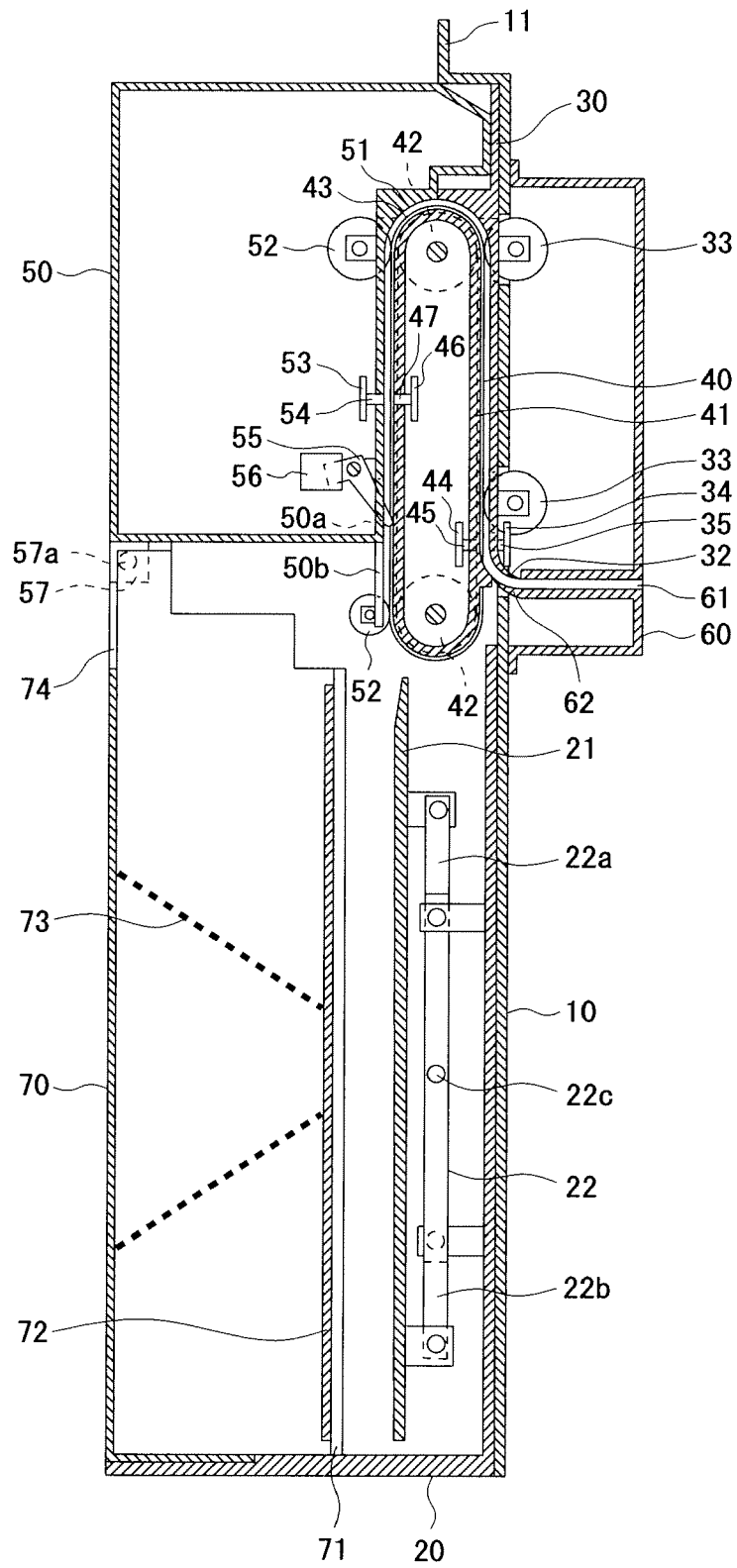
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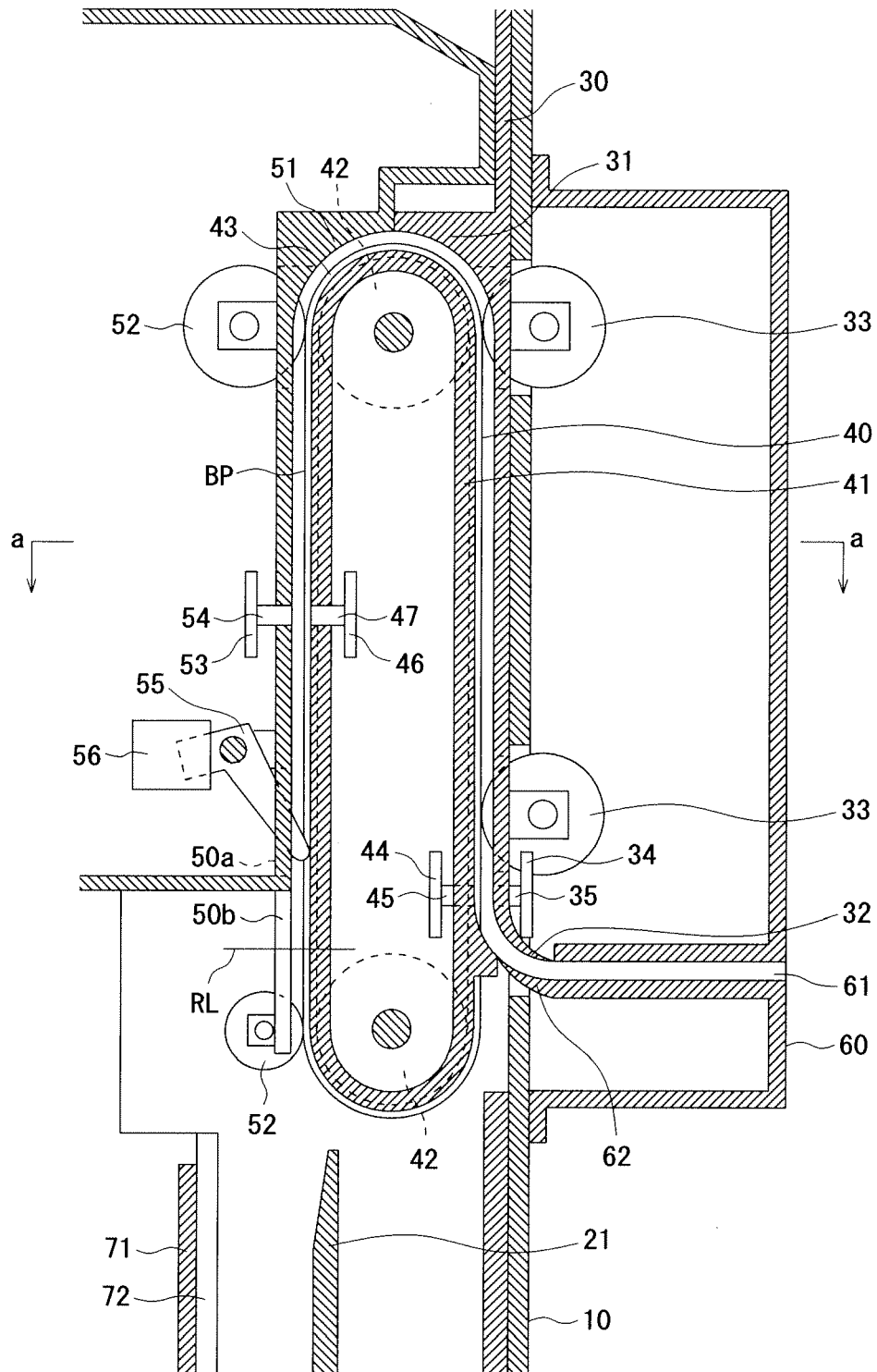
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Fig. 1



F i g . 2



F i g . 3

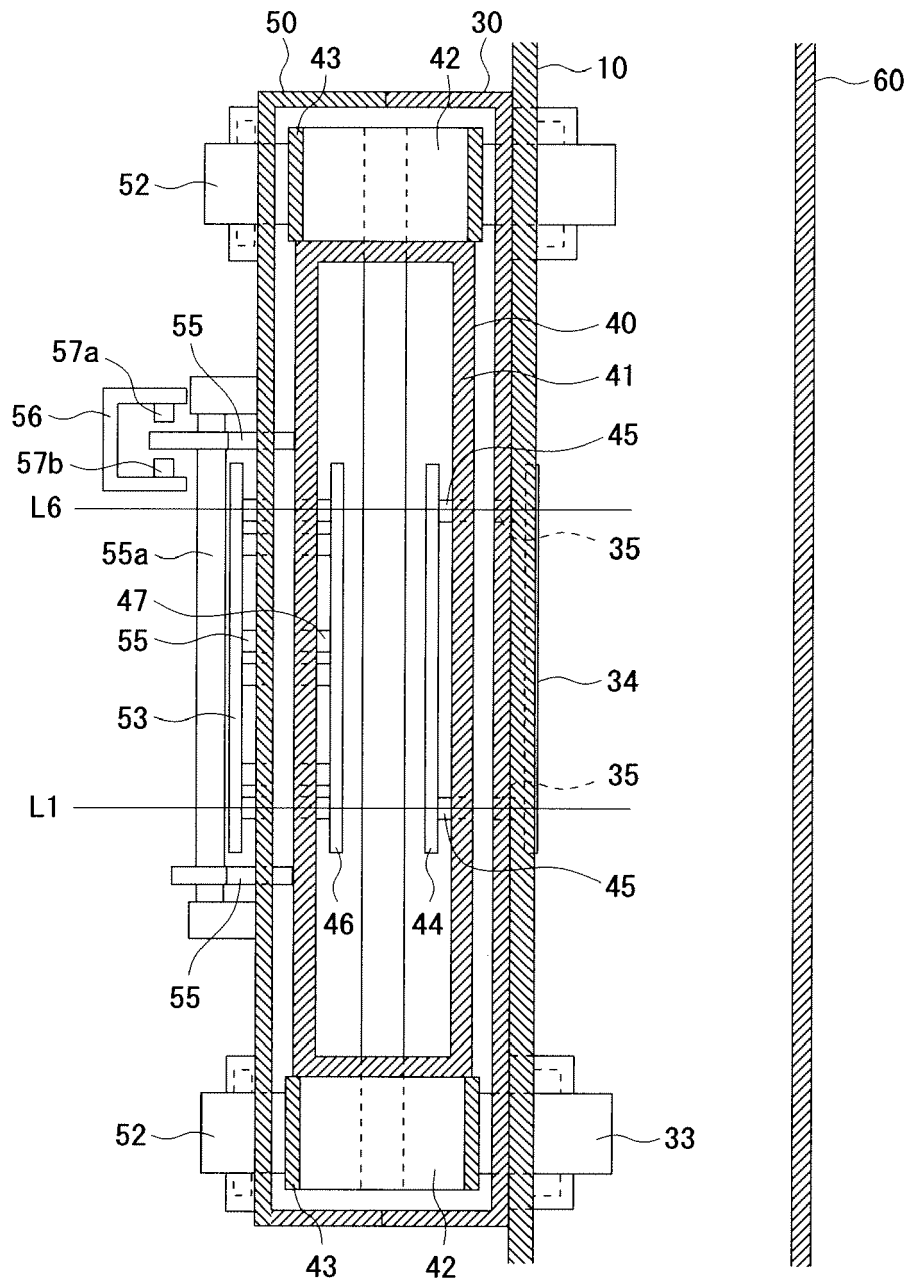
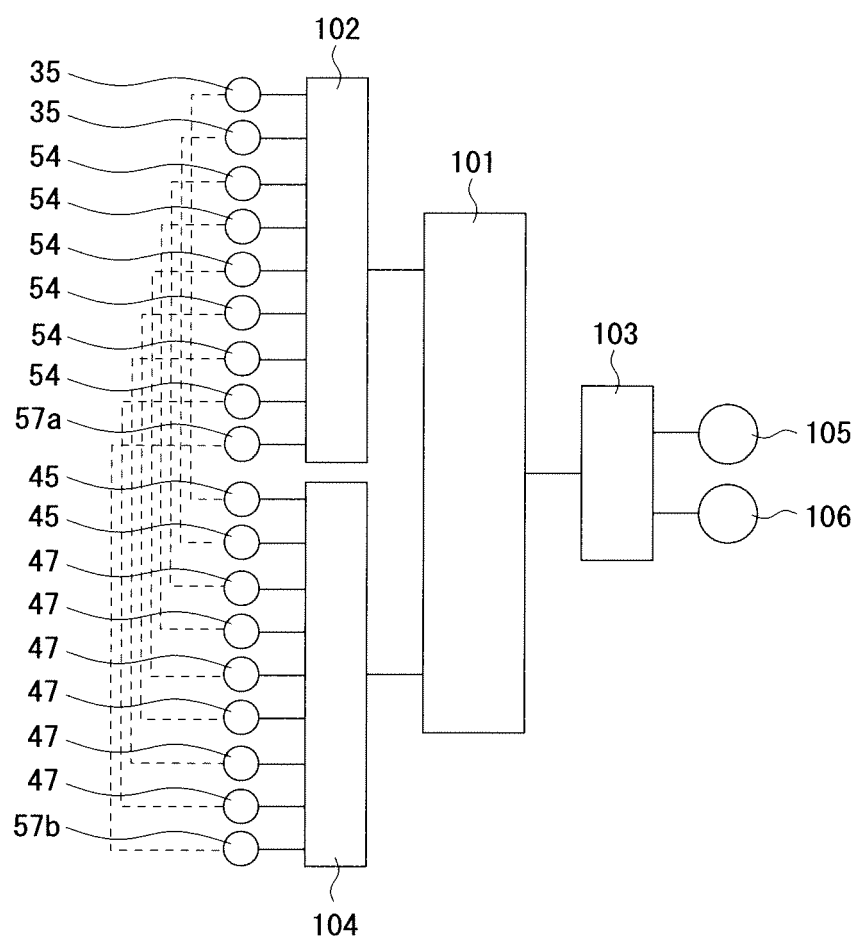
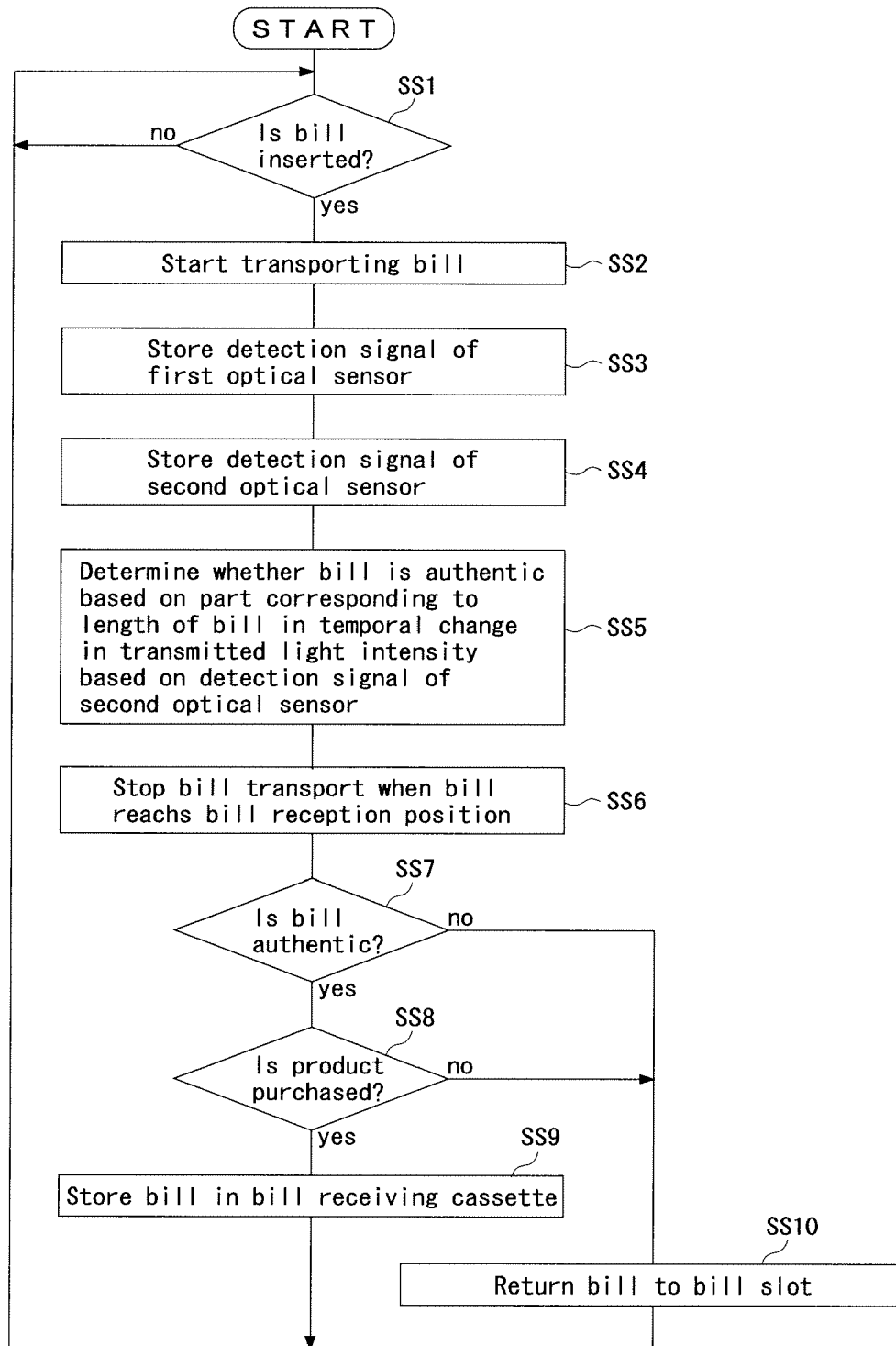


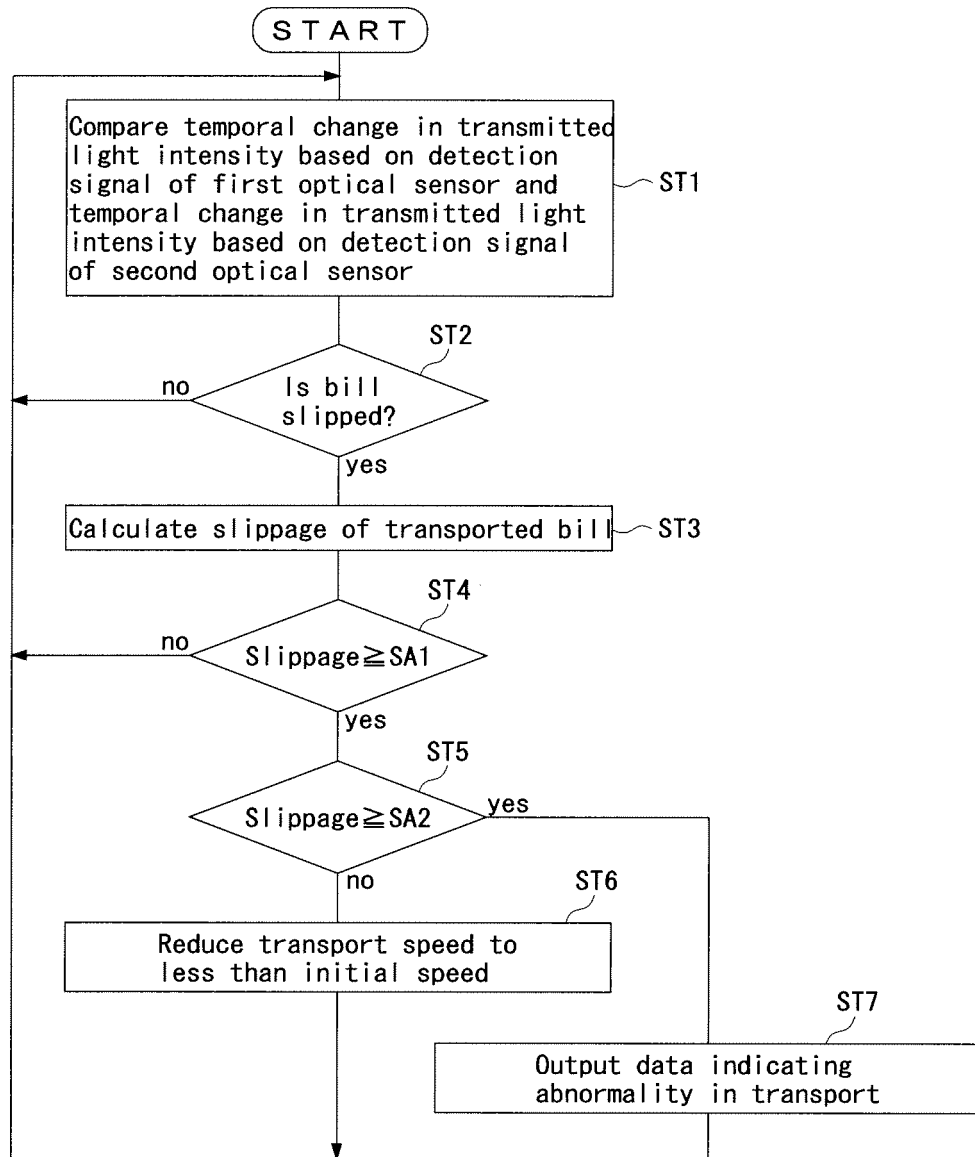
Fig. 4



F i g . 5



F i g . 6



F i g . 7

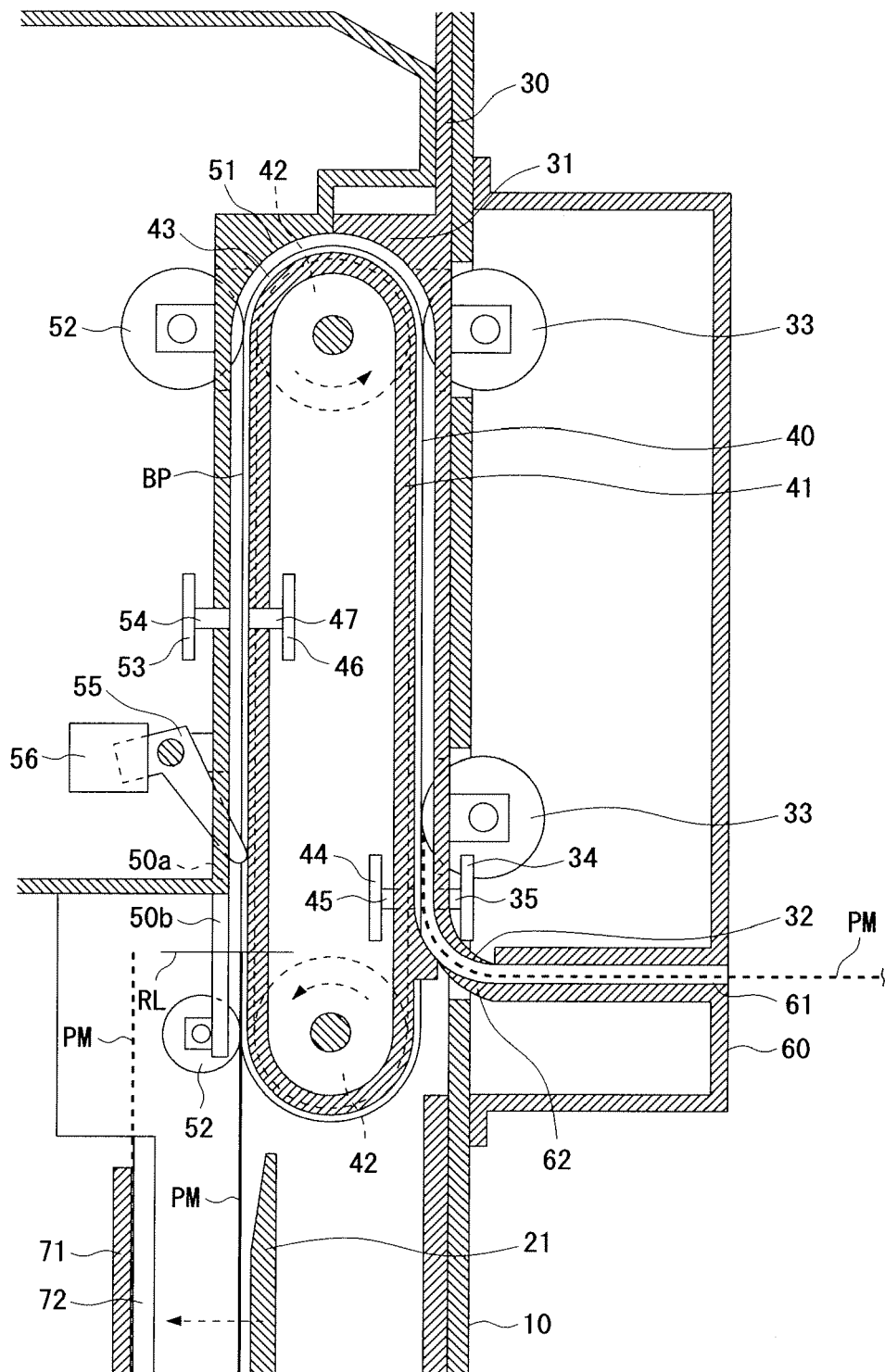
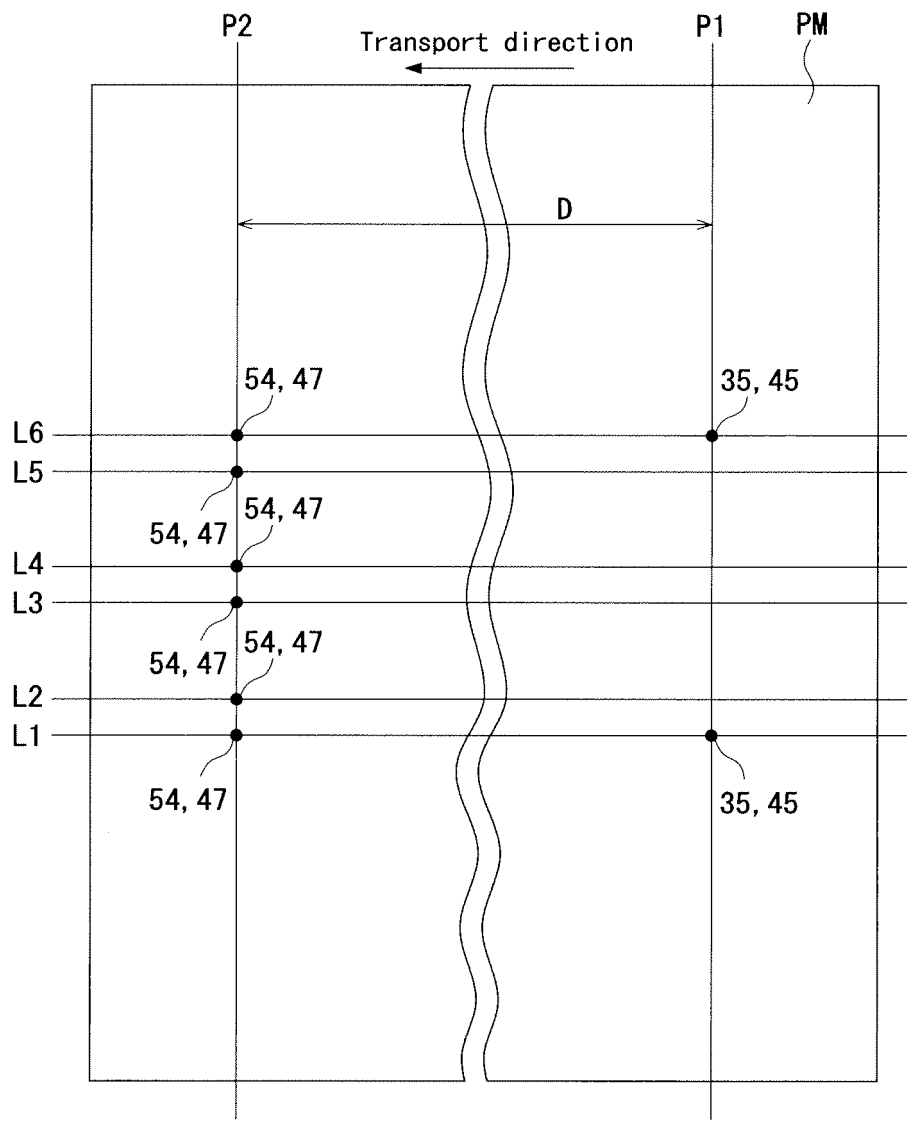
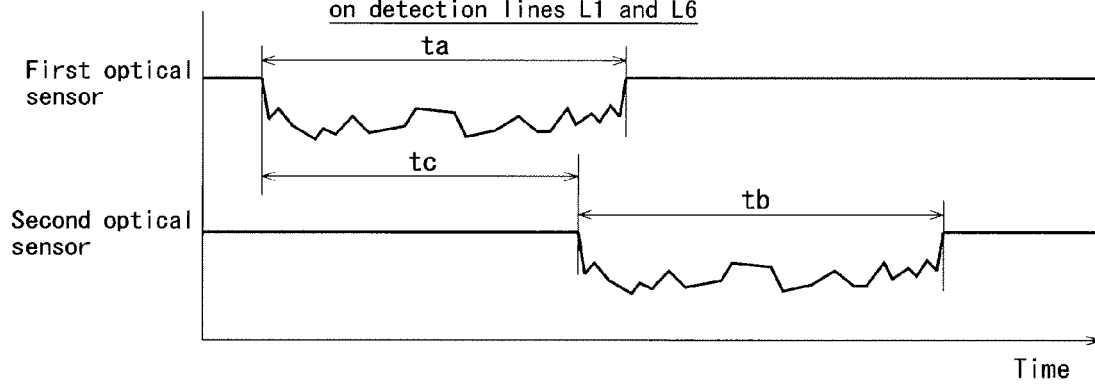


Fig. 8



F i g. 9

Temporal change in transmitted light intensity
on detection lines L1 and L6



F i g. 10

Temporal change in transmitted light intensity
on detection lines L1 and L6

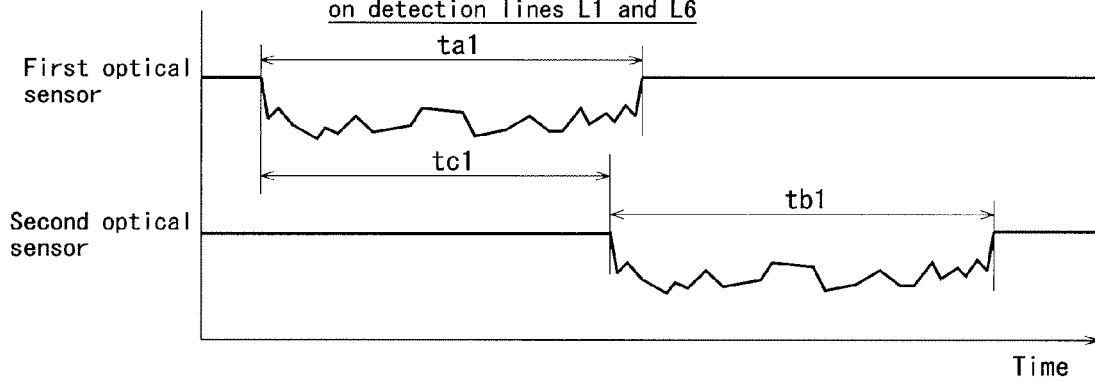
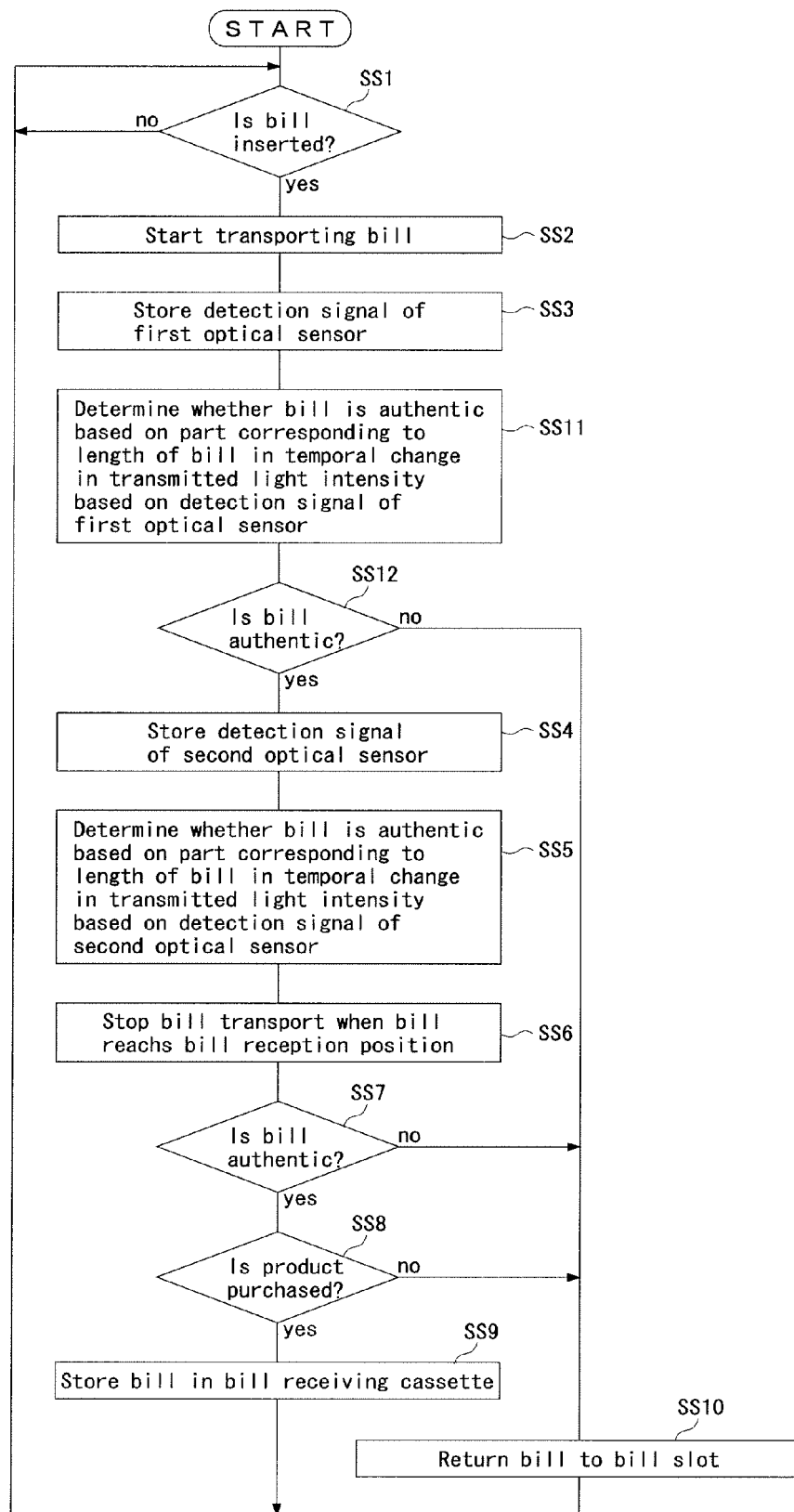
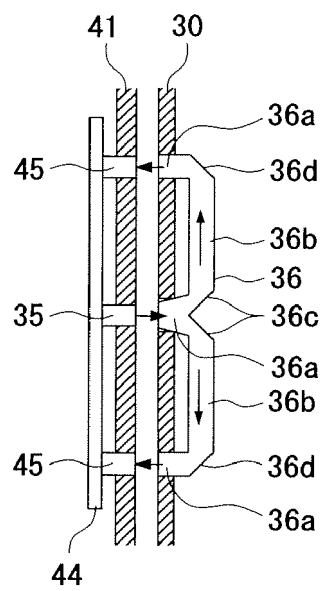


Fig. 11



F i g . 1 2





European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 07 11 6477

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Place of search Munich		Date of completion of the search 14 November 2007	Examiner Königer, Axel
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