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(54) PAPER SHEET FEEDING APPARATUS

(57) A paper sheet feeding apparatus according to an embodiment includes a first feeding tray 210, a pickup unit 150, a second feeding tray 310, an air blow unit 130, a status sensor 140, and a controller 100. The first feeding tray 210 and the second feeding tray 310 respectively feed a batch of sheets to the pickup unit 150. The air blow unit 130 blows air to loosen an upper part of the batch of sheets. The status sensor 140 detects sparseness value of the upper part of the batch of sheets. The controller 100 makes the batch of sheets on the first feeding tray 210 to fall on top of that of the second feeding tray 310 when switching the feeding tray in charge of feeding the sheets from the first feeding tray 210 to the second feeding tray 310.

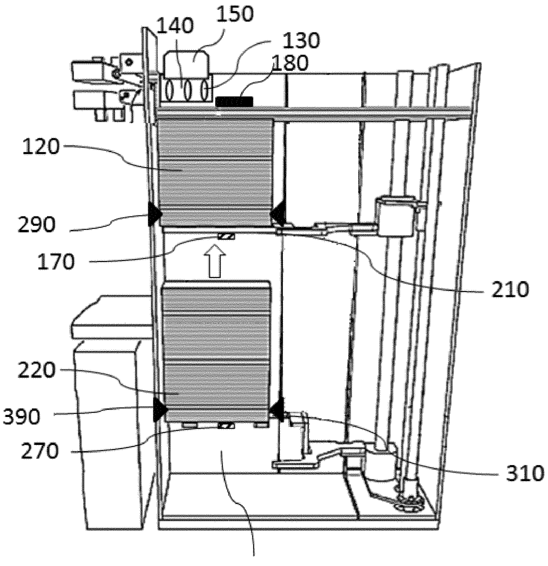

FIG. 1

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Description

FIELD

[0001] Embodiments described herein relate generally to a paper sheet feeding apparatus.

BACKGROUND

[0002] A paper sheet feeding apparatus is equipped in, e.g., a banknote processing machine that inspects and sorts paper sheets such as banknotes. The existing paper sheet feeding apparatus feeds sheets to a pickup unit, which picks up sheets one by one from a batch of sheets and sends them out downstream at a certain interval, by using two feeding trays. Before all the sheets stacked on one of the feeding trays that is in charge of feeding the sheets then (here, the feeding tray in charge will be referred to as "the upper feeding tray") have been picked up, another batch of sheets is additionally supplied to the other feeding tray that is positioned below the upper feeding tray then (here, the other feeding tray will be referred to as "the lower feeding tray"), and the lower feeding tray is elevated to be on standby directly below the upper feeding tray.

[0003] Then the upper feeding tray is moved perpendicularly from the vertical direction, and the remaining sheets stacked on the upper feeding tray are dropped by the force of gravity onto the additionally supplied batch of sheets on the lower feeding tray. By doing so, the batch of sheets on the lower feeding tray and the remaining sheets stacked on the upper feeding tray integrate as one batch of sheets. Then the lower feeding tray takes over the feeding of the sheets to the pickup unit.

[0004] In the vicinity of an area below the pickup unit, an air blow unit that blows air towards the side of the upper part of the batch of sheets is equipped. The pickup unit sucks and picks up the sheets one by one from the cluster of sheets in the upper part of the batch of sheets loosened by the blowing of the air.

[0005] However, there is a gap between the top part of the dropped stacked sheets and the pickup unit when the remaining sheets stacked on the upper feeding tray are dropped onto the batch of sheets on the lower feeding tray. When the gap is too large, the air blows through, above the top part of the dropped stacked sheets. In such state, the sheets cannot be properly picked up by the pickup unit. When the lower feeding tray, now with the integrated batch of sheets, is elevated to fill the gap, the uppermost sheet would be blown away by the blowing air.

[0006] When the air blow is stopped to avoid such state, a certain amount of time would be required to start the next cycle of the pickup operation. As a result, the feeding by the paper sheet feeding apparatus would be paused, and thus the throughput of the paper sheet feeding apparatus decreases.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

FIG. 1	is a perspective view showing a paper sheet feeding apparatus according to an embodiment;
FIGS. 2A and 2B	are a schematic top view and a schematic front view showing the paper sheet feeding apparatus according to the embodiment;
FIG. 3	is a schematic top view showing a meshing structure of feeding trays according to the embodiment;
FIG. 4	is a block diagram schematically showing the paper sheet feeding apparatus according to the embodiment;
FIG. 5	is a schematic front view for explaining an additional supply operation according to the embodiment;
FIG. 6	is a schematic front view for explaining the additional supply operation according to the embodiment;
FIG. 7	is a schematic front view for explaining the additional supply operation according to the embodiment;
FIG. 8	is a schematic front view for explaining the additional supply operation according to the embodiment;
FIG. 9	is a schematic front view for explaining a takeover operation according to the embodiment;
FIG. 10	is a schematic front view for explaining the takeover operation according to an embodiment;
FIG. 11	is a schematic front view for explaining the takeover operation according to the embodiment;
FIGS. 12A and 12B	are schematic front views for explaining a relationship between a sparseness value of sheets and a position of the feeding tray according to the embodiment;
FIG. 13	is a flowchart showing the whole operation of the paper sheet feeding apparatus according to the embodiment;

FIG. 14 is a flowchart showing an initial setup operation of the paper sheet feeding apparatus according to the embodiment;
FIG. 15 is a flowchart showing a feed operation of the paper sheet feeding apparatus according to the embodiment;
FIG. 16 is a flowchart showing the additional supply operation of the paper sheet feeding apparatus according to the embodiment;
FIG. 17 is a flowchart showing the takeover operation of the paper sheet feeding apparatus according to the embodiment;

DETAILED DESCRIPTION

[0008] A paper sheet feeding apparatus according to an embodiment includes a first feeding tray 210, a pickup unit 150, a second feeding tray 310, an air blow unit 130, a status sensor 140, and a controller 100. The first feeding tray 210 is configured to support and feed a batch of sheets, and arranged to be movable in a vertical direction and in a direction perpendicular to the vertical direction. The pickup unit 150 is configured to pick up sheets, and arranged above the first feeding tray 210. The second feeding tray 310 is configured to support and feed a batch of sheets, and arranged below the first feeding tray 210 to be movable in a vertical direction. The air blow unit 130 is configured to blow air towards an upper part of the batch of sheets on the first feeding tray 210 or the second feeding tray 310 from a side of the upper part of the batch of sheets. The status sensor 140 is configured to detect a sparseness value of the upper part of the batch of sheets loosened by the air blow unit 130 by detecting at least two different values including an upper limit sparseness value suitable for picking up sheet, indicating high density, and a lower limit sparseness value suitable for picking up sheet, indicating low density. The controller 100 is configured to make the batch of sheets on the first feeding tray 210 to fall on top of the batch of sheets on the second feeding tray 310 when switching the feeding tray in charge of feeding the sheets from the first feeding tray 210 to the second feeding tray 310, by moving the first feeding tray 210 perpendicularly from the vertical direction after making the first feeding tray 210 ascend until the status sensor 140 detects the upper limit sparseness value.

[0009] Hereinafter, a paper sheet feeding apparatus of an embodiment will be described with reference to the drawings.

[0010] First, the setup of the paper sheet feeding apparatus of the embodiment will be described in detail. FIG. 1 is a perspective view showing the paper sheet feeding apparatus according to the embodiment. FIGS. 2A and 2B are a schematic top view and a schematic front view showing the paper sheet feeding apparatus according to the embodiment. Note that in FIGS. 2A and 2B, only a first feeding tray 210 is shown and a second feeding tray 310 is omitted.

[0011] According to the embodiment, the paper sheet feeding apparatus has a first feeding tray 210 which supports a first batch of sheets 120, comprised of stacked sheets. The first feeding tray 210 is installed against a base 160 of the paper sheet feeding apparatus body, in a way so that it is movable in a vertical direction. The first feeding apparatus is also movable perpendicularly from the vertical direction.

[0012] The first feeding tray 210 has a first sheet sensor 290, which detects whether or not a sheet exists on the first feeding tray 210. The first feeding tray 210 also has a first proximity sensor 170 on its underside, which detects whether or not a second batch of sheets 220 (later to be described) placed on a second feeding tray 310 (later to be described) has approached the first feeding tray 210 by a certain distance.

[0013] Above the first feeding tray 210, there is a pickup unit 150, which picks up sheets one by one from the top of the first batch of sheets 120 fed by the first feeding tray 210, and sends them to a conveyance path. The pickup unit 150 uses negative pressure to pick up sheets by sucking the sheet lying on the uppermost surface of the first batch of sheets 120. Then the pickup unit 150 moves leftwards in FIG. 1 and hands out the sheet that it picked up to the conveyance path. Note that the pickup unit 150 may be embodied in other forms, e.g., a rotating suction pickup system.

[0014] In the vicinity of an area below the pickup unit 150 on the opposite side to the base 160, that is, in the direction coming out of the page in FIG. 1, there is an air blow unit 130. The air blow unit 130 loosens the cluster of sheets in the upper part of the first batch of sheets 120 by blowing air towards it from its side. The things written in this paragraph apply for the later described second batch of sheets 220 as well.

[0015] Opposite to the air blow unit 130, that is, on the side where the base 160 is, there is a status sensor 140. The status sensor 140 detects whether or not the upper part of the first batch of sheets 120 is at a dense state or at a sparse state.

[0016] The status sensor 140 is, e.g., a reflection-type optical sensor. A reflection-type optical sensor reflects more light when the cluster of sheets is at a dense state, and it reflects less light when the cluster of sheets is at a sparse state. The status sensor 140 outputs the value of the measured amount of the reflection light. Thus, the output value and the sparseness of the sheets are in an almost linear correlation.

[0017] Below the first feeding tray 210, a second feeding tray 310 which supports a second batch of sheets 220 is installed against the base 160 in a way so that it is movable in a vertical direction. The second feeding tray 310 has a second sheet sensor 390, which detects whether or not a sheet exists on the second feeding tray 310. The second feeding tray 310 also has a second proximity sensor 270 on its side, which detects whether or not the first feeding tray 210 is at a common plane as the second feeding tray 310.

[0018] On the base 160, there is a limit sensor 180 which detects an elevation limit, which is the highest position that the first feeding tray 210 can ascend to. When there is no more sheet to be additionally supplied, the first feeding tray 210 ascends until the limit sensor 180 detects the first feeding tray 210 to have reached the elevation limit. After the first feeding tray 210 reaches the elevation limit, the first feeding tray 210 stops ascending, and the first feeding tray 210 continues feeding. When all the remaining sheets on the first feeding tray 210 have been picked up by the pickup unit 150, the first sheet sensor 290 turns ’On’, meaning that it detects no existence of sheets left. The things written here in this paragraph apply for the second feeding tray 310 as well.

[0019] The first sheet sensor 290 and the second sheet sensor 390 are, e.g., a pair of transmission-type optical sensor. A light projecting LED and a light receiving sensor are placed facing each other with the batch of sheets on the feeding tray in between. When there are sheets on the feeding tray, the projected light would be blocked and thus the sheet sensor would be in an ’Off’ state.

[0020] Here, a meshing structure of the feeding trays according to the embodiment will be described in detail. FIG. 3 is a schematic top view showing the meshing structure of the first feeding tray 210 and the second feeding tray 310 according to the embodiment.

[0021] The first feeding tray 210 and the second feeding tray 310 configure a meshing structure. As shown in FIG. 3, the first feeding tray 210 is shaped like the alphabet ’E’. The second feeding tray 310 is placed closer to the base 160 than the first feeding tray 210, and it has protruding parts where the first feeding tray 210 has recessed parts, and recessed parts where the first feeding tray 210 has protruding parts. Namely, the recessed parts of the first feeding tray 210 and the protruding parts of the second feeding tray 310 mesh, and vice versa for the protruding parts of the first feeding tray 210 and the recessed parts of the second feeding tray 310.

[0022] The first feeding tray 210 is movable vertically (to the directions coming in and out of the page in FIG. 3) against the base 160, and movable perpendicularly away from the base 160 (to the direction the arrow is pointing at in FIG. 3). The second feeding tray 310, on the other hand, is movable only vertically against the base 160.

[0023] The moving away of the first feeding tray 210 from the base 160 is conducted in order to get out of the way of the vertical moving range of the second feeding tray 310. Once the first feeding tray 210 is moved perpendicularly from the vertical direction, the first feeding tray 210 can descend and then move back to a position below the second feeding tray 310.

[0024] As the first feeding tray 210 and the second feeding tray 310 configure a meshing structure, when there is no sheet placed on the first feeding tray 210, the empty first feeding tray 210 can take over the second batch of sheets 220 on the second feeding tray 310 from below. Once the first feeding tray 210 becomes flush with the second feeding tray 310, the first feeding tray 210, instead of the second feeding tray 310, supports the second batch of sheets 220 and then continues to ascend to support the second batch of sheets 220. This will be described later as a takeover operation.

[0025] Next, a block diagram schematically showing the paper sheet feeding apparatus according to the embodiment will be described in detail. FIG. 4 is a block diagram schematically showing the paper sheet feeding apparatus according to the embodiment.

[0026] As shown in FIG. 4, the outputs of the status sensor 140, the first proximity sensor 170, the second proximity sensor 270, the first sheet sensor 290, the second sheet sensor 390, the limit sensor 180, and a start button 110 are input to a controller 100. The start button 110 is a button pressed when placing the second batch of sheets 220 onto the second feeding tray 310 to start the later described additional supply operation.

[0027] The air blow unit 130, a first drive motor 211 for driving the first feeding tray 210, an actuator 212 for moving the first feeding tray 210, and a second drive motor 311 for driving the second feeding tray 310 are connected to the controller 100. The controller 100 drives the air blow unit 130, the first drive motor 211, the actuator 212, and the second drive motor 311, based on the above-mentioned inputs.

[0028] Next, the basic operations of the paper sheet feeding apparatus according to the embodiment will be described in detail. FIG. 5 to FIG. 8 are schematic front views for explaining an additional supply operation according to the embodiment. FIG. 9 to FIG. 11 are schematic front views for explaining a takeover operation according to the embodiment. FIG. 5 shows a state where the pickup unit 150 is picking up sheets from the first batch of sheets 120 on the first feeding tray 210. While the paper sheet feeding apparatus is at this state, an operator places the second batch of sheets 220 on the second feeding tray 310 so that the second batch of sheets 220 can be picked up next. Once the operator places the second batch of sheets 220, he or she presses the start button 110. When the start button 110 is pressed, the controller 100 issues an instruction to elevate the second feeding tray 310. The second feeding tray 310 then ascends until the top surface of the second batch of sheets 220 is detected by the first proximity sensor 170.

[0029] When the proximity of the second batch of sheets 220 is detected, the second feeding tray 310 synchronizes with the ascending speed of the first feeding tray 210 (as shown in FIG. 6). The two feeding trays continue to ascend until the later described upper limit sparseness value P1 is detected by the status sensor 140. Then, the first feeding tray 210 moves away (away from the base, towards the direction coming out of the pages in FIG. 5 through FIG. 11).

At the same time, the second feeding tray 310 is removed of the synchronization with the first feeding tray 210, and continues to ascend independently. In the meantime, the first batch of sheets 120 on the first feeding tray 210 falls on to the second batch of sheets 220 on the second feeding tray 310 (as shown in FIG. 7).

[0030] Due to this fall, the second feeding tray 310 then supports both the second batch of sheets 220 and the first batch of sheets 120 that had just been transferred. FIG. 8 shows a state where the pickup unit 150 is picking up sheets one by one from the now integrated batch of sheets. While the paper sheet feeding apparatus is at this state, the first feeding tray 210 descends vertically from the moved away position until it reaches a height lower than the second feeding tray 310. Then, the first feeding tray 210 moves back to its original vertical moving range and positions below the second feeding tray 310 (as shown in FIG. 8).

[0031] Then, the first feeding tray 210 starts to ascend in order to take over feeding by the second feeding tray 310 (as shown in FIG. 9). The first feeding tray 210 ascends until the second proximity sensor 270 detects that the first feeding tray 210 and the second feeding tray 310 have become flush (as shown in FIG. 10). The second feeding tray 310 then descends, and with this, the integrated batch of sheets is transferred to the first feeding tray 210 (as shown in FIG. 11). The second feeding tray 310 descends to the lowest position, and the operator supplies the next batch of sheets onto the second feeding tray 310 to prepare for the next cycle of feeding.

[0032] As described above, while the first batch of sheets 120 is being picked up by the pickup unit 150 from the first feeding tray 210, the next batch of sheets to be fed are supplied onto the second feeding tray 310, and then the first batch of sheets 120 fed by the first feeding tray 210 would be transferred to the second feeding tray 310. This series of actions is hereinafter called the additional supply operation.

[0033] Also, while the integrated first batch of sheets 120 and second batch of sheets 220 are being picked up by the pickup unit 150 from the second feeding tray 310, the integrated batch of sheets fed by the second feeding tray 310 would be transferred to the empty first feeding tray 210. This series of actions is hereinafter called the takeover operation.

[0034] The paper sheet feeding apparatus according to the embodiment successively feeds sheets to the pickup unit 150, by repeating these operations.

[0035] Here, a relationship between the sparseness value of sheets and the position of the feeding tray in charge of feeding according to the embodiment will be described in detail. As an example, the state where the first feeding tray 210 is feeding the first batch of sheets 120 will be described. FIGS. 12A and 12B are schematic front views for explaining the relationship between the sparseness value of sheets and the position of the feeding tray according to the embodiment.

[0036] As the first feeding tray 210 elevates and the first batch of sheets 120 gets close to the pickup unit 150, the cluster of sheets in the upper part of the first batch of sheets 120 loosens by the air blow unit 130. In the meantime, the status sensor 140 detects the sparseness value of the cluster of sheets in the upper part of the first batch of sheets 120.

[0037] Of the sparseness values detected by the status sensor 140, the sparseness value which indicates the densest state possible in which sheets can be loosened by the air blow, is hereinafter called the upper limit sparseness value P1. FIG. 12A shows the state in which the status sensor 140 is detecting the upper limit sparseness value P1. This state means that if the cluster of sheets has higher denseness than it currently is, then the sheets would not be able to be loosened properly and thus be liable to a picking up of two or more sheets at once.

[0038] The sparseness value which indicates the sparsest state possible in which sheets can be loosened by the air blow is hereinafter called the lower limit sparseness value P2. FIG. 12B shows the state in which the status sensor 140 is detecting the lower limit sparseness value P2. This state means that if the sheets have lower denseness than it currently is, then the sheets would not be able to be sucked properly by the pickup unit 150 and thus be liable to a malfunction of the picking up of sheets.

[0039] The distance between the position of the top surface of the first feeding tray 210 when the upper limit sparseness value P1 is detected and the position of the top surface of the first feeding tray 210 when the lower limit sparseness value P2 is detected is hereinafter called distance d. Distance d is a distance corresponding to the range from the lower limit sparseness value P2 to the upper limit sparseness value P1. In other words, if the first feeding tray 210 elevates by distance d from the position where the detected sparseness value is the lower limit sparseness value P2, indicating that the upper part of the first batch of sheets 120 is at its lowest denseness possible, the upper part of the first batch of sheets 120 then turns into its highest denseness possible, detecting the upper limit sparseness value P1.

[0040] As the first feeding tray 210 elevates, the distance between the first feeding tray 210 and the pickup unit 150 narrows, and the upper part of the first batch of sheets 120 gradually becomes denser. When the sparseness value reaches the upper limit sparseness value P1, the controller 100 stops the first feeding tray 210. Then, while the first feeding tray 210 is staying where it is, the pickup unit 150 continues picking up sheets and thus the upper part of the first batch of sheets 120 gradually becomes sparser. When the sparseness value reaches the lower limit sparseness value P2, the controller 100 elevates the first feeding tray 210 again.

[0041] The things written here in the above paragraphs apply for the second feeding tray 310 as well.

[0042] As described, the feeding tray that is in charge of feeding would be controlled so that the sparseness of the upper part of the batch of sheets would always stay within the range between the upper limit sparseness value P1 and the lower limit sparseness value P2. Namely, if the lower limit sparseness value P2 is detected, the feeding tray would be elevated, and if the upper limit sparseness value P1 is detected, the feeding tray would be stopped from ascending. These are the basic operations conducted.

[0043] Next, the relationship between the control of the sparseness value and the positions of the feeding trays during the additional supply operation according to the embodiment will be described in detail, referring to FIG. 6 to FIG. 8.

[0044] First, as shown in FIG. 6, the distance from the uppermost surface of the second batch of sheets 220 to the bottommost surface of the first batch of sheets 120 when the top surface of second batch of sheets 220 have neared the first proximity sensor 170 by a certain distance, is hereinafter called distance D0. While the movements of the first feeding tray 210 and the second feeding tray 310 are synchronized, the distance D0 is maintained.

[0045] The time counting from when the first feeding tray 210 is moved perpendicularly from the vertical direction until when the first batch of sheets 120 and the second batch of sheets 220 integrate, is hereinafter called the integrating time. This is the time it takes to change from the state shown in FIG. 7 to the state shown in FIG. 8. The integrating time can be calculated from the falling speed of the first batch of sheets 120 and the ascending speed of the second feeding tray 310.

[0046] The second feeding tray 310 ascends by a distance of distance D1 during the integrating time. The thickness of the total amount of sheets that would be picked up by the pickup unit 150 within the period from when the first feeding tray 210 and the second feeding tray 310 synchronize at distance D0 until when the first batch of sheets 120 and the second batch of sheets 220 integrate, is hereinafter called distance D2.

[0047] Here, the distance that the uppermost surface of the first batch of sheets 120 descends during the moving away of the first feeding tray 210, is hereinafter called margin D. As shown in FIG. 8, this margin D satisfies the following equation: $D = D0 + D2 - D1$.

[0048] If margin D is less than distance d, which corresponds to the range of the suitable sparseness value of the sheets, the sheets can be maintained to be properly picked up, while the first feeding tray 210 moves away and the feeding is taken over by the second feeding tray 310. Thus, the feeding of the sheets would not be interrupted during the additional supply operation.

[0049] While the first feeding tray 210 moves away and the second feeding tray 310 takes over the feeding, the sparseness of the cluster of sheets in the upper part of the first batch of sheets 120 are controlled to stay within the suitable range by satisfying the following equation: $D < d$.

[0050] Note that distance D0 is a distance determined by the thicknesses of the first feeding tray 210 and the first proximity sensor 170. Distance D1 is determined by the speed of the first feeding tray 210 moving away and the ascending speed of the second feeding tray 310. Distance D2 is determined by the speed of the first feeding tray 210 moving away, the ascending speed of the second feeding tray 310, and the picking up speed of the pickup unit 150.

[0051] Next, the whole operation of the paper sheet feeding apparatus according to the embodiment will be described in detail. FIG. 13 is a flowchart showing the whole operation of the paper sheet feeding apparatus according to the embodiment.

[0052] The operator first places the first batch of sheets 120 on the first feeding tray 210 so that they can be fed to the pickup unit 150 (Step 1). This preparation is hereinafter called the initial setup operation. Then, the first feeding tray 210 feeds sheets from the first batch of sheets 120 while maintaining the sparseness within the suitable range (Step 2). This operation is hereinafter called the feed operation.

[0053] Then, as the sheets are fed and the amount of the first batch of sheets 120 decreases, the operator supplies additional sheets by placing the second batch of sheets 220 on the second feeding tray 310 (Step 3). This operation is hereinafter called the additional supply operation. After this operation is conducted, the feeding tray in charge of feeding the sheets is switched from the first feeding tray 210 to the second feeding tray 310. Then, in the same manner as Step 2, the second feeding tray 310 feeds sheets from the integrated first batch of sheets 120 and second batch of sheets 220 while maintaining the sparseness within the suitable range (Step 4).

[0054] Next, the empty first feeding tray 210 ascends until it becomes flush with the second feeding tray 310. By doing so, the first feeding tray 210 takes charge of supporting the stacked sheets remaining on the second feeding tray 310 (Step 5). This operation is hereinafter called the takeover operation. Then, the state of the paper sheet feeding apparatus is back to that of Step 2, and from here onward, the operations Step 2 ~Step 5 are repeated.

[0055] Note that the placement of the batch of sheets by the operator can also be done by other automated machines.

[0056] Next, the initial operation (Step 1) shown in FIG. 13 will be described in detail. FIG. 14 is a flowchart showing the initial setup operation of the paper sheet feeding apparatus according to the embodiment.

[0057] First, the controller 100 elevates the first feeding tray 210 when the first batch of sheets 120 is placed on it (Step 101). Then, when the sparseness value detected by the status sensor 140 reaches an initial sparseness value P0 (Step 102), the controller 100 stops the first feeding tray 210 (Step 103). Then, the controller 100 enables the air blow unit 130 and loosens the cluster of sheets by blowing air towards the upper part of the first batch of sheets 120 from the side of the upper part of the first batch of sheets 120 (Step 104). The controller 100 also enables the pickup unit 150 and makes it pick up sheets one by one from the uppermost sheet on the first batch of sheets 120

[0058] (Step 105). Note that the detected sparseness value P0 is a value that is set so that the sparseness of the upper part of the first batch of sheets 120 reaches the upper limit sparseness value P1 when the air blow starts to loosen the sheets.

[0059] Next, the feed operation (Step 2) shown in FIG. 13 will be described in detail. FIG. 15 is a flowchart showing the feed operation of the paper sheet feeding apparatus according to the embodiment.

[0060] Once the picking up starts at Step 105 in FIG. 14, the status sensor 140 detects whether or not the detected sparseness value has reached the lower limit sparseness value P2 (Step 201). While the detected sparseness value has not reached the lower limit sparseness value P2 ('No' in Step 201), the controller 100 lets the picking up continue without having the first feeding tray 210 elevated. Once the detected sparseness value reaches the lower limit sparseness value P2 ('Yes' in Step 201), the controller 100 elevates the first feeding tray 210 (Step 202).

[0061] Once the first feeding tray 210 starts ascending, the limit sensor 180 detects whether or not the first feeding tray 210 has reached the elevation limit (Step 203). While the first feeding tray 210 has not reached the elevation limit ('No' in Step 203), the status sensor 140 detects whether or not the detected sparseness value reaches the upper limit sparseness value P1 (Step 204). Once the detected sparseness value reaches the upper limit sparseness value P1 ('Yes' in Step 204), the controller 100 stops the first feeding tray 210 (Step 205). Then, the state goes back to Step 201, and the operations (Step 201 ~) are repeated.

[0062] On the other hand, if the first feeding tray 210 has reached the elevation limit ('Yes' in Step 203), the controller 100 stops the ascending of the first feeding tray 210 (Step 206). The first feeding tray 210 reaching the elevation limit means that there are no more sheets additionally supplied and thus it is time to have all the remaining sheets on first feeding tray 210 to be picked up.

[0063] Then, the picking up continues until it is detected by the first sheet sensor 290 that there are no more sheets left on the first feeding tray 210 (Step 207). Once there are no more sheets left on the first feeding tray 210 (Step 207), the pickup unit 150 ends its operation (Step 208).

[0064] According to these steps, the picking up continues successively during the feed operation, having the sparseness value maintained within the range of the upper limit sparseness value P1 and the lower limit sparseness value P2.

[0065] Next, the additional supply operation (Step 3) shown in FIG. 13 will be described in detail. FIG. 16 is a flowchart showing the additional supply operation of the paper sheet feeding apparatus according to the embodiment.

[0066] The controller 100 elevates the second feeding tray 310 when the second batch of sheets 220 is placed on the second feeding tray 310 by the operator and the start button 110 is pressed (Step 301). Then the second feeding tray 310 ascends until the first proximity sensor 170, installed on the underside of the first feeding tray 210, detects the approach of the second feeding tray 310 (Step 302). Once the second feeding tray 310 approaches the first proximity sensor 170 by a certain distance ('Yes' in Step 302), the controller 100 synchronizes the ascending speed of the first feeding tray 210 and the second feeding tray 310 (Step 303).

[0067] When the detected sparseness value reaches the upper limit sparseness value P1 while the first feeding tray 210 and the second feeding tray 310 are ascending ('Yes' in Step 304), the controller 100 stops the first feeding tray 210 and the second feeding tray 310 simultaneously (Step 305).

[0068] Then, the controller 100 moves away the first feeding tray 210 from its vertical moving range (to the direction of the arrow shown in FIG. 3), and then makes it position below the second feeding tray 310 (Step 306). As a result, the feeding tray in charge of feeding switches from the first feeding tray 210 to the second feeding tray 310 (Step 307). Until the integrating time passes (Step 308), the controller 100 elevates the second feeding tray 310 (Step 309).

[0069] After the integrating time passes, namely, when the first batch of sheets 120 and the second batch of sheets 220 have integrated (Step 308), the controller 100 stops the second feeding tray 310 from ascending (Step 310). Then, the procedure continues on to the supply operation (Step 4), described in FIG. 13.

[0070] The details of the supply operation (Step 4) described in FIG. 13 are the same as the supply operation (Step 2) described in FIG. 15; aside from replacing all first feeding trays 210 into second feeding trays 310, so the details will be omitted.

[0071] Lastly, the takeover operation (Step 4) shown in FIG. 13 will be described in detail. FIG. 17 is a flowchart showing the takeover operation of the paper sheet feeding apparatus according to the embodiment.

[0072] The controller 100 elevates the empty first feeding tray 210 while feeding the sheets from the second batch of sheets 220 on the second feeding tray 310 (Step 501). Once the second proximity sensor 270 detects that the first feeding tray 210 has become flush with the second feeding tray 310 ('Yes' in Step 502), the controller 100 stops the first feeding tray 210 and descends the second feeding tray 310 (Step 503). As a result, the feeding tray in charge of feeding switches from the second feeding tray 310 to the first feeding tray 210 (Step 504). Then again, the procedure continues on to the feed operation (Step 2) described in the FIG. 13.

[0073] These were the detailed explanations of the paper sheet feeding apparatus according to the embodiment shown in FIG. 13, using FIG. 14 to FIG. 17.

[0074] By controlling the position of the feeding tray as described, the sparseness of the sheets are maintained within the suitable range at all times, including the feeding of the sheets, the additional supplying of the sheets, and the taking over of the feeding tray. Due to this, a successive feeding of the sheets by the paper sheet feeding apparatus is realized.

[0075] Note that the 'sheets' according to the embodiment include media made of paper or resin, e.g., banknotes, stocks, postal matters, magnetic cards, and the like.

[0076] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions.

Claims

1. A paper sheet feeding apparatus, comprising:

    a first feeding tray configured to support and feed a batch of sheets, said first feeding tray movable in a vertical direction;
    a second feeding tray configured to support and feed a batch of sheets, said second feeding tray movable in a vertical direction;
    a pickup unit configured to pick up sheets, arranged above the first feeding tray or the second feeding tray in charge of feeding;
    an air blow unit configured to blow air towards an upper part of the batch of sheets on the first feeding tray or the second feeding tray in charge of feeding from a side of the upper part of the batch of sheets;
    a status sensor configured to detect a sparseness value of the upper part of the batch of sheets loosened by the air blow unit; and
    a controller configured to control the vertical movement of the first feeding tray or the second feeding tray in charge of feeding so that the sparseness value of the upper part of the batch of sheets stays within an upper limit sparseness value and a lower limit sparseness value that is suitable for picking up a sheet from the batch of sheets;
    wherein the first feeding tray is movable in a direction perpendicular to the vertical direction after making the first feeding tray ascend until the status sensor detects the upper limit sparseness value, such that the batch of sheets on the first feeding tray falls on top of the batch of sheets on the second feeding tray.

2. A paper sheet feeding apparatus according to claim 1,
    wherein the controller is configured to move the first feeding tray in the perpendicular direction so that a distance d is greater than a margin D,
    wherein the distance d is a distance between a position of the first feeding tray when reaching the upper limit sparseness value and a position of the first feeding tray when reaching the lower limit sparseness value, and
    wherein the margin D is a distance the batch of sheets on the first feeding tray falls on top of the batch of sheets on the second feeding tray when the first feeding tray moves perpendicularly from the vertical direction.

3. A paper sheet feeding apparatus according to claim 1 or 2,
    wherein the controller elevates the second feeding tray while moving the first feeding tray perpendicularly from the vertical direction.

4. A paper sheet feeding apparatus according to any one of claims 1 to 3,
    wherein the first feeding tray and the second feeding tray configure a meshing structure in a plane perpendicular to the vertical direction; and
    wherein the controller moves the first feeding tray downwards below the second feeding tray after the first feeding tray is moved perpendicularly from the vertical direction, and then elevates the first feeding tray to a common plane as the second feeding tray such that the batch of sheets on the second feeding tray is transferred to the first feeding tray.

5. A paper sheet feeding apparatus according to any one of claims 1 to 4,
    wherein the controller elevates the first feeding tray or the second feeding tray in charge of feeding when the status sensor detects the lower limit sparseness value, and stops the elevation of the first feeding tray or the second feeding tray in charge of feeding when the status sensor detects the upper limit sparseness value.

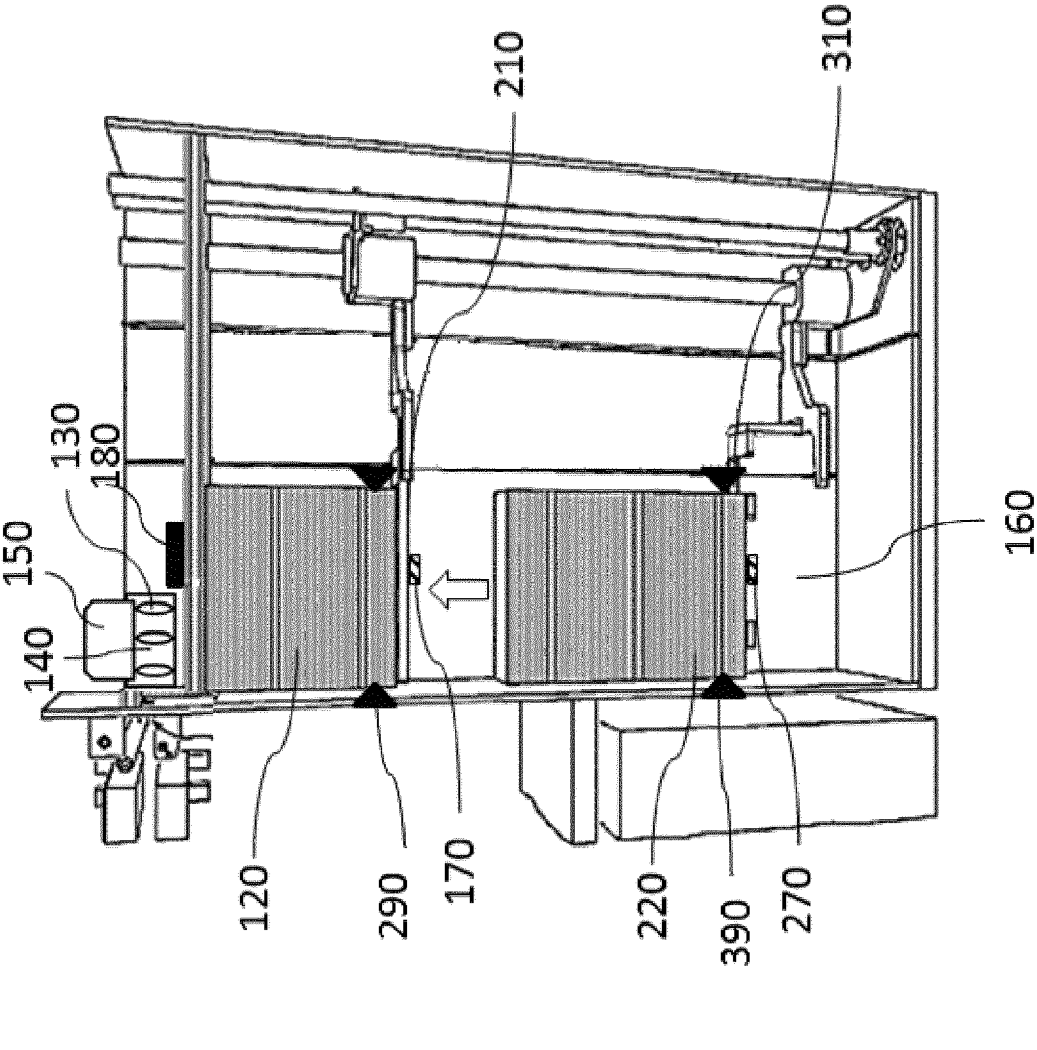

FIG. 1

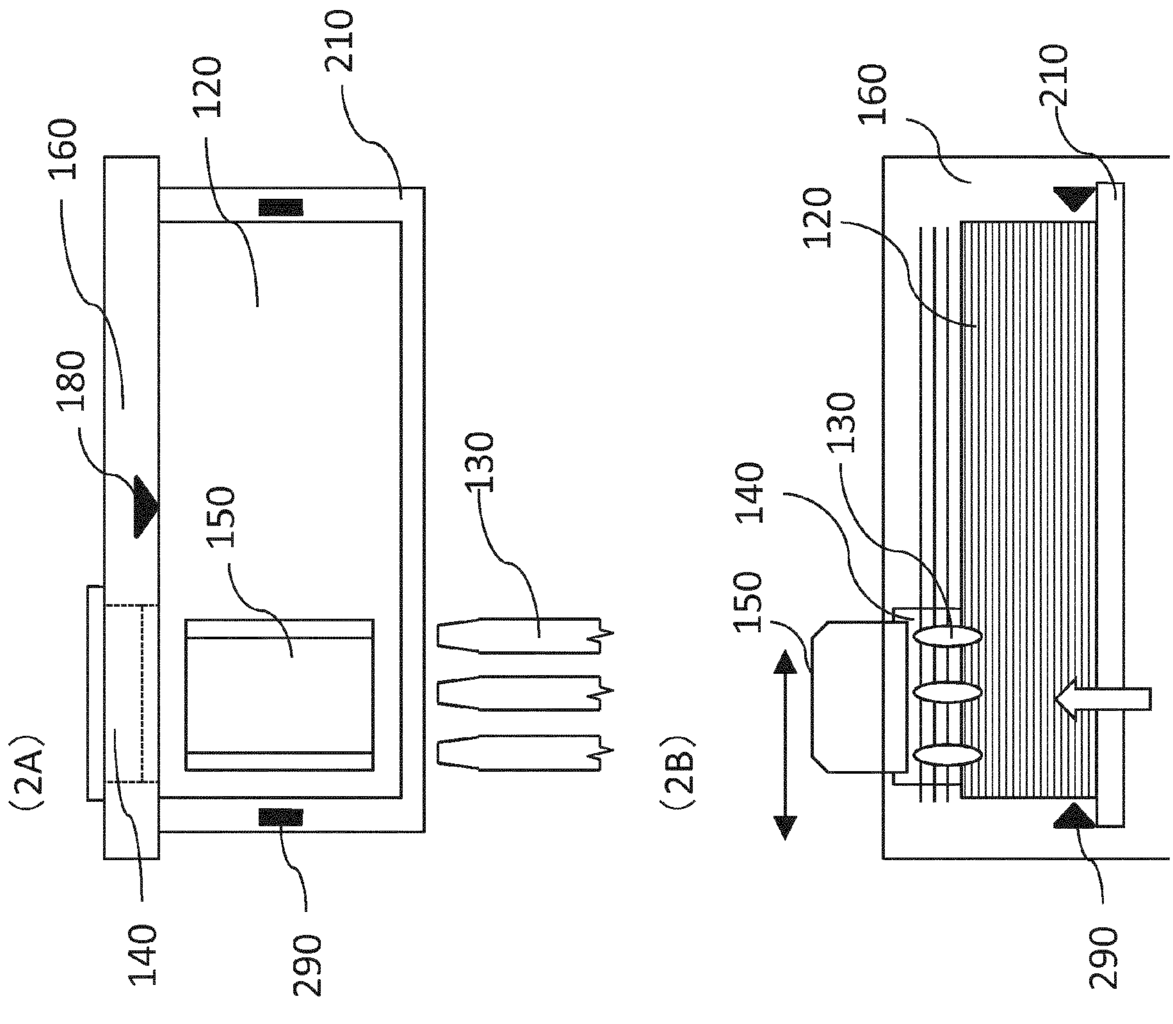

FIG. 2

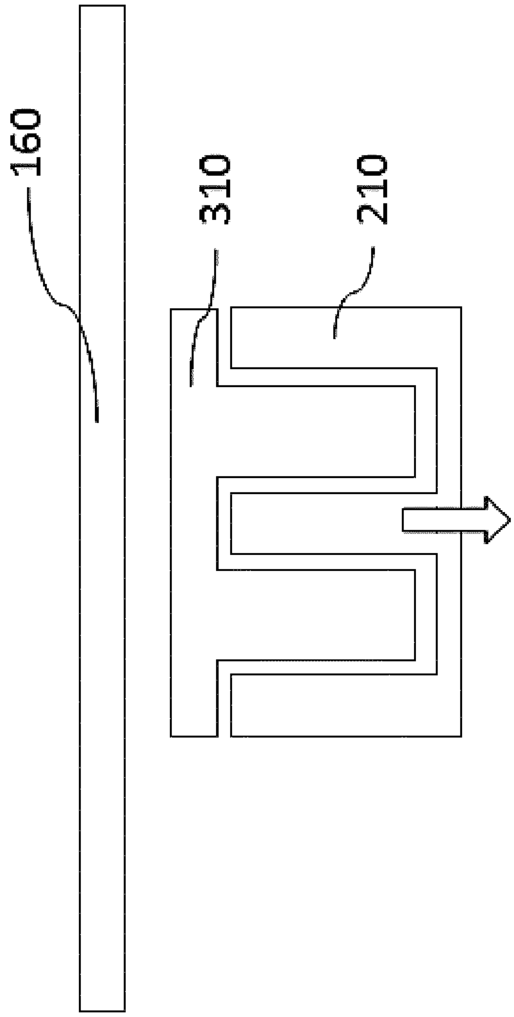

FIG. 3

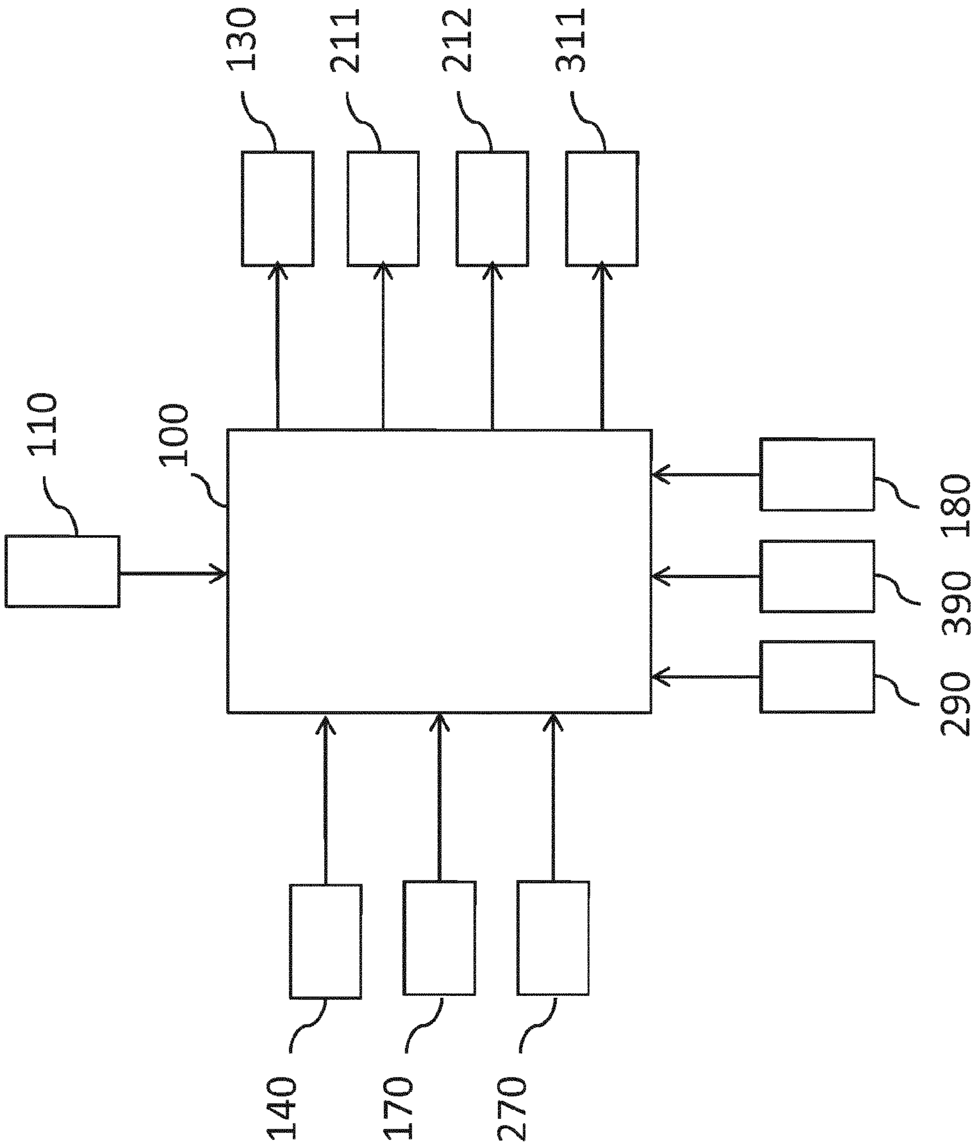

FIG. 4

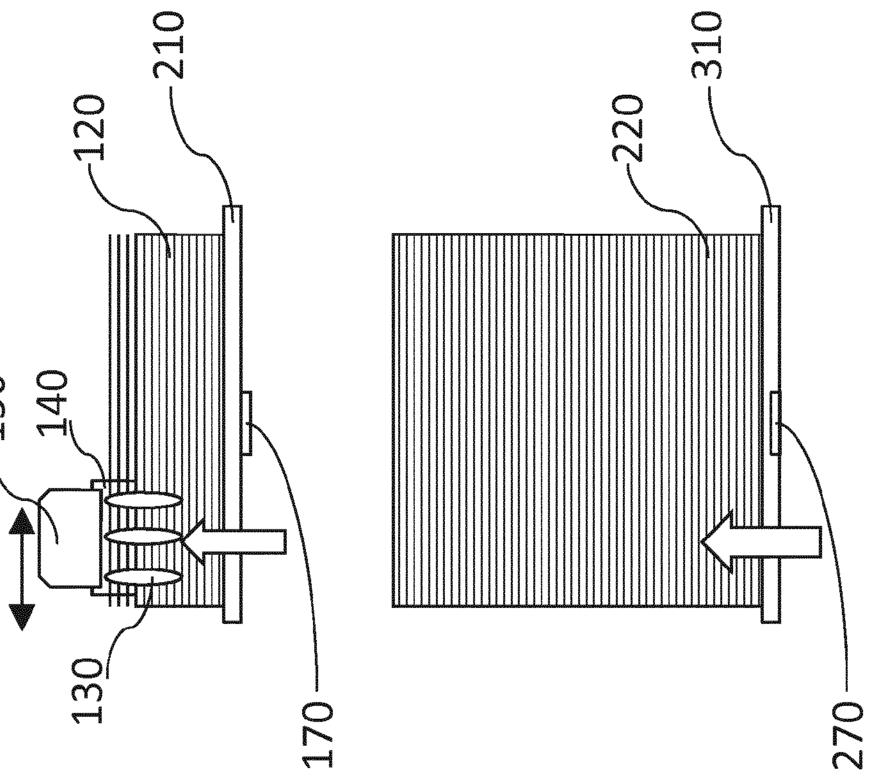

FIG. 5

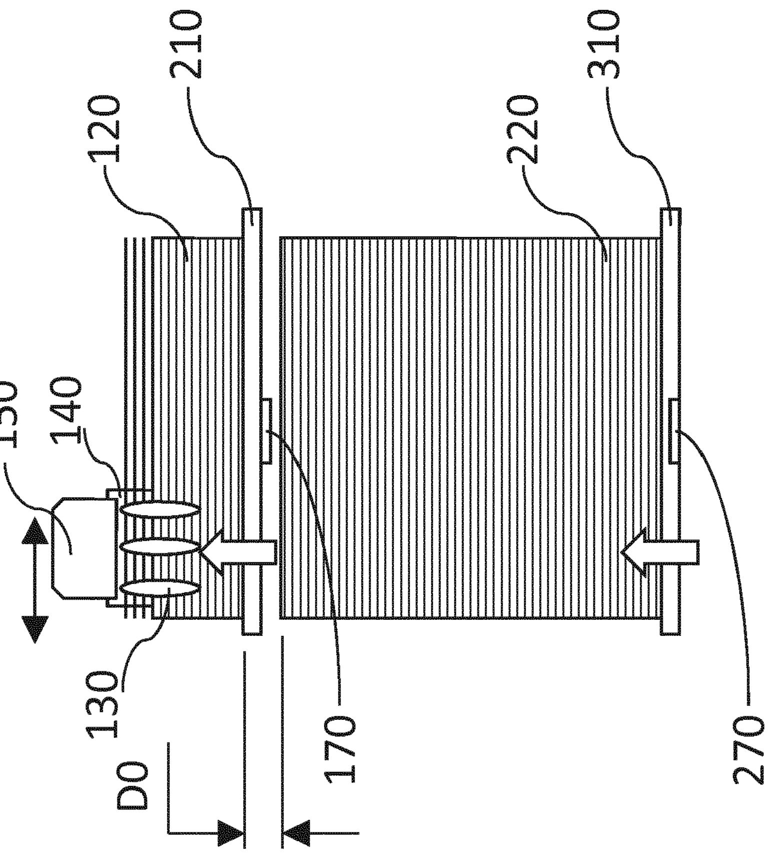

FIG. 6

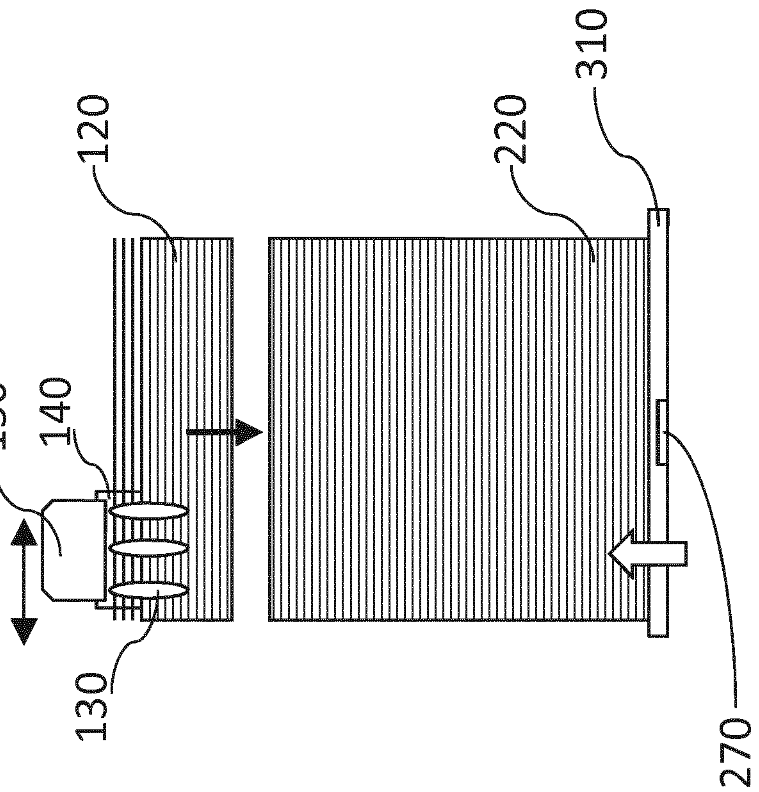

FIG. 7

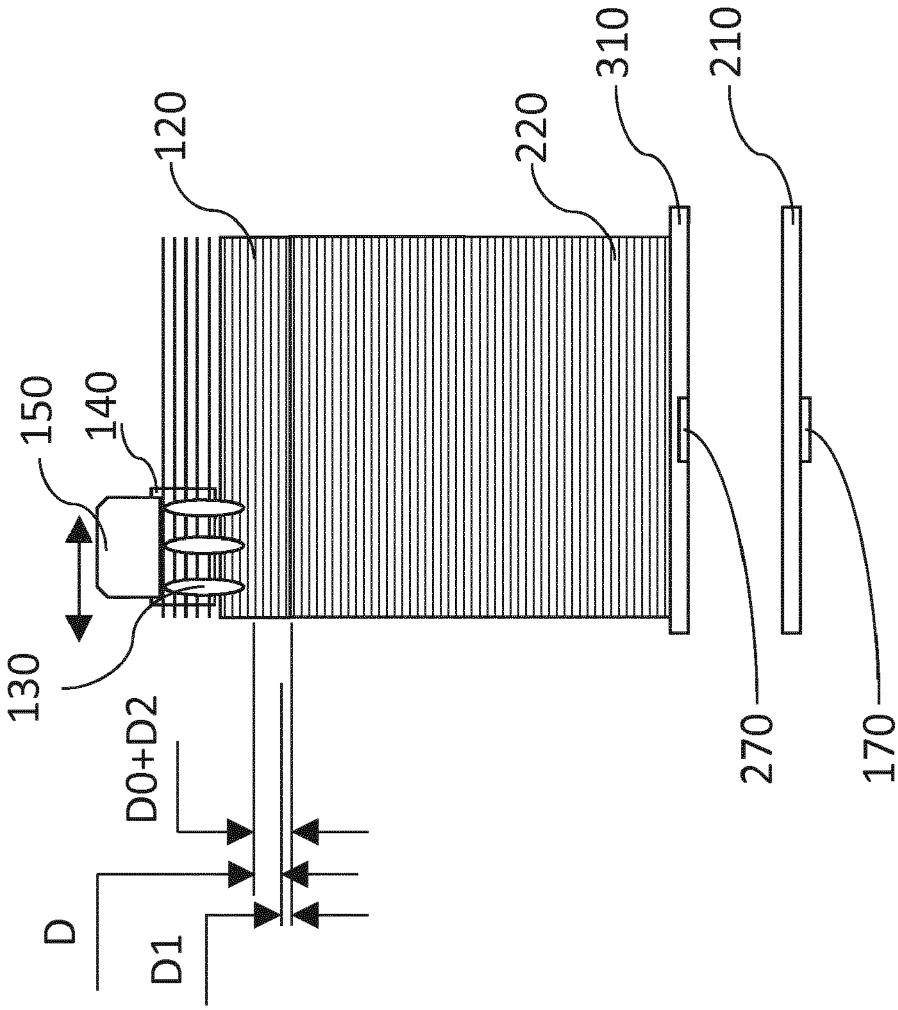

FIG. 8

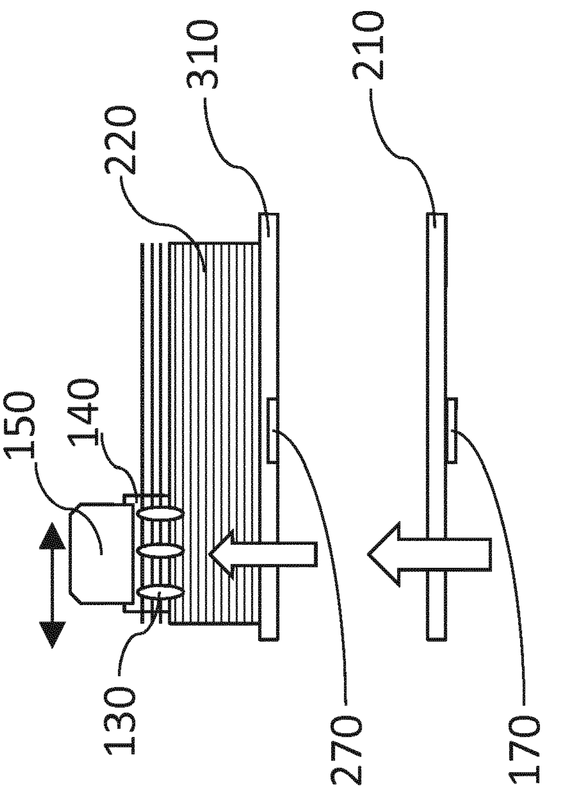

FIG. 9

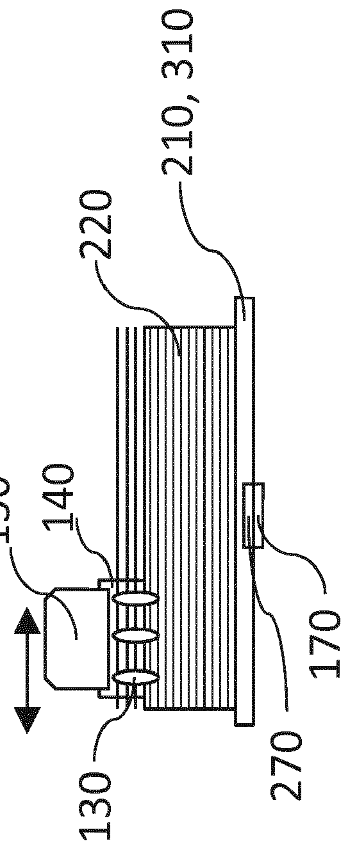

FIG. 10

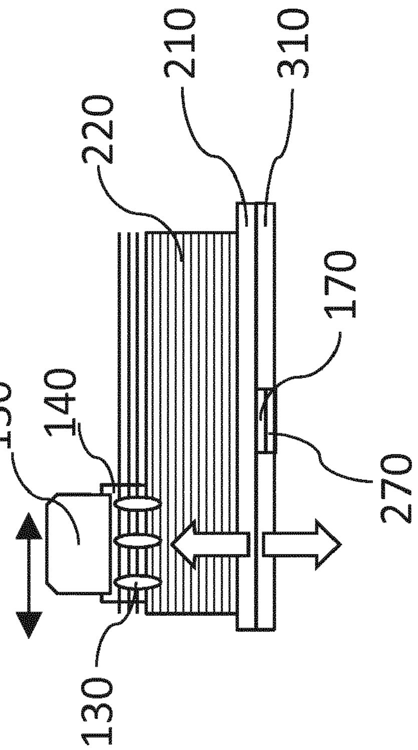

FIG. 11

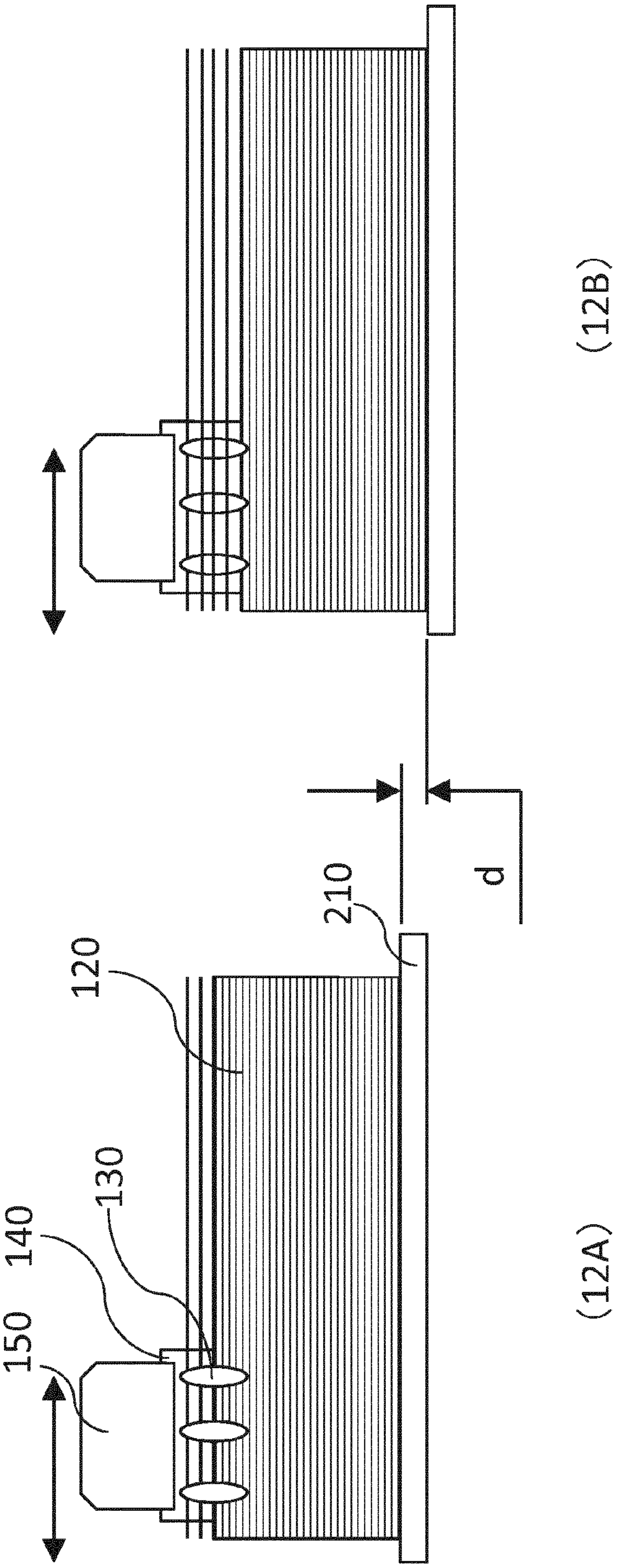

FIG. 12

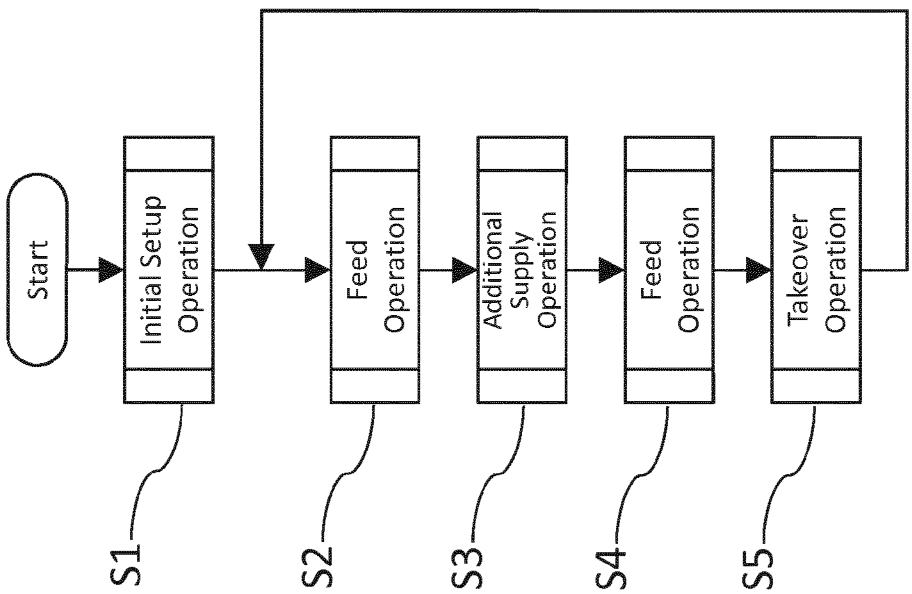
Start
Initial Setup Operation
Feed Operation
Additional Supply Operation
Feed Operation
Takeover Operation
S1
S2
S3
S4
S5

FIG. 13

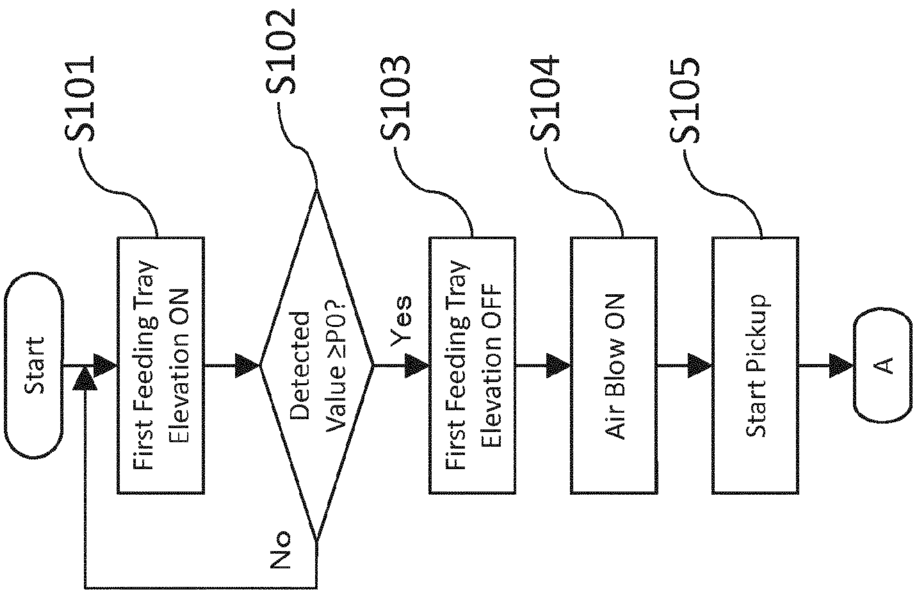
Start
First Feeding Tray Elevation ON
S101
Detected Value ≥P0?
S102
Yes
No
First Feeding Tray Elevation OFF
S103
Air Blow ON
S104
Start Pickup
S105
A

FIG. 14

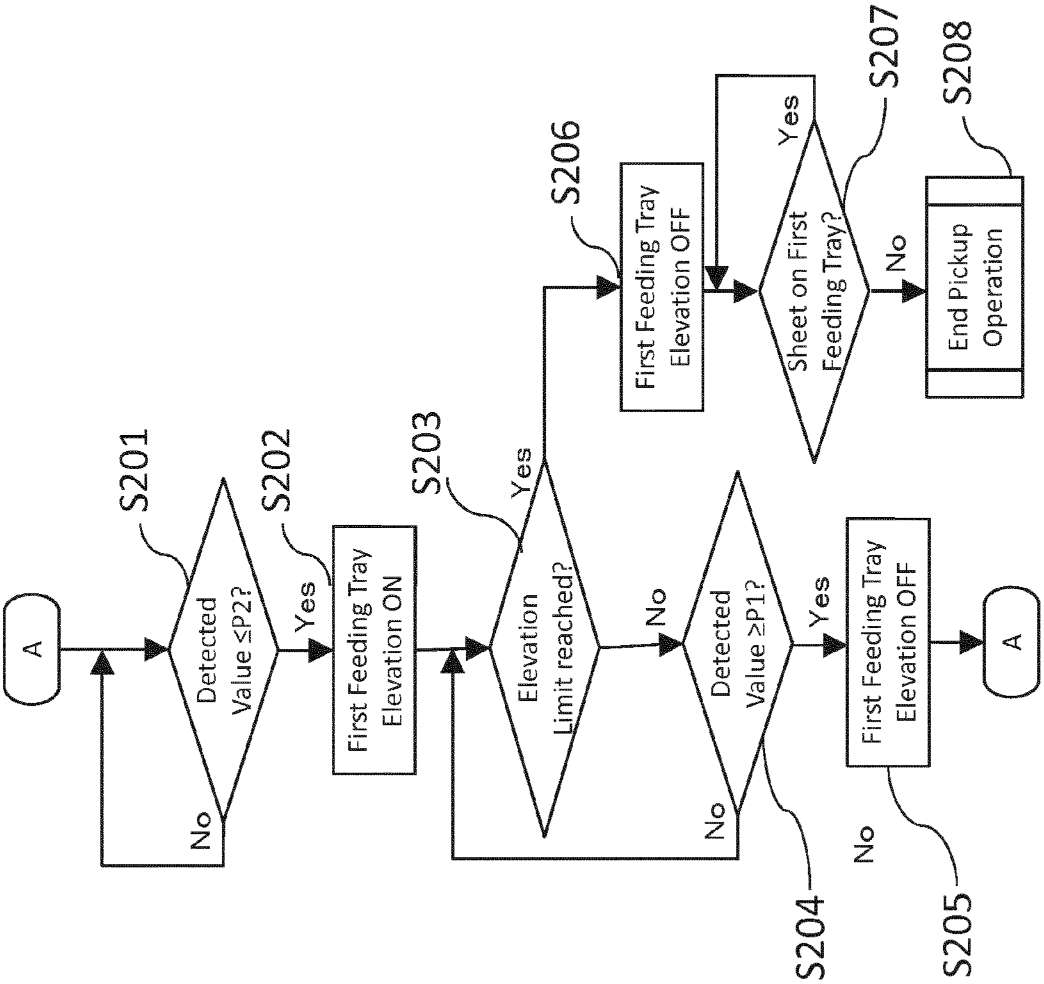
A
S201
Detected Value ≤P2?
Yes
No
S202
First Feeding Tray Elevation ON
S203
Elevation Limit reached?
Yes
No
S204
Detected Value ≥P1?
Yes
No
S205
First Feeding Tray Elevation OFF
A
S206
First Feeding Tray Elevation OFF
S207
Sheet on First Feeding Tray?
Yes
No
S208
End Pickup Operation

FIG. 15

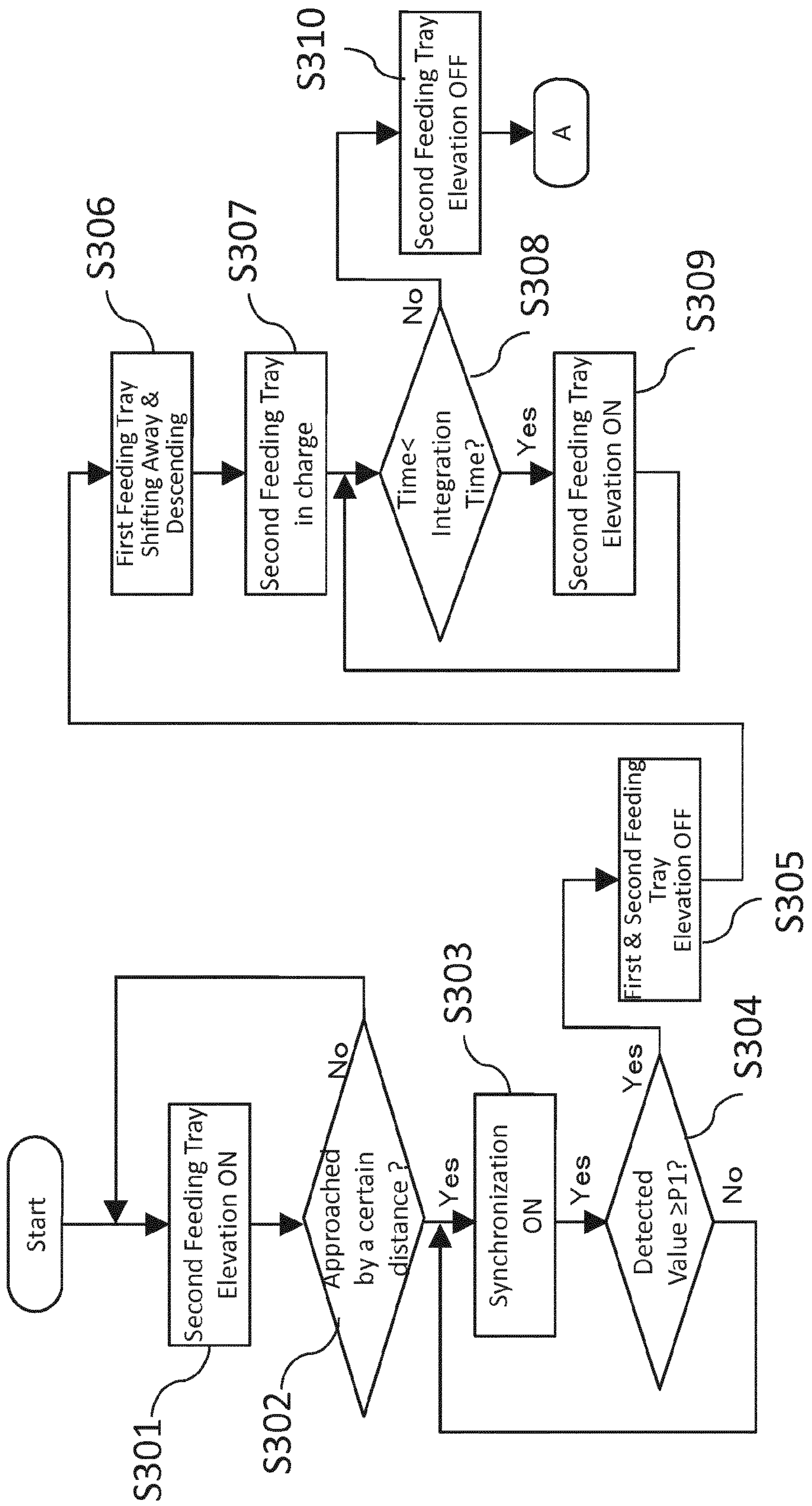
Start
Second Feeding Tray Elevation ON
S301
Approached by a certain distance ?
S302
No
Yes
Synchronization ON
S303
Yes
Detected Value ≥P1?
S304
Yes
No
First & Second Feeding Tray Elevation OFF
S305
First Feeding Tray Shifting Away & Descending
S306
Second Feeding Tray in charge
S307
Time< Integration Time?
S308
No
Yes
Second Feeding Tray Elevation ON
S309
Second Feeding Tray Elevation OFF
S310
A

FIG. 16

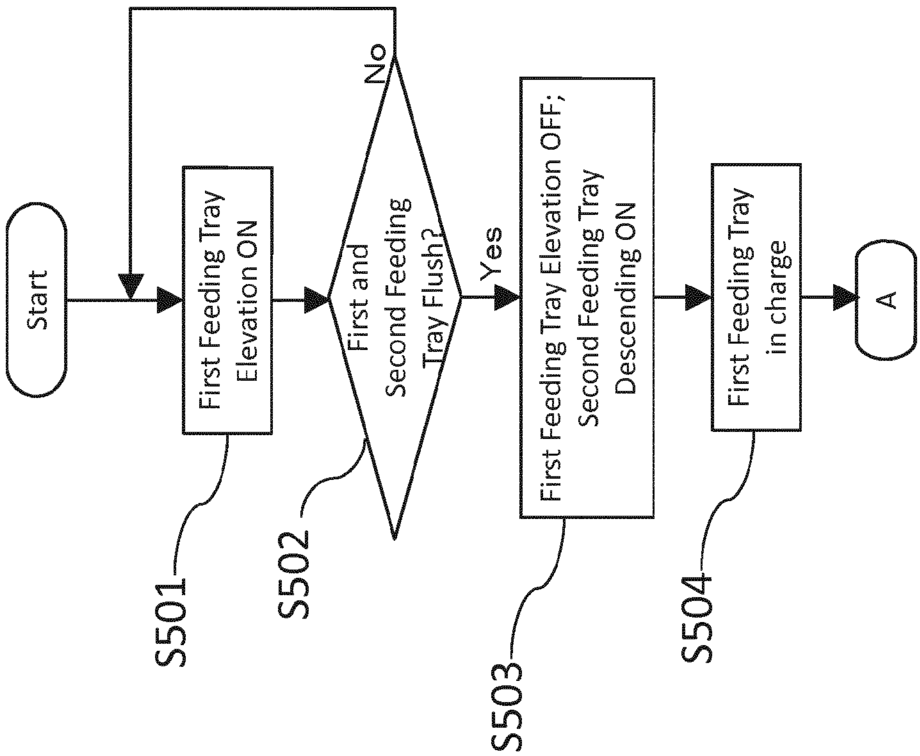
Start
First Feeding Tray Elevation ON
First and Second Feeding Tray Flush?
No
Yes
First Feeding Tray Elevation OFF; Second Feeding Tray Descending ON
First Feeding Tray in charge
A
S501
S502
S503
S504

FIG. 17

Europäisches Patentamt
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EUROPEAN SEARCH REPORT

Application Number
EP 15 18 3204

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	JP 2001 163457 A (TOSHIBA CORP) 19 June 2001 (2001-06-19) * paragraph [0021] - paragraph [0071]; figures 1-28 * -----	1-5	INV. B65H1/26 B65H1/30 B65H3/48 B65H7/04
A	US 2010/194029 A1 (DOPFER PETER [DE] ET AL) 5 August 2010 (2010-08-05) * paragraph [0022] - paragraph [0030]; figures 1-6 * -----	1-5	
A	WO 2014/037119 A1 (GIESECKE & DEVRIENT GMBH [DE]) 13 March 2014 (2014-03-13) * page 4, line 17 - page 6, line 24; figures 1-3 * -----	1-5	
A	US 6 182 962 B1 (LEUTHOLD KARL [DE]) 6 February 2001 (2001-02-06) * column 2, line 18 - column 3, line 41; figures 1-4 * -----	1-5	
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			B65H

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	2 March 2016	Henningsen, Ole

CATEGORY OF CITED DOCUMENTS

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02-03-2016

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