



(51) International Patent Classification:

B65H 3/06 (2006.01) *B65H 13/00* (2006.01)
B65H 5/06 (2006.01)

(21) International Application Number:

PCT/US2019/048089

(22) International Filing Date:

26 August 2019 (26.08.2019)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

2018-166830 06 September 2018 (06.09.2018) JP

(71) Applicant: **HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.** [US/US]; 10300 Energy Drive, Spring, Texas 77389 (US).

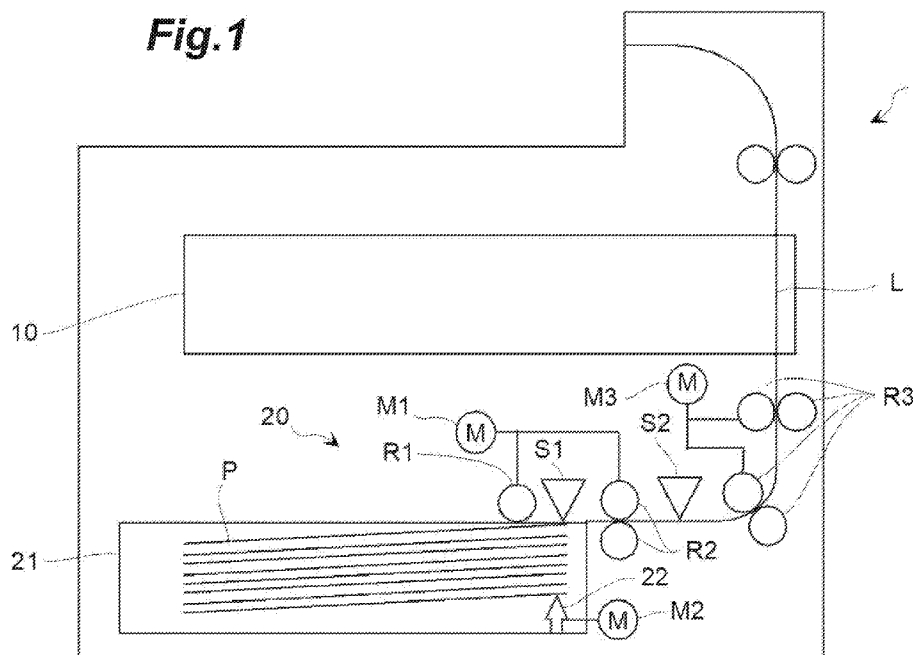
(72) Inventor: **OTAWA, Yasuhiko**; 3-4-39 Tsurumi Chuo, Tsurumi-ku, Yokohama, Kanagawa 230-0051 (JP).

(74) Agent: **KO, Steve Sokbong** et al.; HP Inc., 3390 E. Harmony Rd., Mail Stop 35, Fort Collins, Colorado 80528 (US).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(54) Title: SHEET FEEDING

Fig.1



(57) **Abstract:** A sheet feeding device includes a tray to store a stack of sheets, and a sheet elevation mechanism provided at the bottom of the tray to lift the stack of sheets until a top sheet of the stack of sheets reaches a predetermined height position. A paper feed roller is disposed above the tray to come in contact with the top sheet having reached the predetermined height position and rotated by a motor to deliver the top sheet from the tray. Additionally, the sheet feed device includes a controller to control the sheet elevation mechanism based on a drive torque of the motor to adjust the height position of the stack of sheets, after delivery of the first sheet from the tray by the paper feed roller and upon delivery of a second sheet by the paper feed roller. The frictional force to be produced between the second sheet and the paper feed roller is substantially equal to the frictional force produced between the first sheet and the paper feed roller during delivery of the first sheet.

(84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
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Published:

- *with international search report (Art. 21(3))*
-

SHEET FEEDING

BACKGROUND

[0001] Print media sheets are fed one by one to an imaging device. Each time a sheet is delivered by a paper feed roller, the height of a stack decreases slightly and, as a result, the contact pressure and frictional force to be produced between the paper feed roller and the next sheet during the next paper feeding decrease slightly.

[0002] Some imaging devices raise a stack of sheets each time an upper end position of the stack goes below a lower limit of a paper feedable height (for example, for every several or several tens of fed sheets), so as to maintain the contact pressure and frictional force as constant as possible. In order to perform stable paper feeding, after delivering a first sheet from a tray, successive sheets can be withdrawn at the same contact pressure (and, consequently, at the same frictional force).

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. 1 is a schematic diagram illustrating an example image forming apparatus including a sheet feeding device.

FIG. 2 is a diagram illustrating an example configuration of an electronic circuit of a sheet feeding device.

FIG. 3 is a timing diagram of various signals illustrating an example operation of a sheet feeding device when a current value of a paper feed motor is decreased.

FIG. 4 is a timing diagram of various signals illustrating an example operation of a sheet feeding device when a current value of a paper feed motor is increased.

FIG. 5 is a flow diagram illustrating an example operation of a sheet feeding device.

FIG. 6 is a flow diagram illustrating an example method for delivering sheets from a tray.

DETAILED DESCRIPTION

[0004] An example sheet feeding device may include a tray to store a stack of sheets, a sheet elevation mechanism provided at a bottom of the tray to lift the

stack of sheets until a top sheet of the stack of sheets reaches a predetermined height position, and a paper feed roller disposed above the tray to come in contact with the top sheet having reached the predetermined height position and rotationally driven by a motor to deliver the top sheet from the tray. Additionally, the sheet feeding device may include a controller to control the sheet elevation mechanism based on a drive torque of the motor to adjust the height position of the stack of sheets, after delivery of the first sheet from the tray by the paper feed roller and upon delivery of a second sheet by the paper feed roller. The frictional force to be produced between the second sheet and the paper feed roller may be substantially equal to the frictional force produced between the first sheet and the paper feed roller during delivery of the first sheet.

[0005] The sheet feeding device may further include a current detection circuit to measure a current value of the motor indicative of the drive torque of the motor. The controller may measure a first current value of the motor with the current detection circuit during delivery of the first sheet and the controller may measure a second current value of the motor with the current detection circuit during delivery of the second sheet. The controller may control the sheet elevation mechanism to lift the stack of sheets when the second current value is less than a reference current value determined based on the first current value by more than a predetermined threshold value. Additionally, the controller may control the sheet elevation mechanism to halt the movement of the stack of sheets when the absolute value of a difference between the second current value and the reference current value is not greater than the predetermined threshold value.

[0006] The controller may further control the sheet elevation mechanism to lower the stack of sheets when the second current value is greater than the reference current value by more than the predetermined threshold value.

[0007] The sheet feeding device may comprise a leading edge sensor to detect safe delivery of sheets from the tray. The controller may selectively, or in some cases exclusively deliver the second sheet when the leading edge sensor has detected that delivery of the first sheet from the tray has been completed.

[0008] The controller may measure the first current value of the motor with the

current detection circuit after a predetermined waiting time has passed from the start of delivery of the first sheet. Additionally, the controller may measure the second current value of the motor with the current detection circuit after the predetermined waiting time has passed from the start of delivery of the second sheet.

[0009] The controller may measure the first current value of the motor with the current detection circuit a plurality of times after the predetermined waiting time has passed from the start of delivery of the first sheet. Additionally, the controller may determine the reference current value based on the measured plurality of first current values.

[0010] The sheet feeding device may further include an upper limit sensor to detect that the top sheet of the stack of sheets has reached the predetermined height position.

[0011] In some examples, the controller may additionally halt the motor when the second current value is less than a predetermined non-feeding detection value or greater than a predetermined double-feeding detection value.

[0012] An example method for delivering sheets from a tray may include lifting, with a sheet elevation mechanism, a stack of sheets from a bottom of the tray until a top sheet of the stack of sheets reaches a predetermined height position such that a paper feed roller disposed above the tray makes contact with the top sheet. Additionally, the method may include rotationally driving the paper feed roller by a motor to deliver the top sheet from the tray by the paper feed roller, and controlling the sheet elevation mechanism based on a drive torque of the motor to adjust the height position of the stack of sheets. The height position may be adjusted after delivery of the first sheet from the tray by the paper feed roller and upon delivery of a second sheet by the paper feed roller, such that the frictional force to be produced between the second sheet and the paper feed roller is substantially equal to the frictional force produced between the first sheet and the paper feed roller during delivery of the first sheet.

[0013] The sheet elevation mechanism may be controlled based on a drive torque of the motor by measuring a first current value of the motor indicative of the drive torque of the motor during delivery of the first sheet, and measuring a

second current value of the motor indicative of the drive torque of the motor during delivery of the second sheet. The sheet elevation mechanism may be controlled to lift the stack of sheets when the second current value is less than a reference current value determined based on the first current value by more than a predetermined threshold value. Additionally, the sheet elevation mechanism may be controlled to halt the movement of the stack of sheets when the difference between the second current value and the reference current value is less than or equal to the predetermined threshold value.

[0014] In some examples, the sheet elevation mechanism may additionally be controlled based on a drive torque of the motor by controlling the sheet elevation mechanism to lower the stack of sheets when the second current value is greater than the reference current value by more than the predetermined threshold value.

[0015] The delivery of the second sheet may be selectively, or in some cases exclusively performed when the first sheet has been delivered from the tray.

[0016] The measurement of the first current value of the motor indicative of the drive torque of the motor during delivery of the first sheet may include measuring the first current value of the motor after a predetermined waiting time has passed from the start of delivery of the first sheet. Additionally, the measurement of the second current value of the motor indicative of the drive torque of the motor during delivery of the second sheet may include measuring the second current value of the motor after a predetermined waiting time has passed from the start of delivery of the second sheet.

[0017] Still further, the measurement of the first current value of the motor after the predetermined waiting time has passed from the start of delivery of the first sheet may include measuring the first current value of the motor a plurality of times after the predetermined waiting time has passed from the start of delivery of the first sheet. In some examples, the reference current value may be determined based on the measured plurality of first current values.

[0018] The method may further include halting the motor when the second current value is less than a predetermined non-feeding detection value or greater than a predetermined double-feeding detection value.

[0019] In the following description, with reference to the drawings, the same reference numbers are assigned to the same components or to similar components having the same function, and overlapping description is omitted.

[0020] FIG. 1 illustrates an example image forming apparatus 1 including an image forming section 10 to form images on print media sheets P passed through a transport path L. Additionally, the image forming apparatus 1 may include a sheet feeding device 20 to feed the print media sheets P to the transport path L. FIG. 2 illustrates an example electronic circuit of the sheet feeding device 20.

[0021] With reference to FIG. 1 and FIG. 2, the sheet feeding device 20 includes a tray 21 to store a stack of print media sheets P, and a sheet elevation mechanism 22 provided at the bottom of the tray 21 to lift the stack of sheets P until the top sheet P of the stack of sheets P reaches a predetermined height position H. Additionally, the sheet feeding device 20 may include a paper feed roller R1 disposed above the tray 21 to come in contact with the top sheet P having reached the predetermined height position H. The paper feed roller R1 may be rotationally driven by a paper feed motor M1 to deliver the top sheet P of the stack of sheets P from the tray 21.

[0022] The predetermined height position H may be a height position at which the paper feed roller R1 disposed above the tray 21 is urged at a sufficient contact pressure against the top sheet P that has reached the predetermined height position H so that the top sheet P can be delivered by the rotation of the paper feed roller R1. The sheet feeding device 20 may further include an upper limit sensor S1 to detect that the top sheet P of the stack of sheets P has reached the predetermined height position H. The upper limit sensor S1 may include a sensor configured to detect the height position of the top sheet P of the stack of sheets P, such as a transmissive or reflective optical sensor. The paper feed roller R1 may be vertically and/or oscillatably supported about a rotational shaft of an upper paper feed roller R2 by a resilient support member, such as a spring, extending from the rotational shaft of the upper paper feed roller R2 to the paper feed roller R1, so as to generate the contact pressure.

[0023] The sheet feeding device 20 may further include a pair of paper feed

rollers R2 to forward the sheet P delivered by the paper feed roller R1 toward transport rollers R3 along a transport path L. Additionally, the sheet feeding device 20 may include a pair or plurality of pairs of transport rollers R3 to transport the sheet P forwarded from the paper feed rollers R2 to the image forming section 10 along the transport path L. The sheet feeding device 20 may further include a paper feed controller 23 to control the operation of various components of the sheet feeding device 20, including the sheet elevation mechanism 22, the paper feed rollers R1, R2 and the transport rollers R3.

[0024] The sheet elevation mechanism 22 may include a mechanism configured to move the stack of sheets P vertically in response to control from the paper feed controller 23 such as a rack-and-pinion mechanism that can be driven by an elevation motor M2 to vertically move the stack of sheets P. The paper feed controller 23 may control the operation of the sheet elevation mechanism 22 by controlling a drive circuit of the elevation motor M2.

[0025] At the start of a paper feed operation, the paper feed controller 23 may first control the sheet elevation mechanism 22 to lift the stack of sheets P until the top sheet P of the stack of sheets P reaches the predetermined height position H. When the upper limit sensor S1 detects that the top sheet P of the stack of sheets P has reached the predetermined height position H, the paper feed controller 23 controls the sheet elevation mechanism 22 to halt the operation to lift the stack of sheets P, and turns the paper feed motor M1 on to start rotation of the paper feed rollers R1, R2. The paper feed controller 23 may control the rotation of the paper feed motor M1 by controlling a drive circuit of the paper feed motor M1.

[0026] The top sheet P delivered by the paper feed roller R1 from the tray 21 may be further forwarded by the pair of paper feed rollers R2 toward the transport rollers R3. To prevent double-feeding of the sheets P, however, the lower paper feed roller R2 of the pair of paper feed rollers R2 may be rotated in the same direction (i.e., the direction to force the sheets P back to the tray) as the rotation direction of the upper paper feed roller R2 (e.g., in a counter-clockwise direction).

[0027] After the first sheet P (i.e., the first sheet P to be delivered after the stack

of sheets P is lifted by the sheet elevation mechanism 22) is delivered by the paper feed roller R1, a frictional force to be produced between a second sheet P (i.e., any of subsequent sheets P) and the paper feed roller R1 during delivery of the second sheet P by the paper feed roller may be decreased due to, for example, a reduction in height of the stack of sheets P. Further, after the first sheet P is delivered by the paper feed roller R1, the frictional force to be produced between the second sheet P and the paper feed roller R1 may be increased due to, for example, a slight upward movement of the sheets P. In some examples, the upward movement of the sheets P may be caused by the sheet elevation mechanism 22 affected by vibrations during feeding or by a state of moisture content of the first sheet P, which may cause a difference in frictional force from the second sheet P.

[0028] To correct or adjust for such variations in frictional force, after the first sheet P is delivered from the tray 21 by the paper feed roller R1, the paper feed controller 23 may control the sheet elevation mechanism 22 to adjust the height position of the stack of sheets P based on a drive torque of the paper feed motor M1 when the second sheet P is to be delivered by the paper feed roller R1. In some examples, the frictional force to be produced between the second sheet P and the paper feed roller R1 is substantially equal to the frictional force produced between the first sheet P and the paper feed roller R1 during delivery of the first sheet P. The drive torque of the paper feed motor M1 increases as the frictional force between the second sheet P and the paper feed roller R1 is increased, and decreases as the frictional force between the second sheet P and the paper feed roller R1 is decreased. To this end, the sheet feeding device 20 may further include a current detection circuit 24 to detect current values of the paper feed motor M1 indicative of drive torques of the paper feed motor M1. In some examples, the sheet feeding device 20 may perform such control over the frictional force for each of the subsequent sheets P. In one or more examples, "substantially equal" may be understood to mean that a difference between two compared values is not greater than a predetermined threshold value.

[0029] In some examples, the sheet feeding device 20 may further include a memory device 25 and the paper feed controller 23 may measure, using the

current detection circuit 24, a first current value of the paper feed motor M1 one or multiple times during delivery of the first sheet P. Additionally, the measured first current values may be stored in the memory device 25. After that, during delivery of the second sheet P, the paper feed controller 23 may measure, using the current detection circuit 24, a second current value of the paper feed motor M1. The paper feed controller 23 may adjust the height position of the stack of sheets P by controlling the sheet elevation mechanism 22 such that the measured second current value of the paper feed motor M1 is substantially equal to a reference current value determined based on the first current value stored in the memory device 25. In some examples, the sheet feeding device 20 may perform such adjustment of height position for each of the subsequent sheets P. The paper feed controller 23 may determine an average value of a plurality of first current values stored in the memory device 25 as the reference current value. In some examples, the paper feed controller 23 may determine a single first current value stored in the memory device 25 as the reference current value.

[0030] An example process is described, in which each of the following operations (a) to (c) may be performed during delivery of the second sheet P. At operation (a), when the second measured value of the paper feed motor M1 measured with the current detection circuit 24 is less than the reference current value by more than a predetermined threshold value Th , the paper feed controller 23 may control the sheet elevation mechanism 22 to lift the stack of sheets P. At operation (b), when the second measured value measured with the current detection circuit 24 is greater than the reference current value by more than the predetermined threshold value Th , the paper feed controller 23 may control the sheet elevation mechanism 22 to lower the stack of sheets P. Further, at operation (c), when the absolute value of a difference between the second measured value measured with the current detection circuit 24 and the reference current value is not greater than the predetermined threshold value Th (e.g., is less than or equal to the predetermined threshold value), the paper feed controller 23 may control the sheet elevation mechanism 22 to halt the upward or downward movement of the stack of sheets P. During delivery of the second

sheet P, the paper feed controller 23 may measure the second current value of the paper feed motor M1 repeatedly and continue performing operation (a) and/or operation (b) until the absolute value of a difference between the second measured value measured with the current detection circuit 24 and the reference current value becomes not greater than the predetermined threshold value Th. The predetermined threshold value Th may be approximately 5 mA or more, and in some examples approximately 10 mA or more, so as to shorten the time required to adjust the frictional force. The predetermined threshold value Th may be approximately 5 mA or less, and in some examples approximately 1 mA or less, so as to realize stable feeding.

[0031] At an operation (d), when the second measured value measured with the current detection circuit 24 is less than a predetermined non-feeding detection value or greater than a predetermined double-feeding detection value, the paper feed controller 23 may halt the movement of the paper feed motor M1 on the assumption that non-feeding or double-feeding may have occurred. The predetermined non-feeding detection value may be approximately 90% or less of the reference current value, and in some examples 80% or less of the reference current value, so as to detect non-feeding at the paper feed roller R1 reliably. The predetermined double-feeding detection value may be approximately 110 % or more of the reference current value, and in some examples approximately 120 % or more of the reference current value, so as to detect double-feeding at the paper feed roller R1 reliably.

[0032] The sheet feeding device 20 may further include a leading edge sensor S2 to detect that the delivery of sheets P from the tray 21 has been successfully completed. The leading edge sensor S2 may be disposed adjacent to the transport path L in a position between the paper feed rollers R2 and the transport rollers R3, to detect the leading edge of sheets P delivered from the paper feed rollers R2. The leading edge sensor S2 may include a sensor configured to detect the leading edge of sheets P delivered from the paper feed rollers R2, such as a reflective optical sensor. The paper feed controller 23 may selectively, or in some cases exclusively deliver the second sheet P when the leading edge sensor S2 has detected that delivery of the first sheet P from the

tray 21 has been completed, so as to make sure that the reference current value is determined properly.

[0033] FIG. 3 illustrates an example operation of the sheet feeding device 20 for the case where the current value of the paper feed motor M1 decreases during delivery of the second sheet P. FIG. 3 illustrates relative values or operating states of the operation, including the current value of the paper feed motor M1 (first row), an ON/OFF state of the drive signal of the paper feed motor M1 (second row), an UP/DOWN/OFF state of the drive signal of the elevation motor M2 (third row), and an ON/OFF state of the output signal from the leading edge sensor S2 (fourth row). During delivery of the first sheet P, when the paper feed controller 23 turns the paper feed motor M1 ON at time T_0 , the current value of the paper feed motor M1 (indicated by a solid line in the first row) abruptly increases from zero due to an inrush current. When mechanical elements such as gears to transmit the rotation of the paper feed motor M1 to the paper feed roller R1 engage with each other, the current value of the paper feed motor M1 is stabilized at time T_1 and remains substantially unvaried. After reaching the stable state, the current value of the paper feed motor M1 is proportional to the drive torque of the paper feed motor M1 and, as such, proportional to the frictional force and contact pressure between the paper feed roller R1 and the sheet P being delivered by the paper feed roller R1. Accordingly, the paper feed controller 23 may measure the first current value of the paper feed motor M1 with the current detection circuit 24 at a point in time after time T_1 .

[0034] After the leading edge sensor S2 detects or confirms delivery of the first sheet P from the tray 21 at T_4 , the paper feed controller 23 turns the paper feed motor M1 OFF when a predetermined time TD passes at time T_5 . When the paper feed motor M1 is turned OFF, the current value of the paper feed motor M1 returns to zero. The predetermined time TD is a time period that extends from or begins with the detection of the leading edge of the sheet P with the leading edge sensor S2 and lasts until or concludes when the leading edge of the sheet P reaches the transport rollers R3. The predetermined time TD may be determined in advance by experiments, measurements, calculations or the like.

[0035] In some examples, during delivery of the second sheet P (i.e., any of subsequent sheets P), when the paper feed controller 23 turns the paper feed motor M1 ON at time T_0 , the current value of the paper feed motor M1 (indicated by a broken line in the first row) abruptly increases from zero due to an inrush current. When the mechanical elements to transmit the rotation of the paper feed motor M1 to the paper feed roller R1 engage with each other, the current value of the paper feed motor M1 is stabilized at time T_1 and remains substantially unvaried. After reaching the stable state, the current value of the paper feed motor M1 is proportional to the drive torque of the paper feed motor M1 and, as such, proportional to the frictional force and contact pressure between the paper feed roller R1 and the sheet P being delivered by the paper feed roller R1. Accordingly, the paper feed controller 23 may measure the second current value of the paper feed motor M1 with the current detection circuit 24 at a point in time after time T_1 .

[0036] In some examples, with reference to FIG. 3, the paper feed controller 23 starts measuring the second current value (broken line) of the paper feed motor M1 at time T_2 and, as the measured second current value is less than the previously measured first current value (solid line) and thus is less than the reference current value, controls the elevation motor M2 to lift the stack of sheets P. When the second current value is substantially equal to the reference current value at time T_3 , the paper feed controller 23 controls the elevation motor M2 to stop lifting the stack of sheets P. After the leading edge sensor S2 detects that the second sheet P from the tray 21 at T_4 has been delivered, the paper feed controller 23 turns the paper feed motor M1 OFF when the predetermined time TD passes at time T_5 . When the paper feed motor M1 is turned OFF, the current value of the paper feed motor M1 returns to zero.

[0037] FIG. 4 illustrates an example operation of the sheet feeding device 20 for the case where the current value of the paper feed motor M1 increases during delivery of the second sheet P. FIG. 4 illustrates relative values or operating states of the operation, including the current value of the paper feed motor M1 (first row), an ON/OFF state of the drive signal of the paper feed motor M1 (second row), an UP/DOWN/OFF state of the drive signal of the elevation motor

M2 (third row), and an ON/OFF state of the output signal from the leading edge sensor S2 (fourth row). In some examples, with reference to FIG. 4, as the second current value (broken line) of the paper feed motor M1 measured at time T_2 is greater than the current value (solid line) of the paper feed motor M1 previously measured during delivery of the first sheet P, and thus is greater than the reference current value, the paper feed controller 23 controls the elevation motor M2 at time T_2 to lower the stack of sheets P. After that, when the second current value is substantially equal to the reference current value at time T_3 , the paper feed controller 23 controls the elevation motor M2 to stop lowering the stack of sheets P. The example operation illustrated in FIG. 4 is otherwise the same as that of FIG. 3 and its further description is omitted.

[0038] As mentioned above, after reaching the stable state, the current value of the paper feed motor M1 is proportional to the drive torque of the paper feed motor M1 and, as such, proportional to the frictional force and contact pressure between the paper feed roller R1 and the sheet P being delivered by the paper feed roller R1. As such, the sheet feeding device 20 may further include a time measurement device 26 and, after the time measurement device 26 detects that a predetermined waiting time TW has passed from the start of delivery of the first sheet P at time T_0 , the paper feed controller 23 may measure the first current value of the paper feed motor M1 with the current detection circuit 24 one or multiple times. Further, after the time measurement device 26 detects that the predetermined waiting time TW has passed from the start of delivery of the second sheet P at time T_0 , the paper feed controller 23 may measure the second current value of the paper feed motor M1 with the current detection circuit 24. In some examples, the predetermined waiting time TW is a time period required for the current value of the paper feed motor M1 to stabilize after the paper feed motor M1 is turned ON, and is equal to the time period between time T_0 and T_1 in FIG. 3 and FIG. 4. The predetermined waiting time TW may be determined in advance by experiments, measurements, calculations, or the like.

[0039] The predetermined waiting time TW may be approximately 50 ms or more, and in some examples approximately 80 ms or more, in order to adjust the frictional force accurately. The predetermined waiting time TW may be

approximately 200 ms or less, and in some examples approximately 120 ms or less, so as to secure a sufficient time for the adjustment of the frictional force.

[0040] FIG. 5 is a flow diagram 500 illustrating an example operation (or series of operations) of the sheet feeding device 200. The operation begins at 502 and proceeds to 504, where the paper feed controller 23 turns the paper feed motor M1 ON. Next, the operation proceeds to 506, where the paper feed controller 23 determines whether or not the predetermined waiting time TW has passed. If not determined that the predetermined waiting time TW has passed, the operation goes back to 506 to reiterate the determination. If determined at 506 that the predetermined waiting time TW has passed, the operation proceeds to 508, where the paper feed controller 23 determines whether or not the sheet P delivered by the paper feed roller R1 is the first sheet P (i.e., the first sheet P delivered after the stack of sheets P is lifted by the sheet elevation mechanism 22). If determined at 508 that the sheet P delivered by the paper feed roller R1 is the first sheet P, the operation proceeds to 510, where the paper feed controller 23 measures the first current value of the paper feed motor M1 with the current detection circuit 24, and then stores at 512 the measured first current value in the memory device 25.

[0041] After that, the operation proceeds to 514, where the paper feed controller 23 determines whether or not the leading edge sensor S2 has detected delivery of the first sheet P from the tray 21. If determined at 514 that the leading edge sensor S2 has detected delivery of the first sheet P from the tray 21, the operation is terminated at 540.

[0042] On the other hand, if determined at 514 that the leading edge sensor S2 has yet to detect that the delivery of the first sheet P from the tray 21 has been successfully completed, the operation proceeds to 516, where the paper feed controller 23 determines whether or not a predetermined time limit TL has passed since the turning ON of the paper feed motor M1. If determined at 516 that the predetermined time limit TL has not passed, the operation goes back to 510, where the paper feed controller 23 once again measures the first current value of the paper feed motor M1 with the current detection circuit 24. The following operations are the same as those described above. On the other

hand, if determined at 516 that the predetermined time limit TL has passed, the paper feed controller 23 determines that some glitch has occurred in the delivery of the first sheet P, and the operation is terminated at 516.

[0043] The predetermined time limit TL may be determined based on the position of the leading edge sensor S2, the delivery speed of the sheet, etc. For example, the predetermined time limit TL may be approximately 800 ms or more, and in some examples approximately 1000 ms or more, in order to detect paper feed errors correctly. The predetermined time limit TL may be approximately 700 ms or less, and in some examples approximately 500 ms or less, in order to shorten the paper feed time.

[0044] If determined at 508 that the sheet P delivered by the paper feed roller R1 is not the first sheet P, the operation proceeds to 520, where the paper feed controller 23 determines a reference current value based on the first current value stored in the memory device 25. For example, the paper feed controller 23 may determine an average value of a plurality of first current values stored in the memory device 25 as the reference current value. In some examples, the paper feed controller 23 may determine a single first current value stored in the memory device 25 as the reference current value.

[0045] After the reference current value is determined at 520, the operation proceeds to 522, where the paper feed controller 23 measures with the current detection circuit 24 the second current value of the paper feed motor M1 and then calculates at 524 a difference between the second current value and the reference current value. After that, the operation proceeds to 526, where the paper feed controller 23 determines whether or not the absolute value of the difference between the second current value and the reference current value is equal to or less than the aforementioned predetermined threshold value Th.

[0046] If determined at 526 that the absolute value of the difference between the second current value and the reference current value is not equal to or less than the predetermined threshold value Th (i.e., the absolute value of the difference exceeds the predetermined threshold value Th), the operation proceeds to 528, where the paper feed controller 23 determines whether or not the difference between the second current value and the reference current value is negative

(i.e., whether or not the second current value is less than the reference current value). If determined at 528 that the difference between the second current value and the reference current value is negative (i.e., the second current value is less than the reference current value), the operation proceeds to 530, where the paper feed controller 23 controls the sheet elevation mechanism 22 to lift the stack of sheets P. On the other hand, if determined at 528 that the difference between the second current value and the reference current value is not negative (i.e., the second current value is greater than the reference current value), the operation proceeds to 532, where the paper feed controller 23 controls the sheet elevation mechanism 22 to lower the stack of sheets P. Further, if determined at 526 that the absolute value of the difference between the second current value and the reference current value is equal to or below the predetermined threshold value T_h , the operation proceeds to 534, where the paper feed controller 23 controls the sheet elevation mechanism 22 to halt the lifting or lowering movement of the stack of sheets P.

[0047] After controlling the sheet elevation mechanism 22 at 530, 532 or 534, the operation proceeds to 536, where the paper feed controller 23 determines whether or not the leading edge sensor S2 has detected delivery of the second sheet P from the tray 21. If determined at 536 that the leading sensor S2 has detected delivery of the second sheet P from the tray 21, the operation is terminated at 540.

[0048] On the other hand, if determined at 536 that the leading edge sensor S2 has yet to detect that the second sheet P has been delivered from the tray 21, the operation proceeds to 538, where the paper feed controller 23 determines whether or not the predetermined time limit TL has passed since the turning ON of the paper feed motor M1. If determined at 538 that the predetermined time limit TL has not passed, the operation goes back to 522, where the paper feed controller 23 once again measures the second current value of the paper feed motor M1 with the current detection circuit 24. The following operations are the same as those described above. On the other hand, if determined at 538 that the predetermined time limit TL has passed, the paper feed controller 23 determines that some glitch has occurred in the delivery of the second sheet P,

and the operation is terminated at 542.

[0049] FIG. 6 is a flow diagram illustrating an example method 600 for delivering sheets from a tray. The method may comprise one or more operations beginning at block 602 and proceeding to block 604. At block (operation) 604, a stack of sheets is lifted with a sheet elevation mechanism from the bottom of the tray until the top sheet of the stack of sheets reaches a predetermined height position. At the predetermined height position, a paper feed roller disposed above the tray makes contact with the top sheet. At block 606, the paper feed roller is rotated by a motor to deliver the top sheet from the tray by the paper feed roller. At block 608, after delivery of the first sheet from the tray by the paper feed roller and upon delivery of a second sheet by the paper feed roller, the sheet elevation mechanism is controlled based on a drive torque of the motor. In some examples, the sheet elevation mechanism is controlled to adjust the height position of the stack of sheets, such that the frictional force to be produced between the second sheet and the paper feed roller is substantially equal to the frictional force produced between the first sheet and the paper feed roller during delivery of the first sheet. The method 600 then proceeds to block 610 where it is terminated.

[0050] The sheet elevation mechanism may be controlled based on a drive torque of the motor by measuring a first current value of the motor indicative of the drive torque of the motor during delivery of the first sheet, and measuring a second current value of the motor indicative of the drive torque of the motor during delivery of the second sheet. Additionally, the sheet elevation mechanism may be controlled to lift the stack of sheets when the second current value is less than a reference current value determined based on the first current value by more than a predetermined threshold value. Still further, the sheet elevation mechanism may be controlled to halt the movement of the stack of sheets when the difference between the second current value and the reference current value is not greater than (e.g., is less than or equal to) the predetermined threshold value.

[0051] The sheet elevation mechanism may further be controlled based on a drive torque of the motor by controlling the sheet elevation mechanism to lower

the stack of sheets when the second current value is greater than the reference current value by more than the predetermined threshold value.

[0052] The delivery of the second sheet may be selectively, or in some cases exclusively performed when the first sheet has been delivered from the tray.

[0053] The measurement of the first current value of the motor indicative of the drive torque of the motor during delivery of the first sheet may include measuring the first current value of the motor after a predetermined waiting time has passed from the start of delivery of the first sheet. Additionally, the measurement of the second current value of the motor indicative of the drive torque of the motor during delivery of the second sheet may include measuring the second current value of the motor after the predetermined waiting time has passed from the start of delivery of the second sheet.

[0054] The measurement of the first current value of the motor after the predetermined waiting time has passed from the start of delivery of the first sheet may include measuring the first current value of the motor a plurality of times after the predetermined waiting time has passed from the start of delivery of the first sheet. Additionally, the reference current value based on the measured first current value may be determined based on the measured plurality of first current values.

[0055] In some examples, the motor may be halted when the second current value is less than a predetermined non-feeding detection value or greater than a predetermined double-feeding detection value.

[0056] In some examples, the sheet feeding device 20 is contained in the image forming apparatus 1, as illustrated in FIG. 1. In other examples, the sheet feeding device 20 may be implemented as a device separate from the image forming apparatus 1. The image forming apparatus 1 may be a printer, a component of an imaging system, or an imaging system. Additionally, the image forming apparatus 1 may comprise a developing device used in an imaging system or the like.

[0057] It is to be understood that not all aspects, advantages and features described herein may necessarily be achieved by, or included in, any one particular example. Indeed, having described and illustrated various examples

herein, it should be apparent that other examples may be modified in arrangement and detail is omitted.

CLAIMS

1. A sheet feeding device comprising:
 - a tray to store a stack of sheets;
 - a sheet elevation mechanism provided at a bottom of the tray to lift the stack of sheets until a top sheet of the stack of sheets reaches a predetermined height position;
 - a paper feed roller disposed above the tray to come in contact with the top sheet having reached the predetermined height position and rotationally driven by a motor to deliver the top sheet from the tray; and
 - a controller to control the sheet elevation mechanism based on a drive torque of the motor to adjust the height position of the stack of sheets, after delivery of the first sheet from the tray by the paper feed roller and upon delivery of a second sheet by the paper feed roller, such that the frictional force produced between the second sheet and the paper feed roller is substantially equal to the frictional force produced between the first sheet and the paper feed roller during delivery of the first sheet.
2. The sheet feeding device according to claim 1, comprising a current detection circuit to measure a current value of the motor indicative of the drive torque of the motor,
 - the controller to measure a first current value of the motor with the current detection circuit during delivery of the first sheet,
 - the controller to measure a second current value of the motor with the

current detection circuit during delivery of the second sheet,

the controller to control the sheet elevation mechanism to lift the stack of sheets when the second current value is less than a reference current value determined based on the first current value by more than a predetermined threshold value; and

the controller to control the sheet elevation mechanism to halt the movement of the stack of sheets when the absolute value of a difference between the second current value and the reference current value is not greater than the predetermined threshold value.

3. The sheet feeding device according to claim 2,

the controller to control the sheet elevation mechanism to lower the stack of sheets when the second current value is greater than the reference current value by more than the predetermined threshold value.

4. The sheet feeding device according to claim 1, comprising a leading edge sensor to detect delivery of sheets from the tray,

the controller to selectively deliver the second sheet when the leading edge sensor has detected that the first sheet has been delivered from the tray.

5. The sheet feeding device according to claim 2,

the controller to measure the first current value of the motor with the current detection circuit after a predetermined waiting time has passed from the start of delivery of the first sheet, and

the controller to measure the second current value of the motor with the current detection circuit after the predetermined waiting time has passed from the start of delivery of the second sheet.

6. The sheet feeding device according to claim 5,

the controller to measure the first current value of the motor with the current detection circuit a plurality of times after the predetermined waiting time has passed from the start of delivery of the first sheet, and

the controller to determine the reference current value based on the measured plurality of first current values.

7. The sheet feeding device according to claim 1, comprising an upper limit sensor to detect that the top sheet of the stack of sheets has reached the predetermined height position.

8. The sheet feeding device according to claim 2,

the controller to halt the motor when the second current value is less than a predetermined non-feeding detection value or greater than a predetermined double-feeding detection value.

9. A method comprising:

lifting, with a sheet elevation mechanism, a stack of sheets from the bottom of a tray until a top sheet of the stack of sheets reaches a predetermined height position and a paper feed roller disposed above the tray makes contact with the

top sheet;

rotationally driving the paper feed roller by a motor to deliver the top sheet from the tray by the paper feed roller; and

controlling the sheet elevation mechanism based on a drive torque of the motor to adjust the height position of the stack of sheets, after delivery of the first sheet from the tray by the paper feed roller and upon delivery of a second sheet by the paper feed roller, such that the frictional force to be produced between the second sheet and the paper feed roller is substantially equal to the frictional force produced between the first sheet and the paper feed roller during delivery of the first sheet.

10. The method according to claim 9, wherein controlling the sheet elevation mechanism based on the drive torque of the motor comprises:

measuring a first current value of the motor indicative of the drive torque of the motor during delivery of the first sheet;

measuring a second current value of the motor indicative of the drive torque of the motor during delivery of the second sheet;

controlling the sheet elevation mechanism to lift the stack of sheets when the second current value is less than a reference current value determined based on the first current value by more than a predetermined threshold value; and

controlling the sheet elevation mechanism to halt the movement of the stack of sheets when the difference between the second current value and the reference current value is not greater than the predetermined threshold value.

11. The method according to claim 10, wherein controlling the sheet elevation mechanism based on a drive torque of the motor comprises controlling the sheet elevation mechanism to lower the stack of sheets when the second current value is greater than the reference current value by more than the predetermined threshold value.

12. The method according to claim 10, wherein measuring the first current value of the motor indicative of the drive torque of the motor during delivery of the first sheet includes measuring the first current value of the motor after a predetermined waiting time has passed from the start of delivery of the first sheet, and

wherein measuring the second current value of the motor indicative of the drive torque of the motor during delivery of the second sheet includes measuring the second current value of the motor after the predetermined waiting time has passed from the start of delivery of the second sheet.

13. The method according to claim 12, wherein measuring the first current value of the motor after the predetermined waiting time has passed from the start of delivery of the first sheet includes measuring the first current value of the motor a plurality of times after the predetermined waiting time has passed from the start of delivery of the first sheet, and

wherein determining the reference current value based on the measured first current value includes determining the reference current value based on the

measured plurality of first current values.

14. The method according to claim 10, comprising halting the motor when the second current value is less than a predetermined non-feeding detection value or greater than a predetermined double-feeding detection value.

15. The method according to claim 9, wherein the delivery of the second sheet is selectively performed when the first sheet has been delivered from the tray.

Fig.1

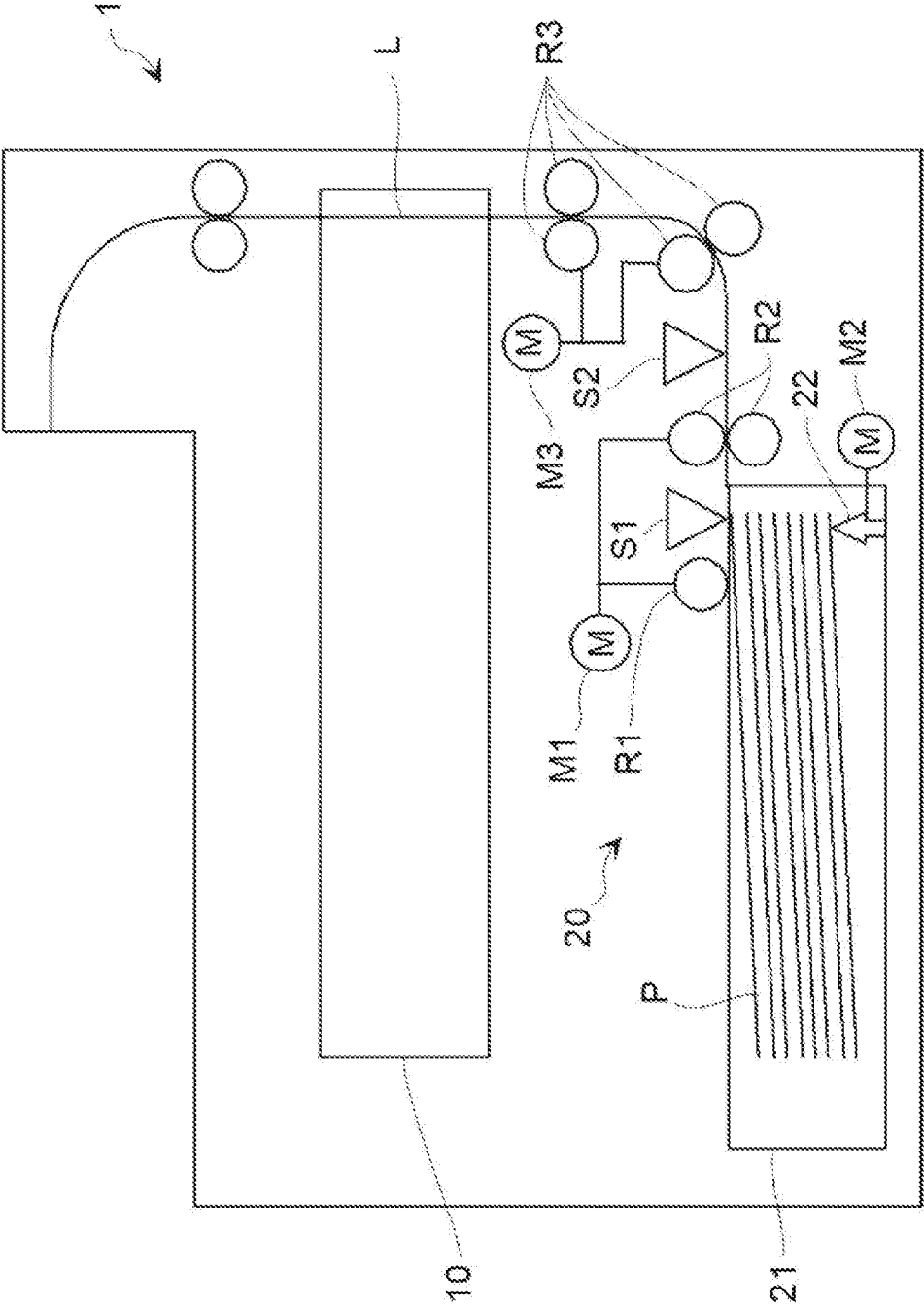


Fig.2

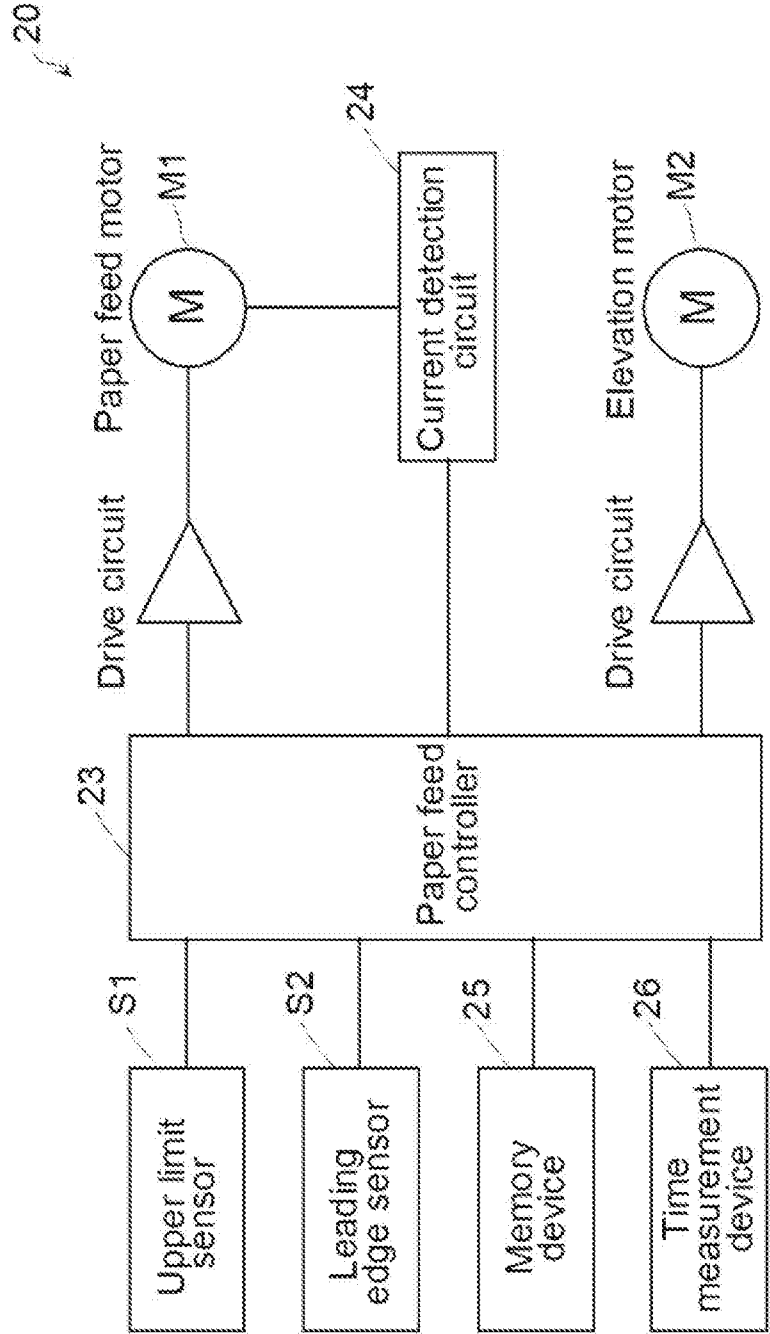


Fig.3

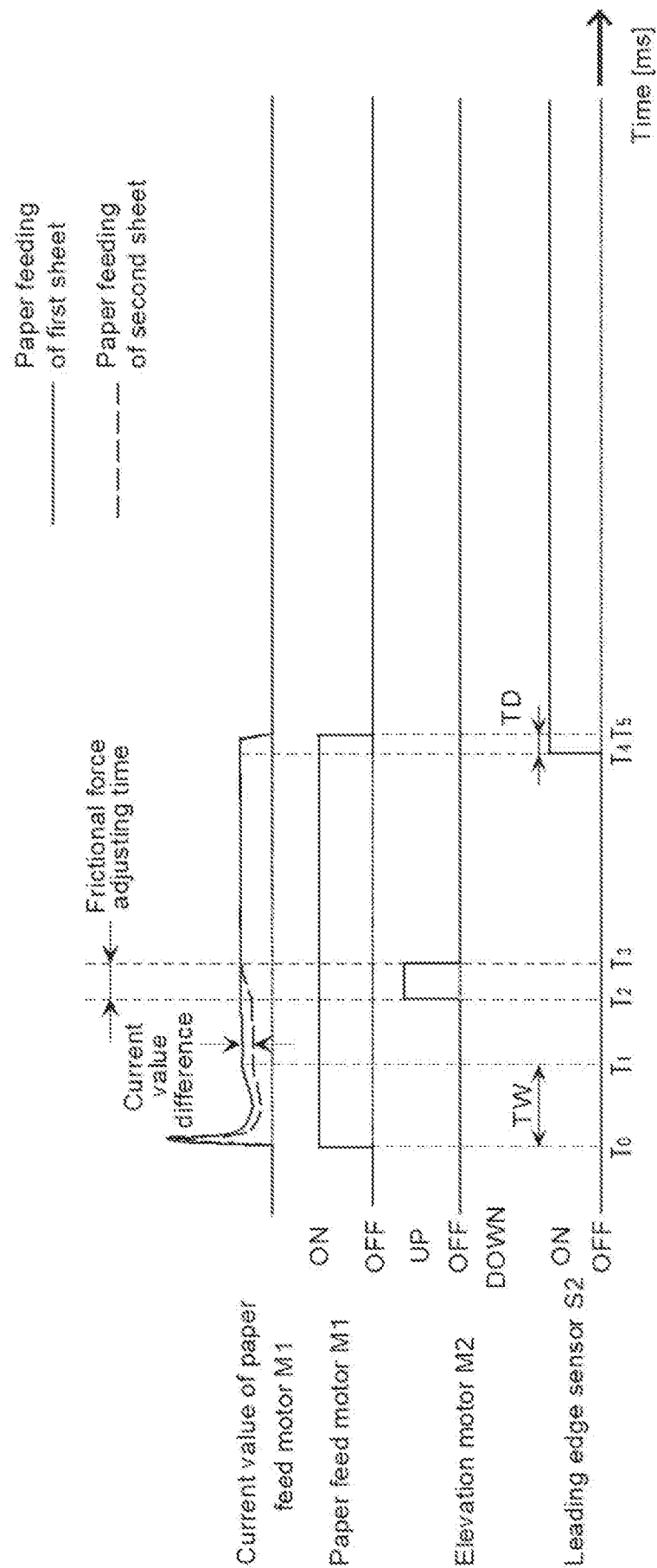


Fig.4

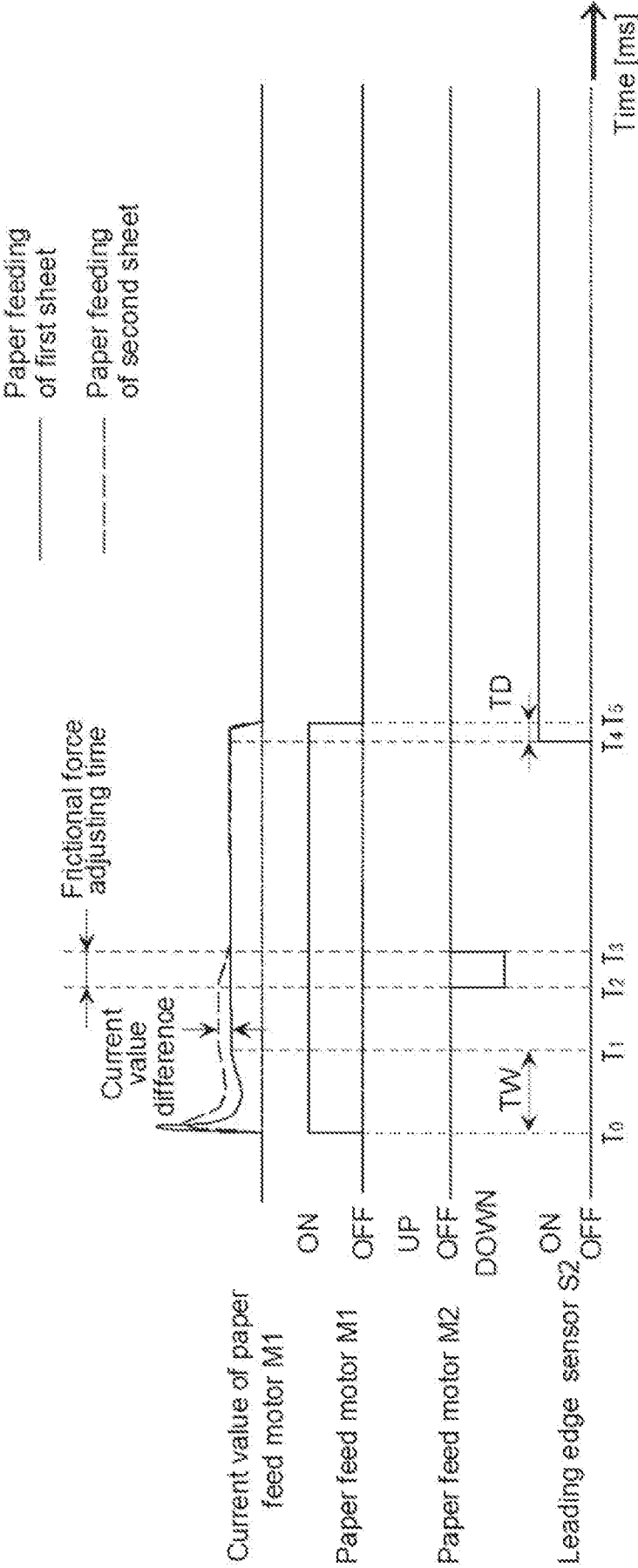


Fig. 5

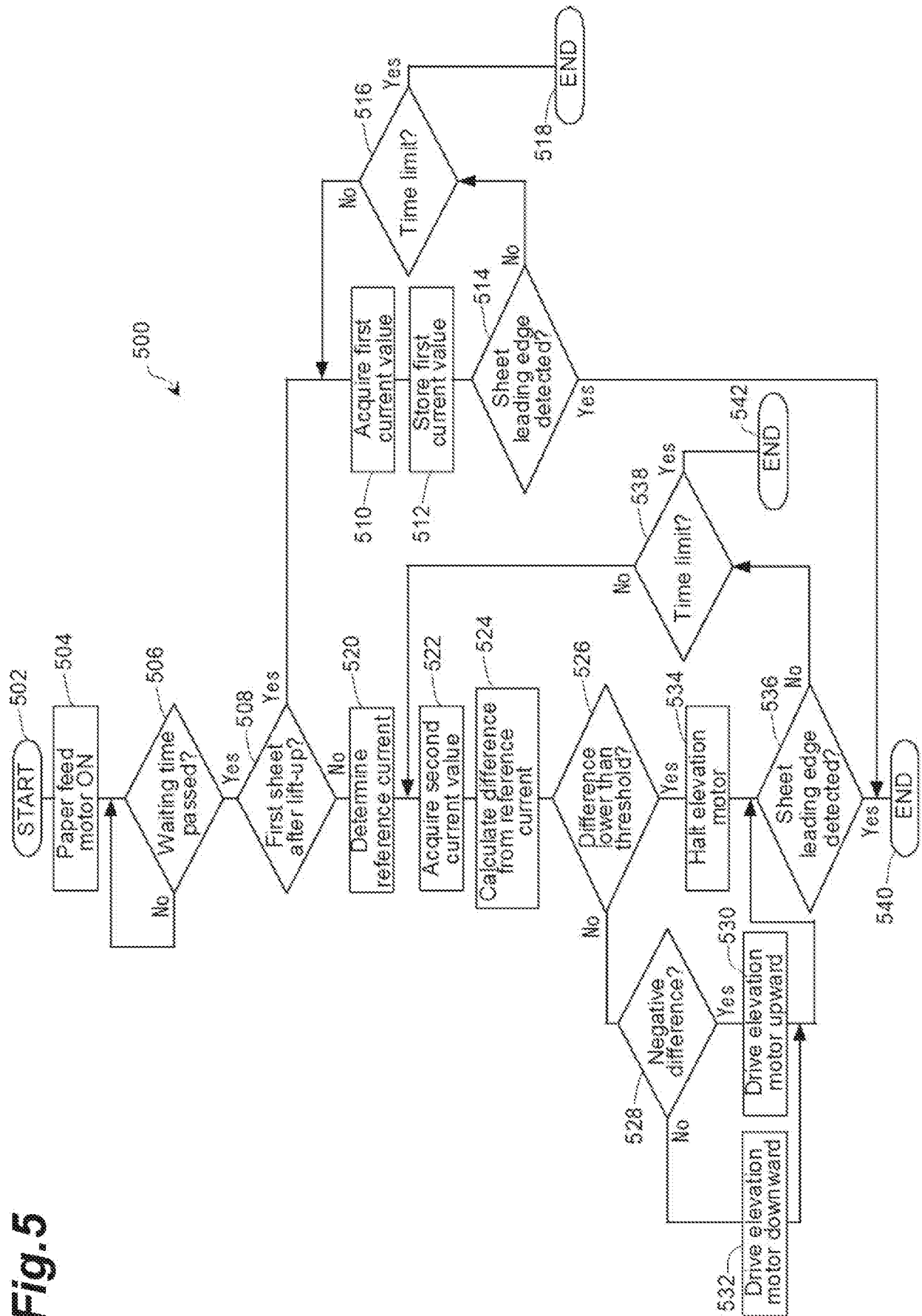
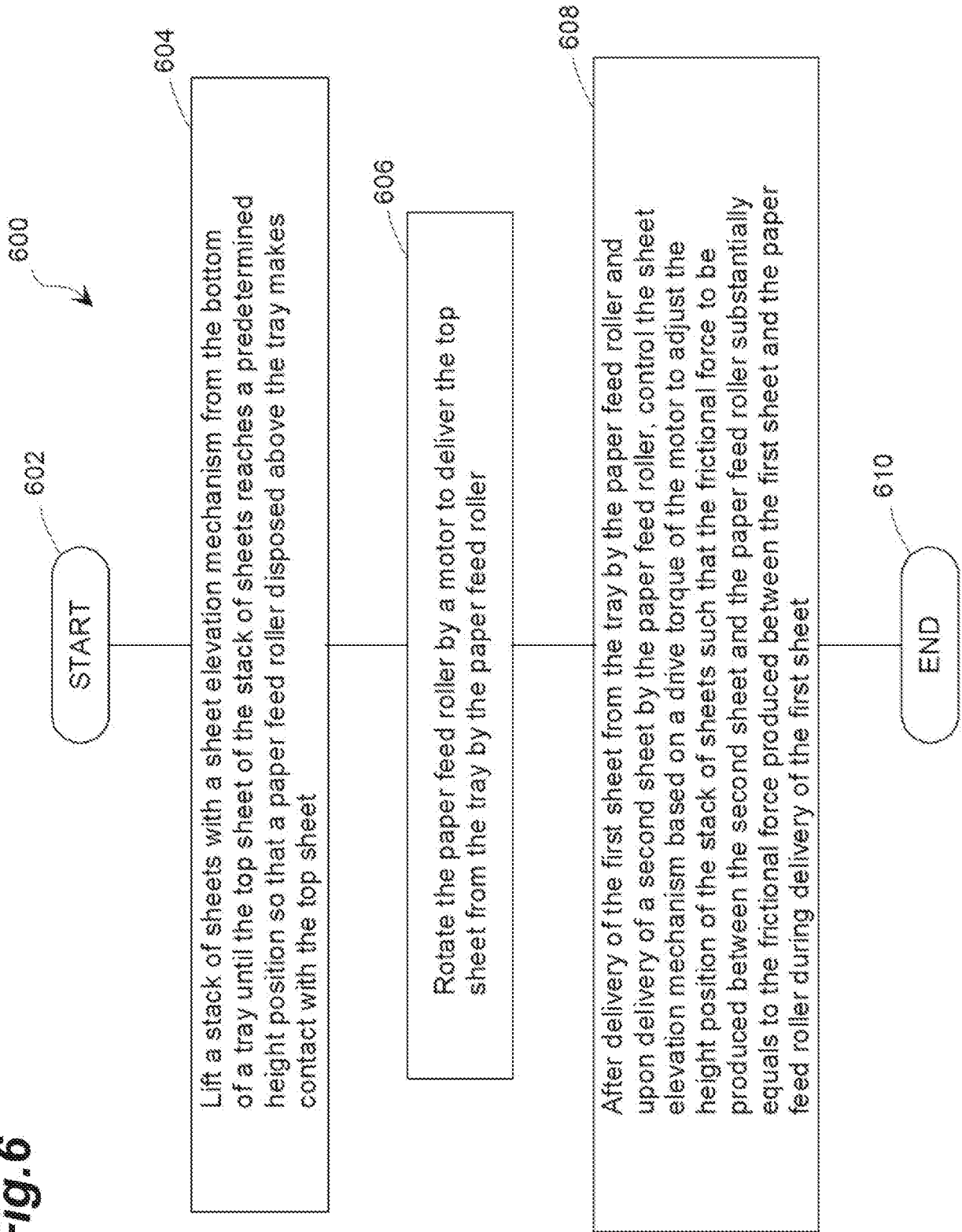


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2019/048089

A. CLASSIFICATION OF SUBJECT MATTER <i>B65H 3/06 (2006.01)</i> <i>B65H 5/06 (2006.01)</i> <i>B65H 13/00 (2006.01)</i> According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) B65H 5/00, 3/00, 3/44, 1/18, 5/06, 13/00, 13/02 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PatSearch (RUPTO Internal), USPTO, PAJ, Espacenet, Information Retrieval System of FIPS		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2018/0215565 A1 (CANON KABUSHIKI KAISHA) 02.08.2018, abstract, paragraphs [0015], [0048], [0055], [0082], [0088] - [0106], fig. 3, 5, claims	1-3, 5-14
Y		4, 15
Y	US 2012/0104679 A1 (BRIAN ALLEN BLAIR et al.) 03.05.2012, abstract, fig. 1	4, 15
A	US 2013/0221607 A1 (CANON KABUSHIKI KAISHA) 29.08.2013	1-15
A	US 2010/0133745 A1 (HIROYUKI IKEUCHI et al.) 03.06.2010	1-15
A	US 2007/0120315 A1 (FRIEDHELM STEINHILBER) 31.05.2007	1-15
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
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“L”	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
“O”	document referring to an oral disclosure, use, exhibition or other means	“&” document member of the same patent family
“P”	document published prior to the international filing date but later than the priority date claimed	
Date of the actual completion of the international search		Date of mailing of the international search report
18 October 2019 (18.10.2019)		14 November 2019 (14.11.2019)
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37		Authorized officer A. Khimachev Telephone No. 8(495) 531-64-81