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(54) **Method and system for conveying and merging two or more groups of shingled mail items**

Verfahren und Vorrichtung zum Transportieren und Zusammenführen von zwei oder mehr Gruppen von geschuppten Poststücken

Procédé et dispositif de transport et de fusion d'au moins deux groupes d'articles postaux imbriqués

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EP-A2- 0 804 975 **EP-A2- 0 923 997**
EP-A2- 2 213 603 **US-A- 5 433 325**

Description

[0001] The present invention relates to a method and system for conveying and merging two or more groups of shingled mail items.

[0002] Forming and conveying groups of shingled items is known, i.e. groups of items aligned in a preferably straight direction, partly overlapping and with respective edges spaced a constant or variable distance apart.

[0003] Shingled groups are typically conveyed by means of conveyor belt systems with either one single belt defining a supporting surface for the shingled groups or a pair of opposite belts, which exert pressure on opposite sides of the shingled groups.

[0004] To merge two shingled groups, the groups are normally fed along respective separate conveyor belt systems, and made to converge at an area common to both systems and at which merging of the two into one is obtained.

[0005] For example, Figures 1A and 1B show consecutive stages in the operation of a conveying system for moving groups of shingled mail items along respective advancement paths. More specifically, each advancement path comprises a number of segments, each at least partly defined by a respective one- or two-belt conveyor system.

[0006] As in the example shown, two-belt systems are normally used along segments of an advancement path arranged vertically or, however, steeply sloping.

[0007] When dealing with groups of shingled mail items, it is normally necessary to merge two groups into a larger one. In practice, then, two or more paths converge at a given intersection zone, and therefore are, from that point on, coincident, regardless of the geometry of the paths. In any case, the converging-path axes being incident, at least one of the groups of shingled items invariably has to travel along a curved path or, at any rate, along a path involving a change in the advancement direction.

[0008] In particular, merging of groups of shingled items is made necessary by processing requirements, e.g. by the presence, along the advancement path, of mail processing (e.g. sorting) devices, or particular conveying or direction-change devices, which demand that the incoming supply of mail items be as constant and homogeneous as possible, so as to both ensure steady operation of the individual devices and, more generally speaking, to achieve high throughput of the conveying system as a whole.

[0009] Merging two groups of shingled mail items poses, on a practical level, various potential problems.

[0010] The group resulting from the merging of two groups of shingled items may, for example, end up being thinner, at the area where the two groups are joined, with respect to the average thickness of either group of shingled items (see Figure 2).

This is to be avoided at all cost, because it may eventually result in the merged group parting altogether, e.g. as it is transferred to another part of the conveyor system, and especially in the event of two consecutive path segments at different levels. Moreover, the merged group being longer than it should be (by sagging at the join) may impair the efficiency of the conveyor system as a whole. Finally, the unevenness described above may impair overall performance of the mail processing (e.g. sorting) devices, thus resulting in errors in the mail conveying and handling sequence.

[0011] Conversely, the area in the merged group where the two groups join may swell with respect to the average thickness of either group of shingled items (as shown in Figure 3).

[0012] This too is to be avoided, as it results in distension of the retaining surfaces (i.e. the opposite surfaces of the two-belt conveyor system between which the group travels). When the retaining surfaces move apart, contact between the retaining surfaces and the thinner portions of the group may be lost, with the result that the mail items in these portions collapse and are no longer conveyed steadily and in controlled manner by the conveyor belt system.

[0013] Consequently, the correct sequence of the mail items in the merged group is no longer guaranteed, i.e. items originally in the second group may be located further forward than items originally in the first group. Furthermore, the type of unevenness described above may cause a blockage of the mail processing (e.g. sorting) devices.

[0014] Another factor affecting the merging of two groups of shingled mail items is a direct consequence of at least one of the groups having to travel along a curved path or, at any rate, change direction on its way to the intersection.

[0015] Each group of shingled mail items is fairly thick, so, as it travels along a curve or changes direction, the surface of the group on the inside of the curve travels at a different speed (speed v_i) from the surface on the outside of the curve (speed v_e) as shown in Figure 4.

[0016] This difference in speed has the effect of altering, i.e. increasing or decreasing, the mean spacing of the mail items in the group, depending on the geometry of the conveyor system and relative paths.

[0017] Because this change in spacing is not normally fully corrected when the group gets back onto a straight course, a slight increase or decrease in the length of the group is often observed. If not compensated for, this group length alteration may impair the accuracy with which the longer/shorter group merges with the other group.

[0018] A simple, effective method is therefore needed to compensate for this group stretching/contracting effect as the group travels along a curved path or, at any rate, a path involving a change in direction.

[0019] Demand therefore exists within the sector for a method and system of conveying and merging converging groups of shingled mail items, which makes it possible to eliminate, in general, the above drawbacks.

[0020] More specifically, a need is felt for a system of conveying and merging groups of shingled mail items of the type comprising a number of conveyor belt systems defining one or more advancement paths for the groups, which provides for effectively merging the groups with no sagging or swelling, and, when necessary, compensates for any stretching or contraction of the groups.

[0021] EP 0 923 997 A2 discloses a device for collecting and transporting groups of partly superimposed postal objects, aligned along a transport direction and having front edges spaced from each other. The device includes a plurality of first transport modules receiving as input groups of partly superimposed postal objects, and supplying these objects as output to a transport system, in particular, a loop transport system in communication with inlets of second transport modules. The transport system is coupled with a control unit to receive a group of partly superimposed postal objects output from any first source module, and supplying it to any second destination transport module.

[0022] EP 0 804 975 A2 discloses a mail accumulating device having a number of stream forming units, each of which has a pair of powered belts superimposed at a point of contact defining the input of the unit, and a sensor for detecting the passage of a mail item into the unit, and for generating a signal for activating the belts, moving the mail items retained on the belts from the input to the output of the unit in discrete steps, and forming a group of overlapping mail items with the leading edges separated by a substantially constant distance. The device also includes a number of conveyor belt devices, each of which has an input communicating with the output of a respective stream forming unit, receives the group of mail items at the input, and feeds the group of mail items to an output of the conveyor belt device to define an accumulating unit.

[0023] US 5 433 325 A discloses a mail accumulating device having ten accumulating units connected at the input to a conveyor belt system and designed to house a number of mail items. Each accumulating unit comprises a conveyor system composed of two belts contacting each other along a substantially straight portion and having a sensor for generating an enabling signal upon a mail item being fed into the accumulating unit. As a consequence of the enabling signal, the belts are shifted one discrete step so that the mail items fed into the accumulating unit are inserted between the two belts and overlap one another.

[0024] EP 2 213 603 discloses a method for feeding a shingled stack of sheet material to a downstream processing device, including the step of identifying a discontinuity in the shingled stack of sheet material wherein the discontinuity has a length dimension from an aft end of a downstream portion of the shingled sheet material to a forward end of an upstream portion of the shingled sheet material. In a next step, the motion of first and second serially arranged conveyors are controlled such that the length dimension of the discontinuity is substantially equal to a prescribed gap of known length dimension. The first conveyor supports the upstream portion of the shingled sheet material and the second conveyor supports the downstream portion of the shingled sheet material. The deck of the first is advanced over the deck of the second conveyor toward the aft end of the downstream portion by the length dimension of the prescribed gap. The upstream portion is then dispensed into shingled engagement with the downstream portion to produce a continuous stack of shingled sheet material.

[0025] It is therefore an object of the present invention to provide a simple, low-cost method and system of conveying and merging groups of shingled mail items, which enables achieving at least one of the above demands.

[0026] The above object is achieved by the present invention, in that it provides a method of conveying and merging groups of shingled mail items as claimed in Claim 1, and a system as claimed in Claim 10.

[0027] A preferred, non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figures 1A, 1B and 1C show schematics of a system for conveying groups of shingled mail items at three consecutive stages;

Figures 2 and 3 show schematics of two phenomena (sagging and swelling of a group formed by merging two groups of shingled mail items) which the method according to the present invention is designed to eliminate;

Figure 4 shows a schematic of a disturbance phenomenon (stretching/contraction of a group of shingled mail items) which the method according to the present invention is designed to compensate;

Figures 5A, 5B, 5C show schematics of three consecutive stages in merging more than two groups of shingled mail items using the method according to the present invention;

Figure 6 shows one embodiment of the method of conveying and merging groups of shingled mail items according to the present invention.

[0028] Number 1 in Figures 1A, 1B and 1C indicates as a whole a system for conveying and merging groups 2, 2' of shingled mail items at consecutive operating stages.

[0029] Each group 2, 2' comprises a number of mail items aligned in a preferably straight direction, partly overlapping, with respective edges spaced a constant or variable distance apart. More specifically, each group 2, 2' has a head 2H, 2H' (or front portion in the travelling direction of the group), and a tail 2T, 2T' (or rear portion in the travelling direction of the group); and the total distance between the head and tail of each group 2, 2' defines its length.

[0030] System 1 is, in particular, designed to move groups 2, 2' of shingled mail items - formed in known manner - along respective advancement paths, each at least partly defined by one or more powered, one- or two-belt conveyor systems 3, 3', 31, 31'.

[0031] System 1 typically comprises a number of conveyor belt systems 3, 3', 31, 31', which extend between respective end pulleys arranged to define supporting surfaces, on which the shingled groups travel at a speed v from respective inputs I to a shared output U. Along vertical or steeply sloping path segments, system 1 preferably comprises two-belt systems 31, 31'.

[0032] The known electric motors and transmissions powering conveyor belt systems 3, 3' are not shown for the sake of simplicity.

[0033] More specifically, system 1 is configured to merge at least one (i-1)th group 2 of shingled mail items with an ith group 2' of shingled mail, at an intersection zone CZ_i, to which the (*i*-1)th and ith groups 2, 2' are conveyed along respective paths.

[0034] In the Figure 1A example, system 1 conveys an (i-1)th group 2 of length L_{i-1}, whose head 2H is initially located at a point $P_{(i-1)0}$ on a first conveyor belt system 3; and an ith group 2' of length L_i, whose head 2H' is located at a point P_{i0} on a second conveyor belt system 3'.

[0035] At the time to which Figure 1A refers, to reach intersection zone CZ_i, the (i-1)th group 2 must travel along a path portion of length $D_{(i-1)}$ and which involves a change in direction. So, in addition to first system 3, on which it is located at the start time shown in Figure 1A, the (i-1)th group 2 will therefore also be conveyed by a first two-belt conveyor system 31 adjacent to first system 3 and extending in a substantially vertical direction.

[0036] Similarly, to reach intersection zone CZ_i, the ith group 2' must travel along a path portion of length D_i followed by a change in direction. So, in addition to second system 3', on which it is located at the time shown in Figure 1A, the ith group 2' will therefore also be conveyed by a second two-belt conveyor system 31' adjacent to second system 3' and extending in a substantially vertical direction.

[0037] System 1 advantageously comprises first sensor means S1, e.g. photocells, laser sensors, proximity sensors, etc., located along the paths of the (i-1)th and ith groups 2, 2' to detect passage of heads 2H, 2H'.

[0038] The exact initial positions $P_{(i-1)0}$, P_{i0} of groups 2, 2' may thus conveniently be determined using motion models (e.g. space motion vs time equations), preferably on the basis of signals from sensor means S1 upon passage of heads 2H, 2H'.

[0039] The exact lengths L_{i-1}, L_i of groups 2, 2' may conveniently be determined on the basis of known parameters (means size, mean spacing, etc.) of the mail items in the groups.

[0040] System 1 preferably also comprises second sensor means S2, e.g. photocells, laser sensors, proximity sensors, etc., located along the paths of groups 2, 2' to detect passage of tails 2T, 2T'.

[0041] On the basis of signals from sensor means S2 indicating passage of tails 2T, 2T', and signals from sensor means S1 indicating passage of heads 2H, 2H', and given the travelling speed v of groups 2, 2' along respective conveyor belt systems 3, 3', the exact length L_{i-1}, L_i of each group 2, 2' can be determined at any time.

[0042] System 1 preferably also comprises further sensor means (not shown), e.g. optical barriers, photocells, laser sensors, etc., for determining the length L_U of the last mail item in each group 2, 2'. Alternatively, the length L_U of the last mail item in each group may be assumed substantially constant and equal to a predetermined value.

[0043] System 1 advantageously comprises a control unit 4 connected functionally to at least first sensor means S1 and the respective drive means (not shown) of conveyor belt systems 3, 3', 31, 31', and which is designed to start and stop conveyor belt systems 3, 3', 31, 31' on the basis of at least the initial positions $P_{(i-1)0}$, P_{i0} of heads 2H, 2H', and the lengths L_{i-1}, L_i of the (i-1)th and ith groups 2, 2' of shingled mail items, so that the leading edge of the (i-1)th group 2 at least overlaps the trailing edge of the ith group 2' in a single merged group 30 of shingled mail items at relative intersection CZ_i. Control unit 4 preferably also starts and stops conveyor belt systems 3, 3', 31, 31' on the basis of lengths $L_{U(i-1)}$, L_{Ui} of the respective last items in the (i-1)th and ith groups.

[0044] Control unit 4 is preferably also connected functionally to second sensor means S2.

[0045] The target condition, in which two groups of shingled mail items are overlapped and merged perfectly as described above, is shown in Figure 1C.

[0046] Similarly, Figure 5C shows the target overlap and merge condition of a number of groups of shingled mail items into one merged group 30 substantially comprising adjacent groups 2, 2', 2" merged two by two, with the leading edge of the (i-1)th group at least overlapping the trailing edge of the ith group. Generally speaking, each group is characterized by a length L_i and an initial position P_{i0} of its head, and is initially separated by a distance D_i from a relative intersection CZ_i with the (i-1) th group.

[0047] As will be obvious from the following description, by applying the method according to the invention to ultimately adjacent pairs of groups of shingled mail items, it is possible to form a multiple merged group 30 of the type shown in Figure 5C.

[0048] Figure 6 shows in greater detail the operations performed by control unit 4 to convey two or more groups 2, 2' of shingled mail items to respective intersections zones CZ_i, i.e. to control starting and stopping of group conveyor belt systems 3.

[0049] Firstly, block 100, control unit 4 determines at least the initial position P_{i0} of the head 2H' of each i^{th} group of shingled mail items to be conveyed and merged, and accordingly determines the length L_i of the i^{th} group and the distance D_i from the relative intersection CZ_i with a respective (i-1)th group.

[0050] Similarly, control unit 4 preferably determines the actual initial position of tail 2T', and accordingly also calculates length Li.

[0051] In other words, groups 2, 2' are assumed to be initially motionless on the respective conveyor belt systems.

[0052] Next, block 101, the control unit temporarily zeroes the start-off time t_1 of the first group.

[0053] In other words, block 101 basically assumes that the first group in the sequence of groups to be merged is the one to be set in motion first. As explained below, the method according to the invention provides for (indirectly) determining the truth of this assumption, and, if it is disproved, for correcting the sequence in which the various groups are set in motion.

[0054] Next, block 102, control unit 4 sets a counter *i* to 2, and, at block 103, resolves, with respect to variable t_i, a motion equation of the ith and (i-1)th groups, which defines the conditions by which, at a given following time t_{merge}, to overlap/merge the two groups at intersection CZ_i as shown in Figure 1C (or Figure 5C in the case of more than two groups). For which purpose, control unit 4 takes into account the values of the variables determined at block 100.

[0055] The groups to be conveyed and merged are preferably imposed a target overlap/merge condition, in which the head 2H of the (i-1)th group overlaps the tail 2T' of the ith group in such a manner as to trail behind the head of the last mail item in the ith group by a distance S equal to the mean spacing of the shingled mail items in each group.

[0056] This relationship is expressed mathematically by the equation :

$$P_{(i-1)\_merge} + S = P_{i\_merge} \qquad (1)$$

where :

- $P_{(i-1)\_merge}$ is the position of the head of the (i-1)th group at the merge time;
- P_{i_merge} is the position of the tail of the ith group at the merge time;
- S is the mean spacing (known beforehand) of the shingled mail items in each group.

[0057] Equations for calculating the position of the head/tail of each group at the merge time may be substituted in equation (1).

[0058] This gives the following motion equation of the (i-1)th and *i*th groups :

$$P_{(i-1)0} - D_{(i-1)} + v(t_{merge}-t_{(i-1)}) + S = P_{i0} - L_i + L_{Ui} - D_i + v(t_{merge}-t_i) \qquad (2)$$

where :

- $P_{(i-1)0}$ is the initial position of head 2H of the (i-1)th group;
- $D_{(i-1)}$ is the initial distance between head 2H of the (i-1)th group and the intersection zone CZ_i with the ith group;
- $t_{(i-1)}$ is the start-off time of the (i-1)th group;
- P_{i0} is the initial position of the head 2H' of the ith group;
- L_i is the length of the ith group;
- L_{Ui} is the length of the last item in the *i*th group;
- D_i is the initial distance between head 2H' of the ith group and the intersection zone CZ_i with the (i-1) th group;
- t_i is the start-off time of the ith group;
- v is the travelling speed of conveyor belt systems 3, 3';
- S is the mean spacing of the shingled mail items in groups 2, 2'.

[0059] The mean spacing of the shingled mail items in groups 2, 2' may normally be used for S, but, in some cases - for example, when groups 2, 2' also contain particularly thick items - this may prove inaccurate and impair the efficiency of the method.

[0060] To prevent this, an alternative embodiment imposes a target overlap/merge condition, in which the head 2H of the (i-1)th group overlaps the tail 2T' of the ith group in such a manner as to trail behind the head of the last mail item in the ith group by a distance S* based on measured dimensions (typically length and thickness) of the two items eventually contacting directly at the join. Accordingly, system 1 may advantageously comprise third sensor means (not shown) for determining the actual thickness of head 2H, 2H' and/or tail 2T, 2T' of the (i-1)th and ith groups.

[0061] It should be noted that the term $P_{i0} - L_i + L_{Ui}$ in equation (2) expresses the initial position of the head of the last item in the ith group.

[0062] The $t_{(i-1)}$ value being imposed or calculated beforehand, and all the other quantities being known (i.e. imposed beforehand as operating parameters of system 1, or measured by the sensors described, or calculated/estimated on the basis of acquired quantities), equation (2) is easily resolvable with respect to variable t_i.

[0063] In other words, each t_i represents the start-off time of an *i*th group, determined with respect to the previously determined start-off time t_{i-1} of the (i-1)th group, i.e. the absolute algebraic difference between them represents the time lag with which the *i*th group must start off with respect to start-off of the (i-1)th group to merge the two groups correctly as designed by the present invention.

[0064] When the advancement path of the ith group involves a change in direction, equation (2) is preferably modified (see equation (3) below) by inserting a correction term to compensate for stretching, as typically occurs when a group changes direction. In which case, the initial position of tail 2T' of the ith group is given, not by $P_{i0} - L_i + L_{Ui}$, but by a respective modified term $(P_{i0} - L_i + L_{Ui})_{MOD}$.

[0065] Mathematically, the modified initial position value of a direction-change ith group can be calculated using the equation :

$$(P_{i0} - L_i)_{MOD} = P_{i0} - (L_i - L_U) . K_S \qquad (3)$$

where :

- L_i is the initial length of the ith group;
- L_{Ui} is the length of the last item in the ith group;
- K_S is the group stretch/contraction coefficient.

[0066] The value of group stretch/contraction coefficient K_S substantially depends on the geometry of system 1 and the thickness of the group. For example, a coefficient K_S value of roughly 1.05 - 1.10 may be assumed when the geometry of system 1 causes the group to stretch.

[0067] At block 104, the control unit determines whether there are any other groups for conveying and merging. This is done in known manner, e.g. using an optoelectronic sensor (S1) defining an optical path that is interrupted by any mail items.

[0068] In the event of an affirmative response, block 104 goes on to a block 105, where control unit 4 increments counter i by one unit, and then returns to block 103.

[0069] Conversely, in the event of a negative response, control unit 4 goes on to a block 106, where it searches for the minimum start-off time t_{i_MIN} of all the start-off times t_i determined.

[0070] At the next block 107, control unit 4 subtracts the minimum start-off time t_{i_MIN} from each start-off time t_i to calculate corrected start-off times t_i^* according to the equation:

$$T_i^* = t_i - t_{i\_MIN} \qquad (4)$$

[0071] It should be noted that each start-off time t_i may be greater than, less than, or equal to zero. More specifically, t_{i_MIN} may be greater than, less than, or equal to zero, so the operation performed in block 107 is an algebraic subtraction (which takes into account the sign of t_{i_MIN}).

[0072] In other words, if start-off times t_i are all positive or zero, block 107 leaves them unchanged, i.e. each $t_i^* = t_i$.

[0073] Alternatively, if at least one of start-off times t_i is negative, control unit 4 determines the negative start-off time with the highest absolute value, and subtracts it algebraically from all the start-off times to 'normalize' them. In other words, after block 107, all the start-off times t_i are 'corrected' so that none have a negative sign. In fact, the minimum start-off time t_i determined is replaced with a corresponding zero start-off time t_i, and the group of mail items associated with this start-off time is moved first, as explained below.

[0074] Finally, at block 108, control unit 4 carries out the conveying and merging procedure by moving each ith group off at the corrected start-off times t_i^* calculated in block 107. In other words, each *i*th group is started off with a time lag, equal to the respective modified start-off time t_i^*, with respect to the start time t_{START} of the conveying and merging procedure.

[0075] In other words, the control unit starts a number of timers, each associated with starting off an *i*th group of shingled mail items.

[0076] Accordingly, control unit 4 moves conveyor belt systems 3, 3' along respective paths to respective intersections with respective time lags, equal to corrected start-off times t_i*, with respect to the start time of the conveying and merging procedure.

[0077] It should be noted that, in the example described with reference to the drawings and motion equations (1) and (2) - possibly with the correction in equation (3) - conveyor belt systems 3, 3' move respective groups of shingled mail items all at the same constant speed v.

[0078] However, equations (1) and (2) may obviously be corrected to allow for movement at a non-constant speed.

[0079] For example, the constant v term in equations (1) and (2) may be replaced with a predetermined function $v_i(t)$ describing, or at least approximating, the speed-time pattern of head 2H' of each ith group, to take into account acceleration and deceleration of the group along the respective path.

[0080] In the above description, all the path portions - each defined by one or more powered, single- or two-belt conveyor systems 3, 3', 31, 31' - are assumed free at the start of the actual conveying and merging procedure, whereas, in actual fact, this is obviously not always so, i.e. quite often, at least one of powered systems 3, 3', 31, 31' is temporarily inaccessible, by already being engaged by another group in transit, or an intersection CZ_i is temporarily occupied.

[0081] This can be taken into account in a variation of the method according to the invention, in which an access time lag r_i is added to the corrected start-off times t_i* calculated in block 107, depending on the engaged/free status of a relative path portion, i.e. of a corresponding powered, single- or two-belt conveyor system 3, 3', 31, 31'.

[0082] In other words, each group, particularly the one with the lowest corrected start-off time t_i*, is set in motion with a time lag r_i with respect to the relative corrected start-off time, to allow the relative path to clear.

[0083] Accordingly, system 1 according to the invention may advantageously comprise access sensor means (not shown), e.g. photocells, for instantly determining the engaged/free status of critical path portions, and which are preferably located at the intersections CZ_i defined by system 1.

[0084] The advantages of the conveying and merging method and system according to the invention will be clear from the above description.

[0085] In particular, the method according to the invention clearly provides, in a simple, low-cost manner, for merging two or more groups of shingled mail items into one with a high degree of precision, reliability and repeatability, as typically required in the mail processing sector.

[0086] Moreover, because the groups of shingled mail items to be merged are set in motion in a start-off time sequence that takes into account at least the initial position and actual length of the groups, the method according to the invention prevents sagging and swelling of merged groups at the join, as frequently occurs in less precise systems.

[0087] Another important point to note is how the conveying and merging method and system according to the invention also take into account the geometry of system 1, and in particular any change in direction and consequent stretching of the groups, which may conveniently be compensated by adapting the motion equation of the groups to the actual characteristics of the respective paths.

[0088] Clearly, changes may be made to the conveying and merging method and system as described and illustrated herein without, however, departing from the protective scope of the accompanying independent Claims.

Claims

1. A method of conveying and merging, at a relative intersection zone (CZ_i), at least one (i-1)th group (2) of shingled mail items with an *i*th group (2') of shingled mail items, the method comprising the step of :

a) conveying said (i-1)th and *i*th groups (2, 2'), as of a start time (t_{START}), along respective advancement paths to said intersection zone (CZ_i);

the method being **characterized by** comprising the steps of:

b) determining, for each group (2, 2') of shingled mail items to be conveyed and merged, at least the position ($P_{(i-1)0}$. P_{i0}) of a head (2H, 2H') of the group (2, 2') at said start time (t_{START}), and the length (L_{i-1}, L_i) of the group (2, 2'); and

c) controlling start-off of each group (2, 2') to said intersection zone (CZ_i) on the basis of at least the position ($P_{(i-1)0}$, P_{i0}) of the head (2H, 2H') of said group (2, 2') at said start time (t_{START}), and the length (L_{i-1}, L_i) of said group (2, 2'), so that a leading edge of said (*i-1*)th group (2) overlaps at least partially a trailing edge of said ith group (2') to form a single merged group (30) of shingled mail items at said intersection zone (CZ_i).

2. A method as claimed in Claim 1, wherein step c) of controlling start-off of each group (2, 2') to the intersection zone (CZ_i) comprises the steps of :

d) calculating (103) a start-off time (t_i) for each group (2, 2') at least on the basis of said position ($P_{(i-1)0}$, P_{i0}); and
e) starting off each group (2, 2') with a time lag (t_i*), with respect to said start time (t_{START}), calculated on the basis of said start-off time (t_i).

3. A method as claimed in Claim 1 or 2, wherein, to merge the groups, said step a) comprises the step of overlapping the head (2H) of the (i-1)th group (2) on the tail (2T') of the ith group (2'), so that said head (2H) trails behind the head of the last mail item in the *i*th group (2') by a distance (S) equal to the mean spacing of the shingled mail items in each group.

4. A method as claimed in Claim 1 or 2, wherein, to merge the groups, said step a) comprises the step of overlapping the head (2H) of the (i-1)th group (2) on the tail (2T') of the *i*th group (2'), so that said head (2H) trails behind the leading edge of the last mail item in the *i*th group (2') by a distance (S*) based on the measured dimensions of the head (2H) of the (i-1) th group (2) and the tail (2T') of the ith group (2').

5. A method as claimed in any one of Claims 2 to 4, wherein said start-off time (t_i) of the *i*th group is also calculated on the basis of :

- the position ($P_{(i-1)0}$) of the head (2H) of the (i-1)th group at said start time (t_{START}) ;
- the distance $D_{(i-1)}$, at said start time (t_{START}), between the head (2H) of the (i-1)th group and said intersection zone (CZ_i) with the *i*th group;
- the start-off time ($t_{(i-1}$) of the (i-1)th group;
- the distance D_i, at said start time (T_{start}), between the head (2H') of the *i*th group and said intersection zone (CZ_i) with the (i-1)th group;
- the travelling speed (v) of said groups along their respective paths; and
- the mean spacing (S) of the shingled mail items in each group (2, 2').

6. A method as claimed in Claim 5, wherein said respective start-off times (t_{i-1}, t_i) of said (i-1) th group and said ith group (2, 2') are related by the equation :

$$P_{(i-1)0} - D_{(i-1)} + v(t_{merge} - t_{(i-1)}) + S = P_{i0} - L_i + L_{Ui} - D_i + v(t_{merge} - t_i)$$

where t_{merge} represents the instant in which said (i-1)th group and said *i*th group (2, 2') merge at the intersection zone (CZ_i) and L_{Ui} is the length of the last item in the ith group.

7. A method as claimed in any one of Claims 2 to 6, wherein said step e) of starting off each *i*th group comprises the steps of :

f) determining the minimum start-off time (t_{i_MIN}) of all the start-off times (t_i) calculated; and
g) calculating a corrected start-off time (t_i*) for each $_i$th group by subtracting said minimum start-off time (t_{i_MIN}) algebraically from the relative start-off time (t_i).

8. A method as claimed in any one of Claims 2 to 7, wherein said step e) of starting off each group (2, 2') commences with a time lag r_i with respect to the relative corrected start-off time (t_i*), so as to allow the relative path to clear.

9. A method as claimed in any one of Claims 1 to 8, wherein, for each *i*th group whose path involves a change in direction, the value of said position (P_{i0}) of the head (2H') of the *i*th group at said start time (t_{START}) is corrected on the basis of a stretch coefficient K_S of the group.

10. A conveying and merging system comprising :

- a number of conveyor systems (3, 3'; 31, 31') for conveying at least one (i-1)th and one ith group (2, 2') of shingled mail items along respective paths, and merging them at a relative intersection (CZ_i);
- first sensor means (S1) located along the paths of said groups (2, 2') to detect passage of the respective heads (2H, 2H') of the groups (2, 2') and determine the respective positions ($P_{(i-1)0}$, P_{i0}) of the heads at a start time

(t_{START}) ; and
- a control unit (4) connected functionally to at least the first sensor means (S1) and to drive means of the conveyor systems (3, 3'; 31, 31'), and programmed to control travel of each group (2, 2') to said intersection (CZ_i) using the method as claimed in any one of Claims 1 to 9.

11. A system as claimed in Claim 10, and comprising second sensor means (S2) located along the paths of said groups (2, 2') to detect passage of the respective tails (2T, 2T') of the groups (2, 2').

12. A system as claimed in Claim 10 or 11, and comprising third sensor means located along the paths of said groups (2, 2') to determine the thickness of the respective tails (2T, 2T') and/or heads (2H, 2H') of the groups (2, 2').

13. A system as claimed in Claim 10 or 12, and comprising access sensor means located along the paths of said groups (2, 2') to instantly determine the engaged/free status of relative portions of said paths.

Patentansprüche

1. Verfahren zum Transportieren und Zusammenführen, innerhalb einer jeweiligen Kreuzungszone (CZ_i), zumindest einer (i-1). Gruppe (2) schuppenartig übereinanderliegender Poststücke mit einer *i*. Gruppe (2') schuppenartig übereinanderliegender Poststücke, wobei das Verfahren den folgenden Schritt umfasst:

a) Transportieren der (i-1). und *i*. Gruppe (2, 2'), ausgehend von einer Startzeit (t_{START}), entlang entsprechender Förderwege zu der Kreuzungszone (CZ_i);

wobei das Verfahren **dadurch gekennzeichnet ist, dass** es die nachstehenden Schritte umfasst:

b) für jede Gruppe (2, 2') zu transportierender und zusammenzuführender schuppenartiger Poststücke Festlegen zumindest der Position ($P_{(i-1)0}$, P_{i0}) des Kopfs (2H, 2H') der Gruppe (2, 2') zur Startzeit (T_{START}) und der Länge ($_{Li-1}$, $_{Li}$) der Gruppe (2, 2'); und
c) Steuern des Startbeginns jeder Gruppe (2, 2') zur Kreuzungszone (CZ_i) aufgrund zumindest der Position ($P_{(i-1)0}$, P_{i0}) des Kopfes (2H, 2H') der Gruppe (2, 2') zur Startzeit (T_{START}) und der Länge (L_{i-1}, L_i) der Gruppe (2, 2'), so dass eine Vorderkante der (*i*-1). Gruppe (2) zumindest teilweise eine Hinterkante der *i*. Gruppe (2') überlappt, um eine einzige zusammengeführte Gruppe (30) schuppenartig übereinanderliegender Poststücke in der Kreuzungszone (CZ_i) auszubilden.

2. Verfahren nach Anspruch 1, bei dem Schritt c) des Steuerns des Startbeginns jeder Gruppe (2, 2') zur Kreuzungszone (CZ_i) die Schritte umfasst:

d) Berechnen (103) einer Zeit des Startbeginns (t_i) für jede Gruppe (2, 2') zumindest aufgrund der Position ($P_{(i-1)0}$, P_{i0}); und
e) Beginn des Starts jeder Gruppe (2, 2') mit einer Zeitverzögerung (t_i*), im Hinblick auf die Startzeit (T_{START}), welche aufgrund der Zeit des Startbeginns (t_i) berechnet ist.

3. Verfahren nach Anspruch 1 oder 2, bei dem zum Zusammenführen der Gruppen der Schritt a) den Schritt des Überlappens des Kopfes (2H) der (i-1). Gruppe (2) des Endes (2T') der *i*. Gruppe (2') umfasst, so dass der Kopf (2H) hinter dem Kopf des letzten Poststücks in der *i*. Gruppe (2') mit einer Entfernung (S) gleich dem Durchschnittsabstand der übereinandergreifenden Poststücke in jeder Gruppe läuft.

4. Verfahren nach Anspruch 1 oder 2, bei dem der Schritt a) zum Zusammenführen der Gruppen den Schritt des Überlappens des Kopfes (2H) der (i-1). Gruppe (2) am Ende (2T') der *i*. Gruppe (2') umfasst, so dass der Kopf (2H) hinter der Vorderkante des letzten Poststücks in der *i*. Gruppe (2') mit einer Entfernung (S*) basierend auf den gemessenen Dimensionen des Kopfs (2H) der (i-1). Gruppe (2) und des Endes (2T') der *i*. Gruppe (2') läuft.

5. Verfahren nach einem der Ansprüche 2 bis 4, bei dem die Berechnung der Zeit des Startbeginns (t_i) der *i*. Gruppe ebenfalls berechnet wird aufgrund:

- der Position ($P_{(i-1)0}$) des Kopfs (2H) der (i-1). Gruppe zur Startzeit (t_{START});
- der Entfernung $D_{(i-1)}$ zur Startzeit (t_{START}), zwischen dem Kopf (2H) der (i-1). Gruppe und der Kreuzungszone

(CZ_i) mit der *i.* Gruppe;
- der Zeit des Startbeginns ($t_{(i-i)}$) der (i-1). Gruppe;
- der Entfernung D_i, zur Startzeit (T_{START}), zwischen dem Kopf (2H') der *i.* Gruppe und der Kreuzungszone (CZ_i) mit der (i-1). Gruppe;
- der Fortbewegungsgeschwindigkeit (v) der Gruppen entlang ihrer entsprechenden Wege; und
- des Durchschnittsabstands (S) der schuppenartig übereinanderliegenden Poststücke in jeder Gruppe (2, 2').

6. Verfahren nach Anspruch 5, bei dem die entsprechenden Zeiten des Startbeginns (t_{i-1}, t_i) der (i-1). Gruppe und der *i.* Gruppe (2, 2') durch die Gleichung in Verbindung stehen:

$$P_{(i-1)0} - D_{(i-1)} + v(t_{merge} - t_{(i-1)}) + S = P_{i0} - L_i + L_{UI} - D_i + v(t_{merge} - t_i),$$

wobei t_{merge} den Zeitpunkt darstellt, in dem die (i-1). Gruppe und die *i.* Gruppe (2, 2') in der Kreuzungszone (CZ_i) zusammengeführt werden und L_{Ui} der Länge des letzten Stücks in der i. Gruppe entspricht.

7. Verfahren nach einem der Ansprüche 2 bis 6, bei dem der Schritt e) des Beginns des Startens jeder *i.* Gruppe die folgenden Schritte umfasst:

f) Bestimmen der kleinsten Zeit des Startbeginns (t_{i_MIN}), sämtlicher berechneter Zeiten des Startbeginns (t_i); und
g) Berechnen einer korrigierten Zeit des Startbeginns (t_i*) für jede i. Gruppe durch algebraische Subtraktion der kleinsten Zeit des Startbeginns (t_{i_MIN}) von der jeweiligen Startzeit (t_i).

8. Verfahren nach einem der Ansprüche 2 bis 7, bei dem der Schritt e) des Startbeginns jeder Gruppe (2, 2') mit einer Zeitverzögerung r_i im Hinblick auf die jeweilige korrigierte Zeit des Startbeginns (t_i*) erfolgt, damit der jeweilige Weg freigegeben werden kann.

9. Verfahren nach einem der Ansprüche 1 bis 8, bei dem für jede *i.* Gruppe, deren Weg einen Richtungswechsel vorsieht, der Wert der Position (P_{i0}) des Kopfes (2H') der *i.* Gruppe bei dieser Startzeit (T_{START}) aufgrund eines Dehnkoeffizienten K_S der Gruppe korrigiert wird.

10. Vorrichtung zum Transportieren und Zusammenführen, umfassend:

- eine Anzahl von Transportsystemen (3, 3'; 31, 31') zum Transportieren zumindest einer (i-1). und einer *i.* Gruppe (2, 2') schuppenartig übereinanderliegender Poststücke entlang entsprechender Wege, und deren Zusammenführen an einer jeweiligen Kreuzung (CZ_i);
- erste Sensorvorrichtungen (S1), die längs der Wege dieser Gruppen (2, 2') angeordnet sind, um den Durchgang der entsprechenden Köpfe (2H, 2H') der Gruppen (2, 2') zu detektieren und die entsprechenden Positionen ($P_{(i-1)0}$, P_{i0}) der Köpfe zu einer Startzeit (T_{START}) zu bestimmen; und
- eine Steuereinrichtung (4), die funktionstechnisch mit zumindest den ersten Sensoreinrichtungen (S1) verbunden ist und um Vorrichtungen des Transportsystems (3, 3'; 31, 31') anzutreiben, und so programmiert ist, um die Bewegung jeder Gruppe (2, 2') zu der Kreuzung (CZ_i) unter Verwendung des in einem der Ansprüche 1 bis 9 beanspruchten Verfahrens zu steuern.

11. Vorrichtung nach Anspruch 10, und umfassend:

zweite Sensorvorrichtungen (S2), die längs der Wege der Gruppen (2, 2') angeordnet sind, um den Durchgang entsprechender Enden (2T, 2T') der Gruppen (2, 2') zu detektieren.

12. Vorrichtung nach Anspruch 10 oder 11, und umfassend: dritte Sensorvorrichtungen, die längs der Wege der Gruppen (2, 2') angeordnet sind, um die Dicke der entsprechenden Enden (2T, 2T') und/oder Köpfe (2H, 2H') der Gruppen (2, 2') zu bestimmen.

13. Vorrichtung nach Anspruch 10 oder 12, und umfassend: Zugangs-Sensorvorrichtungen, die längs der Wege der Gruppen (2, 2') angeordnet sind, um sofort den Zustand besetzt/frei der jeweiligen Wegeabschnitte zu bestimmen.

Revendications

1. Méthode de transport et de fusion, au niveau d'une zone d'intersection correspondante (CZ_i), d'au moins un (i-1)^{ième} groupe (2) d'articles postaux imbriqués avec un i^{ème} groupe (2') d'articles postaux imbriqués, la méthode comprenant les étapes suivantes :

    a) le transport desdits (i-1)^{ième} et i^{ème} groupes (2, 2'), comme d'un temps de départ (t_{START}), le long de parcours de déplacement respectifs vers ladite zone d'intersection (CZ_i) ;

    la méthode étant **caractérisée en ce qu'**elle comprend les étapes suivantes :

    b) la détermination, pour chaque groupe (2, 2') d'articles postaux imbriqués à transporter et fusionner, d'au moins la position ($P_{(i-1)0}$, P_{i0}) d'une tête (2H, 2H') dudit groupe (2, 2') audit temps de départ (t_{START}) et la longueur (L_{i-1}, L_i) dudit groupe (2, 2') ; et
    c) la commande de démarrage de chaque groupe (2, 2') vers ladite zone d'intersection (CZ_i) sur la base d'au moins la position ($P_{(i-1)0}$, P_{i0}) d'une tête (2H, 2H') du groupe (2, 2') audit temps de départ (t_{START}) et la longueur (L_{i-1}, L_i) du groupe (2, 2'), de manière qu'un bord avant dudit (i-1)^{ième} groupe (2) chevauche au moins partiellement un bord arrière dudit i^{ème} groupe (2') pour former un unique groupe fusionné (30) d'articles postaux imbriqués au niveau de ladite zone d'intersection (CZ_i).

2. Méthode selon la revendication 1, dans laquelle l'étape c) de commande de démarrage de chaque groupe (2, 2') vers la zone d'intersection (CZ_i) comprend les étapes suivantes :

    d) le calcul (103) d'un temps de démarrage (t_i) pour chaque groupe (2, 2') au moins sur la base de ladite position ($P_{(i-1)0}$, P_{i0}) ; et
    e) le démarrage de chaque groupe (2, 2') avec un décalage de temps (t_i*), par rapport audit temps de départ (t_{START}), calculé sur la base dudit temps de démarrage (t_i).

3. Méthode selon la revendication 1 ou 2, dans laquelle, pour fusionner les groupes, ladite étape a) comprend l'étape de chevauchement de la tête (2H) du (i-1)^{ième} groupe (2) sur la queue (2T') du i^{ème} groupe (2'), de manière que ladite tête (2H) soit décalée derrière la tête du dernier article postal dans l'i^{ème} groupe (2') d'une distance (S) égale à l'écartement moyen des articles postaux imbriqués dans chaque groupe.

4. Méthode selon la revendication 1 ou 2, dans laquelle, pour fusionner les groupes, ladite étape a) comprend l'étape de chevauchement de la tête (2H) du (i-1)^{ième} groupe (2) sur la queue (2T') du i^{ème} groupe (2'), de manière que ladite tête (2H) soit décalée derrière le bord avant du dernier article postal dans l'i^{ème} groupe (2') d'une distance (S*) basée sur les dimensions mesurées de la tête (2H) du (i-1)^{ième} groupe (2) et de la queue (2T') du i^{ème} groupe (2').

5. Méthode selon l'une quelconque des revendications 2 à 4, dans laquelle ledit temps de démarrage (t_i) du i^{ème} groupe est également calculé sur la base de :

    - la position ($P_{(i-1)0}$) de la tête (2H) du (i-1)^{ième} groupe audit temps de départ (t_{START}) ;
    - la distance $D_{(i-1)}$, audit temps de départ (t_{START}), entre la tête (2H) du (i-1)^{ième} groupe et ladite zone d'intersection (CZ_i) avec l'i^{ème} groupe ;
    - le temps de démarrage ($t_{(i-1)}$) du (i-1)^{ième} groupe ;
    - la distance D_i, audit temps de départ (t_{START}), entre la tête (2H') de l'i^{ème} groupe et ladite zone d'intersection (CZ_i) avec le (i-1)^{ième} groupe ;
    - la vitesse de déplacement (v) desdits groupes le long de leurs parcours respectifs ; et
    - l'écartement moyen (S) des articles postaux imbriqués dans chaque groupe (2, 2').

6. Méthode selon la revendication 5, dans laquelle lesdits temps de démarrage respectifs (t_{i-1}, t_i) dudit (i-1)^{ième} groupe et dudit i^{ème} groupe (2, 2') sont liés par l'équation :

$$P_{(i-1)0} - D_{(i-1)} + v(t_{merge} - t_{(i-1)}) + S = P_{i0} - L_i + L_{Ui} - D_i + v(t_{merge} - t_i)$$

où t_{merge} représente l'instant auquel ledit (i-1)^{ième} groupe et ledit i^{ème} groupe (2, 2') fusionnent au niveau de la zone d'intersection (CZ_i) et L_{Ui} est la longueur du dernier article dans l'i^{ème} groupe.

7. Méthode selon l'une quelconque des revendications 2 à 6, dans laquelle ladite étape e) de démarrage de chaque i^{ème} groupe comprend les étapes suivantes :

f) la détermination du temps de démarrage minimum (t_{i-MIN}) de tous les temps de démarrage (t_i) calculés ; et
g) le calcul du temps de démarrage corrigé (t_i*) pour chaque i^{ème} groupe en soustrayant algébriquement du temps de démarrage correspondant (t_i) ledit temps de démarrage minimum (t_{i_MIN}).

8. Méthode selon l'une quelconque des revendications 2 à 7, dans laquelle ladite étape e) de démarrage de chaque groupe (2, 2') commence avec un décalage de temps r_i par rapport au temps de démarrage corrigé correspondant (t_i*), de manière à permettre au parcours correspondant de se dégager.

9. Méthode selon l'une quelconque des revendications 1 à 8, dans laquelle, pour chaque i^{ème} groupe dont le parcours implique un changement de direction, la valeur de ladite position (P_{i0}) de la tête (2H') de l'i^{ème} groupe audit temps de départ (t_{START}) est corrigée sur la base d'un coefficient d'allongement K_S du groupe.

10. Système de transport et de fusion comprenant :

- une pluralité de systèmes de transport (3, 3' ; 31, 31') pour transporter au moins un (i-1)^{ième} et un i^{ème} groupe (2, 2') d'articles postaux imbriqués le long de parcours respectifs et les fusionner au niveau d'une intersection correspondante (CZ_i) ;
- des premiers moyens de détection (S1) situés le long des parcours desdits groupes (2, 2') pour détecter un passage des têtes respectives (2H, 2H') des groupes (2, 2') et déterminer les positions respectives ($P_{(i-1)0}$, P_{i0}) des têtes à un temps de départ (t_{START}) ; et
- une unité de commande (4) connectée fonctionnellement à au moins les premiers moyens de détection (S1) et à des moyens d'entraînement des systèmes de transport (3, 3' ; 31, 31'), et programmée pour commander une course de chaque groupe (2, 2') vers ladite intersection (CZ_i) en utilisant la méthode selon l'une quelconque des revendications 1 à 9.

11. Système selon la revendication 10, et comprenant des deuxièmes moyens de détection (S2) situés le long des parcours desdits groupes (2, 2') pour détecter un passage des queues respectives (2T, 2T') des groupes (2, 2').

12. Système selon la revendication 10 ou 11, et comprenant des troisièmes moyens de détection situés le long des parcours desdits groupes (2, 2') pour déterminer l'épaisseur des queues (2T, 2T') et/ou des têtes (2H, 2H') respectives des groupes (2, 2').

13. Système selon la revendication 10 ou 12, et comprenant des moyens de détection d'accès situés le long des parcours desdits groupes (2, 2') pour déterminer instantanément l'état occupé/libre des portions correspondantes desdits parcours.

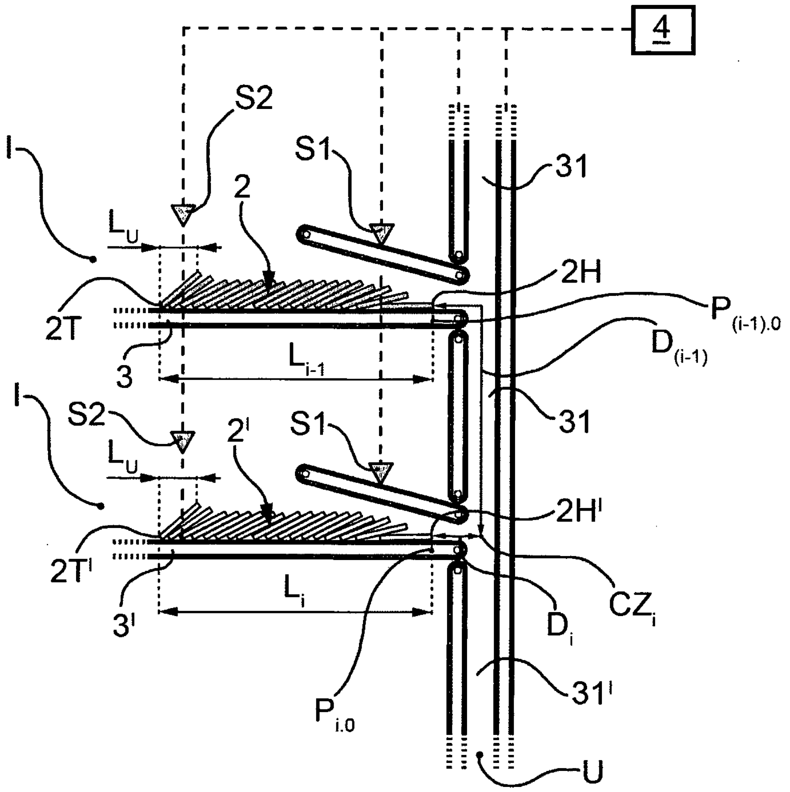
4
S2
S1
I
31
LU
2
2H
2T
P(i-1).0
3
Li-1
D(i-1)
I
S2
2I
S1
31
LU
2HI
2TI
3I
Li
Di
CZi
Pi.0
31I
U

FIG. 1A

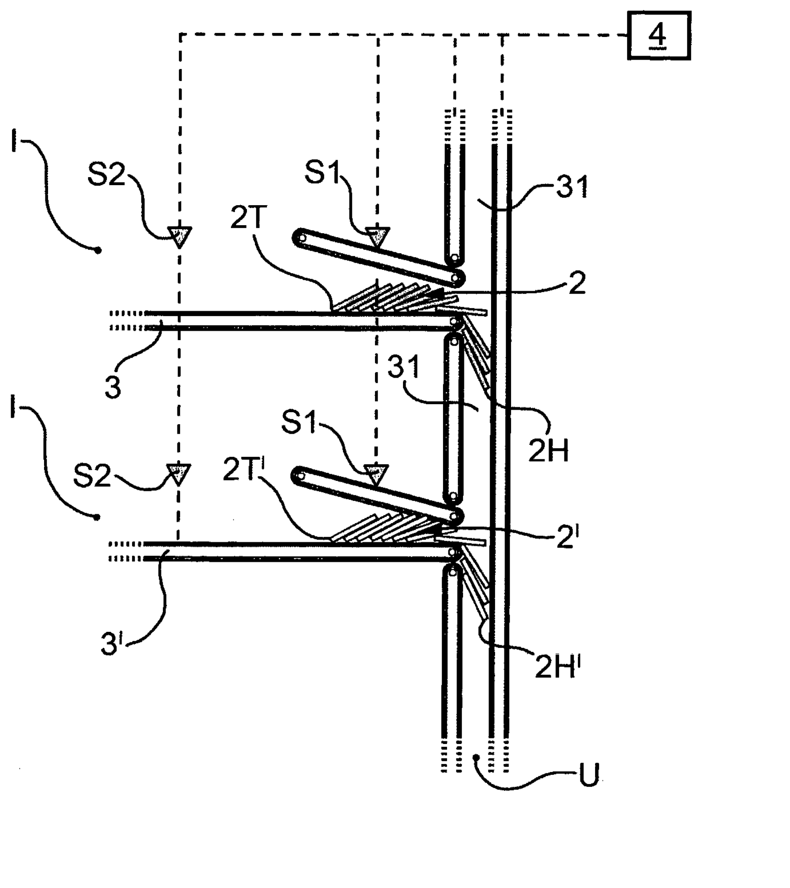
4
I
S2
S1
31
2T
2
3
31
2H
I
S1
S2
2TI
2I
3I
2HI
U

FIG. 1B

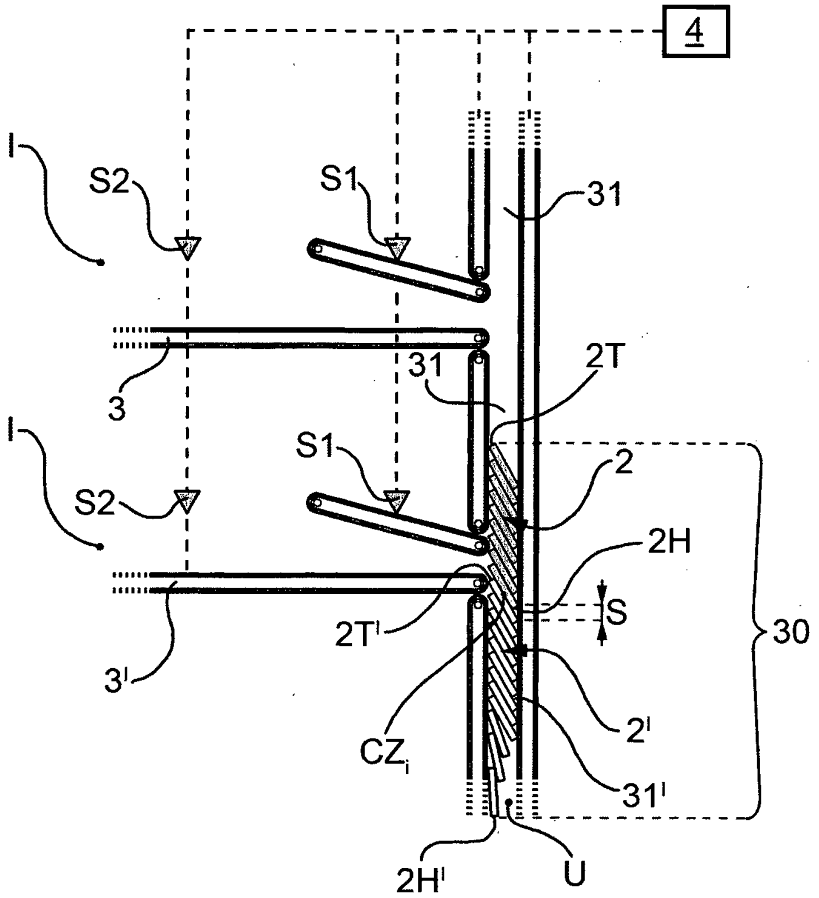

FIG. 1C

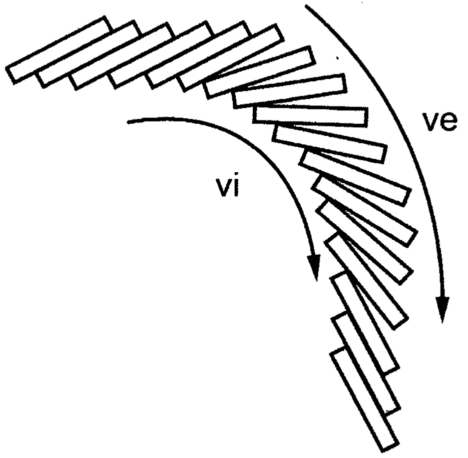

FIG. 4

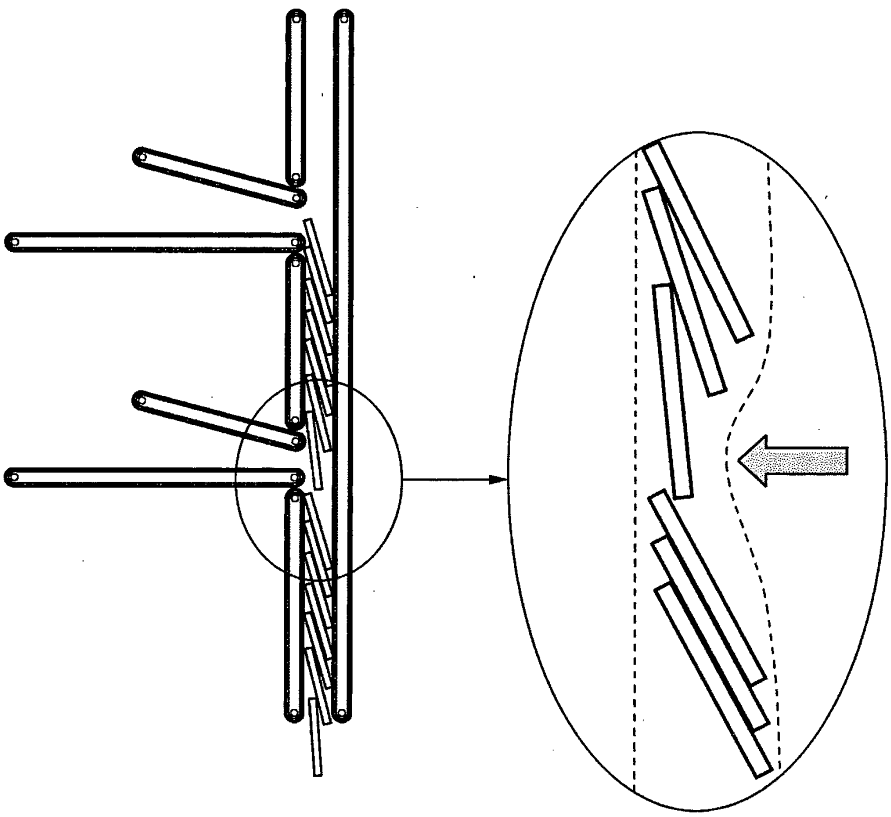

FIG. 2

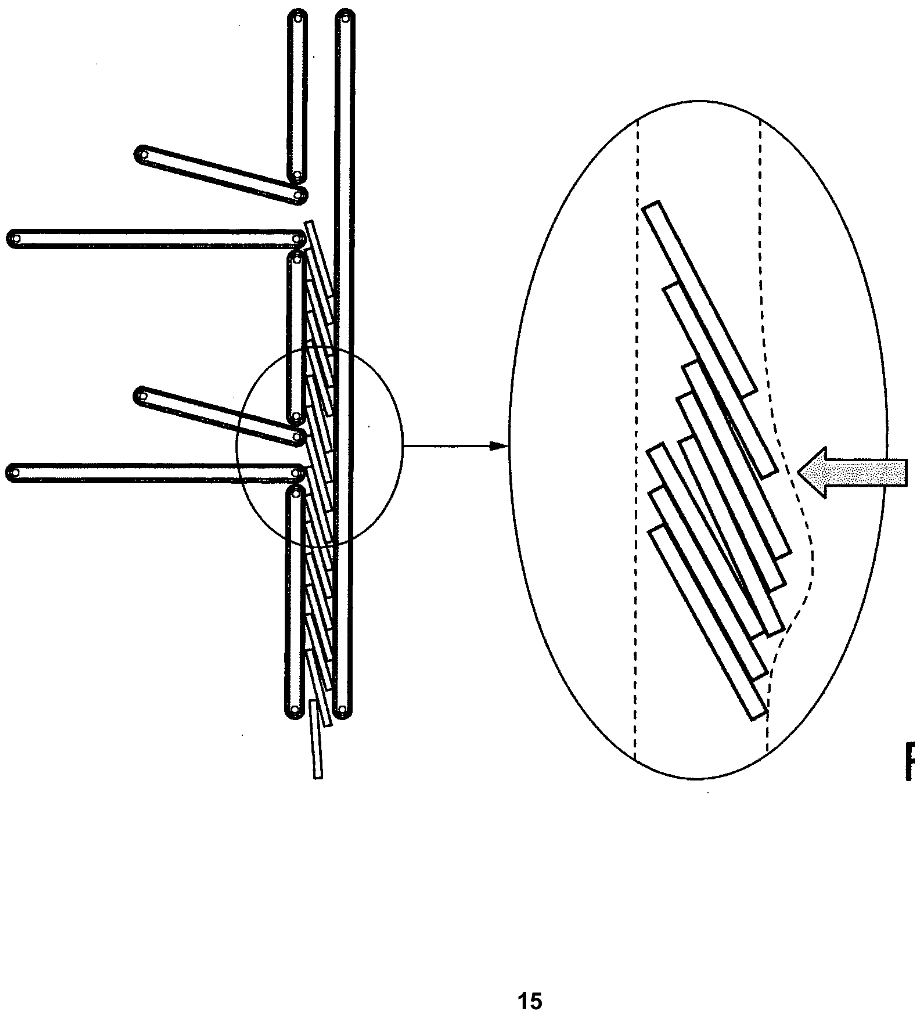

FIG. 3

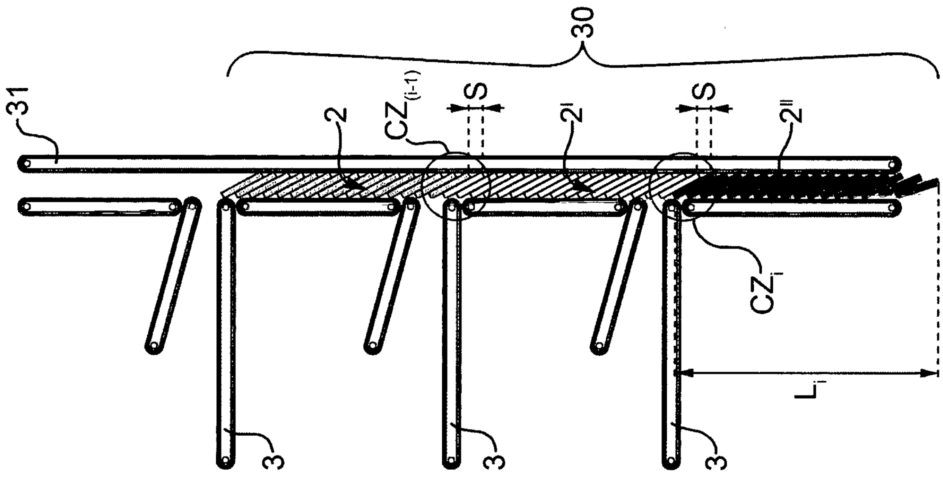

FIG. 5C

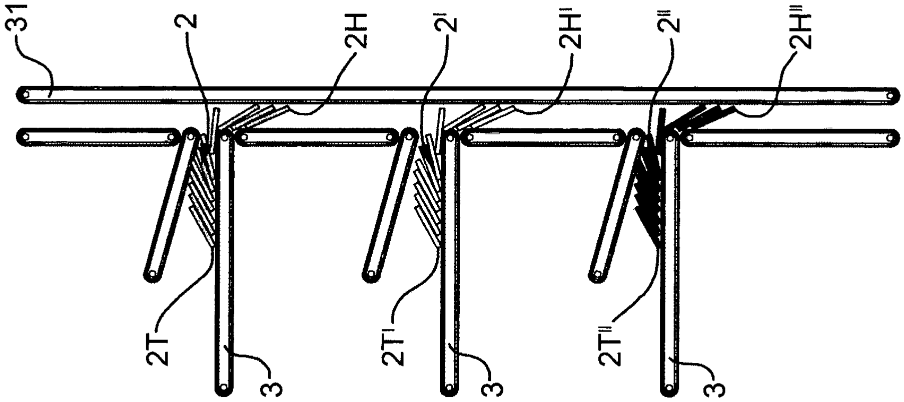

FIG. 5B

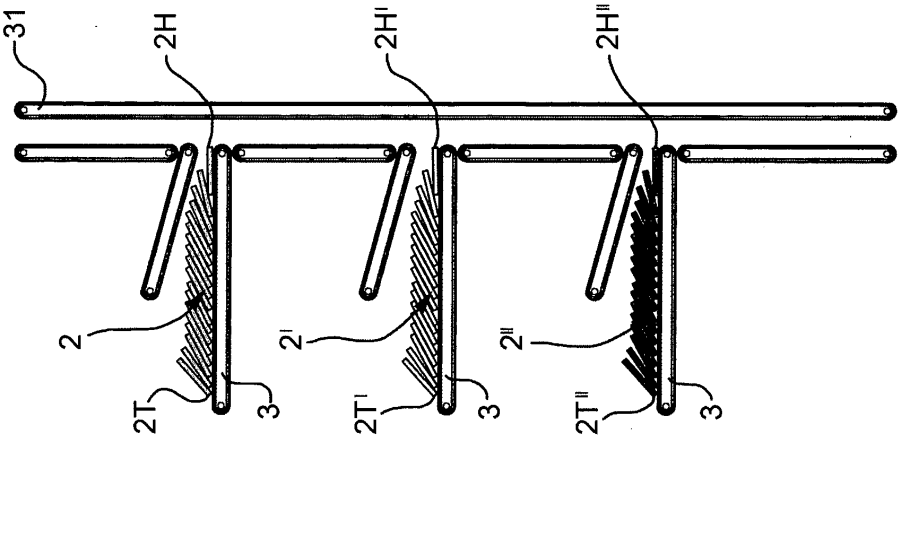

FIG. 5A

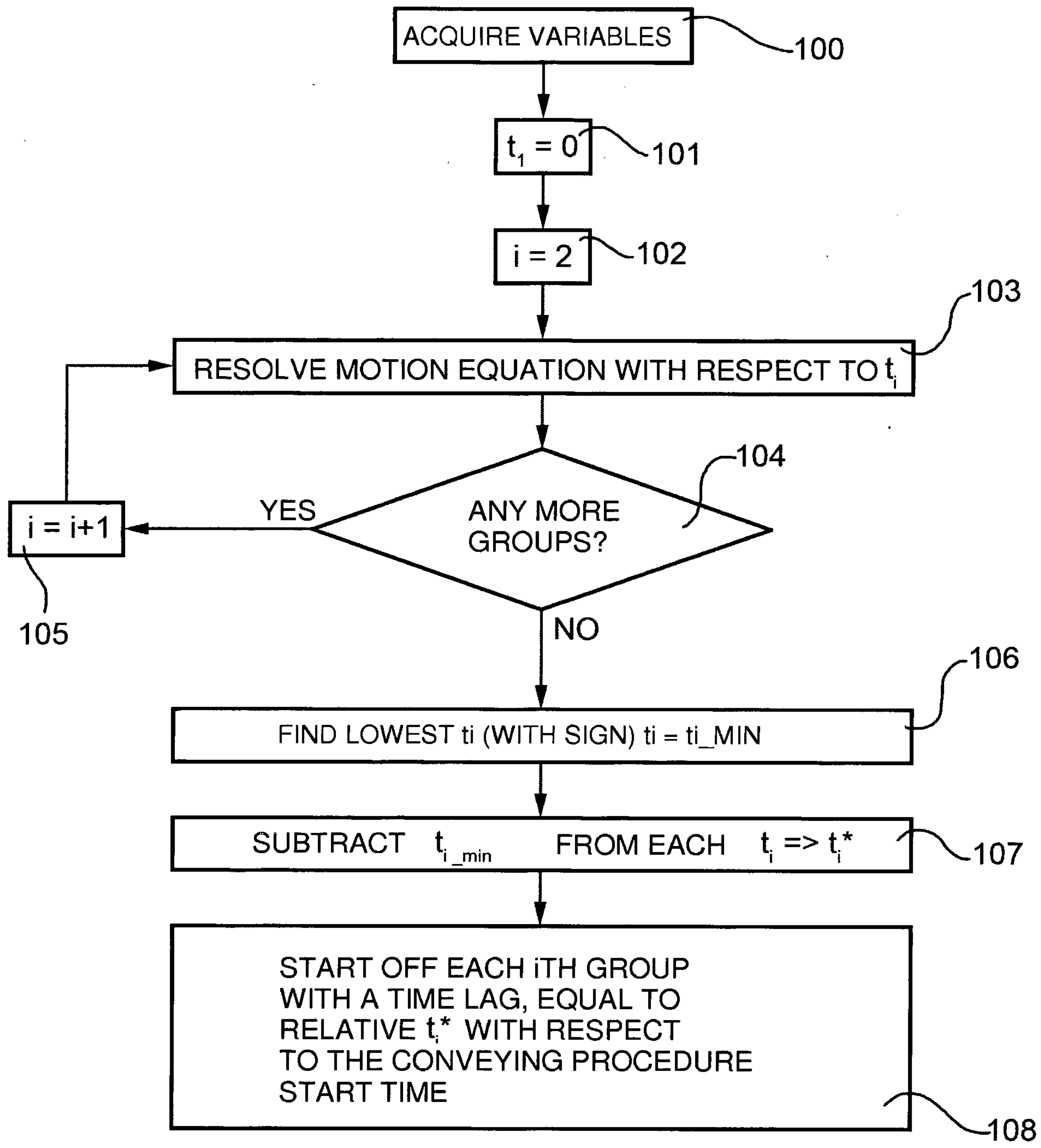
ACQUIRE VARIABLES
100
t1 = 0
101
i = 2
102
103
RESOLVE MOTION EQUATION WITH RESPECT TO ti
104
ANY MORE GROUPS?
YES
i = i+1
105
NO
106
FIND LOWEST ti (WITH SIGN) ti = ti_MIN
SUBTRACT ti_min FROM EACH ti => ti*
107
START OFF EACH iTH GROUP WITH A TIME LAG, EQUAL TO RELATIVE ti* WITH RESPECT TO THE CONVEYING PROCEDURE START TIME
108

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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