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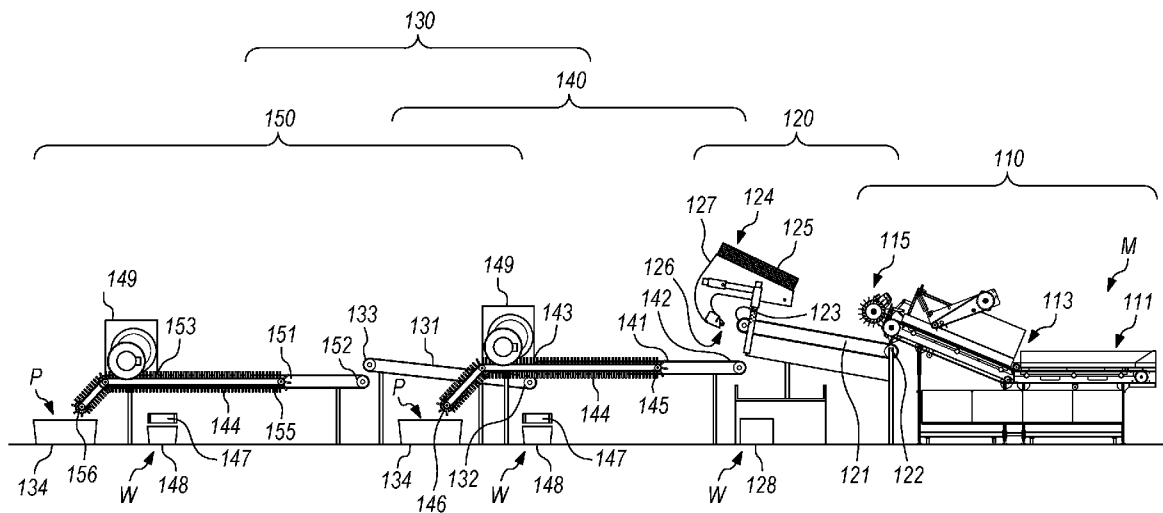


FIG. 2

(57) Abstract: The present invention relates to an apparatus and method for processing plants contained in agricultural material. The apparatus comprises a first conveyor (121), a second conveyor (141), and an air curtain apparatus (124), the air curtain deflects at least some of the agricultural material falling across the gap away from the second conveyor.

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APPARATUS AND METHOD FOR PROCESSING PLANTS

TECHNICAL FIELD

[0001] The present invention generally relates to agricultural equipment, and more particularly to a method and system for processing plants having intertwined roots.

BACKGROUND ART

[0002] Plants are sometimes raised at nurseries and then transplanted for growing in farms. Strawberries are an example of a crop that is raised this way. Thus, for example, a nursery cultivates parent strawberry plants, propagates runners to form daughter plants, and grows the daughter plants until they reach the right size and stage of dormancy for lifting. When the plants are in their dormant period, they are lifted (i.e., dug up), either manually or by machine, by undercutting the plants and removing them from the soil, either manually or with a machine.

[0003] When strawberry plants are lifted from the nursery fields, their roots can become tangled together. Part of the sorting process often involves carefully separating intertwined or tangled plants to prevent damage to the roots. Separating intertwined plants may be performed manually or using a machine as described for example by the “singulator” described in co-owned US Patent No. 9,358,586 (the “’586 patent), the contents of which are hereby incorporated by reference.

[0004] Lifted individual plants, including untangled plants, are then sorted and graded by size and quality, with damaged or diseased plants being discarded. Individual plants are then packed for sale, typically in bundles of 10, 25, or more.

[0005] There exists a need for a machine and method that can process large quantities of harvested plants and separate them into individual plants. Such a machine and method should be highly automated and be capable of separating the plants without damaging the roots. It would also be advantageous to be able to also eliminate plants that do not seem healthy enough to survive transplanting.

DISCLOSURE OF INVENTION

[0006] In some aspects, the techniques described herein relate to an apparatus for sorting agricultural material, the apparatus including: a first conveyor having a head, where the first conveyor is operable to transport agricultural material in a first direction towards the head; a second conveyor having a tail positioned below the head of the first conveyor and separated from the head of the first conveyor by a gap; and an air curtain apparatus having an air discharge,

where the air curtain apparatus is operable to generate an air curtain from air discharge and towards the gap, such that when the first conveyor, the second conveyor, and the air curtain apparatus are operated, the air curtain deflects at least some of the agricultural material falling across the gap away from the second conveyor.

[0007] In some aspects, the techniques described herein relate to an apparatus, where the first conveyor moves upwards at an angle, θ , relative to a horizon, and where the angle is sufficient to prevent rocks in the agricultural material from reaching the head of the first conveyor.

[0008] In some aspects, the techniques described herein relate to an apparatus, where the angle is between 15 degrees and 25 degrees.

[0009] In some aspects, the techniques described herein relate to an apparatus, where the air curtain is directed towards the gap in a second direction opposite to the first direction.

[0010] In some aspects, the techniques described herein relate to an apparatus, where an average air curtain flow velocity at the air discharge is between 20 feet/min (6 m/min) and 200 feet/min (60 m/min).

[0011] In some aspects, the techniques described herein relate to an apparatus, where the air curtain at the air discharge is directed at an angle of between -20° and $+20^\circ$ relative to a horizon.

[0012] In some aspects, the techniques described herein relate to an apparatus, where an initial height of the air curtain at the air discharge is between 1 inch (25 mm) and 5 inches (125 mm).

[0013] In some aspects, the techniques described herein relate to an apparatus, where a horizontal distance between the air discharge and the head of the first conveyor is between 3 inches (75 mm) and 20 inches (0.5 m).

[0014] In some aspects, the techniques described herein relate to an apparatus, where a vertical distance between the air discharge and the head of the first conveyor is between +15 inches (+375 mm) and -15 inches (-375 mm).

[0015] In some aspects, the techniques described herein relate to a method for separating agricultural material, the method including: directing the agricultural material between a head of a first conveyor in a first direction to a tail of a second conveyor, where the tail of the second conveyor is spaced below the head of the first conveyor by a gap; and directing an air curtain

from an air discharge towards the gap, such that the air curtain deflects at least some of the agricultural material falling across the gap away from the second conveyor.

[0016] In some aspects, the techniques described herein relate to a method, where the first conveyor forms an angle to a horizon, and where the angle is sufficient to prevent rocks in the agricultural material from reaching the head of the first conveyor.

[0017] In some aspects, the techniques described herein relate to a method, where the angle is between 15 degrees and 25 degrees.

[0018] In some aspects, the techniques described herein relate to a method, where the air curtain is directed towards the gap in a second direction opposite to the first direction.

[0019] In some aspects, the techniques described herein relate to a method, where an average air curtain flow velocity at the air discharge is between 20 ft/min and 200 ft/min.

[0020] In some aspects, the techniques described herein relate to a method, where the air curtain at the air discharge is directed at an angle of between -20° and $+20^{\circ}$ relative to a horizon.

[0021] In some aspects, the techniques described herein relate to a method, where an initial height of the air curtain at the air discharge is between 1 inch (25 mm) and 5 inches (125 mm).

[0022] In some aspects, the techniques described herein relate to a method, where a horizontal distance between the air discharge and the head of the first conveyor is between 3 inches (75 mm) and 20 inches (0.5 m).

[0023] In some aspects, the techniques described herein relate to a method, where a vertical distance between the air discharge and the head of the first conveyor is between +15 inches (+375 mm) and -15 inches (-375 mm).

[0024] In some aspects, the techniques described herein relate to an apparatus for trimming plants, the apparatus including: conveyor belt having a width between a first side of the conveyor belt and a second side of the conveyor belt, and a plurality of, where each cleat of the plurality of cleats extends a height above the conveyor belt, and where a space between adjacent cleats of the plurality of cleats are adapted to accept plants; a press wheel positioned above conveyor belt, where the press wheel forces accepted plants against the conveyor belt; and a saw blade parallel to the first side of the conveyor belt and adjacent to the press wheel, where the saw blade is operable to trim one end of the accepted plants, such that accepted plants are trimmed by the apparatus.

[0025] In some aspects, the techniques described herein relate to an apparatus, where the saw blade is a first saw blade, where the apparatus further includes a second saw blade parallel to the second side of the conveyor belt and adjacent to the press wheel, where the second saw blade is operable to trim an opposite side of the accepted plants.

[0026] In some aspects, the techniques described herein relate to an apparatus, where the press wheel is positioned over the plurality of cleats and where the press wheel forces one or more cleats and the accepted plants against the conveyor belt.

[0027] In some aspects, the techniques described herein relate to an apparatus, where each cleat of the plurality of cleats has a width less than the width of the conveyor belt, and where the press wheel is positioned between the first side of the conveyor belt and the plurality of cleats.

[0028] In some aspects, the techniques described herein relate to an apparatus, where the press wheel is a first press wheel, and where the apparatus further includes: a second press wheel positioned between the second side of the conveyor belt and the plurality of cleats.

[0029] In some aspects, the techniques described herein relate to an apparatus, where the saw blade is a first saw blade, and where the apparatus further includes: a second saw blade parallel to the second side of the conveyor belt and adjacent to the press wheel, where the second saw blade is operable to trim an opposite side of the accepted plants.

[0030] In some aspects, the techniques described herein relate to an apparatus, further including: a mechanism to count plants on the conveyor belt, where the mechanism includes an arm and an encoder, where the arm extends from a first end that contacts the conveyor belt and a second end supported by the encoder, such that when plants on the conveyor belt pass under the first end of the arm, the arm rotates about the second end and the encoder registers a passage of the plants.

[0031] In some aspects, the techniques described herein relate to a method for trimming plants, the method including: transporting plants between adjacent cleats of a plurality of cleats on a conveyor belt having a first side and a second side, where each cleat of the plurality of cleats extends a height above the conveyor belt, and where a space between adjacent cleats of the plurality of cleats are adapted to accept plants; restraining the accepted plants with a press wheel positioned above trim belt as the accepted plants move under the press wheel; and trimming one end of the restrained plants with a saw blade.

[0032] In some aspects, the techniques described herein relate to a method, where the saw blade is a first saw blade, where said trimming further trims another side of the restrained plants with a second saw blade.

[0033] In some aspects, the techniques described herein relate to a method, where the press wheel is positioned over the plurality of cleats and where the restraining the accepted plants with the press wheel also forces one or more cleats against the conveyor belt.

[0034] In some aspects, the techniques described herein relate to a method, where each cleat of the plurality of cleats has a width less than the width of the conveyor belt, and where the press wheel is positioned between the first side of the conveyor belt and the plurality of cleats.

[0035] In some aspects, the techniques described herein relate to a method, where the press wheel is a first press wheel and where said restraining includes restraining the accepted plants with a second press wheel positioned between the second side of the conveyor belt and the plurality of cleats.

[0036] In some aspects, the techniques described herein relate to a method, where the saw blade is a first saw blade, and where said trimming further trims another side of the restrained plants with a second saw blade parallel to the second side of the conveyor belt and adjacent to the press wheel.

[0037] In some aspects, the techniques described herein relate to a method, further including: counting the plants on the conveyor belt using a mechanism including an arm and an encoder, where the arm extends from a first end that contacts the conveyor belt and a second end supported by the encoder, such that when plants on the conveyor belt pass under the first end of the arm, the arm rotates about the second end and the encoder registers a passage of the plants.

[0038] These features together with the various ancillary provisions and features which will become apparent to those skilled in the art from the following detailed description, are attained by the apparatus of the present invention, preferred embodiments thereof being shown with reference to the accompanying drawings, by way of example only, wherein:

BRIEF DESCRIPTION OF DRAWINGS

[0039] FIGS. 1 and 2 are a top view and side view, respectively, of an agricultural sorting apparatus;

[0040] FIG. 3 is a front left perspective view of one embodiment of air curtain apparatus;

- [0041] FIG. 4 is a left side view of the air curtain apparatus of FIG. 3;
- [0042] FIG. 5 is a perspective view of a trim station;
- [0043] FIG. 6 is a side view of the trim station of FIG. 5;
- [0044] FIG. 7 is a rear view of a trim station showing a counting device;
- [0045] FIGS. 8, 9, and 10 are a perspective view, a top view, and a side view, respectively, of a second embodiment conveyor line;
- [0046] FIGS. 11 and 12 are a top view and a perspective view, respectively, highlighting the waste handling system of the conveyor line of FIG. 8;
- [0047] FIGS. 13 and 14 are a top view and an end view, respectively, a conveyor of FIG. 8; and
- [0048] FIGS. 15, 16, and 17 are a top view, a rear view, and a perspective view of the trim stations of the trim station of FIG. 8.
- [0049] Reference symbols are used in the Figures to indicate certain components, aspects or features shown therein, with reference symbols common to more than one Figure indicating like components, aspects or features shown therein.

MODES FOR CARRYING OUT THE INVENTION

[0050] In certain embodiments, an apparatus is described to sort individual plants, **P**, from lifted agricultural material, **M**. In an illustrative example, which does not limit the scope of the present invention, strawberry plants are grown in a nursery to a size suitable for transplanting, at which time the plants and surrounding agricultural material are removed (“lifted”) from the soil and individual plants are separated, trimmed, and packaged for delivery to a farm. In general, lifted agricultural material, **M**, includes individual plants, clumps of two or more strawberry plants having intertwined roots, and other material including damaged plants, dirt, rocks, etc.

[0051] Figures 1 and 2 are a top view and of a side view respectively, of an apparatus **100** for sorting agricultural material into individual plants. Apparatus **100** includes, sequentially: a separating unit, or singulator **110**, having an input bin **111** for accepting lifted agricultural material, **M**; an air curtain apparatus **120** to perform a first sorting of the lifted agricultural material; and conveyor line(s) **130** for separating individual plants, **P**, trimming the individual plants, packaging the trimmed individual in output bins **134**. In various embodiments, conveyor

line(s) **130** may be one conveyor line, or two or conveyor lines arranged in parallel or in serial. Thus, for example and without out limitation, FIGS. 1 and 2 illustrate illustrative conveyor lines **130** as including a first conveyor line **140** and a second conveyor line **150**. Apparatus **100** also includes waste bins for handling rejected material from air curtain apparatus **120** and conveyor line(s) **130**, as discussed subsequently.

[0052] Singulator **110** includes a conveyor **113** to transport the lifted agricultural material, **M**, from input bin **111** to a distal end **115**, from which individual plants, **P**, and waste **W** exit the singulator. As described in co-owned US Patent No. 9,358,586 (the “’586 patent), the contents of which is hereby incorporated by reference, includes is one example of singulator **110** that the “’586 patent, includes a mechanism that separates at least some individual plants from the clumps of plants.

[0053] In certain embodiments, singulator **110** is configured to process from 300 lbs. (136 kg) to 1,500 lbs. (680 kg) of lifted agricultural material, **M**, has a width, **W1**, of approximately 5 feet (1.5 m) to 6.5 feet (2.0 m), with a velocity of conveyor **113** of from 1 in/sec (25 mm/sec) to 12 in/sec (300 mm/sec).

[0054] Material discharged from distal end 115 is provided to a conveyor tail 122 of an air curtain conveyor **121** for further processing.

AIR CURTAIN APPARATUS

[0055] Figure 3 is a front left perspective view of one embodiment of air curtain apparatus **120** of FIGS. 1 and 2, and Figure 4 is a left side view of the air curtain apparatus of FIG. 3. In general, a right side view of air curtain apparatus **120** is a mirror image of the view of FIG. 3. Air curtain apparatus **120** provides for a first sorting of material from singulator **110**, and includes air curtain conveyor **121** having a conveyor head **123** and a mechanism to provide an air curtain **303**. Conveyor line **140**, as discussed subsequently, includes a first sorting conveyor **141** having a tail **142** positioned below conveyor head **123** such that material from air curtain conveyor **121** falls towards first sorting conveyor **141** while being impinged by air curtain **303**.

[0056] Air curtain conveyor **121** has a length from conveyor tail **122** to conveyor head **123** of from 5.5 feet (1.7 m) to 6.5 feet (2.9 m), and forms at an upwards angle, θ , relative to the horizon, of from of +15 to +25 degrees. The angle, θ , of the moving air curtain conveyor **121** is selected to separate large objects, such as rocks, from reaching air curtain **303**. With a sufficiently large angle, θ , rocks and other large objects are preferentially sorted by not being able to reach conveyor head **123**.

[0057] Air curtain conveyor **121** and all of the other conveyors described herein that are used for transporting lifted agricultural material **M**, individual plants, **P**, and waste, **M**, may be formed from White, Food Grade, PVC type C, Multi-Ply, Friction Underside Belting, such as Grainger model 20103841-06 (W.W. Grainger, Inc., Lake Forest, IL)

[0058] The air curtain **303** is generated within an air curtain apparatus housing **124** having a mesh at an air intake **125**, one or more blowers **301**, and an air curtain duct **127** that directs air from the blowers to an air discharge **126**. In general, adjustable settings of air curtain **303** include an air volumetric flow, **Q**, an average flow velocity, **V**, a flow direction, α , relative to the horizon, a height, **h**, a longitudinal separation, **L**, of air discharge **126** and air curtain conveyor **121**, and a vertical separation, **d**, of air discharge **126** and air curtain conveyor **121**. In general, the direction of air curtain **303** is towards the oncoming material on air curtain conveyor **121**. The settings for air curtain **303**, such as one or more of **Q**, **V**, α , **h**, **L**, and or **V**, may vary from one batch of process material to another and may also depend on the moisture content of the plant material and/or soil.

[0059] Air curtain apparatus **120** includes various mechanisms for adjusting or controlling air curtain **303** include a switch or knob **401** that is operable to control one or more blowers **301** and which thus may be used to adjust **Q** and/or **V**.

[0060] Air curtain apparatus **120** includes various mechanisms to adjust longitudinal separation, **L**, and vertical separation, **d**, of air discharge **126** including a first member **402**, a first set screw **403**, a second member **404** including a first portion **405** and a second portion **406**, a bracket **407**, and a second set screw **408**. Specifically, first member **402**, which may be a tube having a square or rectangular cross section, has one end fixed relative to air curtain conveyor **121** and a second end that passes through the interior of first portion **405**. First set screw **403** passes through first portion **405** to first member **402**, and is used to fix a location of first portion **405** on first member **402**. Second portion **406**, which is attached first portion **405** at a right angle, extends through bracket **407**. Second set screw **408** that passes through bracket **407** to second portion **406**, and is used to fix the location of bracket **407** on the second portion **406**.

[0061] With first member **402** fixed relative to air curtain conveyor **121** and bracket **407** attached to air curtain duct **127**, a user may thus adjust **L** and/or **d** by first set screw **403** and/or second set screw **408** and moving air curtain duct **127** relative to air curtain conveyor **121**.

[0062] Air curtain duct **127** also has a duct portion **409** that is connected to the duct by a hinge **410** and includes a set screw **411** which can be used to set the height, **h**, which can also average flow velocity, **V**.

[0063] With air curtain **303** thus adjusted and blowing back towards air curtain conveyor **121**, and specifically directed towards a gap between conveyor head **123** and tail **142**, the air curtain impinges on falling material from air curtain conveyor **121**, resulting in some of the waste, **W**, directed into first waste bin **128**, and the remaining material, which includes individual plants, **P**, and the remaining waste, **W**, falling onto first sorting conveyor **141**.

[0064] In certain embodiment, the width, **W1**, is the same as the width of singulator **110**, the setting for separating strawberry plants may, have setting that permit, for example and without limitation, an air curtain flow volume, **Q**, between from 2,000 standard cubic feet per minute (57 standard cubic meters per minute) and 8,000 standard cubic feet per minute (225 standard cubic meters per minute), the air curtain flow velocity, **V**, is between 20 feet/min (6 m/min) and 200 feet/min (60 m/min), the air curtain flow direction, **α** , is between -20° and $+20^\circ$ relative to the horizon, the initial air curtain height, **h**, is between 1 inch (25 mm) and 5 inches (125 mm), the distance, **L**, is between 3 inches (75 mm) and 20 inches (0.5 m), and the vertical position, **V**, is between +15 inches (+375 mm) and -15 inches (-375 mm).

INDIVIDUAL PLANT CONVEYORS

[0065] Material from air curtain apparatus **120** is provided to first conveyor line **140**, which includes: a first sorting conveyor **141** having a width, **W1**, a left side **141L**, a right side **141R**, a tail **142**, and a head **143**; a pair of plant conveyors **144** including a left plant conveyor **144L** and a right plant conveyor **144R**; a pair of cutting/trim stations **149** including a left cutting/trim station **149L** and a right cutting/trim station **149R**; a transverse conveyor **147**; and second waste bin **148**. Left plant conveyor **144L** is adjacent to left side **141L**, right plant conveyor **144R** is adjacent to right side **141R**, and the left and right plant conveyors each extend from a corresponding tail **145** to a corresponding head **146**. Left cutting/trim station **149L** is positioned to accept left plant conveyor **144L** and right cutting/trim station **149R** is positioned to accept right plant conveyor **144R**. First transverse conveyor **147** is positioned below head **143**.

[0066] Second conveyor line **150** includes a conveyor **131** having a width, **W2**, that is less than **W1**, and other components that are generally similar to first conveyor line **140** including: a second sorting conveyor **151** having a width, **W2**, a left side **151L**, a right side **151R**, a tail **152**, and a head **153**; a second pair of plant conveyors **144** including left plant conveyor **144L**

adjacent to left side **151L** and right plant conveyor **144R** adjacent to right side **151R**; a second pair of cutting/trim stations **149** including left cutting/trim station **149L** and right cutting/trim station **149R**; a second transverse conveyor **147**; and a waste bin **148**. Left plant conveyor **144L** is adjacent to left side **151L**, right plant conveyor **144R** is adjacent to right side **151R**, and the left and right plant conveyors each extend from corresponding tail **145** to a corresponding head **146**. Left cutting/trim station **149L** is positioned to accept left plant conveyor **144L** and second right cutting/trim station **149R** is positioned to accept right plant conveyor **144R**. Second transverse conveyor **147** is positioned below head **153**.

[0067] Conveyor **131** has width, **W2**, and has a tail **132** and a head **133**, with tail **132** positioned below head **143** and with head **133** positioned above second sorting conveyor **151**. Material conveyed by first sorting conveyor **141** to head **143** thus falls either onto first transverse conveyor **147** as waste provided to second waste bin **148** or onto conveyor **131** and then onto second sorting conveyor **151** for further sorting.

[0068] Second sorting conveyor **151** has a left side **151L**, a right side **151R**, a tail **152** and a head **153**. Left plant conveyor **144L** is adjacent to left side **151L**, right plant conveyor **144R** is adjacent to right side **151R**, and the left and right trim conveyors each extend from corresponding trim conveyor tail **155** to a corresponding trim conveyor head **156**. Second left cutting/trim station **149L** is positioned to accept left plant conveyor **144L** and first right cutting/trim station **149R** is positioned to accept right plant conveyor **144R**. Second transverse conveyor **147** is below head **153** and collects waste from second sorting conveyor **151**.

[0069] In certain embodiments: first sorting conveyor **141** has a length from tail **142** to head **143** of from 12 feet (3.66 m) to 14 feet (4.27 m); conveyor **131** has a length from tail **132** to head **133** of from 8 feet (2.44 m) to 10 feet (3.05 m); second sorting conveyor **151** has a length from tail **152** to head **153** of from 12 feet (3.66 m) to 14 feet (4.27 m). In certain other embodiments: first sorting conveyor **141**, conveyor **131**, and second sorting conveyor **151** each move at the same rate of from 0.5 feet/sec (0.15 m/sec) to 5.0 feet/sec (1.5 m/sec). In certain embodiments, each of plant conveyors **144** has a length from tail **145** to head **146** of from 17 feet (5.2 m) to 19 feet (5.8 m) and they move at the same rate of from 0.5 feet/sec (0.15 m/sec) to 5.0 feet/sec (1.5 m/sec).

[0070] Details of each left plant conveyor **144** are illustrated in Figure 5 as is a perspective view of a trim station **149L** or **149R**, and in Figure 6 is a side view of the trim station.

[0071] Each of left plant conveyor 144L and right plant conveyor 144R include a conveyor belt 501 of thickness, t , and width, $W3$, with a plurality of cleats, or cleats 503 each having a height, $H1$, and equally spaced along conveyor belt 501 with a spacing, S .

[0072] In operation workers, indicated as users U , remove lifted agricultural material, M , from the field and place it in input bin 111 and package individual plants, P , as discussed below. Singulator 110 separates the lifted agricultural material, M , into individual plants, P , and waste, W , which may include some clumps of intertwined plants that were not separated in singulator 110. Next, the air curtain aerodynamically separates some of the waste into first waste bin 128 with the remaining material falling onto first sorting conveyor 141.

[0073] Then, other workers, indicated as users U , take up work stations at first conveyor line 140 adjacent to left plant conveyor 144L and right plant conveyor 144R. These workers manually select and remove individual plants from first sorting conveyor 141 and place them on the adjacent right plant conveyor 144R or left plant conveyor 144L and between a pair of cleats 503.

[0074] Material that was not removed by workers from head 143 either falls on to first transverse conveyor 147, where it is either treated as waste or recycled back into singulator 110 to further separate clumps of plants, or is transported onto conveyor 131 and then onto second sorting conveyor 151.

[0075] Workers at second conveyor line 150 on either side of second sorting conveyor 151 manually remove individual plants, P , from the conveyor and place them on adjacent right plant conveyor 144R or left plant conveyor 144L and between a pair of cleats 503.

[0076] In certain embodiments, individual plants, P , are aligned in plant conveyors 144 with either the roots or stems placed towards users, U .

[0077] Mechanisms for moving and controlling first conveyor line 140 and second conveyor line 150 are well-known in the field and are not repeated here. In addition, the operation of such a system to include safety features and control features are well known are not repeated here.

PLANT TRIM AND PACKAGING CONVEYOR LINE

[0078] Individual plants, P , on plant conveyors 144 then pass through trim stations 149. FIGS. 5 and 6 illustrate a representative trim station 149, which may be one of trim station 149L or trim station 149R. Specifically, left plant conveyor 144L passes through trim station 149L, and right plant conveyor 144R passes through trim station 149R. As shown in FIGS. 5 and 6,

each trim station **149** includes a press wheel **511**, a first saw blade **513** adjacent to an individual plant conveyor, and optionally a second saw blade **515** adjacent to an individual plant conveyor on the opposite side of first saw blade **513**, and a motor **517** for each saw blade.

[0079] In general, each plant conveyor **144** includes a conveyor belt **501** of thickness, **t**, and a width, **W3**, with a cleats **503** each having a height, **H1**, and equally spaced along conveyor belt **501** with a spacing, **S**. Adjacent cleats **503** orient the plants with roots on one side, stems on the other and the crown placed for best stem cost (2" or 4", for example). Each of the cleats **503** are semirigid and are designed to keep plants oriented by their height, pitch, and length by press wheel **511** as they pass by first saw blade **513** and or second saw blade **515**.

[0080] In certain embodiments, the spacing, **S**, between adjacent cleats **503** may hold from between one individual plant, **P**, or as many as 10 individual plants. In certain embodiments the thickness, **t1**, is from 1/8 inch (3.2 mm) to 1/4 inch (1.6 mm), the thickness, **t2**, is from 5/16 inch (8 cm) to 0.5 inch (12 mm), the width, **W4**, is from 4 inches (100 mm) to 7 inches (180 mm), height, **H1**, is from 1.2 inches (30 mm) to 4 inches (100 mm), and spacing, **S**, is from 1 inch (25 mm) to 3 inches (75). As described subsequently, the flights are bendable and may be formed from or include, for example and without limitation, a rubber material.

[0081] As individual plant conveyors move through trim stations **149**, press wheel **511** pushes down on cleats **503** holding the individual plants in place and proper orientation for trimming by first saw blade **513** and/or second saw blade **515**. The spacing between first saw blade **513** and/or second saw blade **515** is selected so that a proper amount of excess material is removed from the plants, resulting in the exact amount of stem and/root material remaining on the plants for packaging.

[0082] In certain embodiments, the first saw blade **513**, and second saw blade **515** are Diablo brand, 10 inch, 90 Tooth, Ultimate Polished Finish blades (Diablo Tools, High Point, NC), the motors driving each blade is a 1/2 horse power electric motors. Press wheel **511** is a 10 inch (.25 m) to 12 inch (.30 m), heavy foam rubber outer layer bonded to forged metal wheel, and operates as an idle wheel with gravity leveraged from hinged moment arm.

[0083] Figure 7 is a rear view of a trim station **149** and the respective plant conveyor **144** as it leaves the trim station, and a counting device **700** including an arm **701** having one contacting the plant conveyors and a second end rotatably attached to an encoder **703**, and electronics **705**. As individual plants, **P**, pass under arm **701**, the arm rotates about encoder **703** and sends a

signal to electronics **705** indicating the presents of plants. The construction and operation of counting device **700** would be obvious to one skilled in the art.

[0084] The individual plants, **P**, then reach the end of plant conveyor **144** and are deposited into output bins **134**. In certain embodiments, a worker transfers individual plants, **P**, into output bins **134**, and may alternate their direction to pack the plants into the output bins.

ALTERNATIVE PLANT TRIM AND PACKAGING CONVEYOR LINE EMBODIMENTS

[0085] Figures 8, 9, and 10 are a perspective view, a top view, and a side view, respectively, of a second embodiment conveyor line **800**. Second embodiment conveyor line **800** is generally similar to conveyor line(s) 130, except as explicitly stated.

[0086] Conveyor line **800** has an input end **801**, a first output end **803**, and a second output end **806**, and includes distribution system **810** at input end **801**, and two conveyor lines, each shown as conveyor line **820** at first output end **803**, and a waste conveyor **805** at second output end **806**.

[0087] Distribution system **810** includes a right conveyor **811** having a tail **812** and a head **813** and a left conveyor **814** having a tail **815** and a head **816**. Tail **812** and tail **815** are, for example and without limitation, provided with agricultural material to be sorted. In one embodiment, right conveyor **811** and left conveyor **814** are positioned to both receive material from air curtain apparatus **120**, such as by replacing first sorting conveyor **141** of FIG. 1.

[0088] Conveyor line **820** includes: a conveyor **821** having a tail **822** and a head **823** and includes a right conveyor **821R** and a left conveyor **821L**; a plant conveyor **824** having a tail **825** and a head **826** and includes a right plant conveyor **824R** and a left plant conveyor **824L**; a trim station **830** including a right trim station **830R** and a left trim station **830L**; waste transport system **840** including a waste deflector **841** and a conveyor **842** having a tail **843** and a head **844**; and conveyors **851** for holding output bins **134**.

[0089] Plant conveyor **824** is generally similar to plant conveyors **144**. Right conveyor **811** and left conveyor **814** each have a length of from 10 ft (3.0 m) to 12 ft (3.7 m), an upwards angle of from 10 degrees to 30 degrees, and a speed of from 0.5 ft/sec (0.15 m/sec) to 5.0 ft/sec (1.5 m/sec).

[0090] Figures 11 and 12 are a top view and a perspective view, respectively, highlighting the waste transport system **840**. The views of FIGS. 11 and 12 are similar to those of FIGS. 8-10, where certain components have been removed to show waste transport system **840**.

[0091] Waste transport system **840** includes conveyor **842** with tail **843** and waste deflector **841** positioned below trim station **830** and shaped to direct waste from the trim station to conveyor **842**. Head **844** of waste transport system **840** of one of conveyor line **820** provides waste to waste conveyor **805**, where it is conveyed to second output end **806**, and head **844** of waste conveyor **805** located at second output end **806**.

[0092] Figures 13 and 14 are a top view and an end view, respectively, a conveyor **821**. Tail **822** includes a deflector **1301** which is positioned below head **813** of right conveyor **811** or head **816** of left conveyor **814**, to ensure that material is directed to one of right conveyor **821R** or left conveyor **821L**. As shown in FIG. 14, right conveyor **821R** and left conveyor **821L** are both at an angle, β , to the horizon. This angle permits material falling onto right conveyor **821R** to move towards right plant conveyor **824R** and material falling onto left conveyor **821L** to move towards left plant conveyor **824L**. In certain embodiments, the angle, β , is from 10 degrees to 24 degrees.

[0093] Figures 15, 16, and 17 are a top view, a rear view, and a perspective view of the trim stations of trim station **830**. Trim station **830** is generally similar to trim station **149** except where explicitly stated.

[0094] Trim station **830** has a frame **1501** that supports a right trim station **830R** and a left trim station **830L**, where the left and right trim stations are generally similar and may be mirror images of each other. Thus, for example and without limitation, right trim station **830R** includes a first trim system **1510**, a second trim system **1540**, a first press wheel system **1520**, a second press wheel system **1530**, and a chute **1550**. First trim system **1510** includes a motor **1511** operable to rotate a first saw blade **1513** and a translation mechanism **1515** to transversely position first saw blade **1513** relative to and near one edge of conveyor belt **501** of right plant conveyor **824R**. Second trim system **1540** includes a motor **1541** operable to rotate a second saw blade **1543** and a translation mechanism **1545** to transversely position second saw blade **1543** relative to and near the opposite edge of conveyor belt **501** of right plant conveyor **824R**. First press wheel system **1520** includes a first press wheel **1521** and a mechanism **1523** to translate first press wheel **1521** to a region between an edge of conveyor belt **501** and cleats **503** of right plant conveyor **824R** and to provide a force onto conveyor belt **501**. Second press wheel system **1530** includes a second press wheel **1531** and a mechanism **1533** to translate second press wheel **1531** to a region between the opposite edge of conveyor belt **501** and cleats **503** of right plant conveyor **824R** and to provide a force onto conveyor belt **501**. Chute **1550** has a housing **1551**

with a first opening **1552** near tail **825** of right plant conveyor **824R**, a second opening **1554**, and a flap **1553**.

[0095] Second embodiment conveyor line **800** operates in a manner similar to conveyor line(s) **130**. Material from air curtain apparatus **120** is deposited at input end **801** onto right conveyor **811** and left conveyor **814**, and is transported to head **813** of right conveyor **811** and to head **816** of left conveyor **814**. The material from right conveyor **811** then falls onto conveyor **821**, with deflector **1301** directing the material onto either right conveyor **821R** or left conveyor **821L**. Workers on either side of right conveyor **811** select individual plants from conveyor **821** and transfer the plants onto the nearest one of right plant conveyor **824R** or left plant conveyor **824L**. Any material not removed from conveyor **821** by the workers falls from head **823** on to conveyor **842** and is transported towards second output end **806**, where it is disposed of.

[0096] Right plant conveyor **824R** continues through right trim station **830R**, where first press wheel **1521** and second press wheel **1531** press plants on right plant conveyor **824R** onto conveyor belt **501** and where first saw blade **1513** and second saw blade **1543** trim the plants at the edge of conveyor belt **501**. Similarly, left plant conveyor **824L** continues through left trim station **830L** where first press wheel **1521** and second press wheel **1531** press plants on left plant conveyor **824L** onto conveyor belt **501** and where first saw blade **1513** and second saw blade **1543** trim the plants at the edge of conveyor belt **501**.

[0097] First press wheel **1521** and second press wheel **1531** are generally similar to press wheel **511**, and the saw blades and motors of first trim system **1510** and second trim system **1540** are generally the same as the saw blade and motor illustrated in FIGS. 5 and 6.

[0098] Waste from the trimming of the plants falls to waste deflector **841** and onto conveyor **842** and eventually to second output end **806**.

[0099] In certain embodiments, second embodiment conveyor line **800** includes counting device **700**. In certain other embodiments, second embodiment conveyor line **800** includes a counting device **700** including an LED and photodetector to count plants. In yet other embodiments, second embodiment conveyor line **800** does not include a counting device.

[00100] Trimmed plants from tail **825** of right plant conveyor **824R** fall by entering first opening **1552**, exiting second opening **1554**, and then into waiting output bins **134**. For continuous operation of the apparatus while changing output bins, flap **1553** may be operated to prevent plants from exiting second opening **1554** while a new output bins **134** is in place. In

certain embodiments, a worker assists the loading of output bins **134** by alternating the orientation of plants, P, to tightly pack the output bins.

[00101] Trimmed plants from tail **825** of right plant conveyor **824R** fall by entering chute **1550**. The counting system will allow a number of plants to collect in the accumulator (from 1 plant to 100 plants), as selected by the operator, before it opens flap **1553** to allow the group of plants to drop into the packing box. This allows for groups of oriented plants to drop into the box and for the box loader operator to change out boxes during the continuous operation of the plant belt.

[00102] Reference throughout this specification to “one embodiment” or “an embodiment” means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases “in one embodiment” or “in an embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures or characteristics may be combined in any suitable manner, as would be apparent to one of ordinary skill in the art from this disclosure, in one or more embodiments.

[00103] Similarly, it should be appreciated that in the above description of exemplary embodiments of the invention, various features of the invention are sometimes grouped together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of one or more of the various inventive aspects. Thus, for example, an apparatus may include a singulator, an air curtain and then, as in apparatus **100**, a single second embodiment conveyor line **800** having the same width as the singulator and the air curtain. This method of disclosure, however, is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the claims following the Detailed Description are hereby expressly incorporated into this Detailed Description, with each claim standing on its own as a separate embodiment of this invention.

[00104] It is to be understood that the invention includes all of the different combinations embodied herein. Throughout this specification, the term “comprising” shall be synonymous with “including,” “containing,” or “characterized by,” is inclusive or open-ended and does not exclude additional, unrecited elements or method steps. “Comprising” is a term of art which means that the named elements are essential, but other elements may be added and still form a

construct within the scope of the statement. “Comprising” leaves open for the inclusion of unspecified ingredients even in major amounts.

[00105] Thus, while there has been described what is believed to be the preferred embodiments of the invention, those skilled in the art will recognize that other and further modifications may be made thereto without departing from the spirit of the invention, and it is intended to claim all such changes and modifications as fall within the scope of the invention.

CLAIMS

We Claim:

1. An apparatus for sorting agricultural material, the apparatus comprising:
 - a first conveyor having a head, where the first conveyor is operable to transport agricultural material in a first direction towards the head;
 - a second conveyor having a tail positioned below the head of the first conveyor and separated from the head of the first conveyor by a gap; and
 - an air curtain apparatus having an air discharge, where the air curtain apparatus is operable to generate an air curtain from air discharge and towards the gap, such that when the first conveyor, the second conveyor, and the air curtain apparatus are operated, the air curtain deflects at least some of the agricultural material falling across the gap away from the second conveyor.
2. The apparatus of claim 1, where the first conveyor moves upwards at an angle, θ , relative to a horizon, and where the angle is sufficient to prevent rocks in the agricultural material from reaching the head of the first conveyor.
3. The apparatus of claim 2, where the angle is between 15 degrees and 25 degrees.
4. The apparatus of claim 1, where the air curtain is directed towards the gap in a second direction opposite to the first direction.
5. The apparatus of claim 1, where an average air curtain flow velocity at the air discharge is between 20 feet/min (6 m/min) and 200 feet/min (60 m/min).
6. The apparatus of claim 1, where the air curtain at the air discharge is directed at an angle of between -20° and $+20^\circ$ relative to a horizon.
7. The apparatus of claim 1, where an initial height of the air curtain at the air discharge is between 1 inch (25 mm) and 5 inches (125 mm).
8. The apparatus of claim 1, where a horizontal distance between the air discharge and the head of the first conveyor is between 3 inches (75 mm) and 20 inches (0.5 m).
9. The apparatus of claim 1, where a vertical distance between the air discharge and the head of the first conveyor is between +15 inches (+375 mm) and -15 inches (-375 mm).
10. A method for separating agricultural material, the method comprising:
 - directing the agricultural material between a head of a first conveyor in a first direction to a tail of a second conveyor, where the tail of the second conveyor is spaced below the head of the first conveyor by a gap; and
 - directing an air curtain from an air discharge towards the gap,

such that the air curtain deflects at least some of the agricultural material falling across the gap away from the second conveyor.

11. The method of claim 10, where the first conveyor forms an angle to a horizon, and where the angle is sufficient to prevent rocks in the agricultural material from reaching the head of the first conveyor.
12. The method of claim 10, where the angle is between 15 degrees and 25 degrees.
13. The method of claim 10, where the air curtain is directed towards the gap in a second direction opposite to the first direction.
14. The method of claim 10, where an average air curtain flow velocity at the air discharge is between 20 ft/min and 200 ft/min.
15. The method of claim 10, where the air curtain at the air discharge is directed at an angle of between -20° and $+20^{\circ}$ relative to a horizon.
16. The method of claim 10, where an initial height of the air curtain at the air discharge is between 1 inch (25 mm) and 5 inches (125 mm).
17. The method of claim 10, where a horizontal distance between the air discharge and the head of the first conveyor is between 3 inches (75 mm) and 20 inches (0.5 m).
18. The method of claim 10, where a vertical distance between the air discharge and the head of the first conveyor is between +15 inches (+375 mm) and -15 inches (-375 mm).
19. An apparatus for trimming plants, the apparatus comprising:
 - conveyor belt having a width between a first side of the conveyor belt and a second side of the conveyor belt, and a plurality of, where each cleat of the plurality of cleats extends a height above the conveyor belt, and where a space between adjacent cleats of the plurality of cleats are adapted to accept plants;
 - a press wheel positioned above conveyor belt, where the press wheel forces accepted plants against the conveyor belt; and
 - a saw blade parallel to the first side of the conveyor belt and adjacent to the press wheel, where the saw blade is operable to trim one end of the accepted plants,
 - such that accepted plants are trimmed by the apparatus.
20. The apparatus of claim 19, where the saw blade is a first saw blade, where the apparatus further includes a second saw blade parallel to the second side of the conveyor belt and adjacent to the press wheel, where the second saw blade is operable to trim an opposite side of the accepted plants.
21. The apparatus of claim 19, where the press wheel is positioned over the plurality of cleats and where the press wheel forces one or more cleats and the accepted plants against the conveyor belt.

22. The apparatus of claim 19, where each cleat of the plurality of cleats has a width less than the width of the conveyor belt, and where the press wheel is positioned between the first side of the conveyor belt and the plurality of cleats.
23. The apparatus of claim 22, where the press wheel is a first press wheel, and where the apparatus further includes:
a second press wheel positioned between the second side of the conveyor belt and the plurality of cleats.
24. The apparatus of claim 22, where the saw blade is a first saw blade, and where the apparatus further includes:
a second saw blade parallel to the second side of the conveyor belt and adjacent to the press wheel, where the second saw blade is operable to trim an opposite side of the accepted plants.
25. The apparatus of claim 19, further comprising:
a mechanism to count plants on the conveyor belt, where the mechanism includes an arm and an encoder, where the arm extends from a first end that contacts the conveyor belt and a second end supported by the encoder, such that when plants on the conveyor belt pass under the first end of the arm, the arm rotates about the second end and the encoder registers a passage of the plants.
26. A method for trimming plants, the method comprising:
transporting plants between adjacent cleats of a plurality of cleats on a conveyor belt having a first side and a second side, where each cleat of the plurality of cleats extends a height above the conveyor belt, and where a space between adjacent cleats of the plurality of cleats are adapted to accept plants;
restraining the accepted plants with a press wheel positioned above trim belt as the accepted plants move under the press wheel; and
trimming one end of the restrained plants with a saw blade.
27. The method of claim 26, where the saw blade is a first saw blade, where said trimming further trims another side of the restrained plants with a second saw blade.
28. The method of claim 26, where the press wheel is positioned over the plurality of cleats and where the restraining the accepted plants with the press wheel also forces one or more cleats against the conveyor belt.
29. The method of claim 26, where each cleat of the plurality of cleats has a width less than the width of the conveyor belt, and where the press wheel is positioned between the first side of the conveyor belt and the plurality of cleats.

30. The method of claim 29, where the press wheel is a first press wheel and where said restraining includes restraining the accepted plants with a second press wheel positioned between the second side of the conveyor belt and the plurality of cleats.

31. The method of claim 29, where the saw blade is a first saw blade, and where said trimming further trims another side of the restrained plants with a second saw blade parallel to the second side of the conveyor belt and adjacent to the press wheel.

32. The method of claim 29, further comprising:

counting the plants on the conveyor belt using a mechanism including an arm and an encoder, where the arm extends from a first end that contacts the conveyor belt and a second end supported by the encoder, such that when plants on the conveyor belt pass under the first end of the arm, the arm rotates about the second end and the encoder registers a passage of the plants.

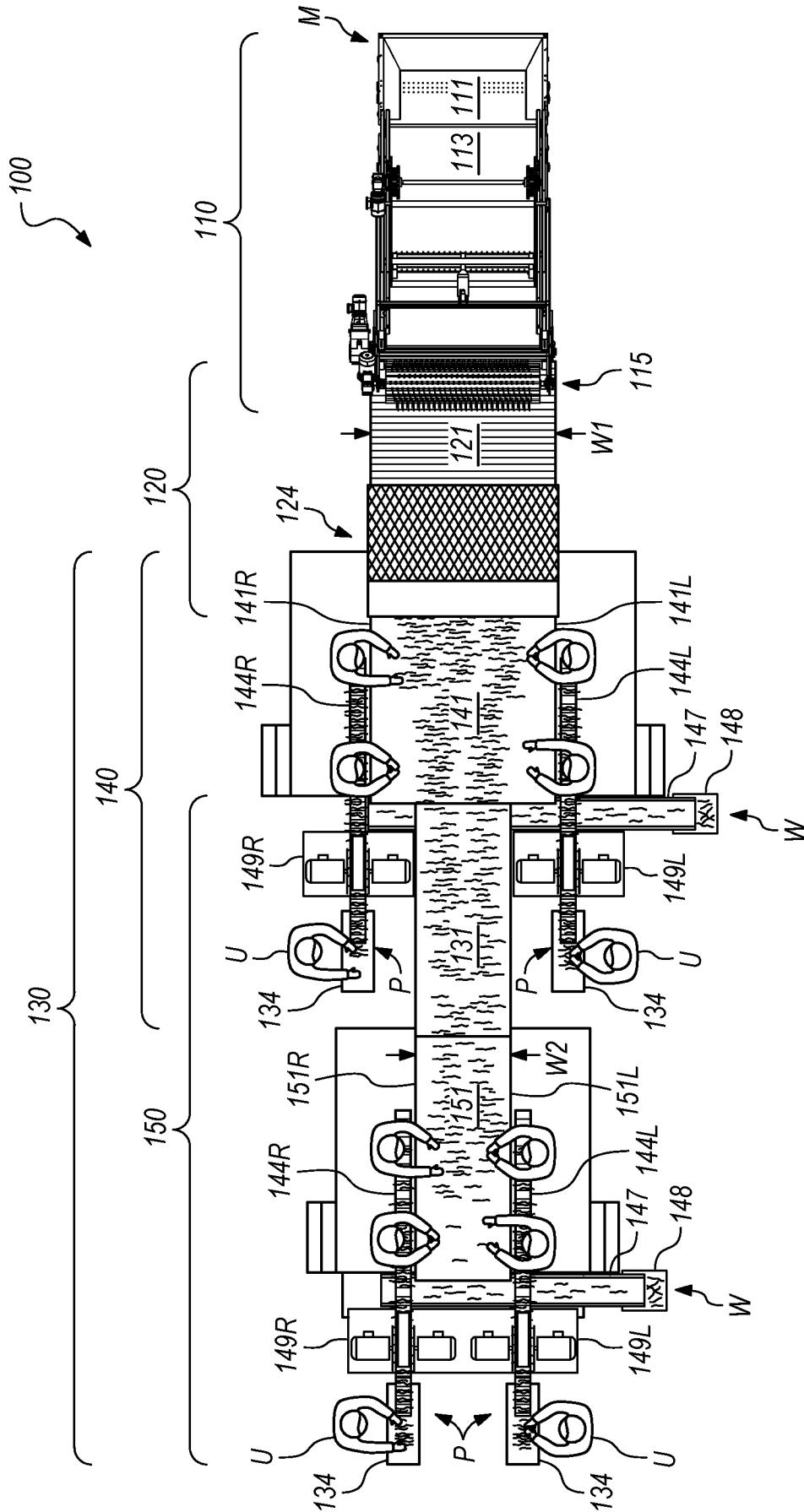


FIG. 1

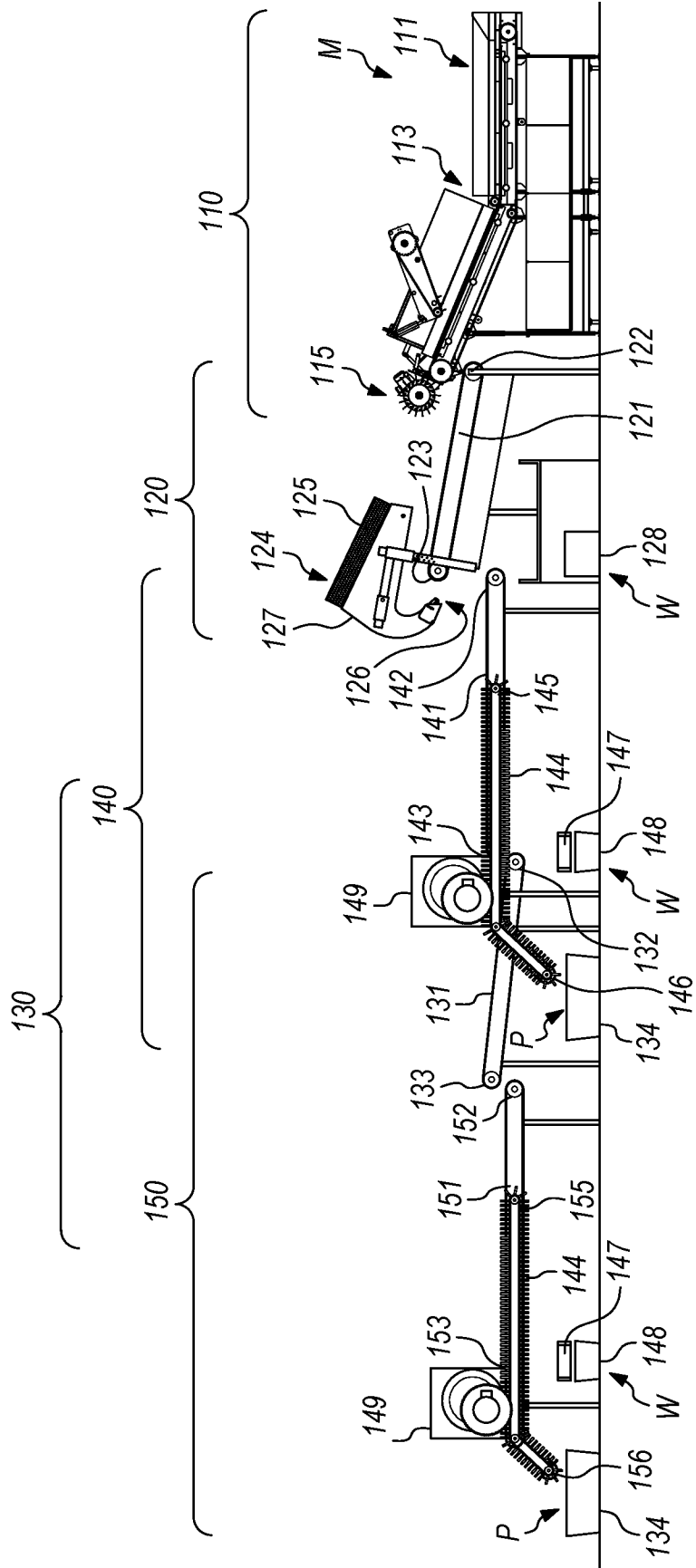


FIG. 2

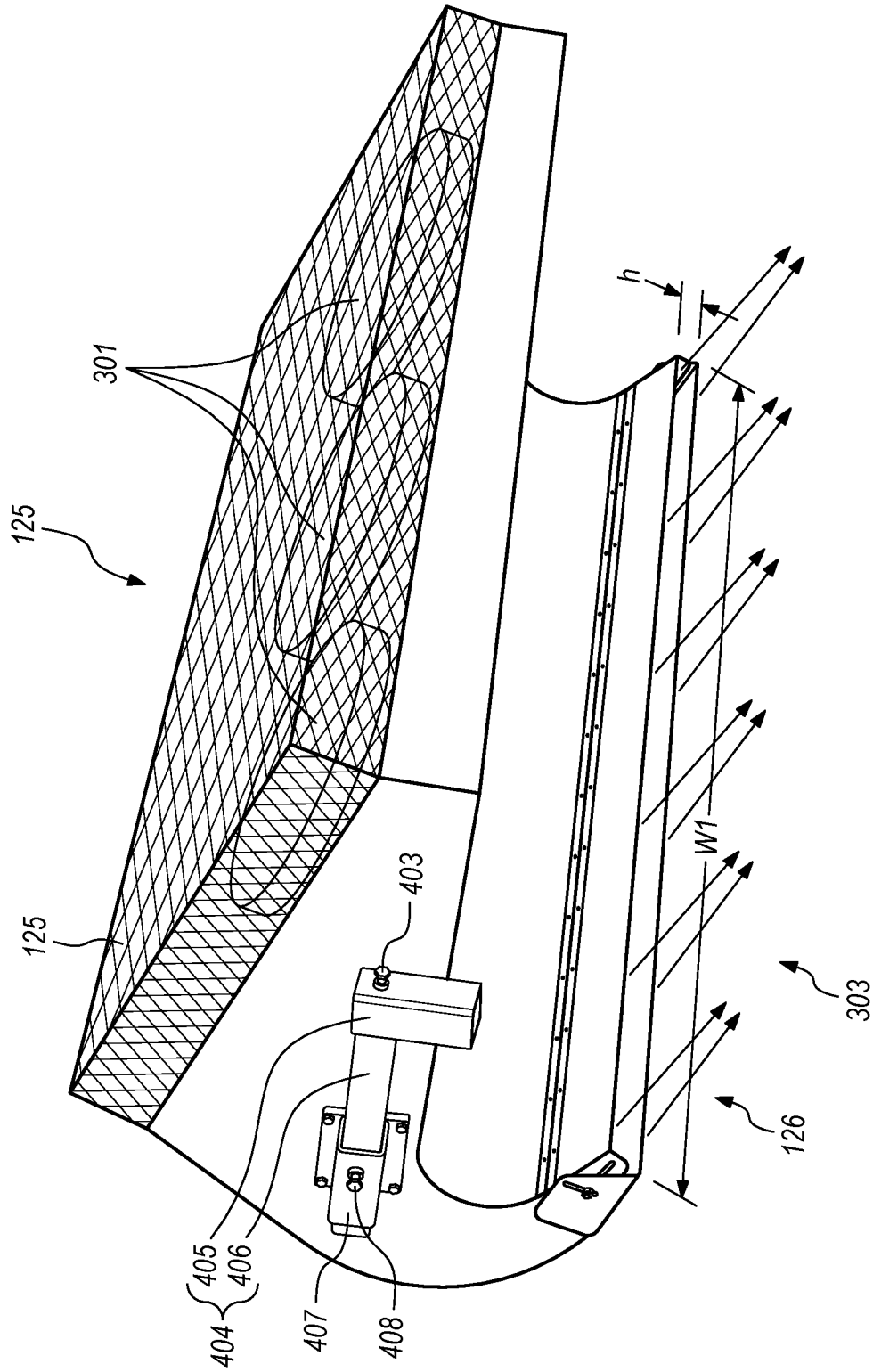


FIG. 3

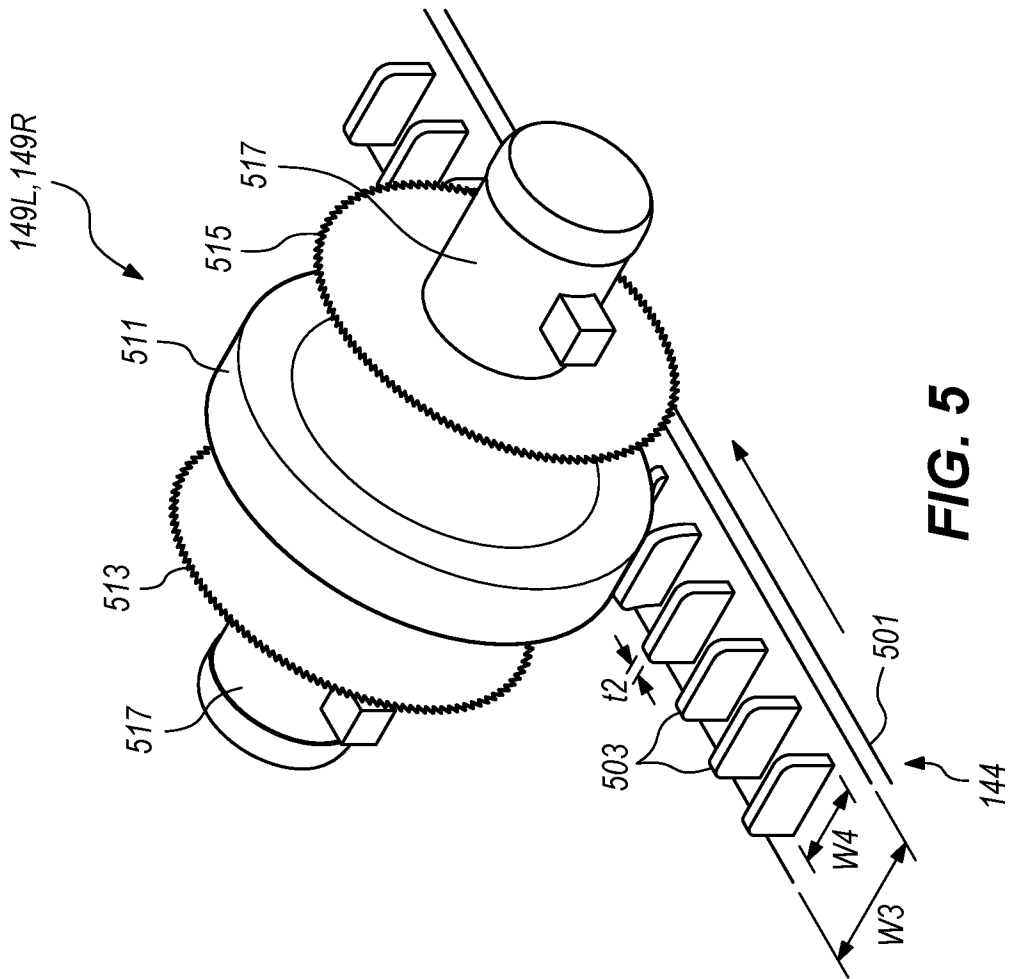


FIG. 5

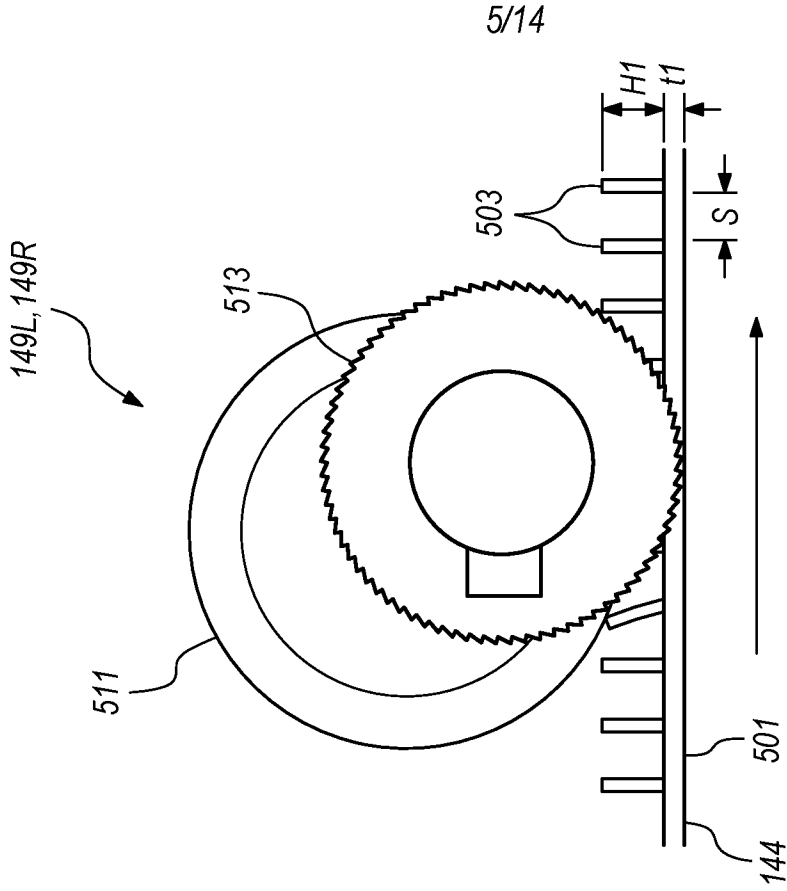


FIG. 6

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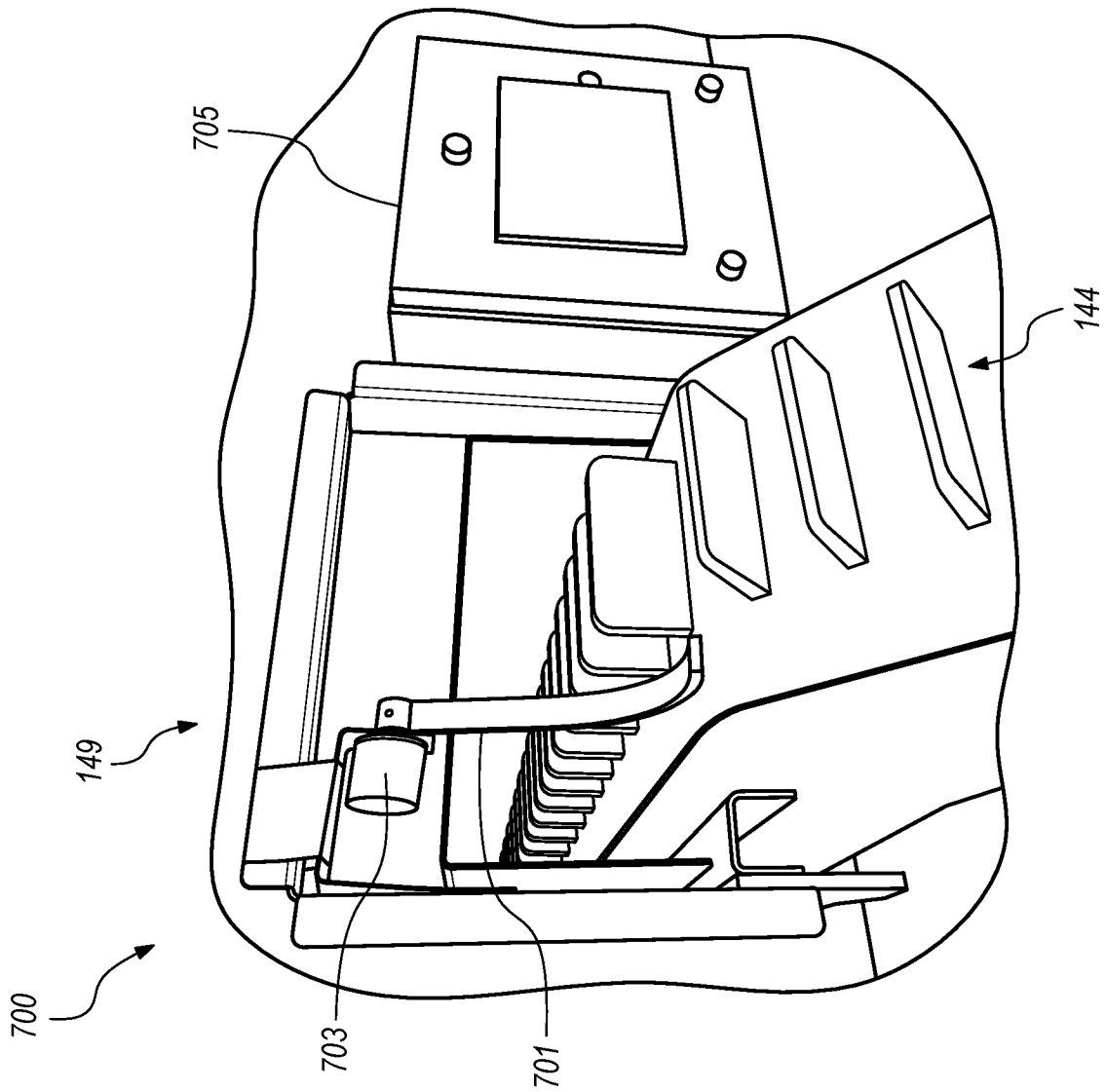


FIG. 7

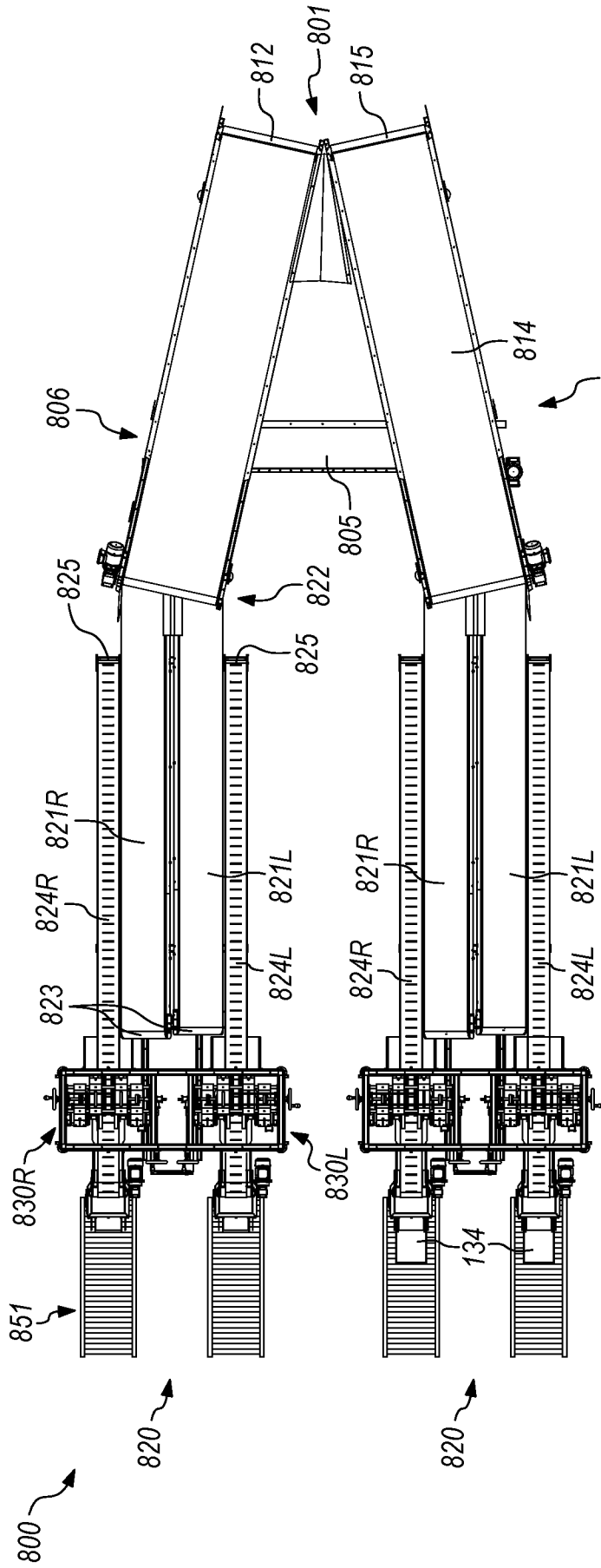


FIG. 9

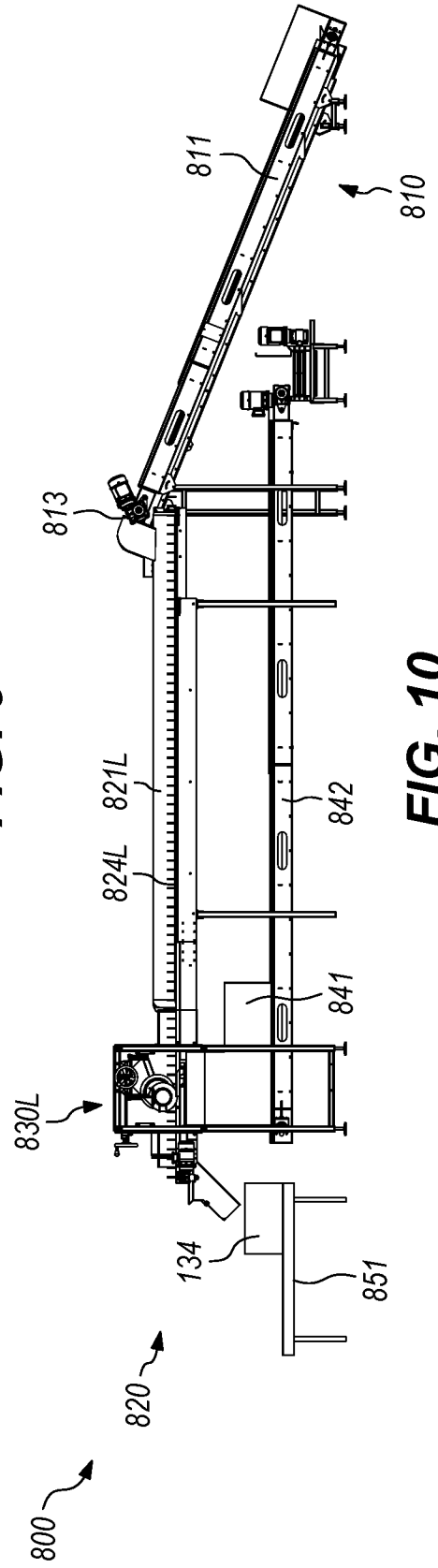


FIG. 10

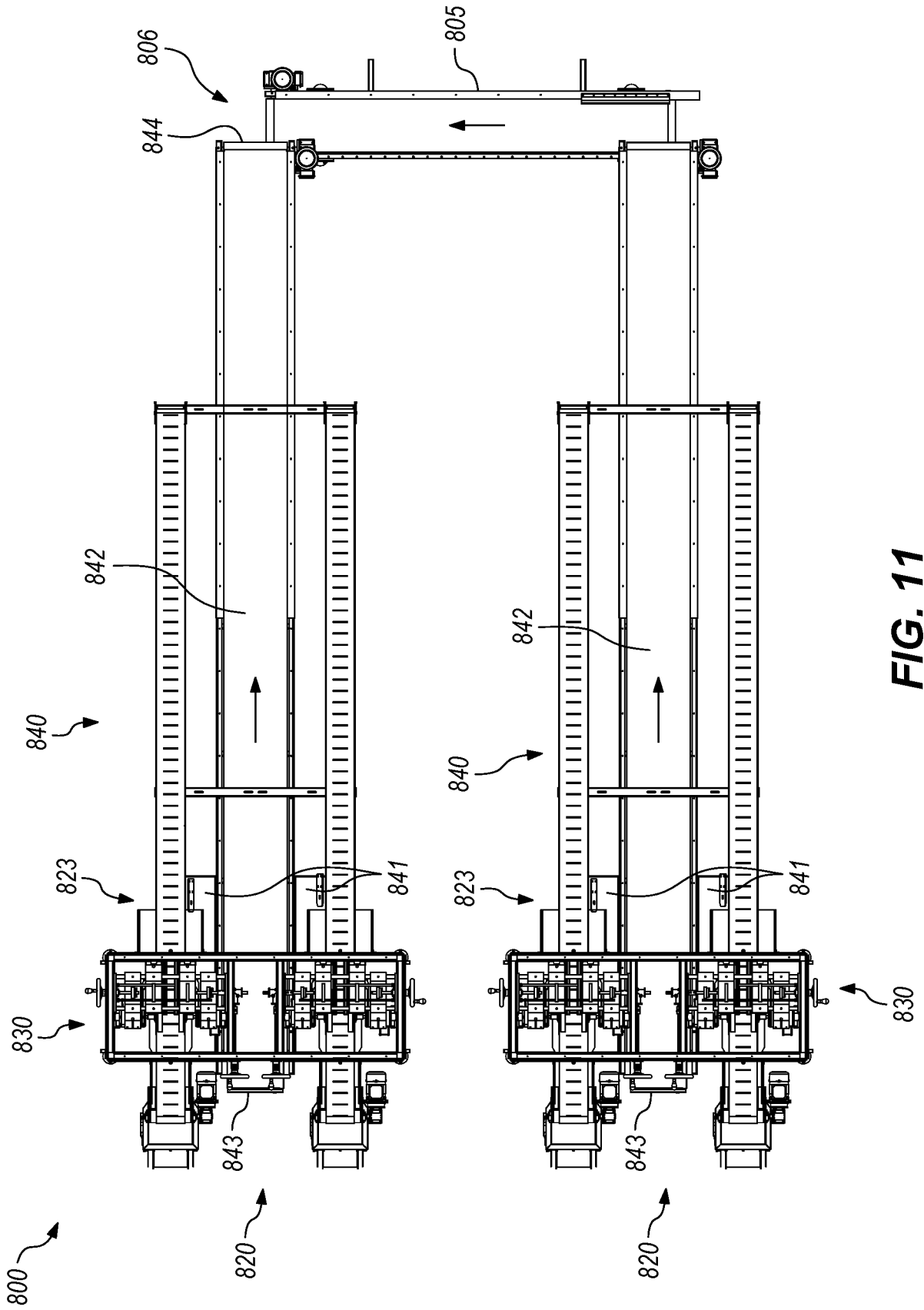


FIG. 11

10/14

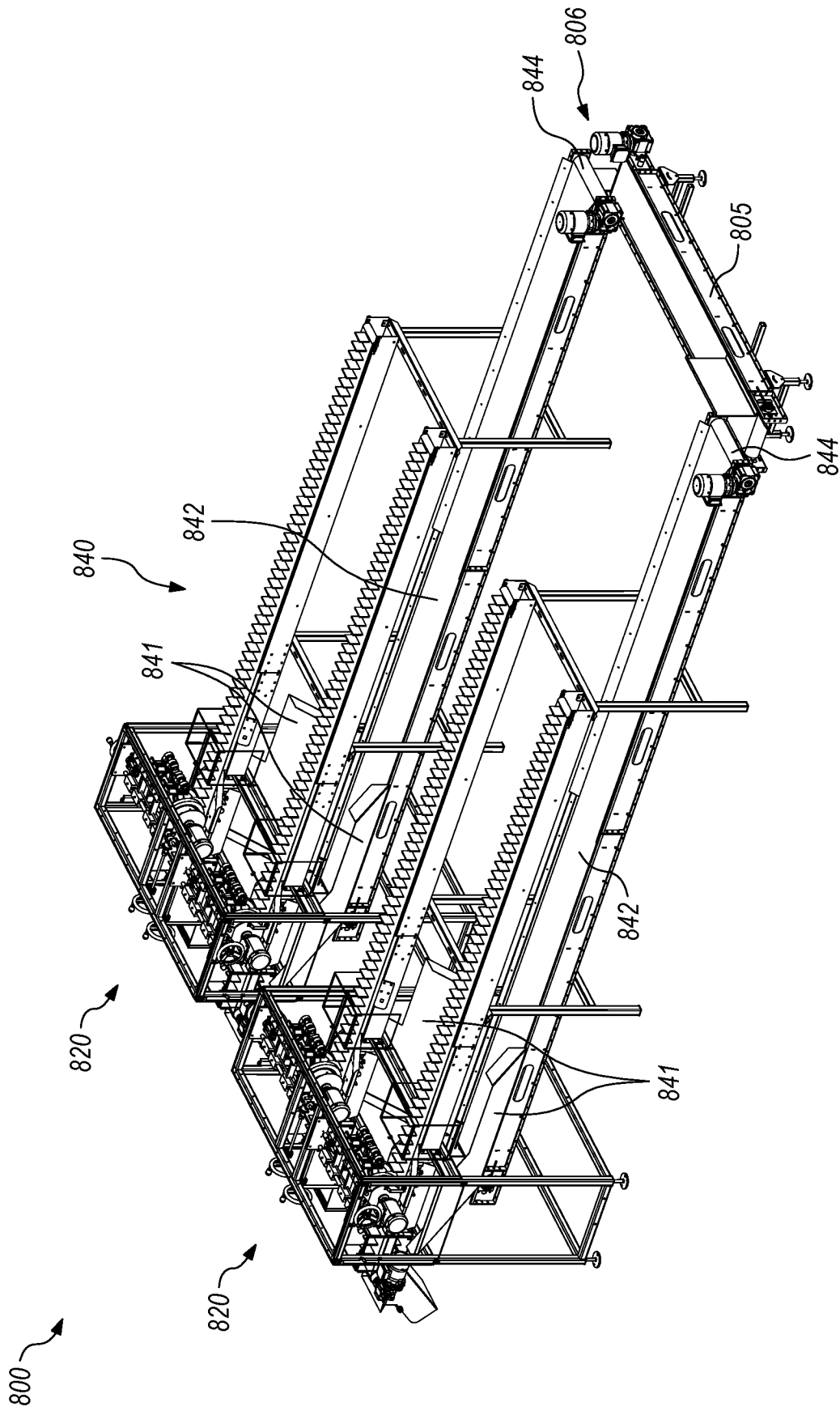


FIG. 12

11/14

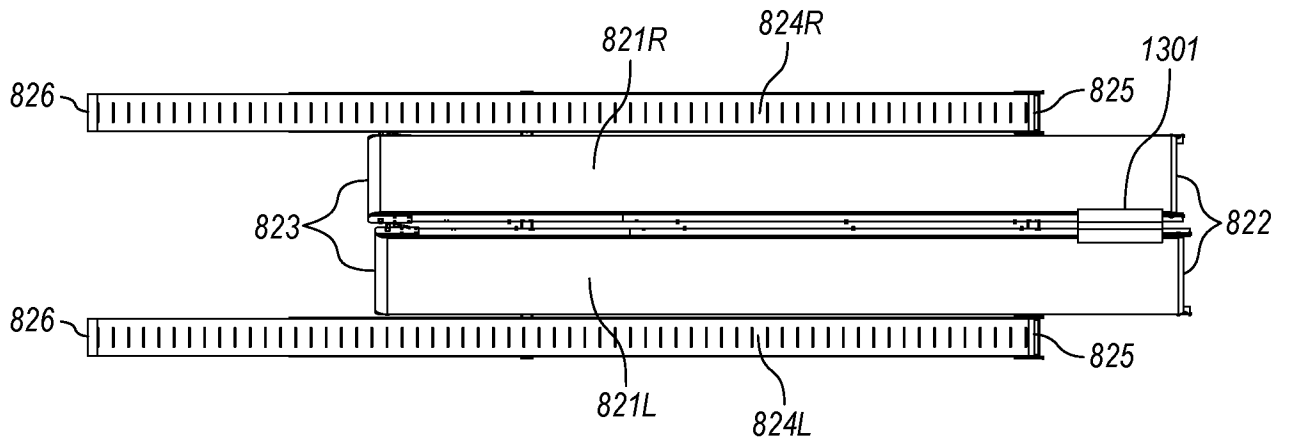


FIG. 13

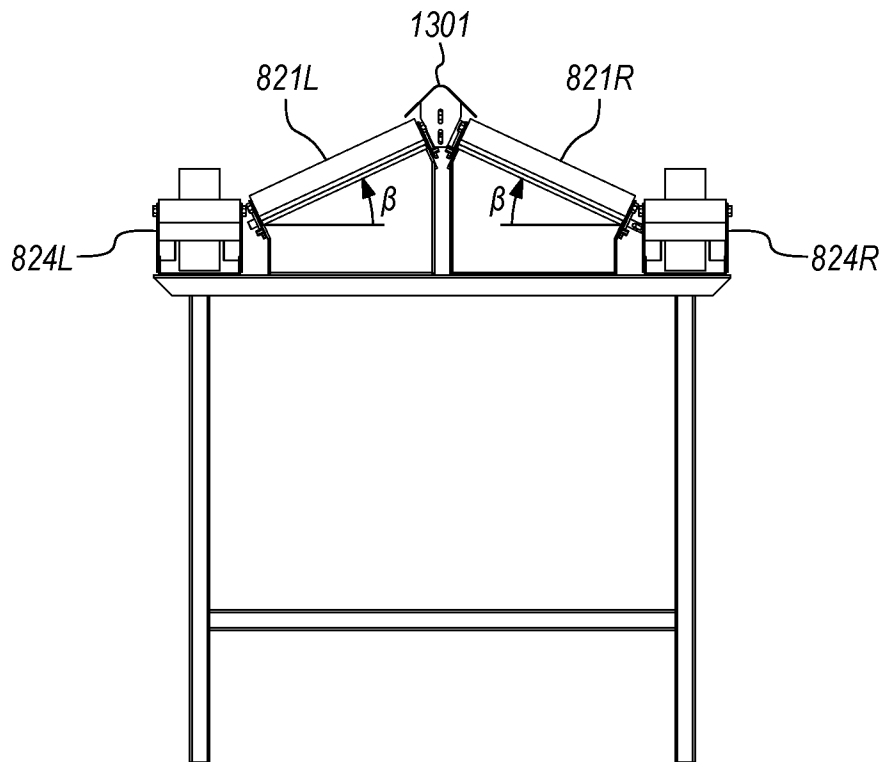


FIG. 14

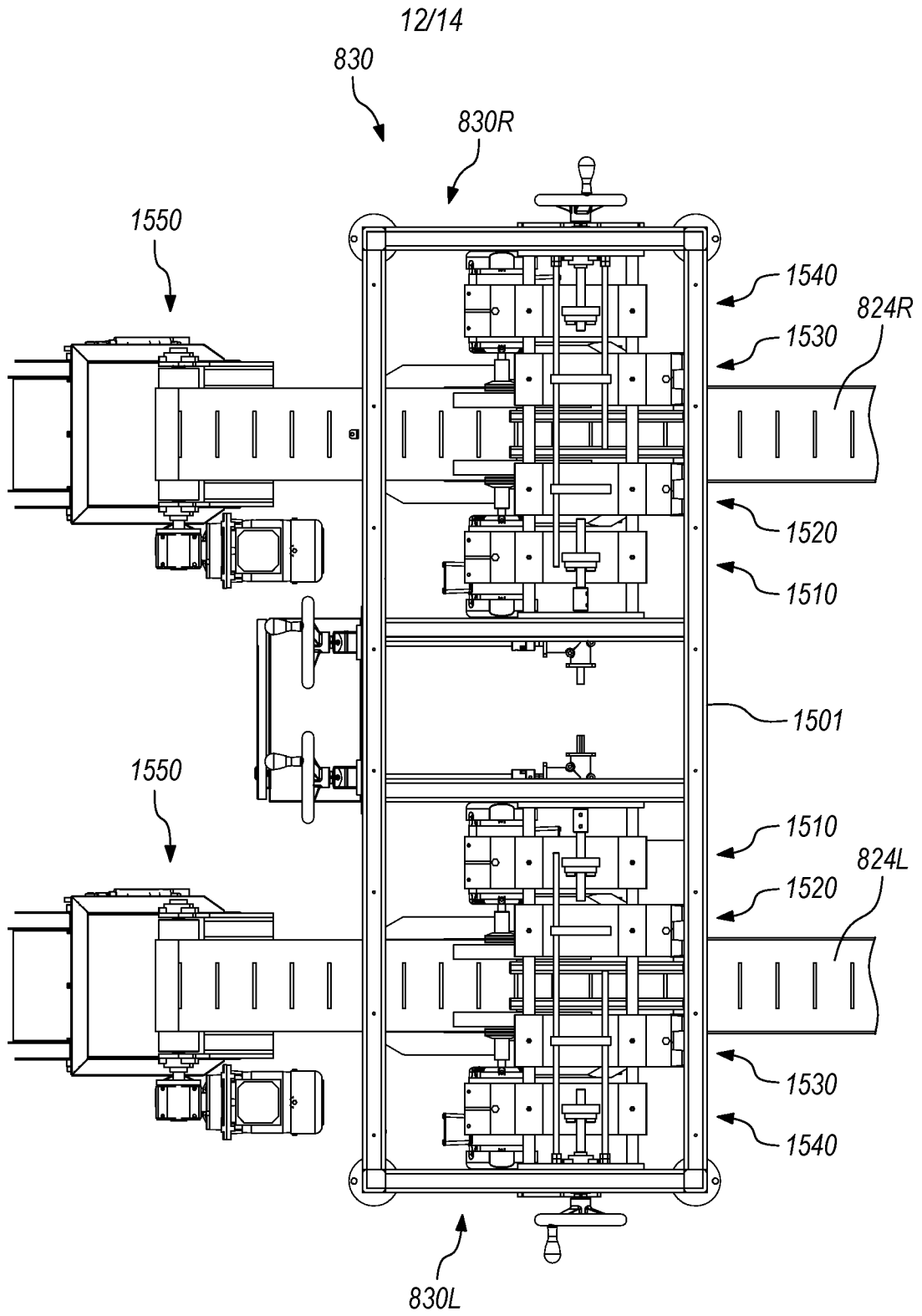


FIG. 15

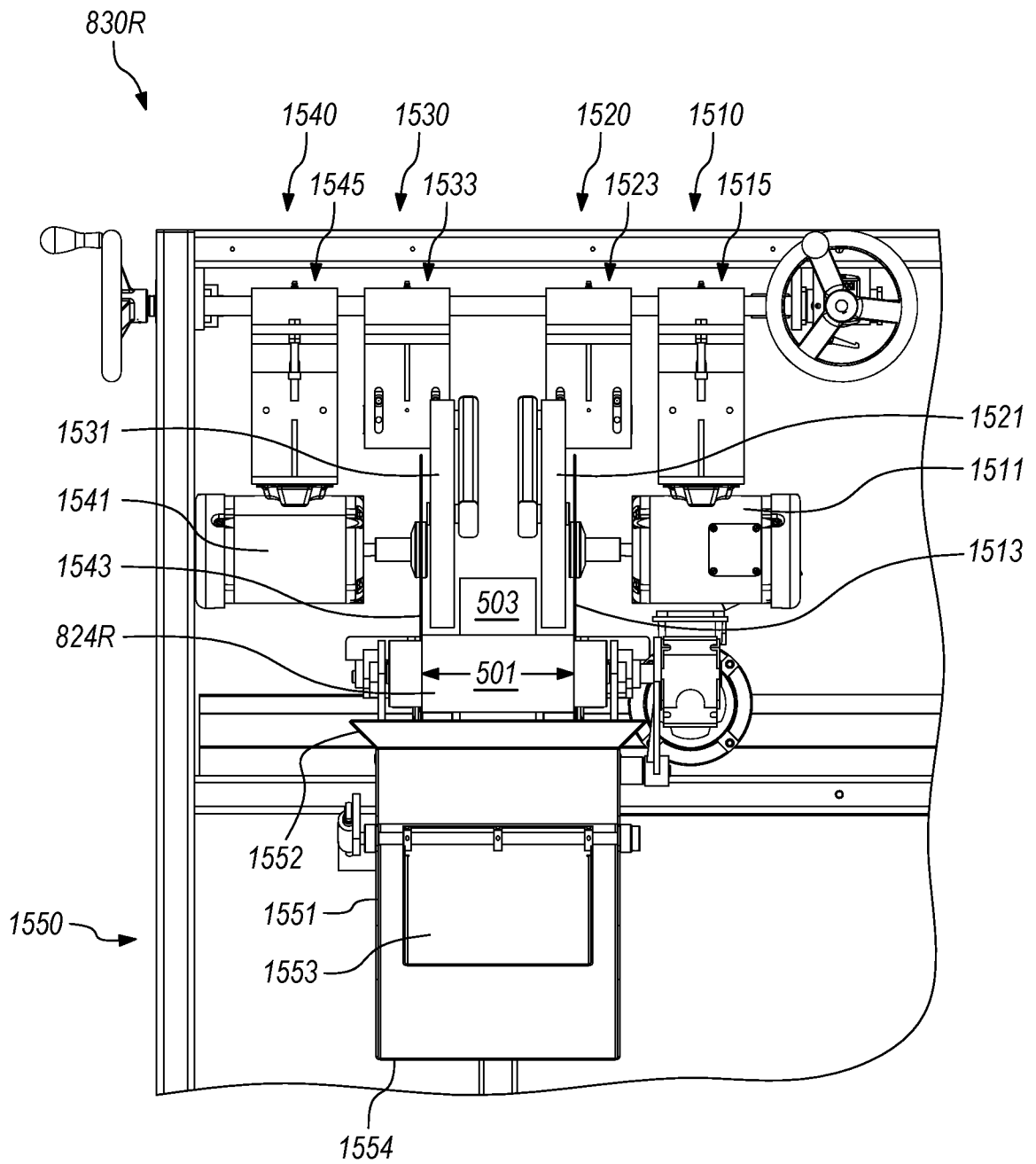


FIG. 16

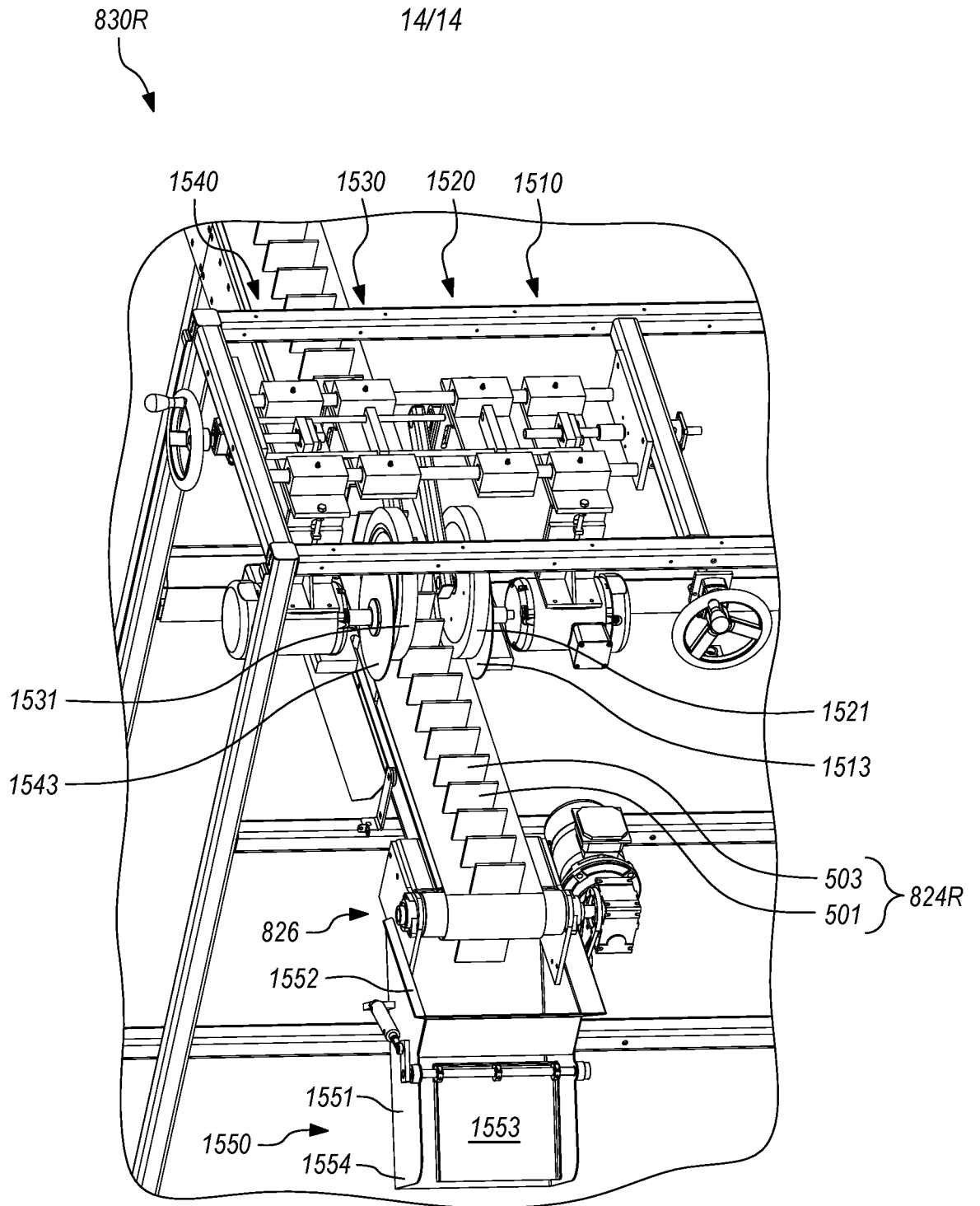


FIG. 17

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2023/069082

A. CLASSIFICATION OF SUBJECT MATTER

INV. B07B4/04 B07B7/01 B07C5/36
ADD. B07B7/12 B65G47/52

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)
B07B B65G B07C

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)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/034222 A1 (RICKETTS JONATHAN E [US] ET AL) 10 February 2011 (2011-02-10) columns 6-7; figures 2-4, 9, 10, 14 -----	1-18
A	EP 0 613 615 A1 (G A E C RADET AGRI [FR]) 7 September 1994 (1994-09-07) the whole document -----	1-18

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "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)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "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
- "&" document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

30 September 2023

04/12/2023

Name and mailing address of the ISA/
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Béguin-Adriaenssens

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2023/069082

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims;; it is covered by claims Nos.:

1-18

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-18

An apparatus for sorting agricultural material and method for separating agricultural material with such apparatus.

2. claims: 19-32

An apparatus for trimming plants and a method for trimming plants with such apparatus.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2023/069082

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011034222 A1	10-02-2011	NONE	

EP 0613615 A1	07-09-1994	DE 69416434 T2	21-10-1999
		EP 0613615 A1	07-09-1994
		FR 2702122 A1	09-09-1994
