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(71) Demandeur/Applicant:  
ANHEUSER-BUSCH INBEV S.A., BE  
(72) Inventeurs/Inventors:  
DUPERRAY, PHILIPPE, FR;  
DEKOCKER, WIM, BE  
(74) Agent: MARKS & CLERK

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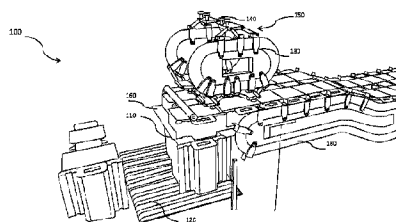


Fig. 1

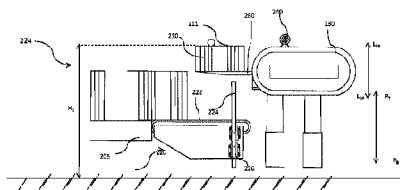


Fig. 3a

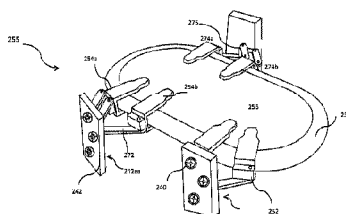


Fig. 4a

(57) **Abrégé/Abstract:**

The present invention provides a denesting apparatus (100, 200), the apparatus comprising: - one or more closed loop conveying tracks (130, 230), each closed loop conveying track comprising a plurality of sets of one or more de-stacking means (140, 240) movingly configured thereon through one or more de-stacking means moving mechanism (150, 250); - one or more stacking magazines (120, 220), each adapted to hold a stack of sheets (110, 210) supported thereon; wherein each of the plurality of sets of de-stacking means is adapted to selectively engage an uppermost sheet from at least one of the stacking magazines in any desired order either sequentially and/or simultaneously so as to discharge the picked-up sheets onto an out-feed conveyor (180, 280) in any desired manner either one besides another or otherwise one overlapping the other.

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(71) Applicant: **ANHEUSER-BUSCH INBEV S.A.** [BE/BE];  
Grand'Place 1, 1000 Brussels (BE).

(72) Inventors: **DUPERRAY, Philippe**; 42 Rue de l'Indre,  
3600 Châteauroux (FR). **DEKOCKER, Wim**; Brouwerij-  
plein 1, 3000 Leuven (BE).

(74) Agent: **BIIP CVBA**; Lambroekstraat 5A, 1831 Diegem  
(BE).

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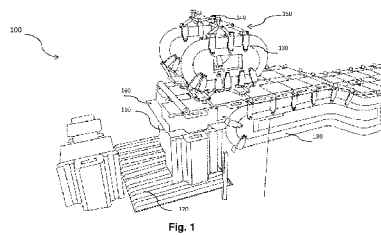


Fig. 1

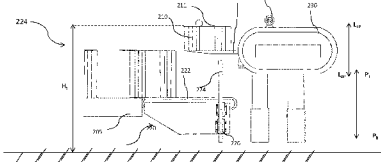


Fig. 3c

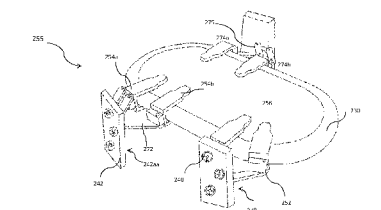


Fig. 4a

(57) Abstract: The present invention provides a denesting apparatus (100, 200), the apparatus comprising: • - one or more closed loop conveying tracks (130, 230), each closed loop conveying track comprising a plurality of sets of one or more de-stacking means (140, 240) movably configured thereon through one or more de-stacking means moving mechanism (150, 250); • - one or more stacking magazines (120, 220), each adapted to hold a stack of sheets (110, 210) supported thereon; wherein each of the plurality of sets of de-stacking means is adapted to selectively engage an uppermost sheet from at least one of the stacking magazines in any desired order either sequentially and/or simultaneously so as to discharge the picked-up sheets onto an out-feed conveyor (180, 280) in any desired manner either one besides another or otherwise one overlapping the other.



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## **Denesting Apparatus**

### **TECHNICAL FIELD**

5        [001]        The present invention relates generally to a denesting apparatus for denesting one or more stacks of sheets.

### **BACKGROUND**

10        [002]        In the recent years, there has been a many-fold increase in the trend of grouping large number of items such as food items, including liquid foods, home essentials, stationary items, beverage containers, and the like, in the form of secondary packages, for various purposes such as to enable bulk selling, easy transportation, handling, and the like.

15        [003]        Recently there has been a considerable increase in use of cardboard based packaging for holding liquid foods and beverages which resulted in an increase in the manufacture of cardboard packaging or cartons in a variety of shapes and sizes.

20        [004]        Cardboard based packaging is generally formed of foldable blank or sheets, received generally in one or more stacks and therefore, during the packaging manufacturing process, it is required to sequentially and individually de-stack or unstack these blanks or sheets from the stacks thereof which are then fed on to a packing process for formation of various kinds of packaging.

25        [005]        Conventionally, the step of de-stacking these blanks or sheets has been performed by utilizing various kind of pickers such as for example, manipulators, which may also take the form of robots and/or robotic arms, adapted to pick up a top sheet from the stack intermittently. Unfortunately, such pickers are often not cost-efficient and have a high turn-around time and therefore do not reconcile well at instances where a continuous in-feed of these sheets at a high speed is required.

30        [006]        Accordingly, numerous efforts have been imparted to produce tools that de-stack sheets from the stacks individually, sequentially and at a high speed. Examples include various mechanical assemblies including so called fingers and/or grippers adapted to lift and/or pull away either the uppermost or lowermost sheet from the stack. However, these fingers and grippers based

pulling mechanisms were generally adapted to pull either a fixed size sheet or at least having similar shape and/or size convenient to be handled by such fingers or grippers. Additionally, such devices may result in high rates of rejection since the sliding contact of these pulling devices frequently damages the sheets.

**[007]** While it is usually desirable to provide a system which de-stacks sheets of material as quickly as possible, it is also important that the same de-stacking apparatus may be utilized for a variety of shapes and sizes of sheets. To overcome the problems of mechanical assemblies, various kind of air-nozzle based de-stacking mechanisms were introduced.

**[008]** For example, WO2008015347 discloses the use of a retractable blower member disposed generally perpendicularly to a stack of sheets so as to blow a jet of air onto the flat items thereby removing the top sheet from the stack thereof.

**[009]** Similarly, US20110229297 discloses a denesting apparatus having a product carrier plate including a pair of air nozzle assemblies operable to separate a tray from the stack of trays and force the tray against the product carrier plate such that movement of the product carrier plate can selectively discharge the separated tray.

**[0010]** However, these air nozzle-based side blowing mechanisms are generally not effective in un-stacking sheets having different thickness. Further, in most instances, these de-stacking mechanisms uncontrollably dislodged more than one sheet, which is not acceptable particularly in an automated system.

**[0011]** Therefore, various other solutions were tried out to denest the top sheet from stacks thereof. Recently, the trend has been shifting towards use of a variety of suction mechanisms for performing the denesting operation. These mechanisms generally utilize suction mechanisms either singly or in conjunction with air nozzles.

**[0012]** For example, EP1541508 discloses a device for the de-stacking of flat objects laid on a stack. The device has a suction device located above the stack support, and a pushing away device with pushing components. The suction device and pushing away device are located at a fixed distance above the stack support, and the pushing components on their end face facing the

stack support during the pushing away of an object from the suction head of the suction device have a stop for the next object lifted from the stack by the suction head. US 3,401,831 discloses a denester which, in addition to the suction grippers, includes nozzles which blow pressurized air between the outermost tray and the tray immediately succeeding it, in order to facilitate their separation. Such suction mechanism utilizes suction heads/nozzles which further requires vacuum hoists/supply to create negative air pressure for suction. Therefore, these arrangements are often overly complex in design, and were also undesirably slow in their operation.

**[0013]** Recently, various kind of de-stacking means or cups-based mechanisms have been utilized due to their simple structure and designs. For example, as disclosed in US5,254,071, these mechanisms generally include a drive mechanism with a vacuum cup which is alternatively brought close, put into contact then moved away from the stack of sheets. The vacuum cup is laid against the top sheet of the stack and then carries away the top sheet to bring it away from the stack before laying it down on another work area, for example, on a packaging line conveyor.

**[0014]** In some other variations, de-stacking means were utilized to pick the sheet/tray from bottom as described in US20140056684 which discloses a tray denesting apparatus presenting stacks of trays placed upside down within a storage area to a picker mechanism and separating single trays from the stack of trays. A de-stacking means is used to remove individual trays from the tray stack. After picking up the individual tray, a driven rotary device inverts the tray and places the tray onto a tray conveyor located beneath the denesting apparatus.

**[0015]** However, all such packaging apparatuses have certain shortcomings as well. Firstly, these de-stacking means based mechanisms utilize drive mechanisms adapted to pick up and denest the sheets in accordance to a predetermined distance setting from a predetermined stack. Such system is, however, not designed for cases where a same packaging is a combination of different kind of sheets, such as e.g. a package blank combined with a partition blank.

**[0016]** Accordingly, as can be understood from the foregoing discussion, none of the existing solutions completely provides flexibility of varying the de-

stacking operation in accordance to varying requirements of multiple stacks simultaneously while preventing suspending the operation. Thus, in the context of the above, it is desirable to provide a denesting device that overcomes these problems associated with the prior art, is affordable, and allows to carry out de-stacking of multiple stacks of different packaging material blanks or sheets of varying configurations, size, shape, material and caliper in the desired manner, without requiring to change functional elements thereof.

## **SUMMARY**

**[0017]** In one aspect of the invention, a denesting apparatus for denesting sheets of foldable blanks from one or more stacks thereof is provided. The denesting tool includes one or more closed loop conveying tracks comprising a plurality of sets of de-stacking means movingly configured thereon through a de-stacking means moving mechanism. The denesting apparatus further includes one or more stacking magazines each adapted to hold one or more stacks of sheets to be denested. In operation, each of the plurality of sets of de-stacking means is adapted to selectively engage an uppermost sheet from at least one of the stacking magazines and discharge it onto an out-feed conveyor. The picking up of the sheets from the one or more stacks may be performed in various desired order either sequentially or otherwise simultaneously so as to discharge the picked-up sheets in any desired manner either one besides another or in an overlapping manner i.e. one over the other.

**[0018]** Generally, the de-stacking means of attachment to the packaging material sheet or blank, may be a conventionally known suction cup and/or vacuum cup having a generally bell-shaped structure and formed of a generally soft material such as a rubber, silicon, and the like, that is impenetrable by air, or may be any of a number or means of temporarily attaching (holding on to) an article including methods of pin, clamping, magnetic, static electric, Van Der Waals force, Bernoulli contactless suction, to name a few.

**[0019]** Optionally, the de-stacking means moving mechanism includes a plurality of de-stacking lugs, each adapted to movingly engage one of the sets of one or more de-stacking means through an engagement means.

**[0020]** Further optionally, each of the de-stacking lugs is movingly configured onto one of the closed loop conveying tracks through one or more de-stacking movers movingly configured thereon.

**[0021]** In a specific embodiment, the denesting apparatus comprises one, or two or more, generally parallel closed loop conveying tracks which are horizontally adjustable in pitch and in absolute position relative to the machine datum and wherein the de-stacking means moving mechanism includes a plurality of de-stacking lugs movingly configured onto the parallel closed loop conveying tracks through one or more de-stacking movers movingly configured thereon and wherein the de-stacking movers on the parallel closed loop conveying tracks are independently controlled to achieve controlled elevation or loweration whilst in translation of the picked-up sheet.

**[0022]** Possibly, the engagement means may be any conventionally known mechanism suitable for supporting one or more de-stacking means onto the de-stacking lugs and is selected from one or more of, but not limited to, a supporting plate. Alternatively, the engagement means includes an articulating engagement assembly to movingly engage one of the sets of one or more de-stacking means onto the one or more de-stacking lugs, and adapted to provide generally a perpendicular and/or transversal movement along with a longitudinal movement, enabling a picking up a sheet from one of the stacking magazines.

**[0023]** Possibly, the articulating engagement assembly includes an articulated bracket having a first end connected to a first de-stacking mover through a first de-stacking lug, a second open end connected to a second de-stacking mover through a second de-stacking lug and a pivotally movable center end connected to a supporting plate having one or more de-stacking means configured thereon, such that a longitudinal movement of the de-stacking movers towards and/or away from each other enables a generally perpendicular movement to the supporting plate and in turn to the one or more de-stacking means so as to pick up a sheet positioned at a distance thereto. So by changing the relative distance between the first and second de-

stacking movers, the position of the de-stacking means relative to the uppermost sheet to be picked-up (ie so-called picking plane) may be adjusted.

**[0024]** In another embodiment, possibly, the articulating engagement assembly includes an articulated bracket having a first end connected to a first de-stacking mover through a first de-stacking lug, a second end connected to a second de-stacking mover through a second de-stacking lug and third end connected to a third de-stacking mover through a third de-stacking lug and a pivotally movable center end connected to a supporting plate having one or more de-stacking means configured thereon, such that a longitudinal movement of the de-stacking movers towards and/or away from each other enables a generally perpendicular movement to the supporting plate and also control of the angle of approach, contact and translation of the supporting plat and picking means with the picking plane of the destacking mechanism, so as with the additional degree of freedom to optimize the contact, attach and accelerate away with the packaging material blank there so picked.

**[0025]** Further possibly the supporting plate is a generally horizontally rotatable plate facilitating rotation of the sheet picked up by the one or more de-stacking means.

**[0026]** In an embodiment of the present invention, the de-stacking means movement mechanism may be adapted for moving the de-stacking means horizontally upon picking the uppermost sheet before lifting it. The horizontal movement before liftingtending to fly the sheet off the following and tending to establish an air gap thus enhancing the separation of the sheets.

**[0027]** In a particular embodiment in accordance with the present invention, the denesting apparatus may further comprise a means for forcing the underside of a picked-up sheet against a means for applying friction in reverse direction relative to conveying direction onto the underside of the uppermost sheet. The means for forcing may be an air blower blowing on the top side of the picked sheet that the underside of the sheet is cause to bear up against a means for applying friction such as a reverse spinning wheel or belt. By forcing the underside of the picked sheet against a means for applying reverse acting friction, any tendency

for one or more sheets to follow the picked-up sheet is counter-acted such that any duplicated sheets are pushed back into the enclosure of the magazine.

5       **[0028]** In another embodiment, the denesting apparatus comprises two of said closed loop conveying tracks in parallel and a movement mechanism for varying the distance between said two parallel tracks and their position relative to the datum of the machine, thereby enabling to pick sheets of various size and enabling where on the different sized and shaped sheet to attach during the picking operation.

10       **[0029]** Optionally, the one or more stacking magazine is a vertically movable supporting rack adapted to move between a top position  $P_T$  and a bottom position  $P_B$  using a vertical movement mechanism.

15       **[0030]** Further optionally, the vertical movement comprising a vertical rail comprising one or more stacking movers movingly configured thereon and each of the stacking movers engaging the supporting rack using a connecting member such that the stacking member is movable between the top position  $P_T$  and the bottom position  $P_B$  through the stacking movers.

20       **[0031]** Alternatively, the vertical movement mechanism may be any suitable movement mechanism.

25       **[0032]** Possibly, the top position  $P_T$  of the stacking magazine is positioned at a height  $H_T$  away from a base platform, corresponding to the base position  $P_B$ , such that a top sheet of the stack is positioned at a height  $H_S$  suitable to be picked up by at least one of set of the de-stacking means.

30       **[0033]** Generally, the denesting apparatus further includes a retractable lifting means positioned over the one or more stacking magazine and adapted to support at least a sub-stack of sheets such that the top sheet of the corresponding sub-stack is positioned at the height  $H_S$  suitable to be picked up by at least one of the de-stacking means.

35       **[0034]** Further, the retractable lifting means is adapted to be vertically movable such that after removal of the top sheet, the next top sheet is always positioned at the height  $H_S$  suitable to be picked up by the one or more de-stacking means.

[0035] Furthermore, the retractable lifting means is configured to retract back and move back to its base position, once each of the sheets supported thereon is picked up by the one or more de-stacking means.

5 [0036] Additionally, the retractable lifting means is further configured to open and pick up another sub-stack of the sheets at its base position.

[0037] Possibly, the apparatus further includes an infeed conveying line connected to the one or more stacks such that as soon as an empty magazine is received at its bottom position, it gets replenished with new stack of sheets.

10 [0038] Optionally, the stacking magazine may be a horizontally moving conveyor.

[0039] Optionally, the one or more closed loop conveying tracks, the lifting plate, and the one or more stacking magazines are adapted to move at a predetermined pitch so as to denest the stacks of the one or more sheets onto the out-feed conveyor continuously.

15 [0040] Alternatively, the one or more closed loop conveying tracks, the lifting plate, and the one or more stacking magazines are adapted to move intermittently at a variable pitch as required, so as to denest the stacks of the one or more sheets onto the out-feed conveyor intermittently.

20 [0041] Preferably, the vertical movement of the stacking magazine is configured in such a way that when the lifting plate is in its retracted position, the stacking magazine is in its top position such that the top sheet is positioned at the height  $H_s$  suitable to be picked up by the one or more de-stacking means.

25 [0042] Optionally, the denesting apparatus includes a first powering means enabling a movement of each of the one or more closed loop conveying tracks, the infeed conveyor, the retractable lifting means, the stacking magazine and the out-feed conveyor.

30 [0043] Further optionally, the first powering means may be selected from one or more of but not limited to various conventionally known linear motors, asynchronous motors, machines, servo drives, and the like conventionally known in the art.

[0044] Possibly, each of the plurality of movers on the closed loop conveying tracks is individually powered by a second powering means,

preferably a linear motor, utilizing each of the movers as a rotor thereof and the corresponding track as a stator thereof. Alternatively, any other type of driving means adapted to propel the movers in an independent and controlled way may be used.

5 **[0045]** Alternatively, the second powering means may be selected from one or more of, but not limited to, various conventionally known asynchronous motors, machines, servo drives, and the like, conventionally known in the art.

10 **[0046]** In addition, the de-stacking means and the de-stacking moving mechanism may be wirelessly powered, for example via sliding contacts on the de-stacking movers, and preferably contactless powered, for example by providing inductive power to the de-stacking movers. Further, the de-stacking means and its moving mechanism may be wirelessly controlled, including but not limited to short range wireless, such as Bluetooth, Infrared, Microwave, WLAN, narrow through broadband telecommunication and the like, preferably  
15 in combination with wirelessly powering. Wireless machine control and contactless power supplies enable highly flexible, large range, untethered movement and motion controlled operation of the recirculating de-stacking means to achieve efficient denesting operations.

20 **[0047]** Particularly, the sheet of foldable blank is formed of a material selected from one or more of, but not limited to paperboard, corrugated board, thermoplastic, hybrid material, laminated board and the like.

25 **[0048]** Possibly, the denesting apparatus further comprises a control unit for optimizing the movement of the one or more closed loop conveying tracks, the one or more de-stacking means, the one or more stacking magazines, the retractable lifting means, and the incoming conveying line.

**[0049]** Further possibly, the control unit includes one or more sensors, one or more input units, a processor unit and an output unit.

30 **[0050]** In a particular embodiment, the apparatus may comprise one or more sensors enabling real-time, inline measurement of the distance between the de-stacking means and the uppermost sheet of a magazine to be picked up and a control unit to dynamically control and adjust the position and reach of the de-stacking means for optimum performances.

**[0051]** In further particular embodiment in accordance with the present invention, the denesting apparatus may comprise two closed loop conveying

tracks, and one or more sensors may measure the position of the picked-up sheet, preferably of its leading edges, while moving it onto the out-feed conveyor, and a control unit may control and adjust the position of the de-stacking movers of the respective closed loop conveying tracks relative to each other to correct any angular and/or translational mis-alignment of the picked-up sheet.

**[0052]** The denesting apparatus may comprise two one or more sensors enabling real-time, inline measurement of the angular and position alignment of any picked sheet or packaging material blank and a control units to dynamically adjust the relative positions of the mover mounted denesting mechanisms opposite each other between the generally parallel closed loop tracks, or controlled rotation of the denesting mechanism, to dynamically correct any angular or translational error.

**[0053]** Further, de denesting apparatus may comprise one or more sensors enabling real-time, inline detection of a double or more sheet pick and the activation of means of pressing the picked sheet against the said reverse acting friction device to counter the multi-sheet pick and return the excess to the stacking magazine. The sensor would also enable detection of any no-pick, invoking appropriate remedial action within the overall product loading functions of the machine.

**[0054]** In yet another aspect of the invention, a method of denesting one or more stacks of sheets, each supported onto a corresponding stacking magazine, using the denesting apparatus of the present invention, is provided. The method includes receiving one or more stacks of sheets of a predetermined material. The method further includes picking up a top sheet from the one or more stacks in a predetermined manner either sequentially or otherwise simultaneously. The method further includes placing the picked-up sheet onto the out-feed conveyor in any desired manner, either one besides the other or otherwise one over the other.

**[0055]** Optionally, the method includes rotating the picked-up sheet before placing it onto the out-feed conveyor.

**[0056]** Optionally, the method includes forming, folding, stretching or otherwise shaping the picked-up sheet before placing it onto the out-feed

conveyor or, merging or assembling it with another packaging material already picked within the Denesting System.

[0057] Optionally, the step of picking up the one or more sheets from the one or more stack includes the step of contacting at least the one or more de-stacking means, with one of the stacks such that the top sheet of the stack is picked up by the corresponding de-stacking means.

[0058] Optionally, the method includes picking one sheet at a time sequentially.

[0059] Alternatively, the method includes picking more than one sheet at a time simultaneously.

[0060] Further alternatively, the method includes dropping the simultaneously picked up sheet either simultaneously one besides other or otherwise sequentially one over the other.

[0061] Possibly, the method includes moving the each of the one or more or more pair of de-stacking lugs together in a predetermined sequence of vertical movement and/or transversal movement and/or longitudinal movement, so as to position the corresponding de-stacking means in contact with the top sheet of the desired stack of sheet.

[0062] Further possibly, the pushing sequence is determined by the control unit on the basis of an input from a user and/or input from one or more sensors.

[0063] Other aspects, features and advantages of the subject matter disclosed herein will be apparent from the description, the drawings, and the claims.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

[0064] FIG. 1 illustrates a schematic diagram representing a denesting apparatus, in accordance with a preferred embodiment of the present invention;

[0065] FIG. 2 illustrates a schematic diagram representing another exemplary denesting apparatus, in accordance with another preferred embodiment of the present invention;

[0066] FIGS. 3a, 3b, 3c, 3d illustrate a front view diagram representing the exemplary denesting apparatus at different steps, in accordance with a preferred embodiment of the present invention;

5 [0067] FIG. 4a illustrates a perspective view diagram representing an exemplary engaging means, in accordance with the preferred embodiment of the present invention;

[0068] FIG. 4b illustrates a perspective view diagram representing another exemplary engaging means, in accordance with another embodiment of the present invention;

10 **DETAILED DESCRIPTION**

[0069] The present application discloses a denesting apparatus, for picking up sheets individually from one or more stacks in any desired order and discharging them onto an out-feed conveyor in any desired manner. The denesting apparatus while being efficient, is able to de-stack sheets from multiple stacks having sheets of different shapes, sizes, material and caliper (thickness) without requiring any changes in the functional elements thereof. Further, the sheets may be picked up either simultaneously or otherwise sequentially and may be dynamically discharged in a synchronized manner, on to an out-feed conveyor, with the sheets placed either one besides another or otherwise one over another, either continuously or otherwise intermittently and in varying configurations, speeds, and the like, without making any physical change within the apparatus.

25 [0070] As illustrated in FIG. 1, the present invention provides a denesting apparatus **100** for de-stacking one or more stacks of sheets **110** individually and delivering them in a synchronized fashion onto attachment means (not shown) of an out-feed conveyor **180**.

[0071] The denesting apparatus **100** includes one or more overhead closed loop conveying tracks **130** comprising a plurality of sets of de-stacking means **140** movingly configured thereon, through a de-stacking means moving

mechanism **150**. The denesting apparatus **100** further includes one or more stacking magazines **120**, each adapted to support one of the one or more stacks of sheets **110**. Further, each of the stacking magazines **120** is connected to an incoming conveying line (not shown) carrying a supply of stacks of sheets **110**. The denesting apparatus **100** furthermore includes a retractable lifting mechanism **160** adapted to support at least a sub-stack of the stack of sheets **110** such that a top sheet is positioned at a height suitable to be picked up by at least one of the sets of de-stacking means **140**. In operation, the one or more stacks of sheets **110** are first positioned onto the one or more stacking magazines **120**. Thereafter, one or more sets of the de-stacking means **140** is movingly positioned towards the one of the one or more stacks **110** such that the top sheet from at least one of the stacking magazines **120** is picked up in any desired order, and discharged towards the out-feed conveyor **180** in any desired manner.

**[0072]** In description of the FIGS. 2 that follow, elements common to the schematic system will have the same number designation unless otherwise noted. In a first preferred embodiment, as illustrated in Fig. 2, an exemplary denesting apparatus **200** having a single closed loop conveying track **230** for denesting one or more stacks of sheets **210**, including a first stack **210a** positioned onto a first stacking magazine **220a**, and a second stack **210b** positioned onto a second stacking magazine **220b**, onto an out-feed conveyor **280**.

**[0073]** The closed loop conveying track **230** includes a plurality of sets of one or more de-stacking means **240** movingly configured thereon through a de-stacking means moving mechanism **250**. The de-stacking means moving mechanism **250** includes a plurality of de-stacking lugs **252** (Figs 5A, 5b), each movingly configured onto the closed loop conveying track **230** through a de-stacking mover **254** (Figs 4A, 4b). Further, each of the de-stacking lugs **252** is adapted to engage to at least one of the sets of de-stacking means **240** through an engagement means **255** (Fig. 4a). In a preferred embodiment of the present invention, the engaging means **255** includes an articulating engagement assembly **270** to movingly engage

one of the sets of one or more de-stacking means **240** onto one or more de-stacking lugs **252**. In such an embodiment, each set of the one or more de-stacking means **240** is positioned onto a supporting plate **242**, having a first side **242a** connected to a pair of de-stacking movers **254a**, **254b**, pivotally and movably attached to each other through one or more articulated mounting brackets **272**. The articulated bracket **272** is a conventionally known mounting bracket and includes a first attachment bracket **274** connected to a second attachment bracket **276** at their distal ends at a connection point **C** such that the articulated bracket has three open ends, i.e. a first open end **274a** at a proximal end of the first attachment bracket **274**, a second open end **276a** at the proximal end of the second attachment bracket **276** and a pivotally movable center end **275** at the connection point **C**.

**[0074]** Further, as illustrated in Fig. 4a, the articulated movement assembly **270** includes a first de-stacking mover **254a** connected to a second de-stacking mover **254b** through the articulated mounting brackets **272**, each of the movers **254a**, **254b** connected at one of the open ends **274a**, **274b** of the articulated bracket **272**, such that the articulated bracket **272** is pivotally movable in a generally perpendicular plane to the track throughout the longitudinal range of motion of the first mover **254a** and the second movers **254b**, towards and/or away from each other. The articulated assembly **270** is connected to the first side **242a** of the supporting plate **242** at the pivotally movable center end **275** thereof.

**[0075]** In a collapsed position, where the articulated mounting bracket **272** is closed, such that each of the pair of pivotally connected de-stacking movers **254a**, **254b** are oriented in a substantially coinciding position, the supporting plate **242** is at its initial position. In an opened position, where the articulated mounting bracket **272** opens up pivotally, the pair of the movers **254a**, **254b** may be moved towards or away from each other such that the corresponding supporting plate **242** is moved perpendicular to the track which the movers traverse along, i.e. upward or pivotally towards or away from corresponding de-stacking lugs **252a**, **252b**.

[0076] One skilled in the art will recognize that the articulated movement assembly **270** having the pair of movers **254a**, **254b** is pivotally connected for longitudinal movement in a generally horizontal plane in a conventional manner. The articulated movement assembly **270** is movingly supported on to the closed loop conveying track **230** such that a horizontal longitudinal movement of the movers **254a**, **254b** towards and away from each other is possible. Such a movement of the pair of movers **254a**, **254b** provides operative power for enabling the movement of the mounting bracket **272** between its collapsed position and its open position, thereby enabling a range of vertically upward and pivotal extensions along with a longitudinal movement of the shaping supporting plate **242** onto the closed loop conveying track **230**.

[0077] Therefore, by appropriate manipulation of the first mover **254a** and the second mover **254b** and therefore the articulated assembly **270**, the supporting plate **242** and the corresponding set of de-stacking means **240** may be positioned at any desired distance away from the de-stacking lugs **252**, while moving in an operative orientation generally in a vertical and/or transversal and/or horizontal direction.

[0078] In yet other embodiments, the engagement means **255** may be any conventionally known mechanism suitable for supporting the set of one or more de-stacking means **240** onto the de-stacking lugs **252** and is selected from one or more of but not limited to a supporting plate as illustrated in Fig. 4b

[0079] In a modification of the first embodiment, as illustrated in FIG. 2, the denesting apparatus **200** includes multiple and preferably a pair of overhead closed loop conveying tracks **230** namely **230a**, **230b** for denesting one or more stacks **210** including a first stack **210a** positioned onto a first stacking magazine **220a**, and a second stack **210b** positioned onto a second stacking magazine **220b**.

[0080] In such an embodiment, the individual movement of the sets of de-stacking means **240** of each of the tracks **230a**, **230b** may be utilized to speed

up the process by utilizing either as a dedicated track **230** for predetermined stacks **210** or otherwise in situations where there is a need of simultaneously pick up and drop down of the sheets within stacks **210** onto the out-feed conveyor **280**. In yet other embodiments, de-stacking means **240** of both the tracks may be adapted to sequentially or simultaneously pick up the top sheet from the same stack **210**. In yet other embodiments, the sets of de-stacking means of the pair of tracks **230a**, **230b** may be utilized in any possible manner so as to de-stack one or more, stacks **210**, onto the out-feed conveyor **280**.

**[0081]** This embodiment is particularly advantageous due to the fact that it provides multiple closed loop conveying tracks **230** and therefore the de-stacking means **240** each powered by a single light weight powering means for managing the operation of the denesting apparatus **200** and therefore is considered as a further efficient way to implement various embodiments of the present invention.

**[0082]** FIGS. 2 schematically show the arrangement of the basic components of the denesting apparatus **200** of the present invention. However, in the construction of commercial functional units, secondary components such as couplers, connectors, support structures and other functional components known to one of skill in the field of denesting apparatuses and more particularly the denesting of foldable blanks for use with conveyor systems, may be incorporated within the denesting apparatus **200**. Such commercial arrangements are included in the present invention as long as the structural components and arrangements disclosed herein are present. Accordingly, it is to be contemplated that the denesting apparatus **200** may be configured to be used for any kind of foldable blank of any possible shapes as deems possible without deviating from the scope of the current invention.

**[0083]** In a preferred embodiment, the one or more stacks of sheets **210** may be formed of a plurality of sheets in the form of foldable blanks, each adapted to form a primary or secondary package and/or a component thereof. For example, and as illustrated in Fig 2, the first stack **210a** positioned onto the first stacking magazine **220a** may be stack of plurality

of blanks each adapted to form a box shaped secondary package. Further, the second stack **210b** positioned onto the second stacking magazine **220b** may be a stack of plurality of partition sheets, each adapted to form a partition for the box shaped secondary package. However, in other  
 5 embodiments, the stack of sheets **210**, may include any number of stacks of sheets, adapted to form any kind of output product, to be denested using the apparatus **200** of the present invention. Each of the stacking magazines **220a**, **220b** is connected to an incoming conveying line **205** each carrying a supply of stack of sheets **220a**, **220b** respectively.

10 **[0084]** In an embodiment and referring to Figs 3a-3d, the stacking magazines **220** are generally vertically movable storage racks **222** adapted to move between a top position **P<sub>T</sub>** and a bottom position **P<sub>B</sub>** through a vertical movement mechanism **224**. The top position **P<sub>T</sub>** is positioned at a height **H<sub>T</sub>** away from a base platform corresponding to the  
 15 base position **P<sub>B</sub>**, such that the top sheet of the stack **210** is positioned at a height **H<sub>S</sub>** suitable to be picked up by at least one set of the de-stacking means **240**.

**[0085]** Further in such embodiments, in preferred instances, as illustrated in Fig. 3, the vertical movement mechanism **224** includes a vertical rail (not  
 20 shown) positioned besides the storage rack **222** having one or more stacking movers **226** movingly configured thereon, and adapted to engage the storage rack **222** using a connecting member (not shown) such that the storage rack **222** is movable between its top position **P<sub>T</sub>** and the bottom position **P<sub>B</sub>** through the stacking movers **226**.

25 **[0086]** However, in other instances, the vertical movement mechanism **224** may be any suitable movement mechanism.

**[0087]** The denesting apparatus **200** further includes a retractable lifting means **260**, illustrated in Figs 3a-3d positioned over each of the one or more stacking magazines **220** and adapted to support at least a sub-stack  
 30 of the sheets, such that the top sheet is positioned at the height **H<sub>S</sub>** suitable

to be picked up at least by one set of the de-stacking means **240** of the one or more closed loop conveying tracks **230**.

**[0088]** In an embodiment, the retractable lifting means **260** is generally a flat lifting plate and is moveable vertically between a base position **L<sub>BP</sub>** and a top position **L<sub>TP</sub>** thereof, such that at any moment the top sheet is made to be positioned at the **H<sub>S</sub>** suitable to be picked up by at least one set of the de-stacking means **240**. Further, the retractable means **260** is movable between an open position **P<sub>O</sub>** and a retracted position **P<sub>R</sub>** (not shown). Such lifting plate may alternatively also consist of a plurality of forks that may move away or towards each other

**[0089]** In some instances, as illustrated in Fig. 3a, the base position **L<sub>BP</sub>** of the retractable lifting means **260** is generally same as the top position **P<sub>T</sub>** of the storage rack **222** of the stacking magazine **220** such that when moved to open position **P<sub>O</sub>** from the retracted position **P<sub>R</sub>**, the retractable lifting means **260** supports the entire stack **210** thereon. Further, in such instances, the lifting means **260** moves vertically with removal of each top sheet to a distance same as a thickness of the sheet such that the top sheet is always positioned at the height **H<sub>S</sub>**. The top position **L<sub>TP</sub>** of the lifting means **260** is such that a bottommost sheet **215** (Fig. 3d) of the stack **210** is positioned as the top sheet. Once the stack **210** has been completely denested, lifting means **260** is adapted to retract back to the retracted position **P<sub>R</sub>** and vertically move down to the base position **L<sub>BP</sub>**.

**[0090]** The out-feed conveyor **280** is generally an outgoing conveyor positioned substantially below the one or more closed loop conveying track **230** at a height **H<sub>C</sub>** from the base platform, substantially similar to the height **H<sub>T</sub>** of the top sheet such that the already pick up top sheet may be suitably dragged and/or dropped onto the out-feed conveyor **280** for further processing.

**[0091]** The denesting apparatus **200** further includes a first powering means (not shown) for enabling a movement of the one or more closed loop conveying tracks **230**, the in-feed conveyor **205**, each of the one or

more stacking magazines **220**, the retractable lifting mechanism **260**, the out-feed conveyor **280** and various sub-components thereof. In a preferred embodiment, the first powering means is a linear servo motor adapted to move each of the one or more closed loop conveying tracks **230**, the in-feed conveyor **205**, each of the one or more stacking magazines **220**, the retractable lifting mechanism **260**, the out-feed conveyor **280** at a first predetermined pitch facilitating a continuous operation of each of the components of the denesting apparatus **200** such that the incoming supply of the stacks of sheets **210** is continuously denested and transferred onto the out-feed conveyor **280** in any desired order and in any desired manner. However, in other embodiments, the first powering means is a linear servo motor adapted to move each of the one or more closed loop conveying tracks **230**, the in-feed conveyor **205**, each of the one or more stacking magazines **220**, the retractable lifting mechanism **260**, the out-feed conveyor **280** at a dynamically adjustable variable pitch facilitating an intermittent operation of each of the components of the denesting apparatus **200** such that the incoming supply of the stacks **210** of the sheets is denested and transferred onto the out-feed conveyor **280**, intermittently and when desired.

**[0092]** The denesting apparatus **200** further includes a second powering means (not shown) for enabling controlled independent movement of each of the movers including the de-stacking movers **254**, and optionally the stacking movers **226** along the corresponding tracks and/or rails. In a preferred embodiment, the first powering means is linear servo motor or equivalent thereof providing independent motion control of each mover. In such an embodiment, the linear motor is a generally moving magnet type of motor conventionally known in the art. Further in such embodiments, the linear motor utilizes the corresponding tracks and/or rails as a stator and each of the movers as a rotor thereof.

**[0093]** In other embodiments, the movers **254**, **226** are utilized as stator whereas the tracks or rails are utilized as the rotors. In such an embodiment, each of the movers **254**, **226** may include built in coils and

each of the corresponding tracks or rails may include magnets configured thereon in a longitudinal direction such that the movers are able to come into an electromagnetic interaction, thereby enabling a movement thereof.

5       **[0094]**     The denesting apparatus **200** may further include one or more control units (not shown) for managing the operations thereof, and particularly for managing the working of the first powering means and/or the second powering means and more particularly the movement of the de-stacking movers **254a and b**, so as to optimize the sequence of the longitudinal and/or vertical and/or transversal movement of the supporting  
10       plate **242**, and therefore the one or more support pads **240**, in a predetermined sequence. The predetermined sequence is particularly required to be evaluated in the instances where a specific predetermined order has to be followed for picking up the top sheets **211**, from the one or more stacks **210**.

15       **[0095]**     In some embodiments, the control unit may include an input unit for receiving inputs related to the predetermined order of denesting the stacks **210** and the desired manner of discharge of the already picked up top sheets **211**, onto the out-feed conveyor **280**. Further, the control unit may include a plurality of sensors (not shown) for tracking the parameters such  
20       as for example, position, width and/or height of the of the sheets or blanks to be discharged, sheet or blank mis-alignment, for sensing when the one or more stacks **210** is empty, for sensing if the lifting means reached its top position, and the like. The control unit may further include a processor unit for processing the data captured by the input unit on the basis of  
25       predetermined logics / rules for facilitating the movement of the plurality of movers **254, 226**, the vertical movement of the stacking magazine **220**, and the retractable lifting mechanism **260**. The control unit may further include an instruction unit that delivers the instructions to various components such as various powering means, linear motors, motors,  
30       driving units, or the like, to facilitate a desired and smooth operation.

**[0096]** In some embodiments, the control unit may be provided as a computer program product, such as may include a computer-readable storage medium or a non-transitory machine-readable medium maintaining instructions interpretable by a computer or other electronic device, such as to perform one or more processes.

**[0097]** In some embodiments, each of the plurality of sheets of the stack **210** is generally formed from a recyclable material selected from one or more of but not limited to any desired material such as including all kind of papers, fiberboard, corrugated board, foldable blanks, hybrid material, laminated board or any combinations thereof. Further, the shape and size, including the thickness of the sheets or blanks, and surface finish, may be varied depending on the design constraints and requirements for its application. In some other embodiments, the sheets or blanks may be made of a light weight plastic material selected from one or more of, but not limited to, plastic material such as group of thermoplastics including acetal, acrylic, cellulose acetate, polyethylene, polystyrene, vinyl, and nylon. In yet other embodiments, the sheets or blanks may be made of any material suitable to be denested using the denesting apparatus **200**, of the present invention

**[0098]** In an embodiment, the one or more de-stacking means **240** is formed of a conventionally known suction cup and/or vacuum cup having a generally bell-shaped structure and formed of a generally soft material such as a rubber, silicon, and the like, that is impenetrable by air. As may be contemplated by a person skilled in art, such de-stacking means **240** has been vastly utilized for lifting an object by application of vacuum created there within, when applied with a force against a flat surface such as a sheet. The number, size, and dimension of such de-stacking means **240**, is determined on the basis of weight, dimensions, and material of the sheets or blanks to be picked up from the stack **210**. In some embodiments, where the sheet or blank is of a heavy material, the denesting apparatus **200** may further be provided with a supply of negative pressure, for example, in the form of a

vacuum creator, which may be utilized by de-stacking means **240** for picking such heavy sheets.

**[0099]** In a particular embodiment, variable suction force or vacuum at the point of application, at any location about the picking cycle may be applied for enabling faster cycle times. Further, control of the suction force or vacuum may avoid sheet material distortion and avoid the suction effect acting through porous materials and influencing optional other materials behind the porous primary material of the sheet.

**[00100]** In another embodiment, the air flow to the suction or vacuum cups may be reversed at discharging the sheet, thereby rapidly cancelling out the vacuum and applying a fast discharge force.

**[00101]** It is to be contemplated that while the number of stacks **210** has been mentioned as two in exemplary embodiments, the present invention may be utilized for any number of stacks without deviating from the scope of disclosure and depending upon the design constraints of the package to be formed. For example, in some instances, the one or more stacks **210** may include a first stack **210a** of foldable blank of carton, a second stack **210b** of a partition for the carton, a third stack **210c** holding sheet for forming a handle of the carton and so on. In other embodiments, the denesting apparatus **200** may be used to denest only a single stack **210**. In all such embodiments, the number of stacking magazines **220** remains equal to number of stacks **210** so as to individually support the stacks **210** thereon.

**[00102]** In a preferred embodiment of the present invention, each of the conveyors of the denesting apparatus **200** including the one or more closed loop conveying tracks **230**, the in-feed conveyor **205**, and the receiving conveyor **280** is generally a vertically positioned closed loop conveying track conventionally known in the art. In other embodiments, each of the conveyors of the denesting apparatus **200** including the one or more closed loop conveying tracks **230**, the in-feed conveyor **205**, and the out-feed conveyor **280** may be a generally horizontal positioned closed loop conveying track. In yet other embodiments of the present invention,

each of the conveyors of the denesting apparatus **200** including the one or more closed loop conveying tracks **230**, the in-feed conveyor **205**, and the receiving conveyor **280** may be configured as a virtual closed loop conveyor.

5     **[00103]** The virtual closed loop conveyor, as known in the art, is generally a closed loop conveyor similar to a circular conveyor, in which the circular connecting edges of the conveyors on both the ends are replaced by straight shiftable conveyor portions adapted to move back and forth and avoiding the need of moving the movers through the entire circumference  
10     of the closed loop conveying track, and is therefore a very fast alternative to the conventionally known closed loop conveying tracks. Further, the closed loop conveyor being made of longitudinal rails, is therefore much more cost efficient than any conventionally known closed loop conveying tracks and/or conveyors. Additionally, the back and forth movement may  
15     also be helpful in providing additional pressure while performing operations such as pushing operation is therefore further preferred.

**[00104]** While the stacking magazine **220** has been disclosed to be a generally vertically movable supporting rack **222**, in some embodiments, the stacking magazine **220** may be inclined to the vertical or otherwise a  
20     horizontal conveyor (not shown) adapted to receive a supply of stacks **210** of the sheets or blanks such that the top sheet of one of the stack **210** is positioned at a distance suitable to be picked up by the one or more de-stacking means **240**. Further, once the stack **210** is nearly exhausted, another stack **210** is positioned at the distance suitable to be picked up by  
25     the one or more de-stacking means **240** such that there is no interruption there between.

**[00105]** In use, as disclosed earlier, the denesting apparatus **200** is adapted to be positioned onto an input line of a package manufacturing unit provided with one or more stacks **210** of foldable blanks for forming  
30     generally box shaped secondary packages. The denesting apparatus **200** denests the foldable blanks from the one or more stacks **210** placed onto

the one or more stack magazines **220** in any predetermined order and places onto the out-feed conveyor **280** in any desired manner. Each of the stacks **210** is denested in a generally top to bottom manner, however, not restricted to any particular way of denesting and therefore it is contemplated that the denesting apparatus of the present invention may be utilize to perform denesting operation in any possible way without deviating from the scope of the present invention.

**[00106]** Fig. 5 with reference to Figs. 1 through 4, is a flow diagram illustrating a method **600** of de-stacking sheets or blanks from one or more stacks **210** thereof placed onto one or more stacking magazines **220**, either simultaneously, or otherwise sequentially in any desired manner, either one besides other or otherwise in an overlapping manner, using denesting apparatus **200** of the present invention.

**[00107]** The present invention relates to a denesting apparatus **200** for continuously and/or intermittently at a constant and/or variable speed, de-stacking sheets individually from one or more stacks in any desired order and discharging them onto an out-feed conveyor in any desired manner.

**[00108]** Additionally, the possibility of providing different kind of pushing sequence to the one or more sets of de-stacking means **240** allows picking up the top sheets **211** in any desired order and discharging in any desired manner. Such an optimized and focused picking up and dropping down the sheets in addition to a complete control of the speed, direction of the placement of the sheets, allows the possibility of using a same conveying line for discharging multiple sheets together while utilizing the width of the out-feed conveyor and avoiding misalignment and therefore, any damage to the sheets being discharged there through.

**[00109]** Particularly, the present invention is additional advantageous in providing an input line of packaging apparatus of different sub-parts of the packages, in accordance with the predetermined shape and configurations of the packages to be achieved.

**[00110]** Further, the denesting tool is adaptable to different dimensions of foldable blanks and is therefore well suitable to process packages of different

sizes and shapes with ease and efficiently and not requiring changing the entire apparatus for denesting sheets of different predetermined shapes and sizes.

5 [00111] Further, the present invention provides the possibility of manufacturing the conveyor system with integrally formed denester apparatus **200**. Such a conveyor system for forming secondary package, while being cost-efficient, is very quick and easy to use and offers comfortable handling of packages of any shape, size or any variety of configurations.

10 [00112] Additionally, since the denester apparatus of the present invention while being applicable onto the conveyor system, does not impact the rest of the conveying process. A single conveyor system may utilize as many as denesting apparatuses within the same arrangement. Further, in case of one denesting apparatus is not working, rest can keep working and therefore, the fault tolerance of the plant can be increased.

15 [00113] While the denesting apparatus **200** of present invention has been disclosed with reference to foldable blanks, it may be used to denest all currently known sheet types, e.g., constructed of materials such as thermoplastic, hybrid materials, woven metallic fabric that may include ferrous or nonferrous metals, etc., or any other suitable material. Even in instances  
20 where heavy sheets are to be picked up, the strength or number of de-stacking means **240** may be adapted in accordance without having to change the entire apparatus **200**.

25 [00114] Moreover, it is also contemplated for a person skilled in the art that the denesting apparatus **200** of the present invention may be implemented in various industries such as food industry, transport industry, house hold appliance industry in denesting of any kind of product or group of products, of any shape, size or any variety of configurations, without limiting it to the packaging industry.

**Claims**

1. A denesting apparatus, the apparatus comprising:

5           One or more closed loop conveying tracks, each closed loop conveying track comprising a plurality of sets of one or more de-stacking means movingly configured thereon through one or more de-stacking means moving mechanism;

10           one or more stacking magazines, each adapted to hold a stack of sheets supported thereon;

wherein each of the plurality of sets of de-stacking means is adapted to selectively engage an uppermost sheet from at least one of the one or more stacking  
15           magazines in any desired order either sequentially or simultaneously so as to discharge the picked-up sheets onto an out-feed conveyor in any desired manner either one besides another or otherwise one overlapping the other.

2. The apparatus of claim 1, wherein the de-stacking means are selectively  
20           engaged by an engagement means having an articulating engagement mechanism.

3. The apparatus of claim 2, wherein the articulating engagement mechanism comprises:

25           - a supporting plate adapted to fixedly support one or more de-stacking means thereupon;  
              - a pivotally movable mounting bracket having a first open end connected to a first articulated mover, a second open end connected to a second articulated mover and a pivotally movable central end connected to the supporting plate;

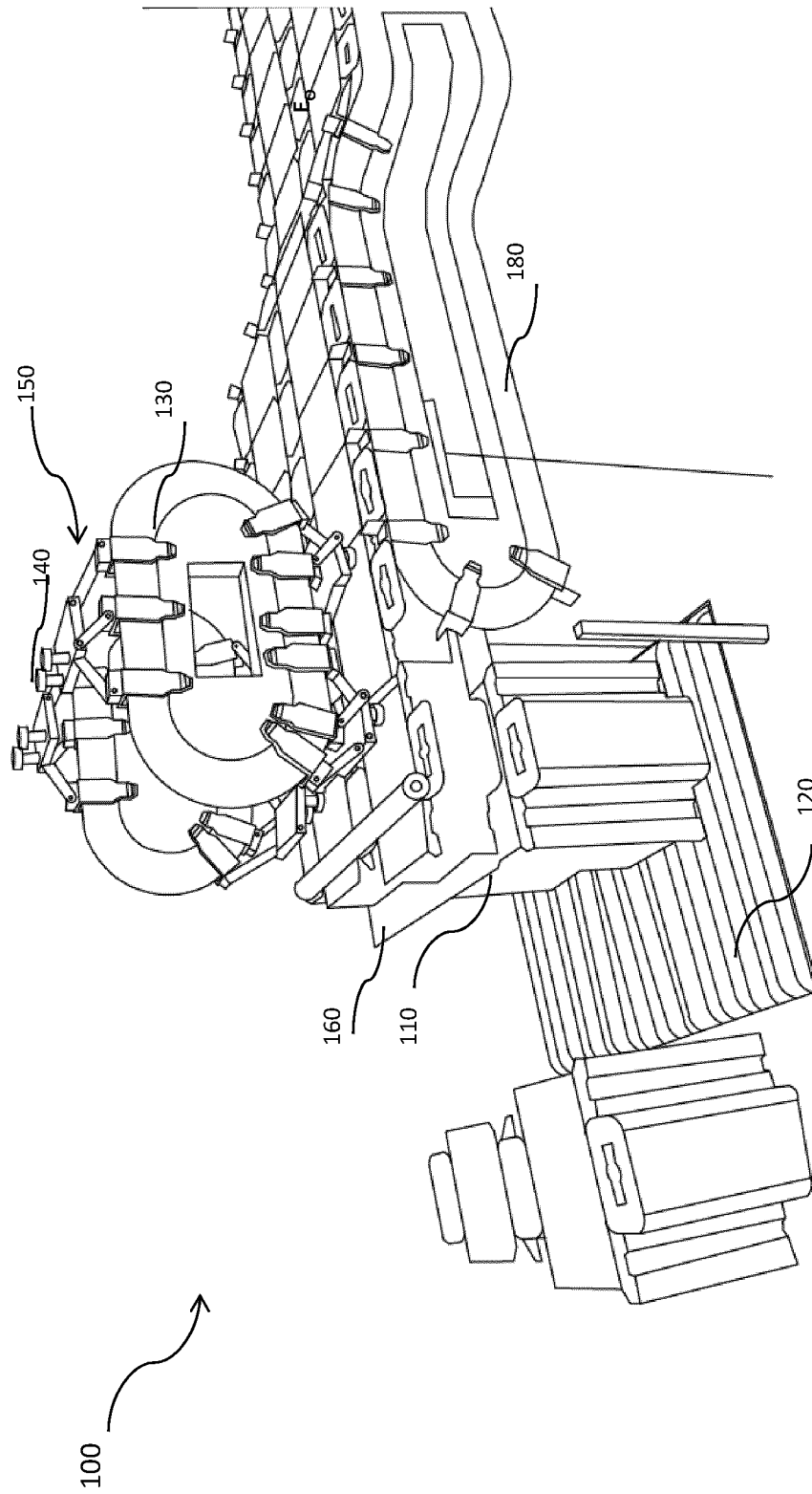
30           wherein a longitudinal movement of the first articulated mover and the second articulated mover towards and/or away from each other enables a generally

perpendicular movement of the supporting plate relative to the rail system of the movers thereby selectively facilitating a pick-up movement of the de-stacking means for picking up the sheets from at least one of the stacking magazines.

- 5 4. The apparatus of claim 3, comprising one, or two or more parallel closed loop conveying tracks and wherein de-stacking means moving mechanism includes a plurality of de-stacking lugs movingly configured onto the one, or parallel multiple closed loop conveying tracks through one or more de-stacking movers movingly configured thereon and wherein the de-stacking movers on the parallel closed
- 10 loop conveying tracks are independently controlled to achieve translation of the picked-up sheet.
5. The apparatus of claim 1, further comprising a means for forcing the underside of the picked-up sheet against a means for applying friction in the reverse direction
- 15 relative to conveying direction.
6. The apparatus of claim 1, comprising one, or two or more, of said closed loop conveying tracks in parallel and a movement mechanism for varying the distance (pitch) between said two or more generally parallel tracks relative to each other
- 20 and relative to alignment with the machine datum
7. The apparatus according to any of aforementioned claims, comprising a first powering means for enabling a movement of the closed loop conveying tracks, wherein the first powering means is a linear motor.
- 25
8. The apparatus according to any of aforementioned claims, comprising a second powering means for enabling a movement of each of the plurality of movers including the de-stacking movers and the stacking movers wherein further the second powering means is selected from a linear motor, servo motors and
- 30 synchronic and/or asynchronous motor drives.
9. The apparatus according to any of the aforementioned claims, wherein the de-stacking means and the de-stacking moving mechanism are wirelessly powered

and wirelessly controlled.

10. The apparatus of claim 1 further comprising a control unit for optimizing a movement of each of the closed loop conveying tracks, the de-stacking movers,  
5 the de-stacking means, the lifting plate, and the stacking movers of the stacking magazines in such a way that an uninterrupted denesting operation is achieved.
11. The apparatus of claim 1, comprising one or more sensors enabling real-time, inline measurement of the distance between the de-stacking means and the  
10 uppermost sheet of a magazine to be picked up and a control unit to dynamically control and adjust the position and reach of the de-stacking means.
12. The apparatus of claim 1, comprising one or more sensors enabling real-time, inline measurement of the angular and position alignment of any picked sheet  
15 or packaging material blank and a control units to dynamically adjust the relative positions of the mover mounted de-stacking means opposite each other between the generally parallel closed loop tracks, or controlled rotation of the de-stacking means, to dynamically correct any angular or translational  
20 error.
13. The apparatus of claim 1, comprising one or more sensors enabling real-time, inline detection of a double or more sheet pick and the activation of means of pressing the picked sheet against the means for applying friction to counter  
25 the multi-sheet pick and return the excess to the stacking magazine.

**Fig. 1**

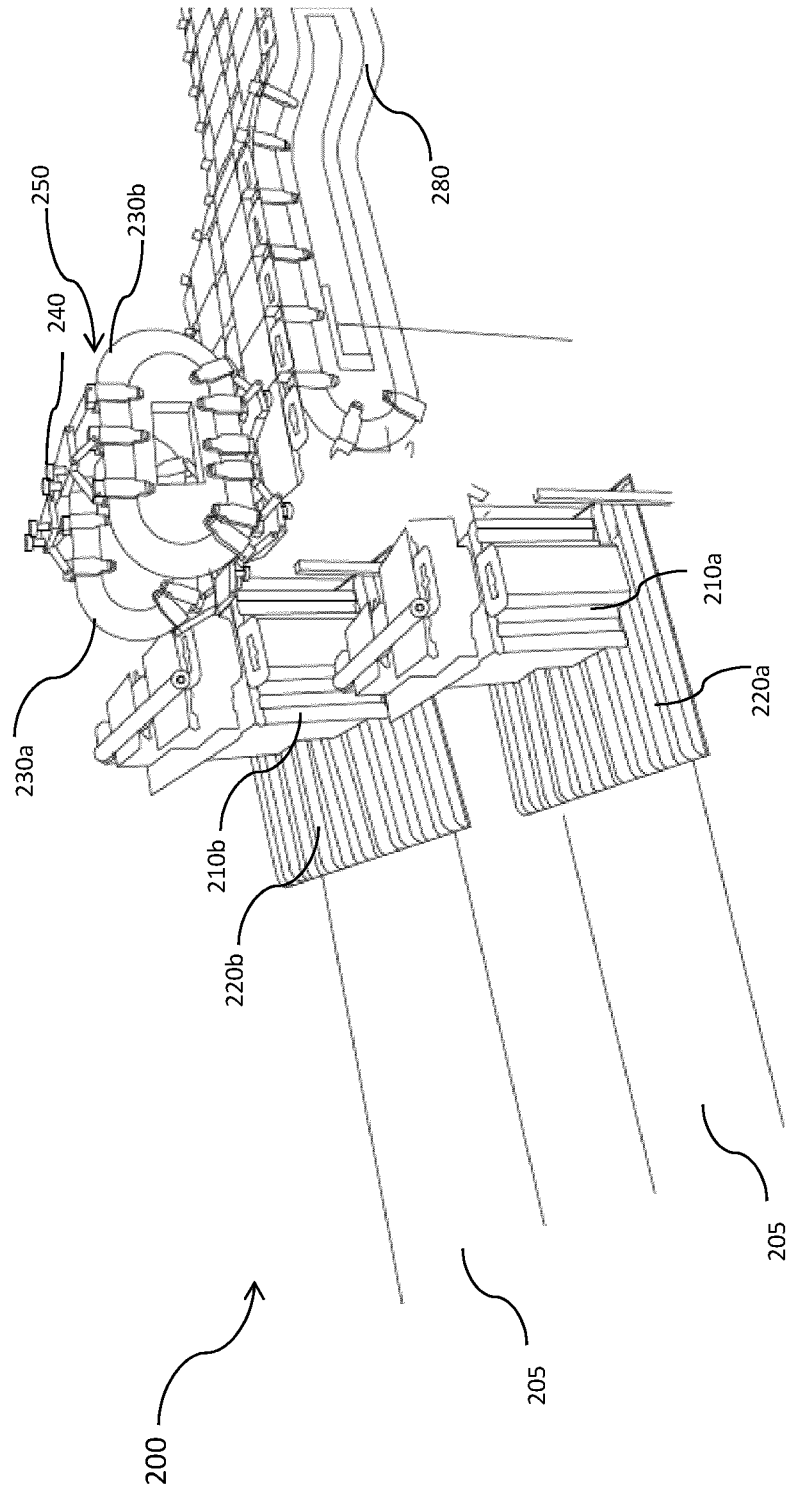
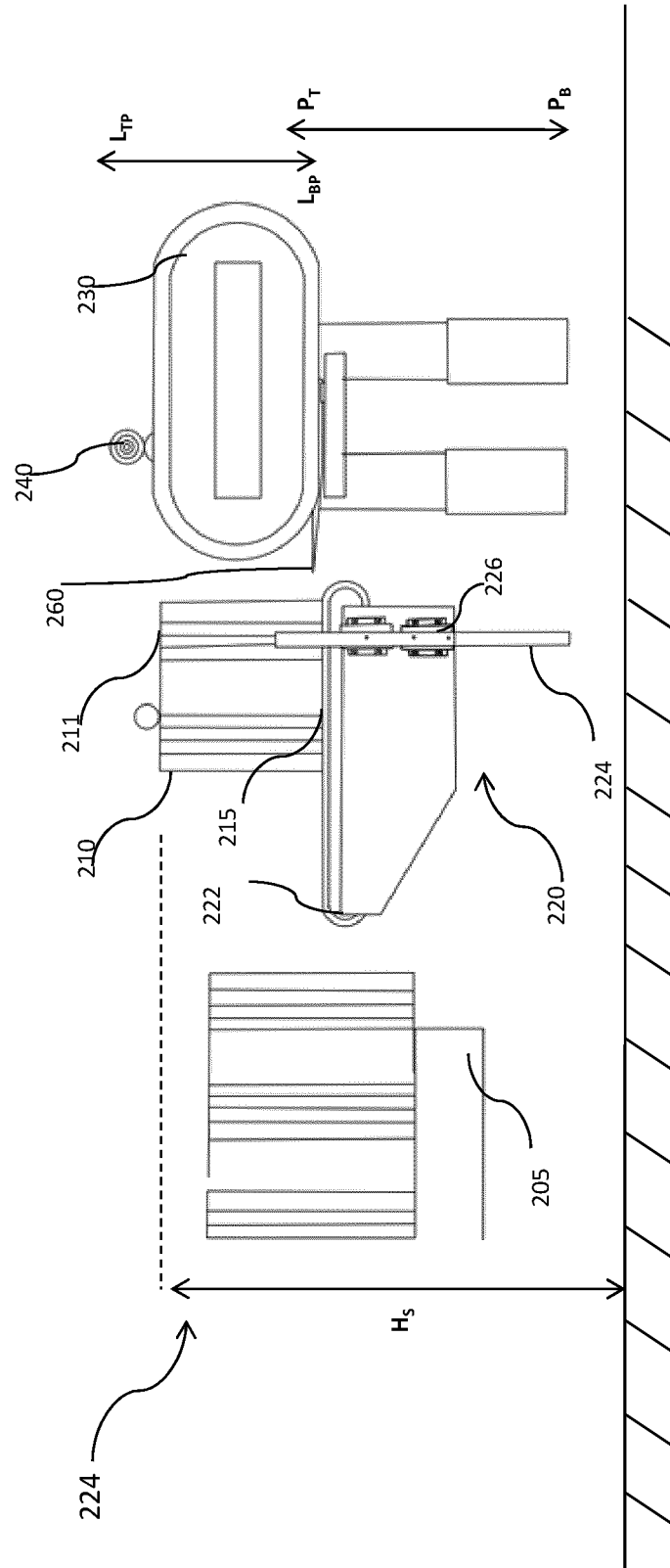
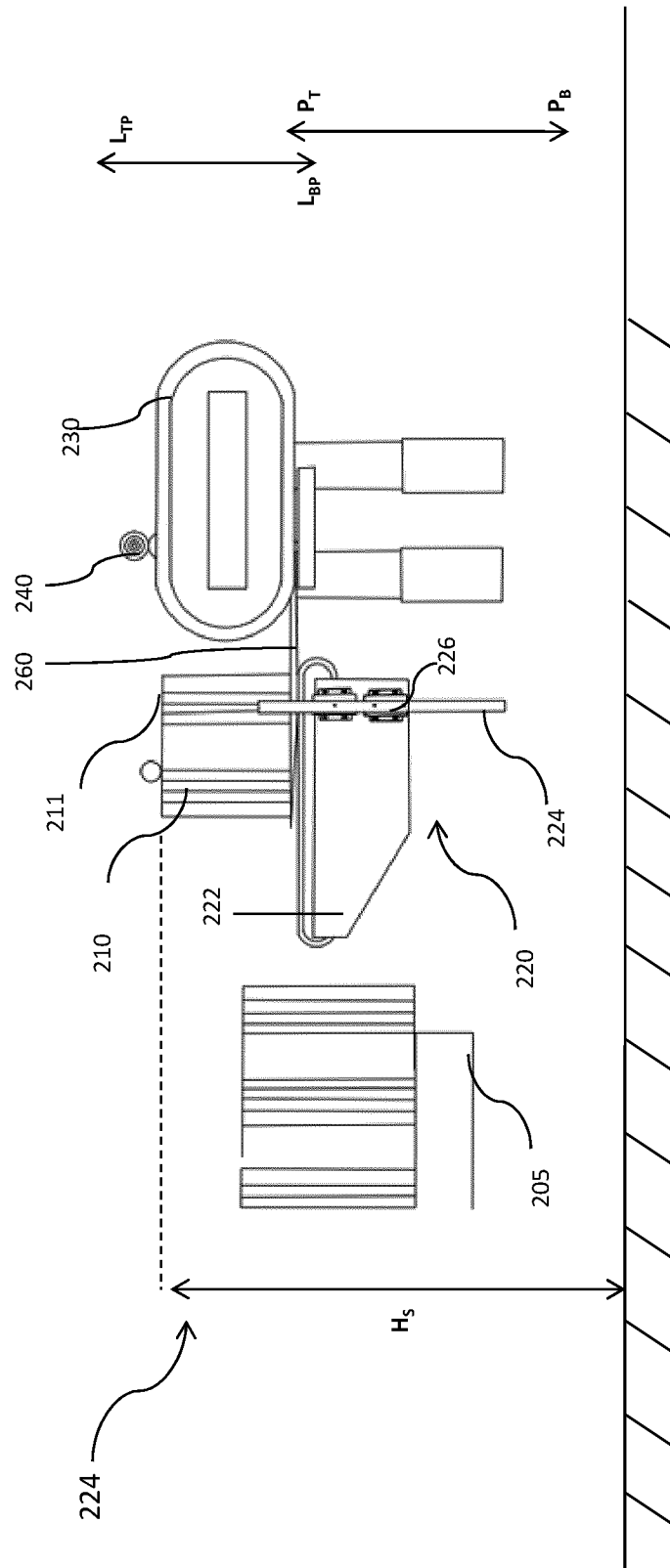


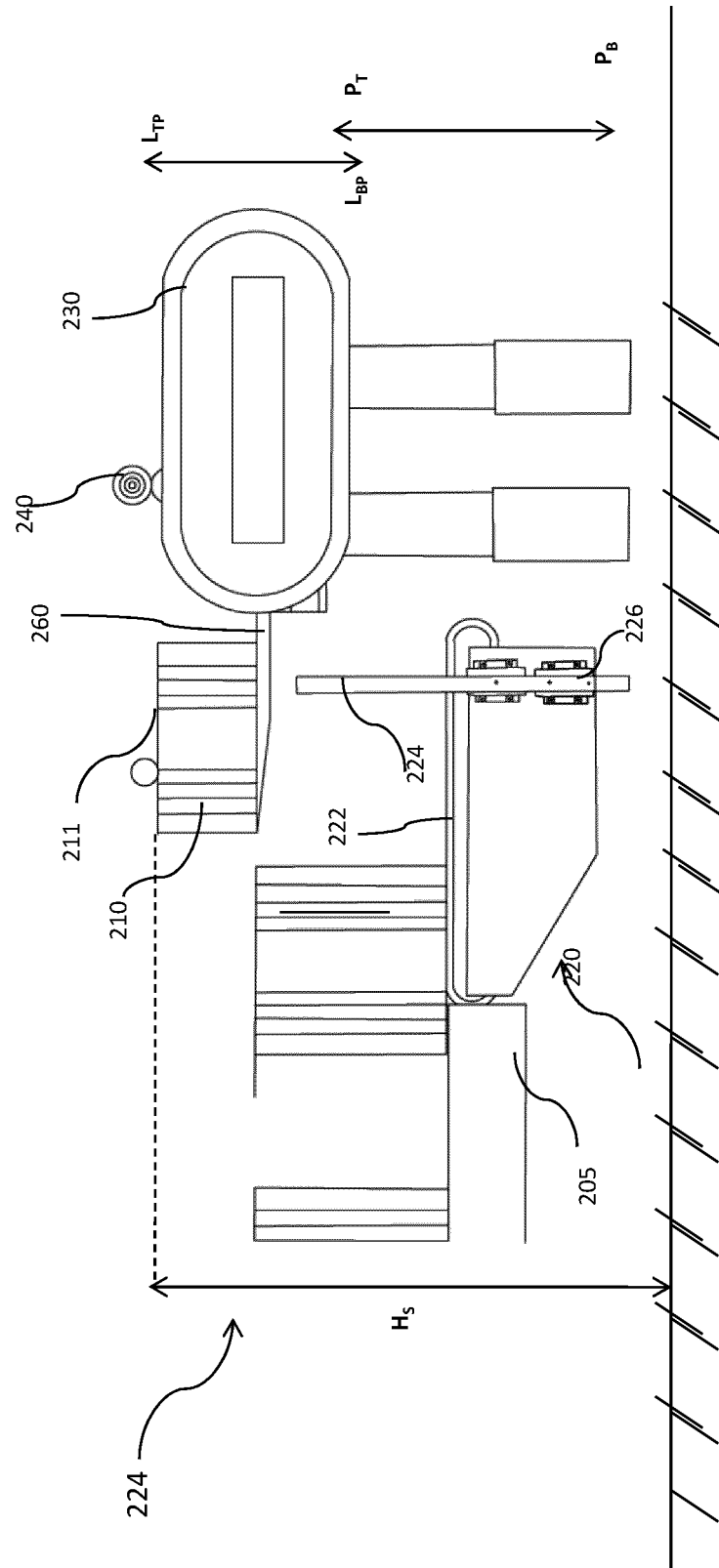
Fig. 2



**Fig. 3a**



**Fig. 3b**



**Fig. 3c**

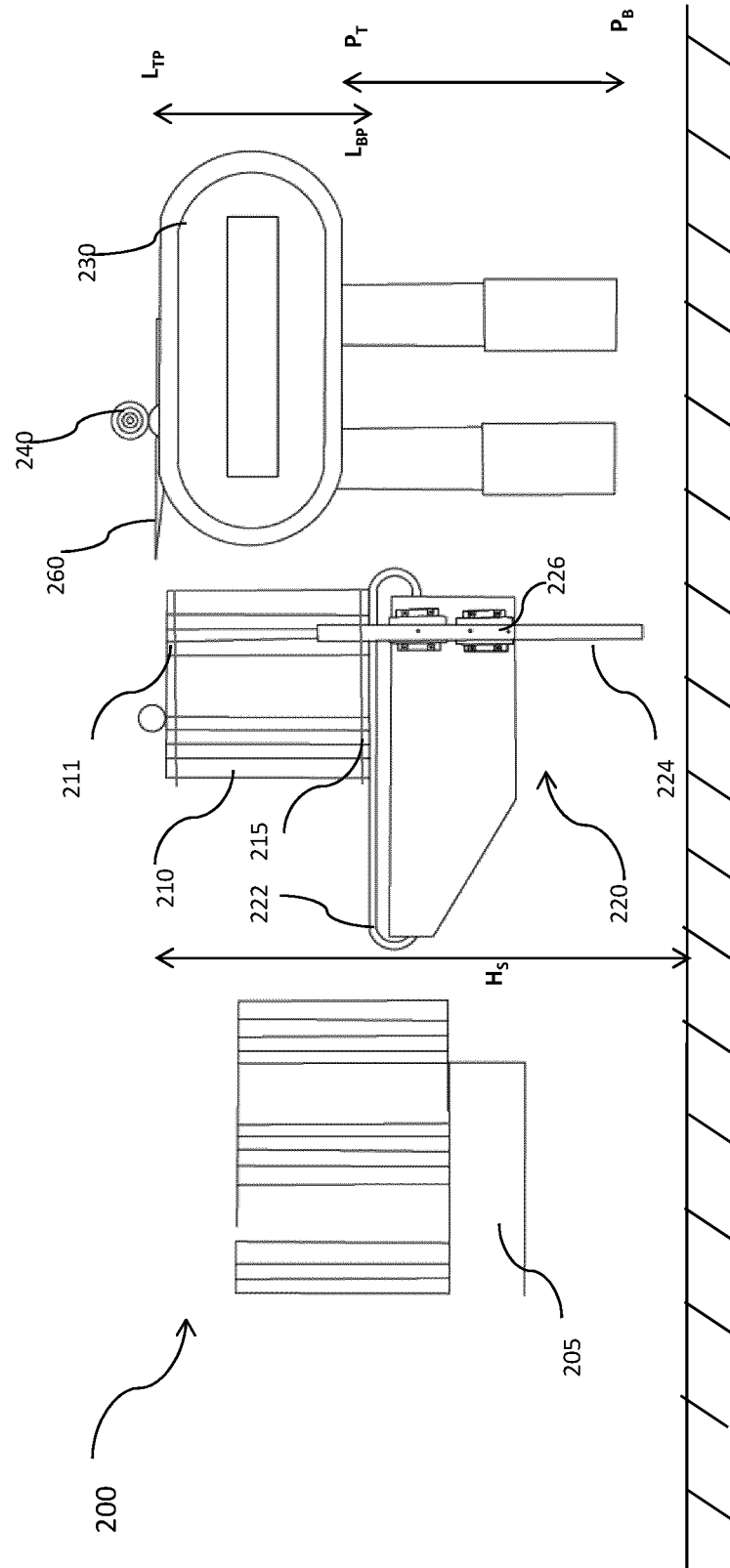
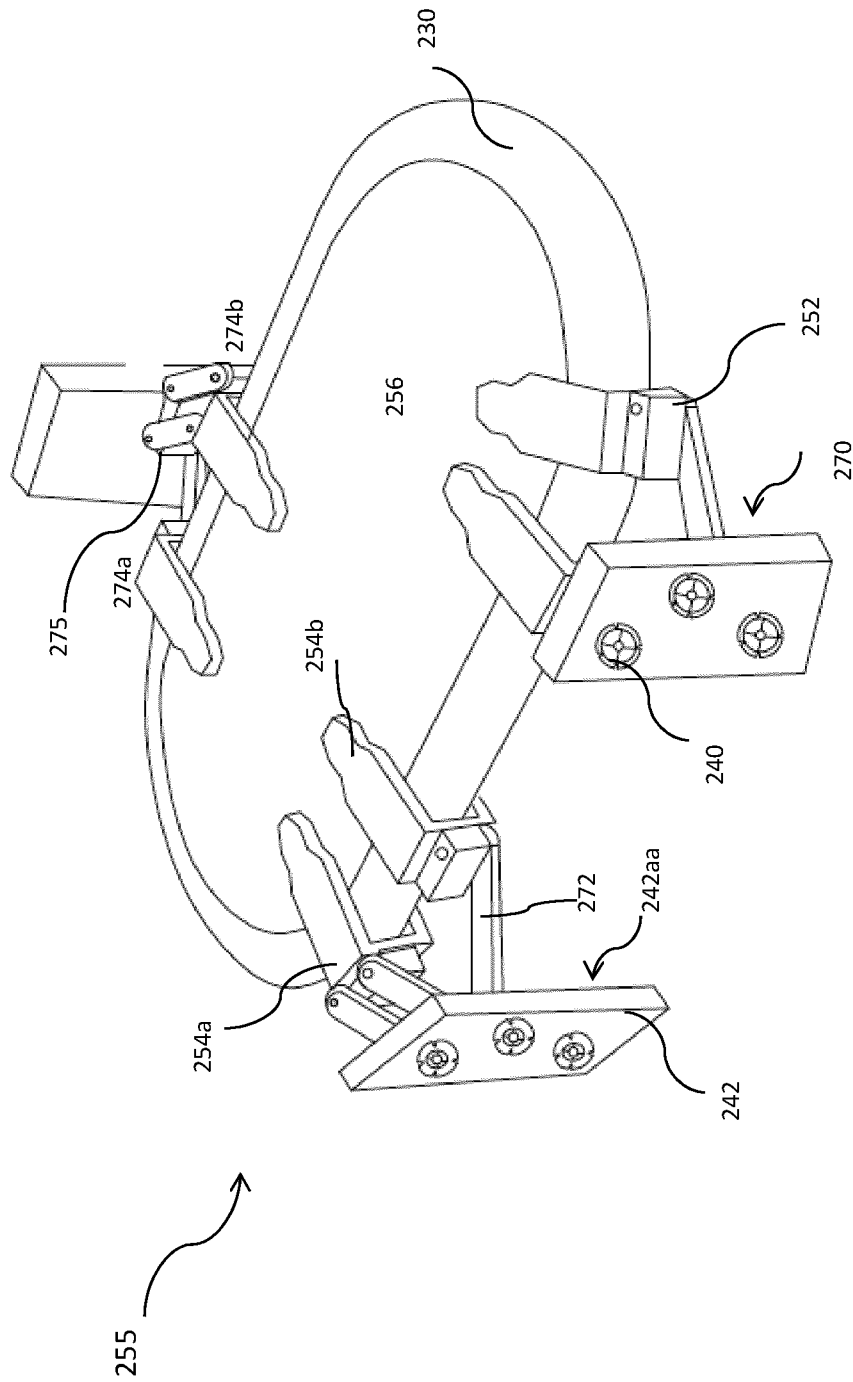
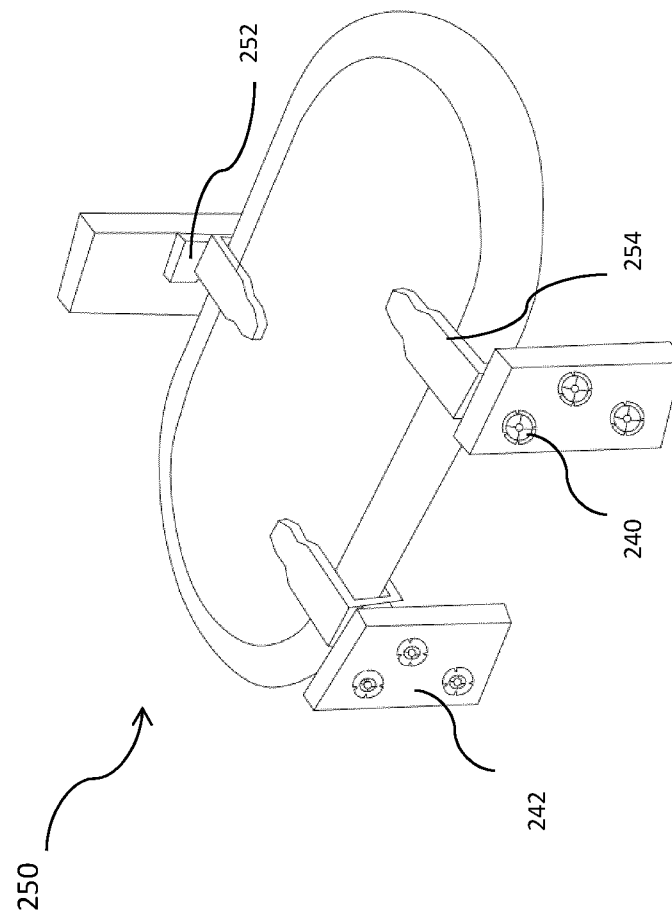


Fig. 3d



**Fig. 4a**

**Fig. 4b**

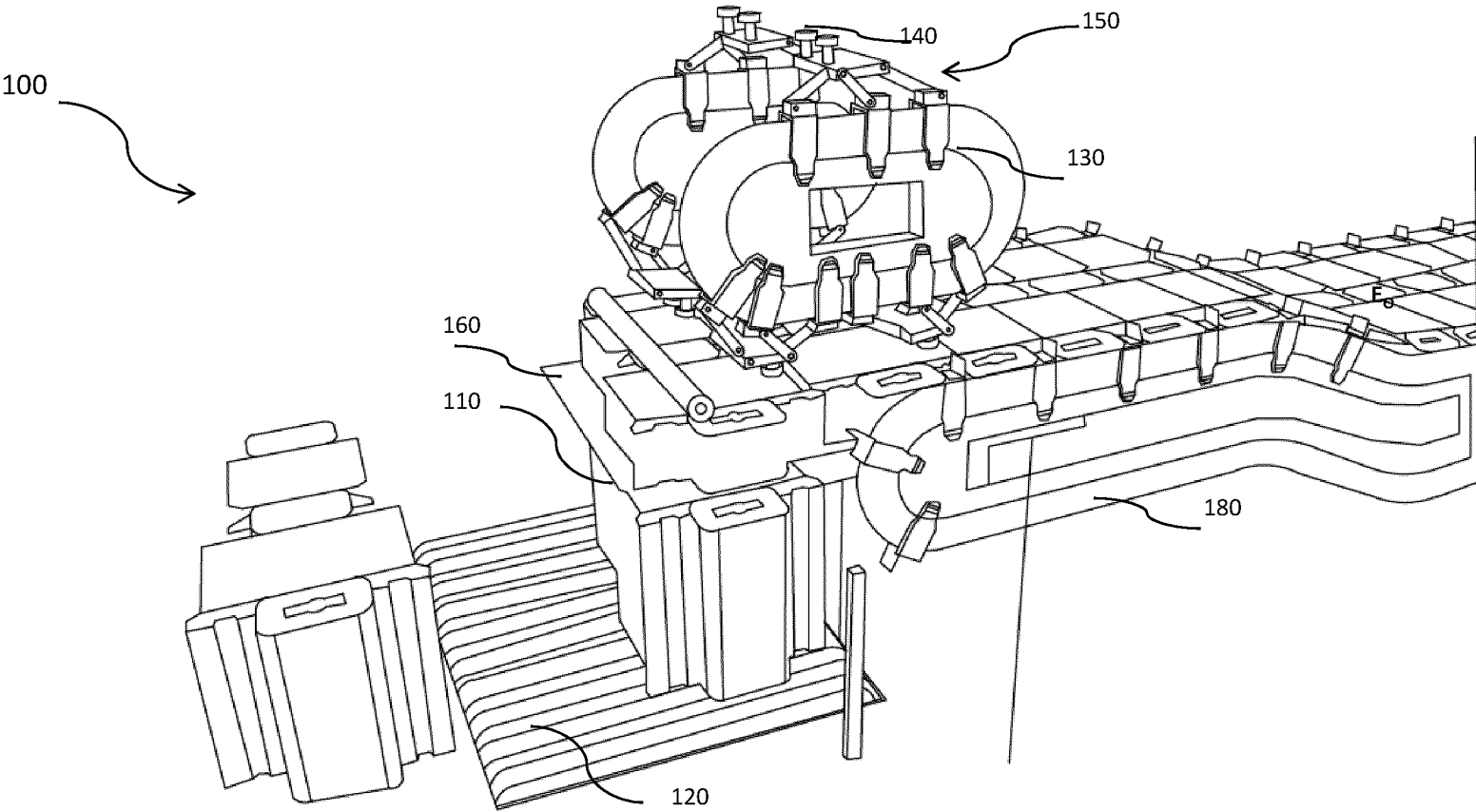


Fig. 1

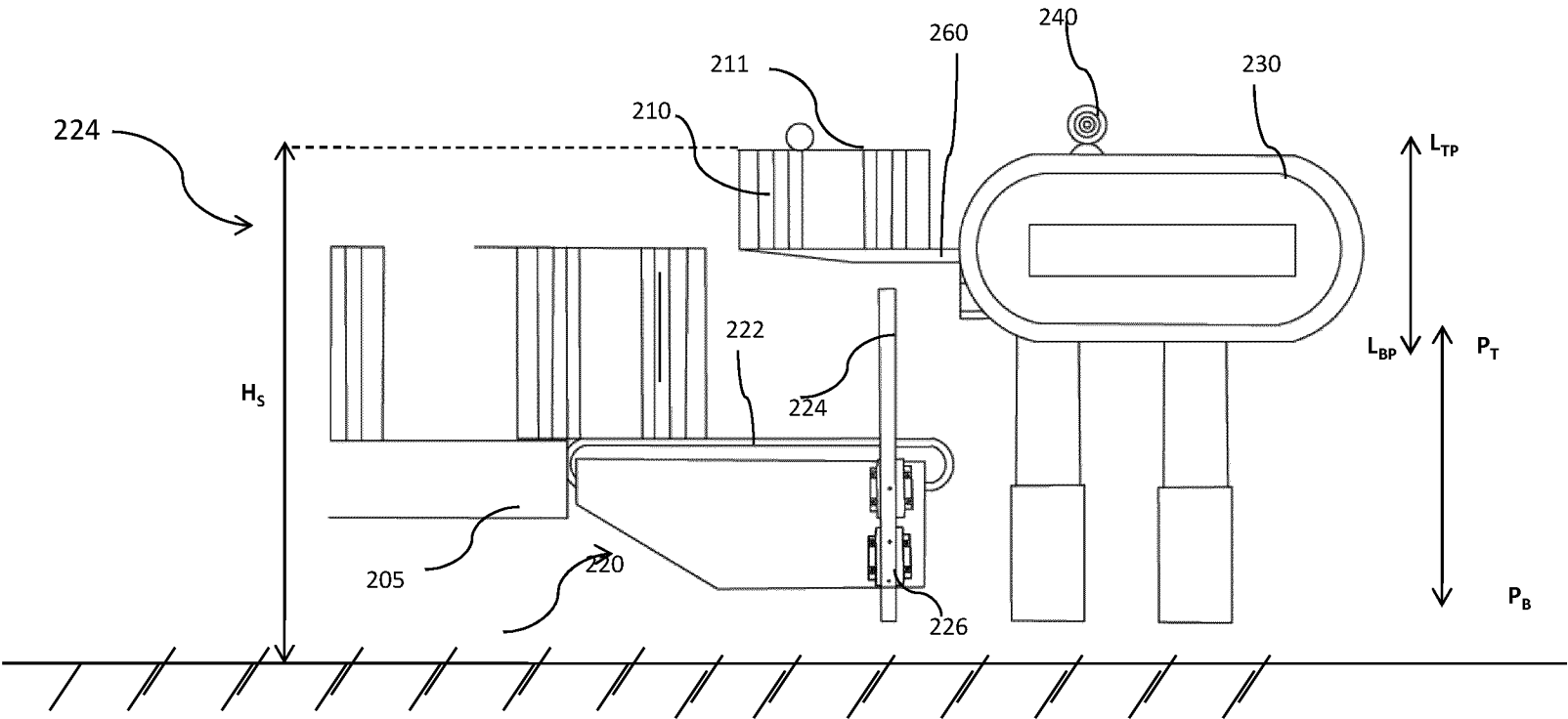


Fig. 3c

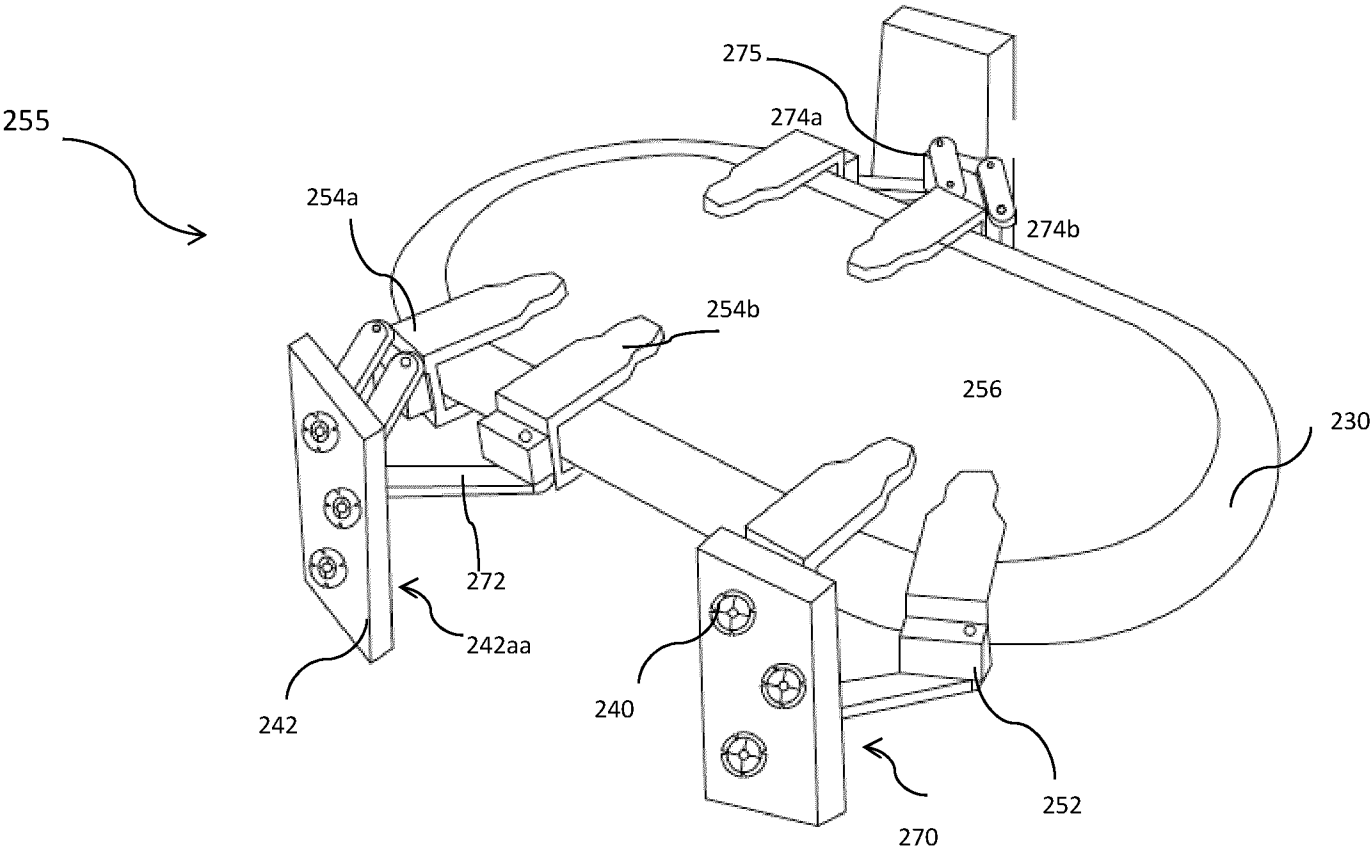


Fig. 4a