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(12) **United States Patent**
**Langen**

(10) **Patent No.: US 11,752,723 B2**
(45) **Date of Patent: Sep. 12, 2023**

(54) **METHOD AND APPARATUS FOR ERECTING CARTONS AND FOR ORDER FULFILMENT AND PACKING**


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(72) Inventor: **H. J. Paul Langen**, Brampton (CA)



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(22) Filed: **Mar. 3, 2020**

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(51) **Int. Cl.**

| | |
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| ***B31B 50/26*** | (2017.01) |
| ***B31B 50/02*** | (2017.01) |
| ***B65H 5/08*** | (2006.01) |

(52) **U.S. Cl.**

CPC ............ ***B31B 50/07*** (2017.08); ***B31B 50/022*** (2017.08); ***B31B 50/262*** (2017.08); ***B65H 5/08*** (2013.01); *B65H 2701/1764* (2013.01)

(58) **Field of Classification Search**

CPC ....... B31B 50/04; B31B 50/044; B31B 50/06; B31B 50/07; B31B 50/022; B31B 50/26; B31B 50/262; B31B 2100/00; B31B 2120/30; B65H 5/08; B65H 2701/1764

USPC ................................ 493/313, 315, 183, 309

See application file for complete search history.


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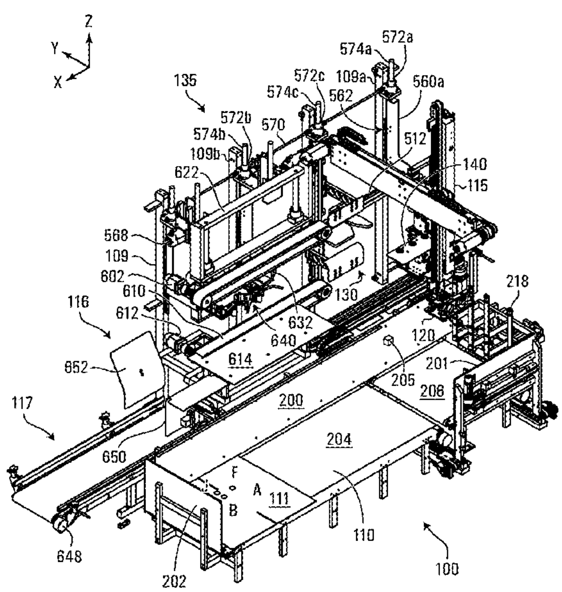
*Assistant Examiner* — Jacob A Smith

(57) **ABSTRACT**


A system and method of packing an order. A first sequence of bins corresponding to orders is transported on a first conveyor to a packing station. A case for each order is constructed by a case forming system, the case forming system able to construct cases from blanks of various sizes. The cases are transported from the case construction apparatus to the packing station in a second sequence, wherein the sequential order of the cases corresponds to the bins in the first sequence. The bin in the first sequence are brought to the packing station with the cases in the second sequence.


**27 Claims, 45 Drawing Sheets**



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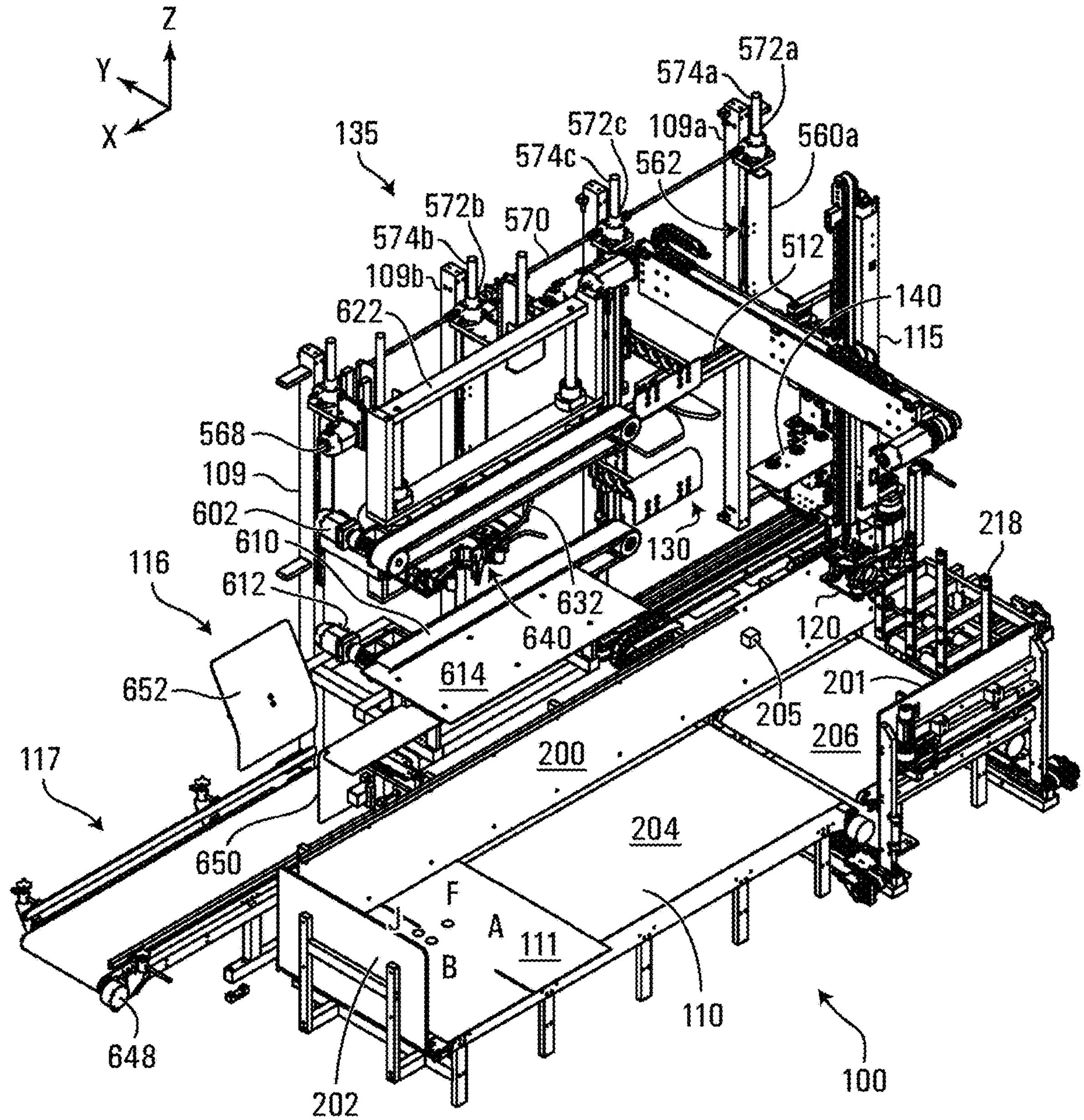
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FIG. 1

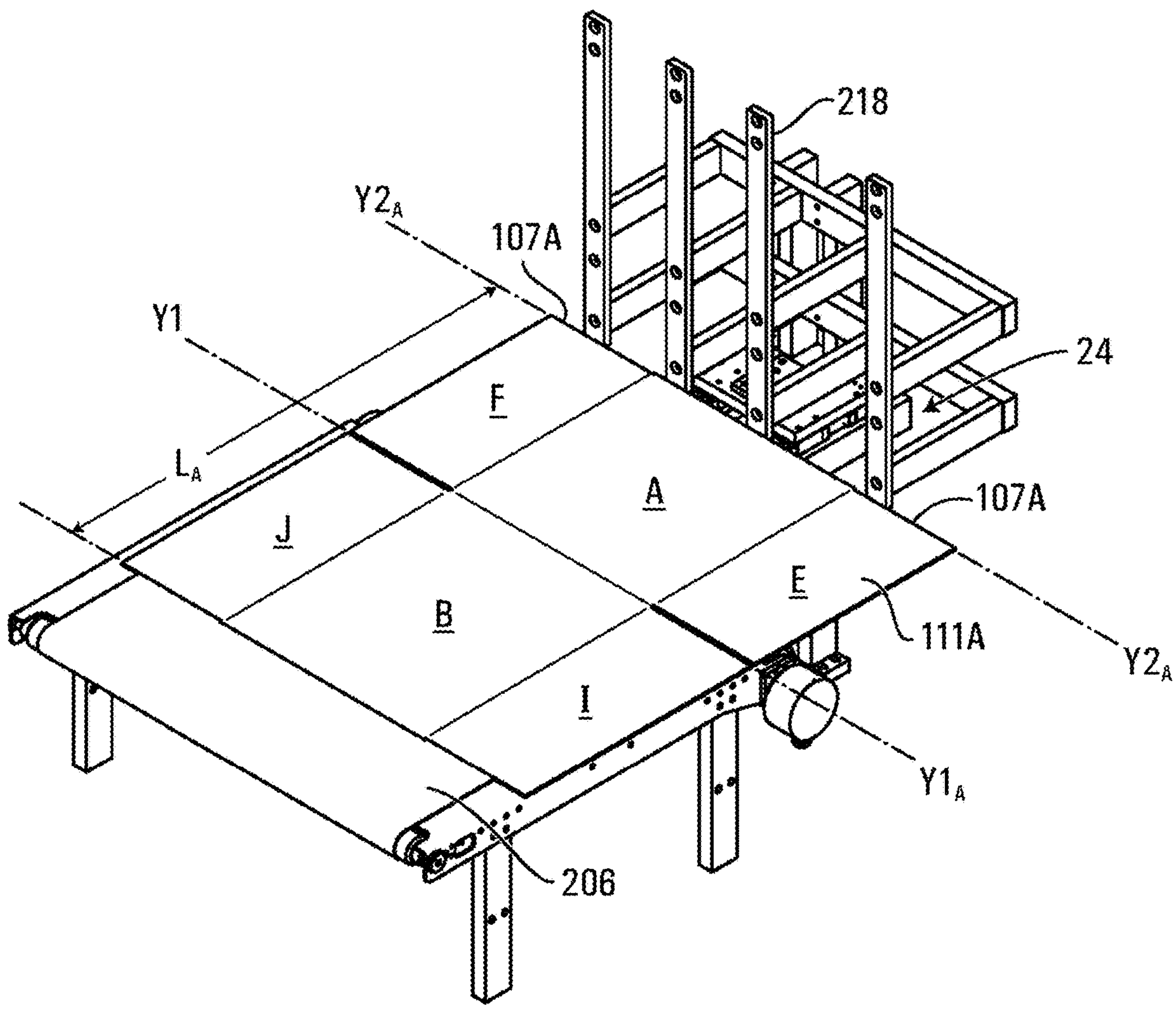
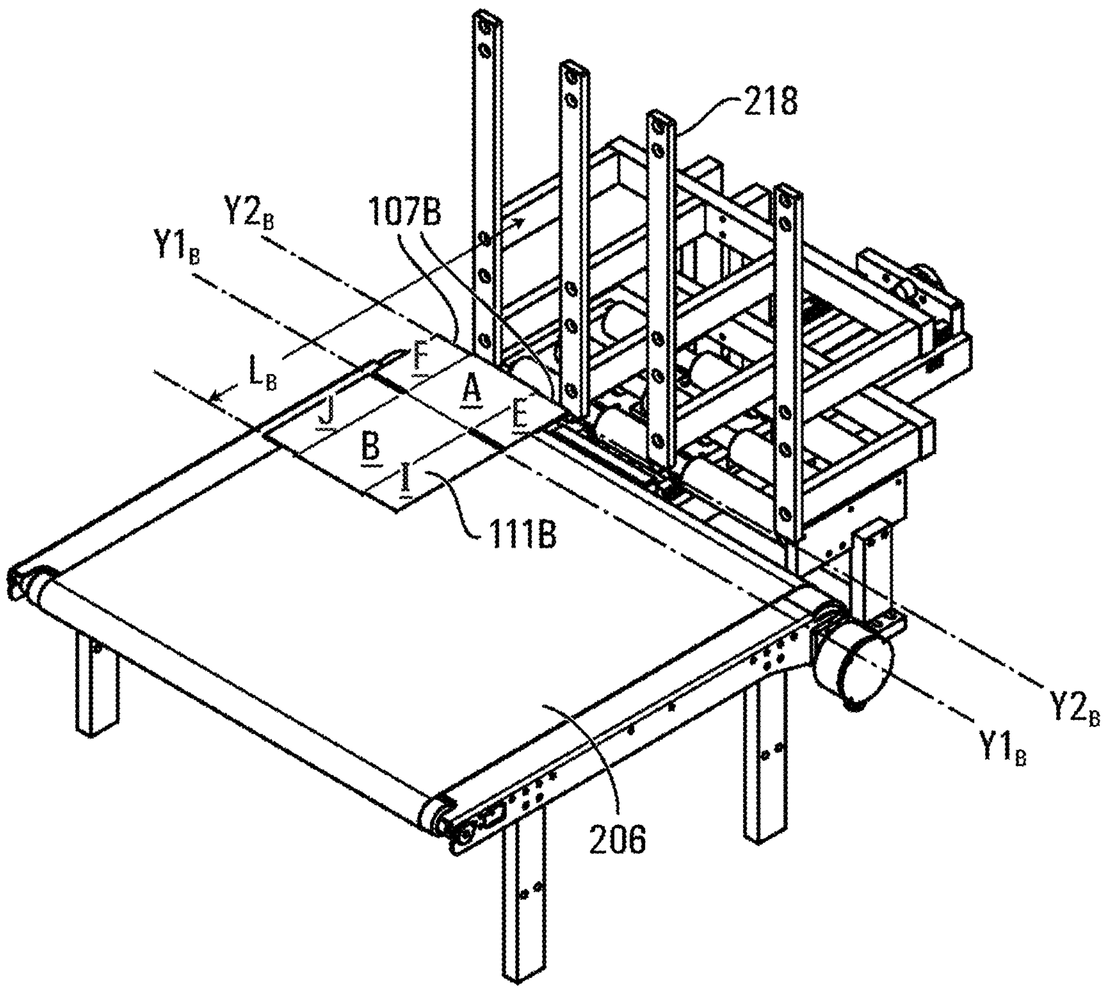



FIG. 1A

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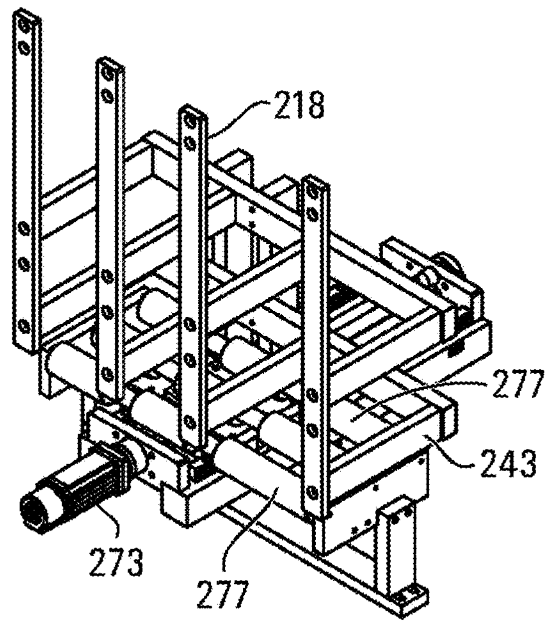



FIG. 1C

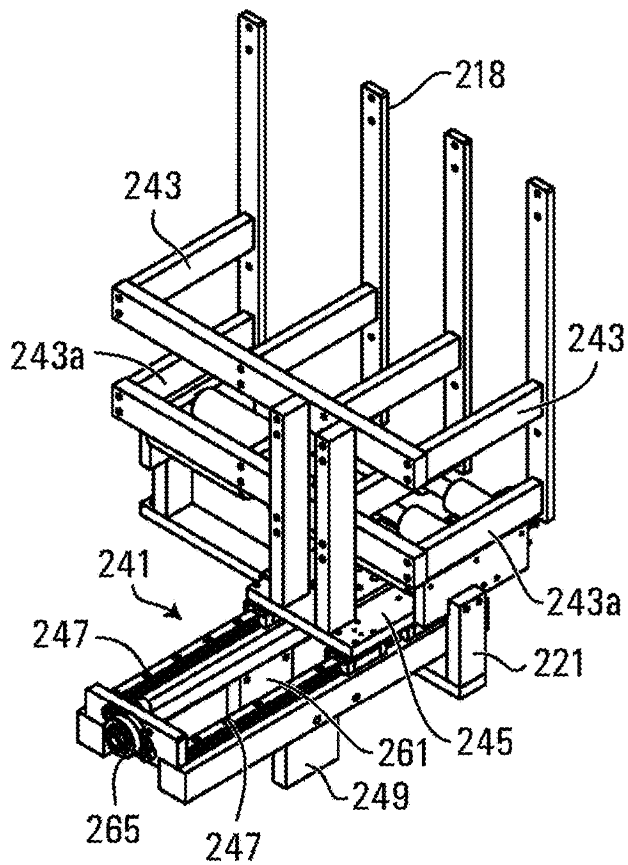



FIG. 1D

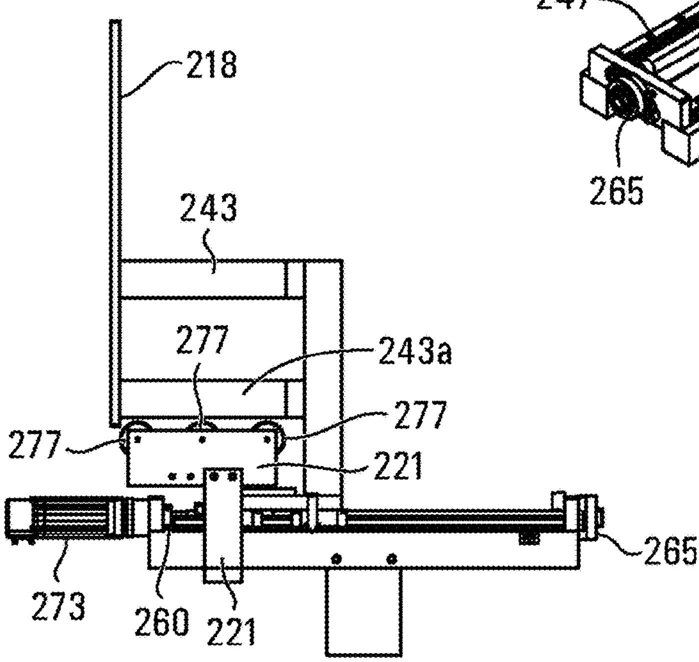
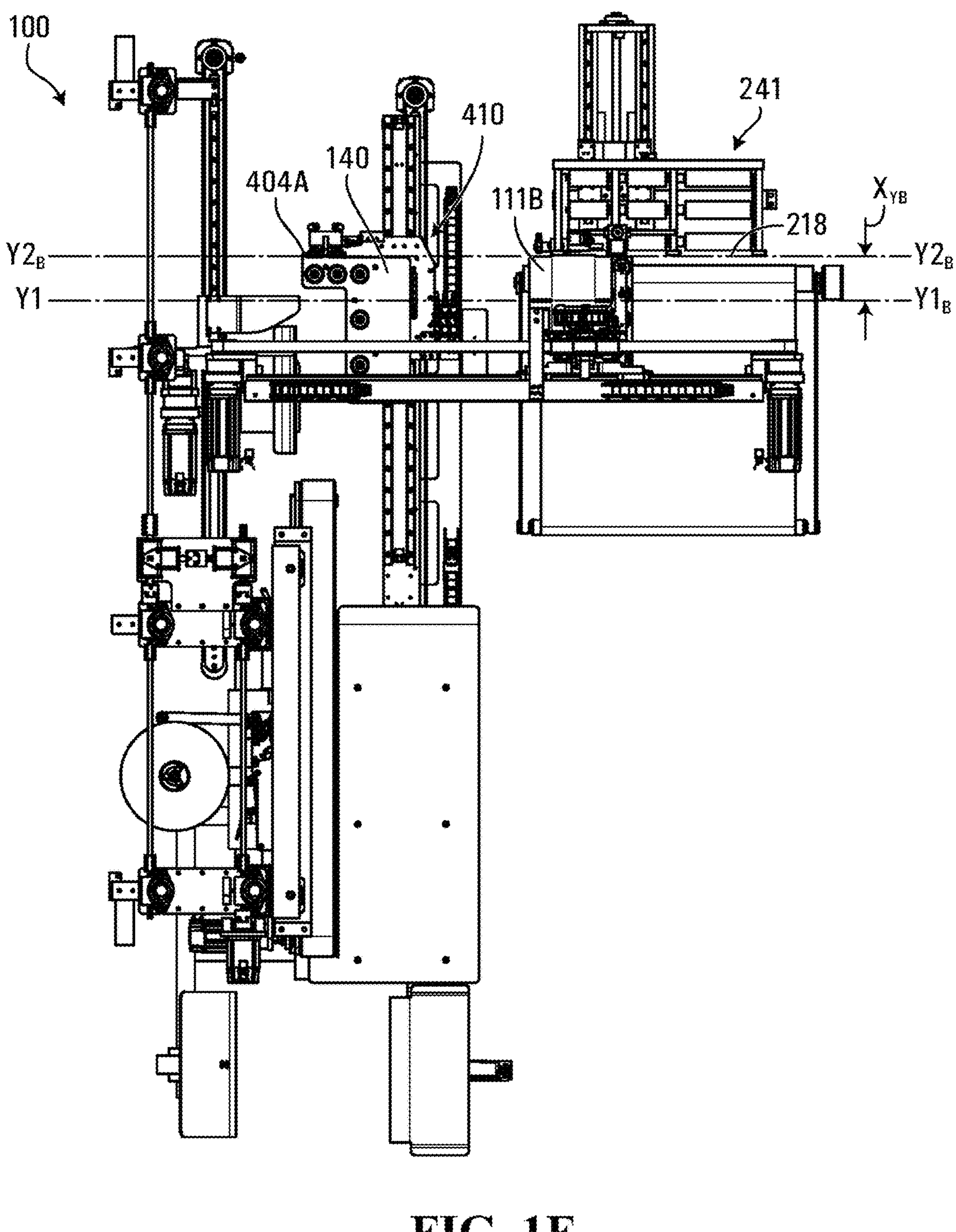



FIG. 1E

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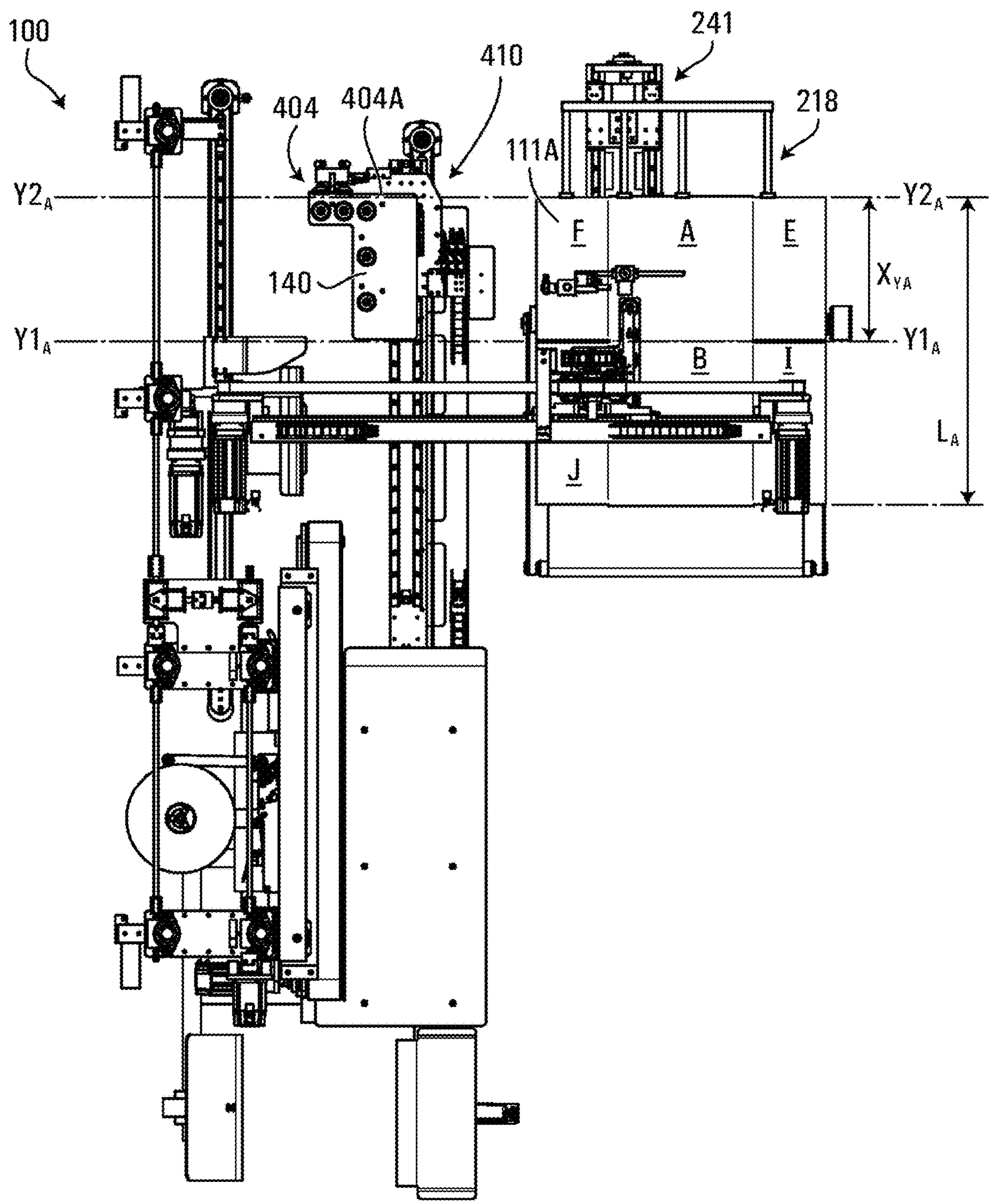



FIG. 1G

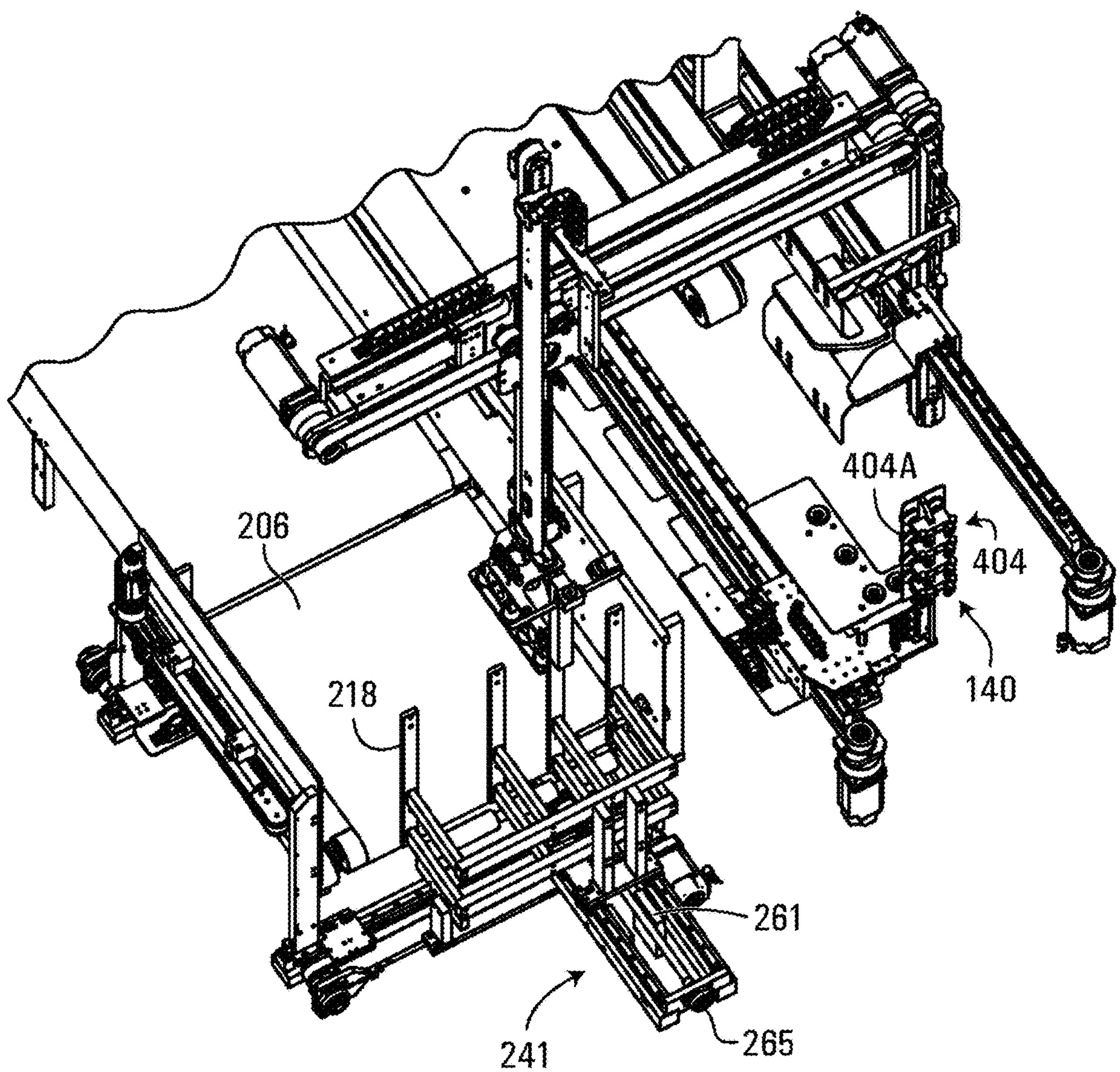



FIG. 1H

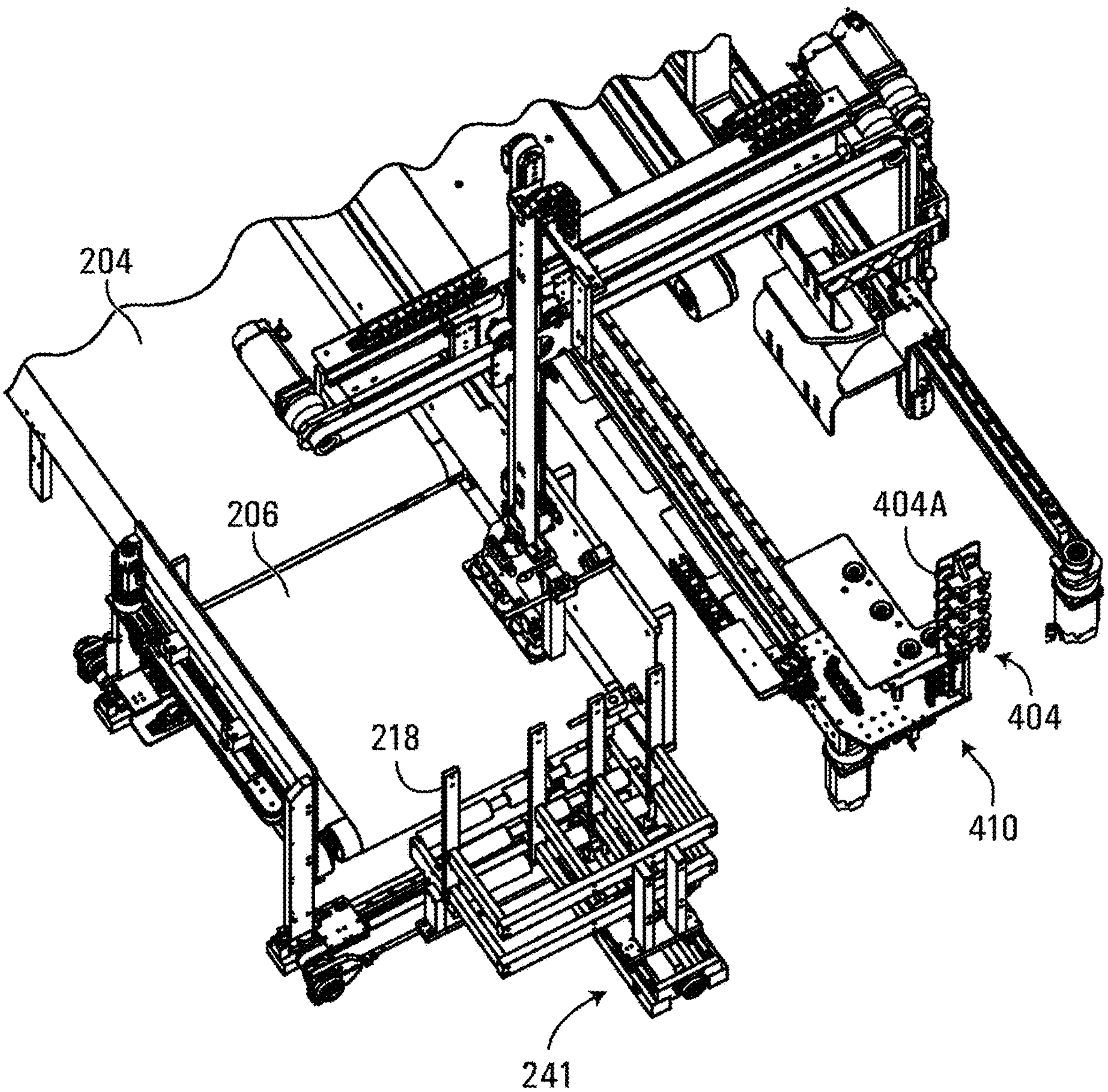



FIG. 1I

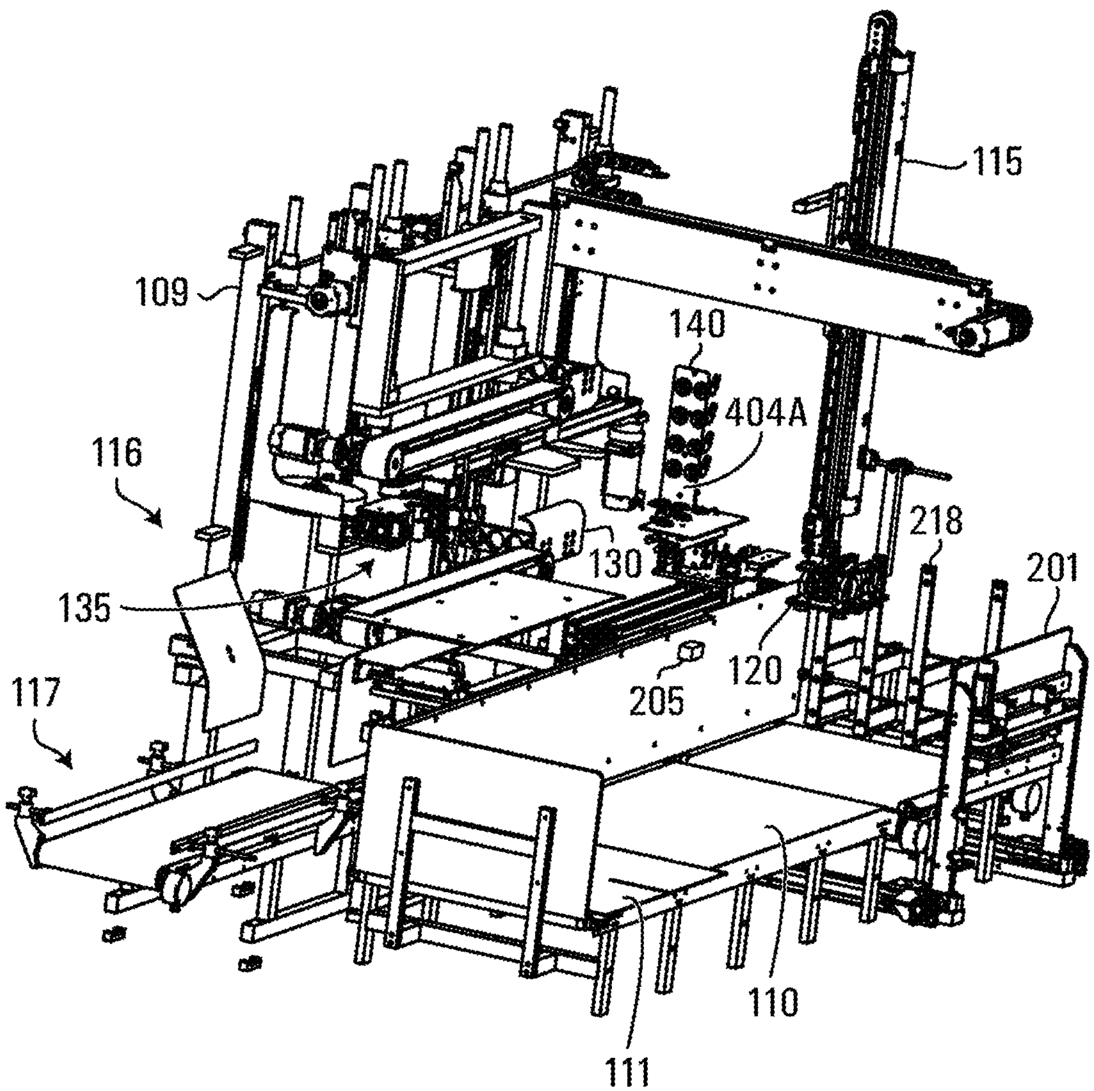



FIG. 2

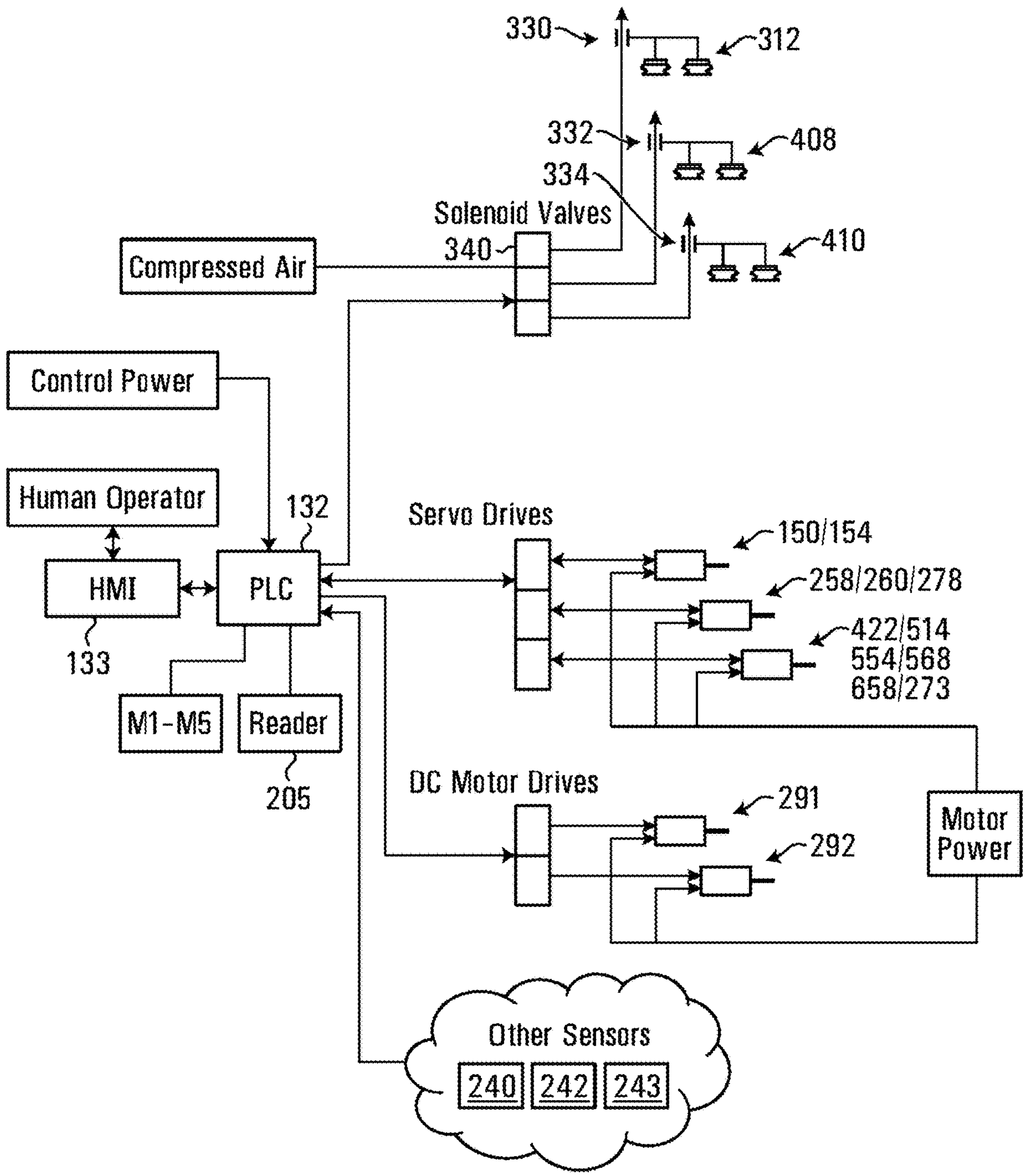

330
312
332
408
334
Solenoid Valves
340
410
Compressed Air
Control Power
Human Operator
132
Servo Drives
150/154
HMI
PLC
258/260/278
422/514
554/568
658/273
133
M1-M5
Reader
205
DC Motor Drives
291
292
Motor Power
Other Sensors
240
242
243

FIG. 3

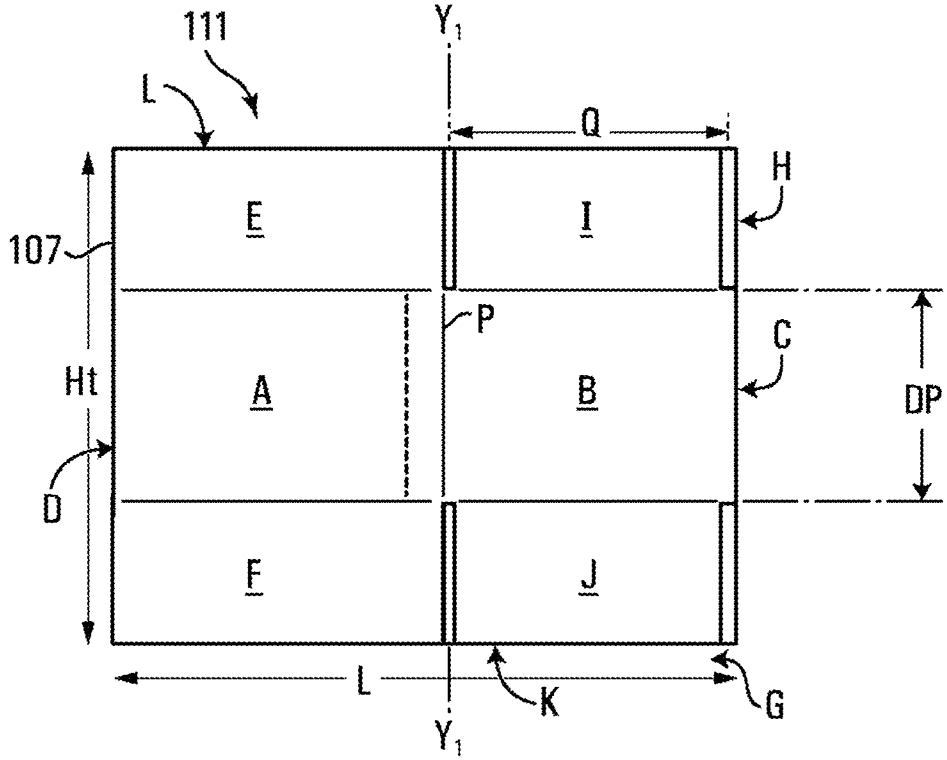



FIG. 4A

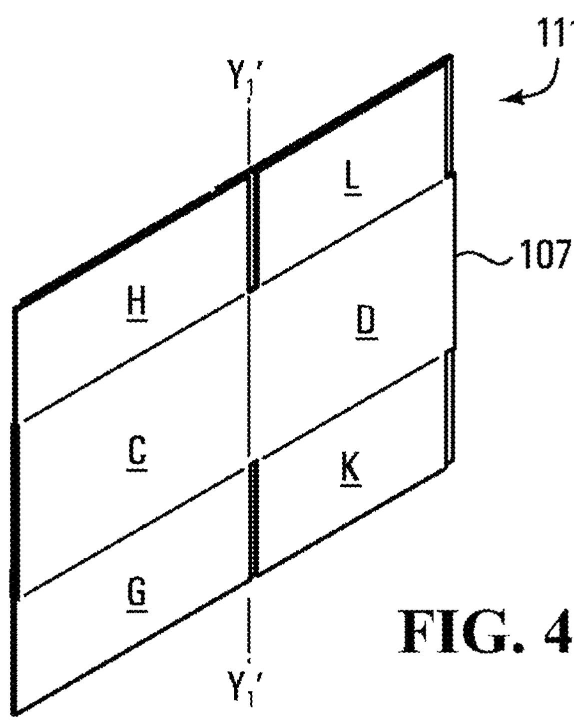



FIG. 4B

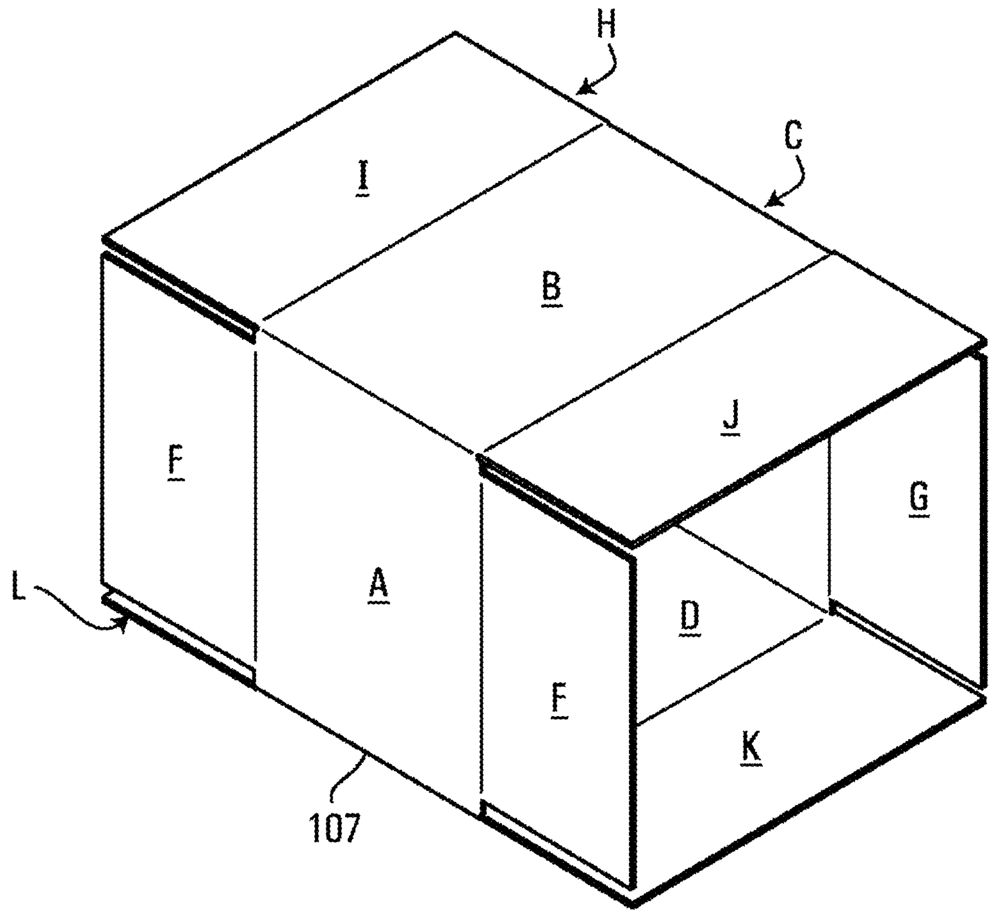



FIG. 5

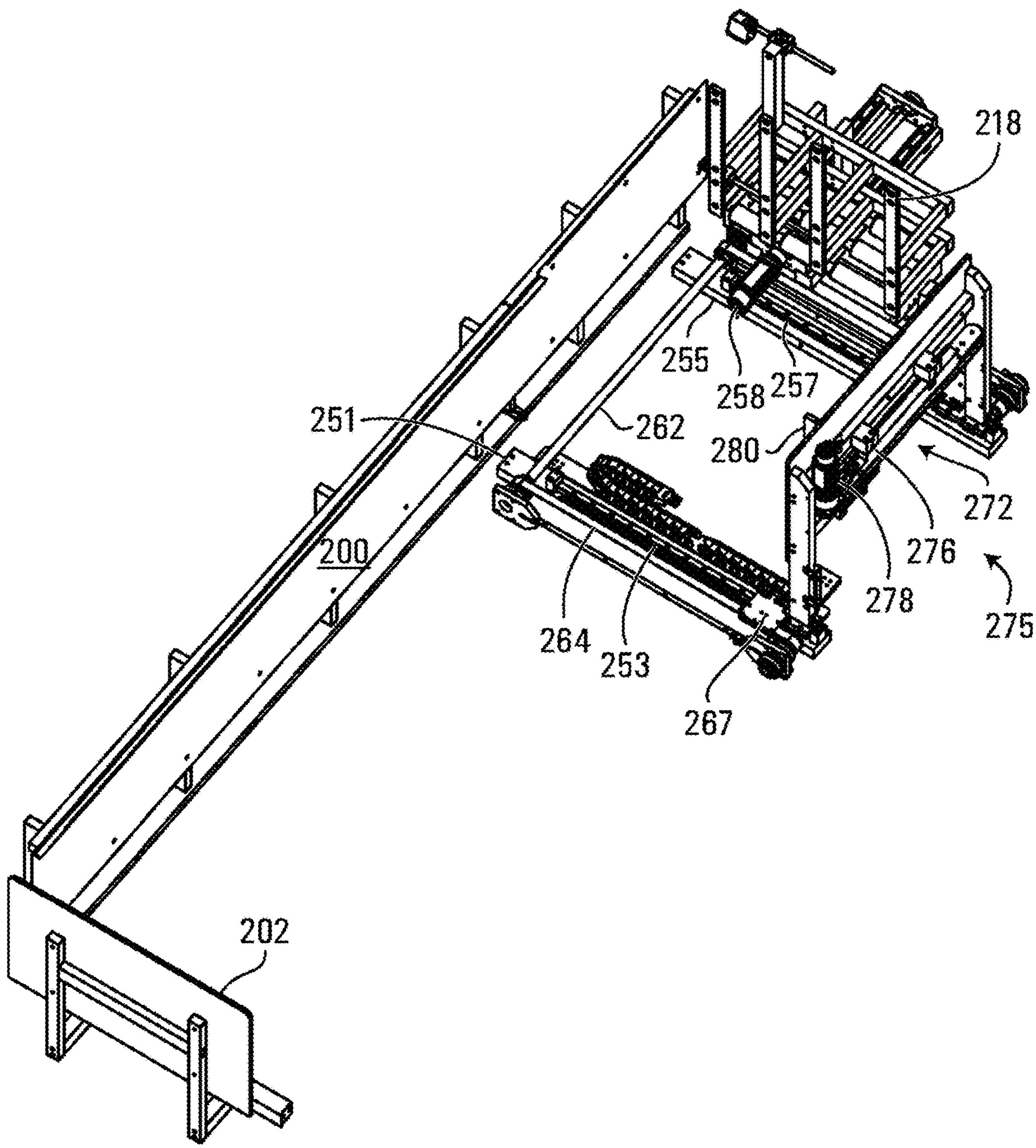



FIG. 6

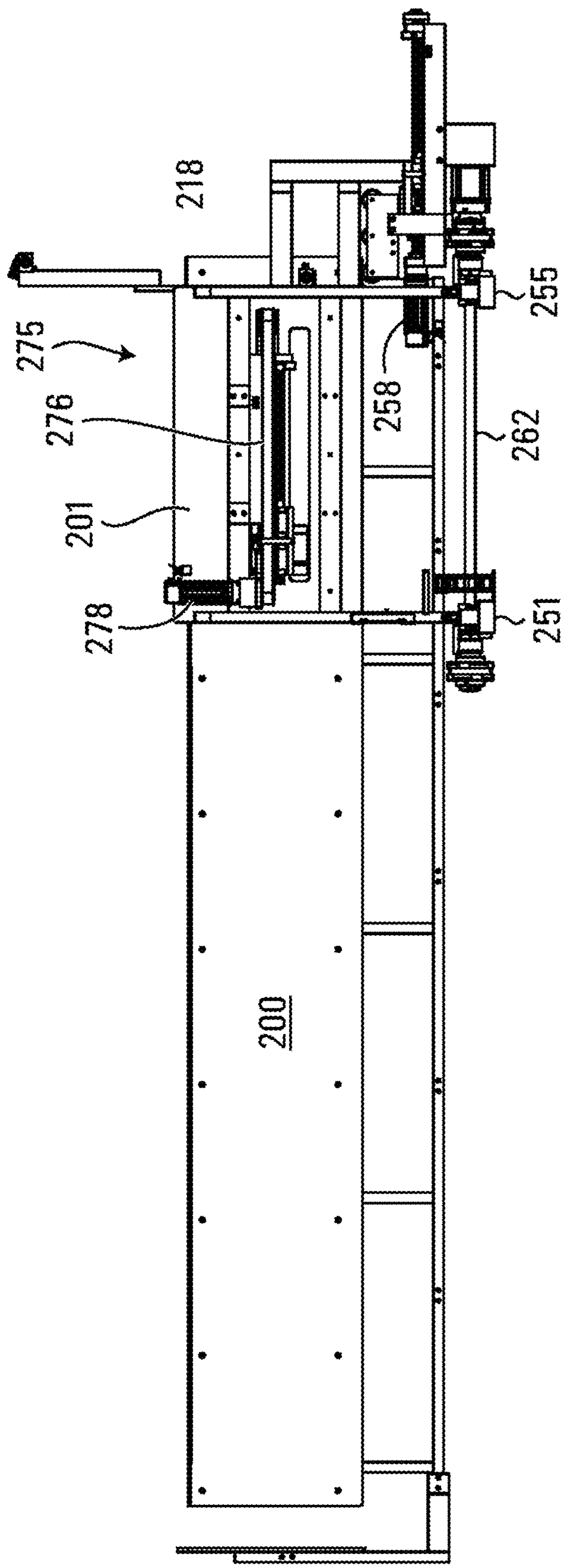



FIG. 7

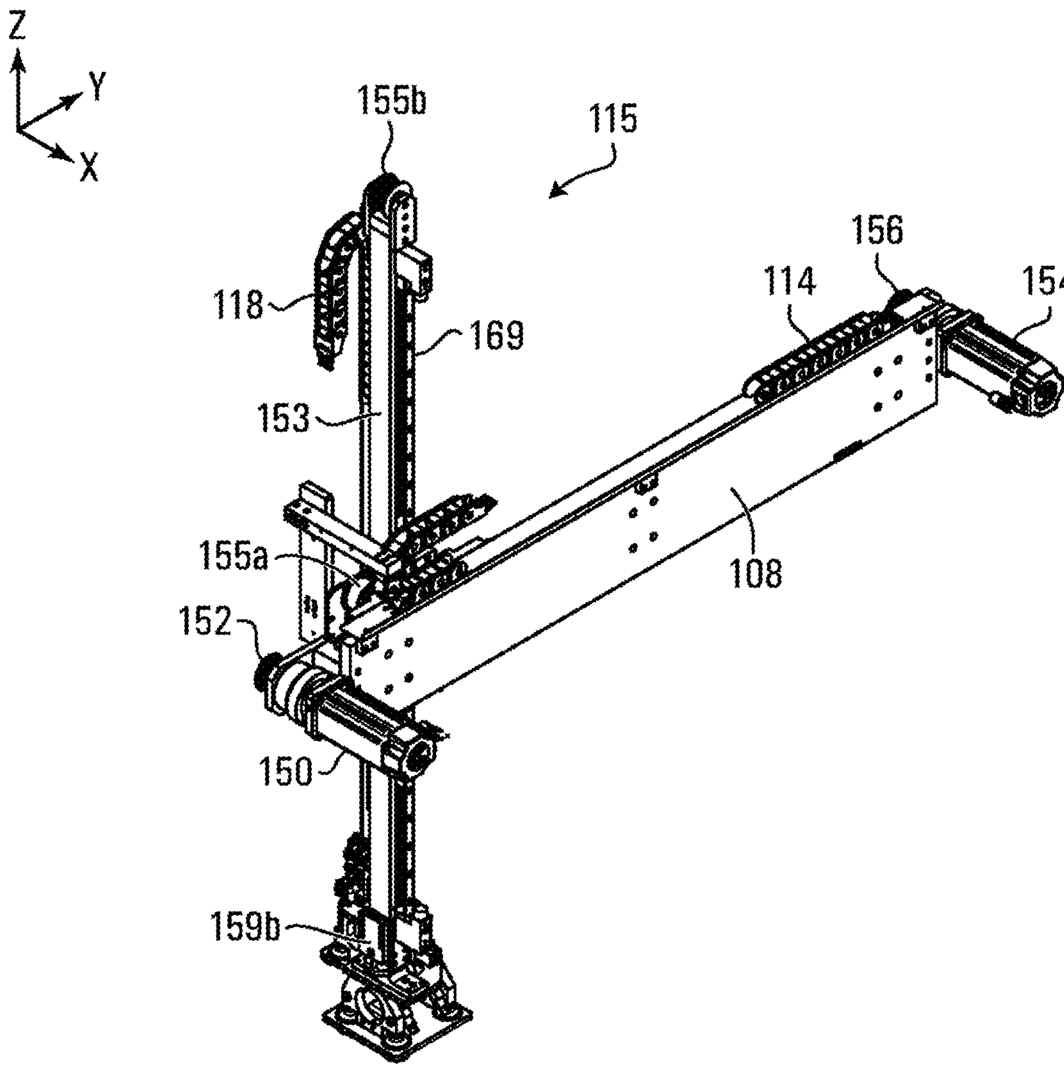



FIG. 8

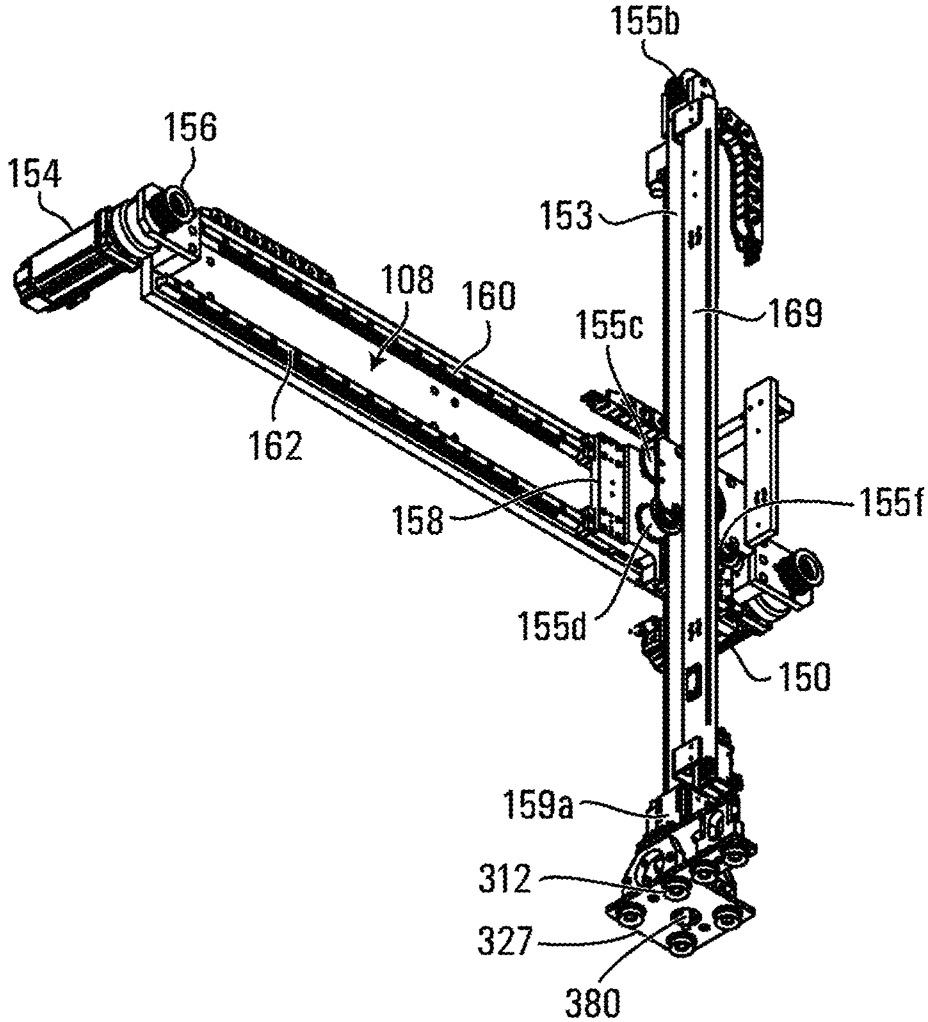

155b
156
154
153
108
160
169
155c
162
155f
158
155d
150
159a
312
327
380

FIG. 9

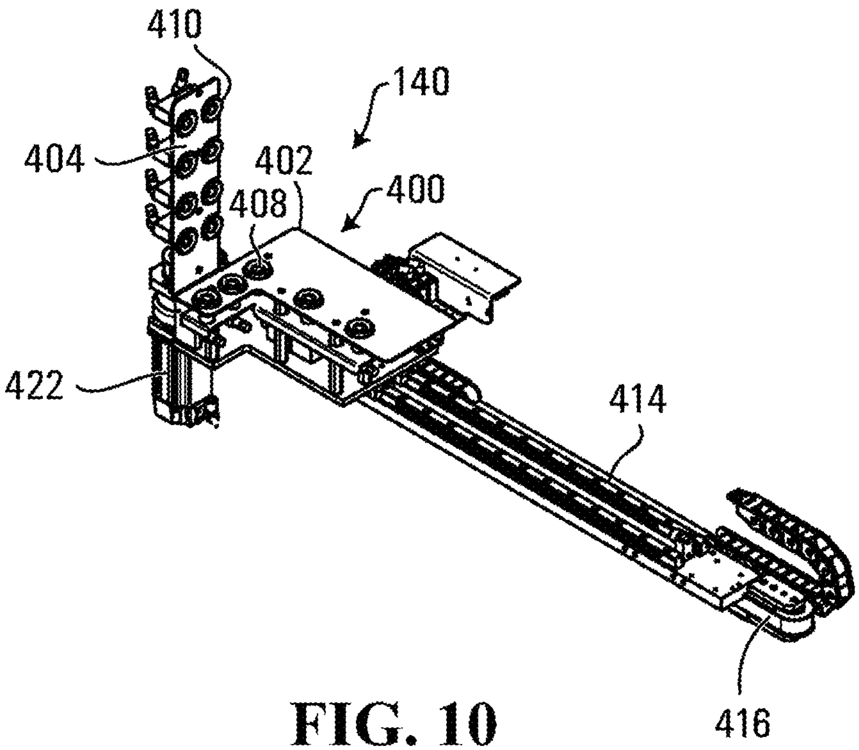

410
140
404
402
408
400
422
414
416

FIG. 10

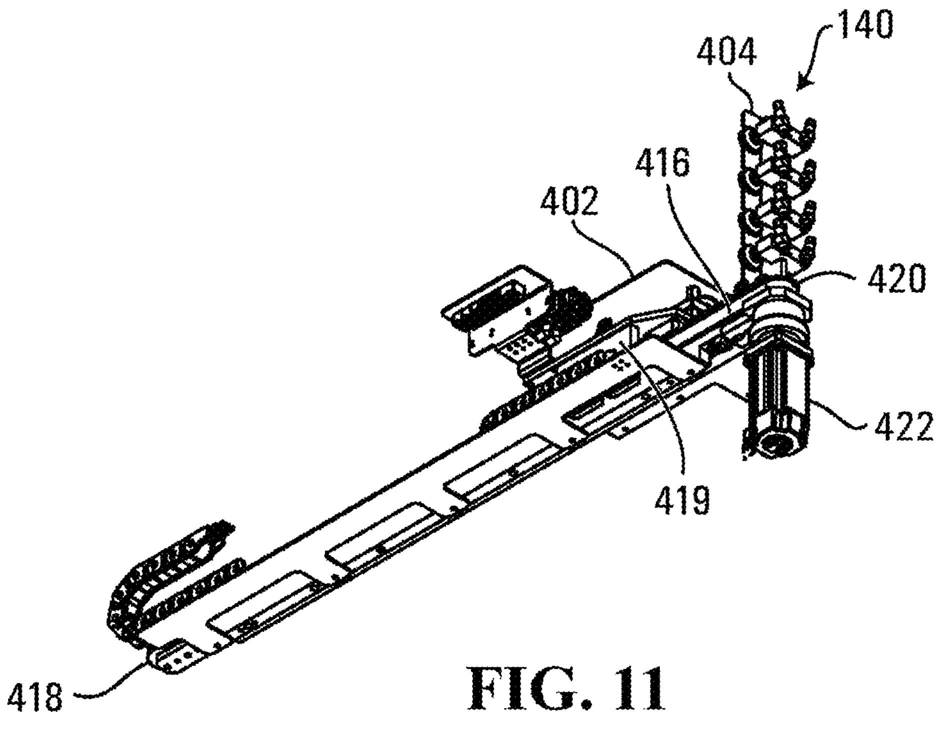

140
404
416
402
420
422
419
418

FIG. 11

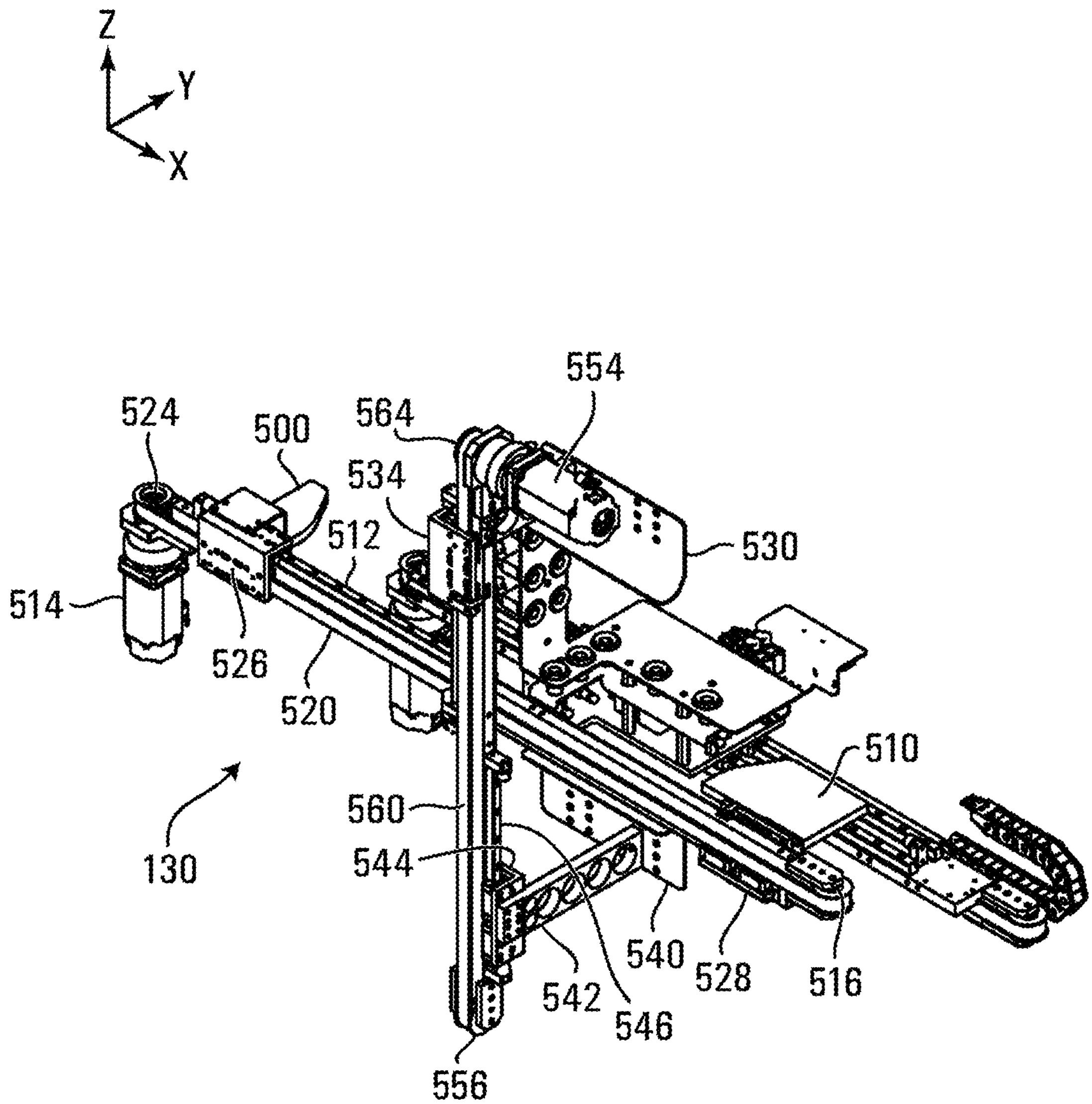

Z
Y
X
554
524
500
564
534
512
530
514
526
520
510
130
560
544
540
528
516
542
546
556

FIG. 12

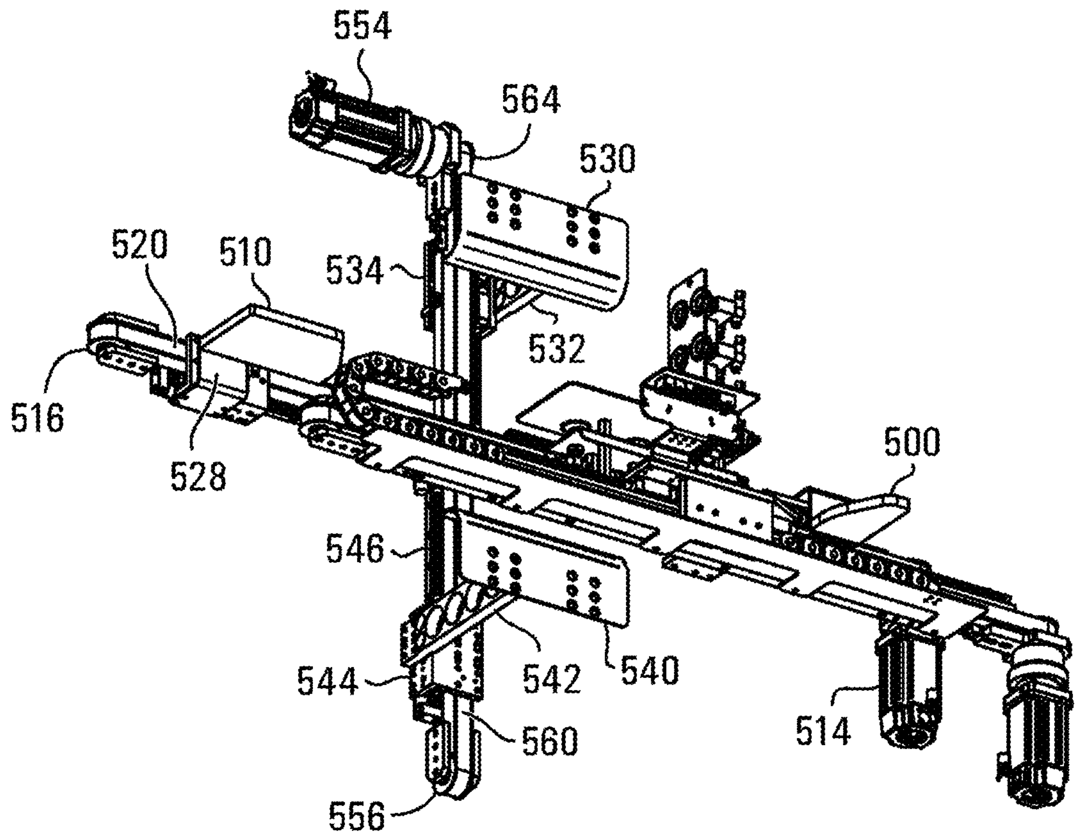

554
564
530
520
510
534
532
516
528
500
546
544
542
540
514
560
556

FIG. 13

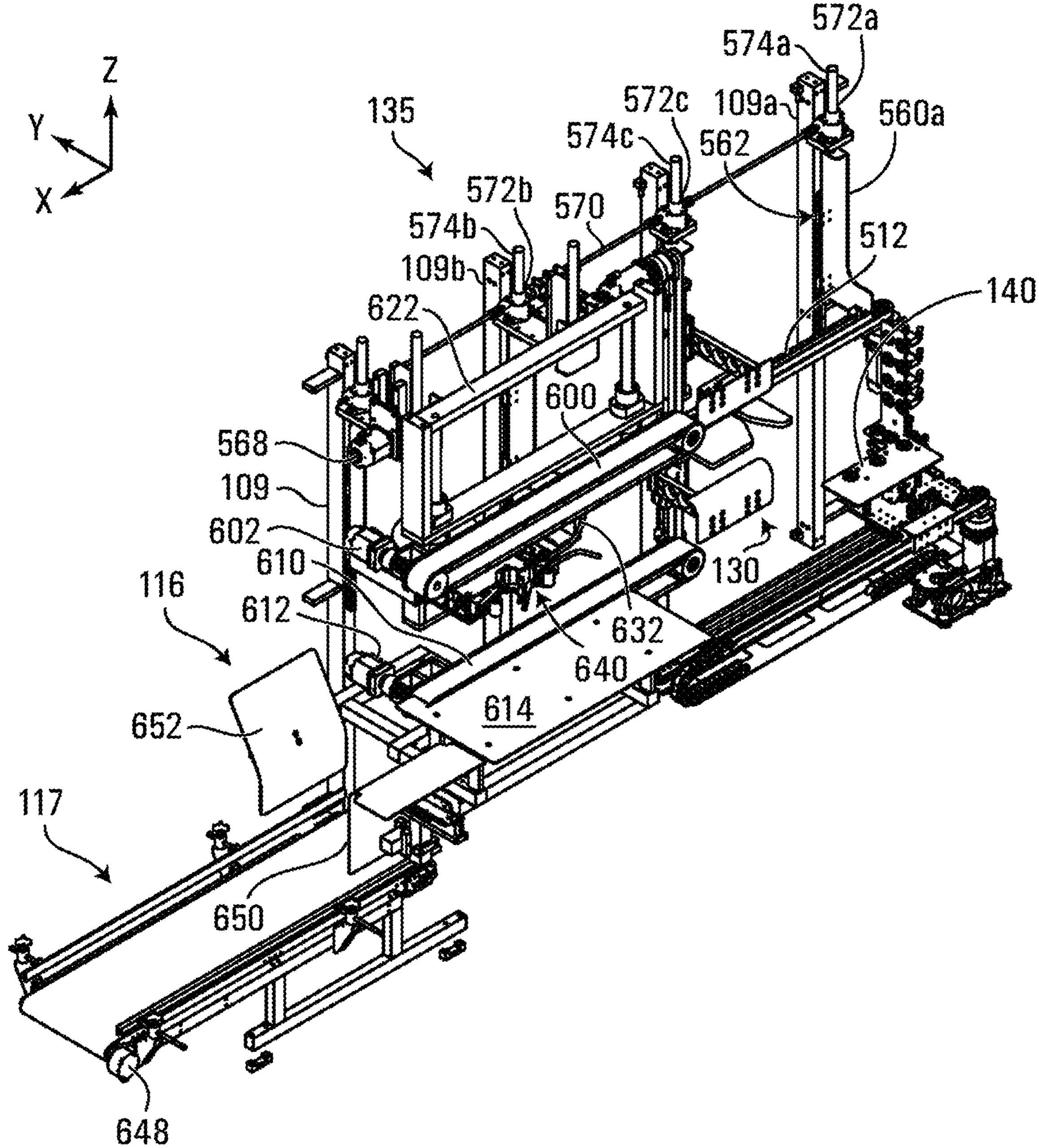

Z
Y
X
135
572a
574a
109a
560a
572c
574c
562
572b
570
574b
109b
512
140
622
600
568
109
602
610
612
116
130
632
640
614
652
117
650
648

FIG. 14

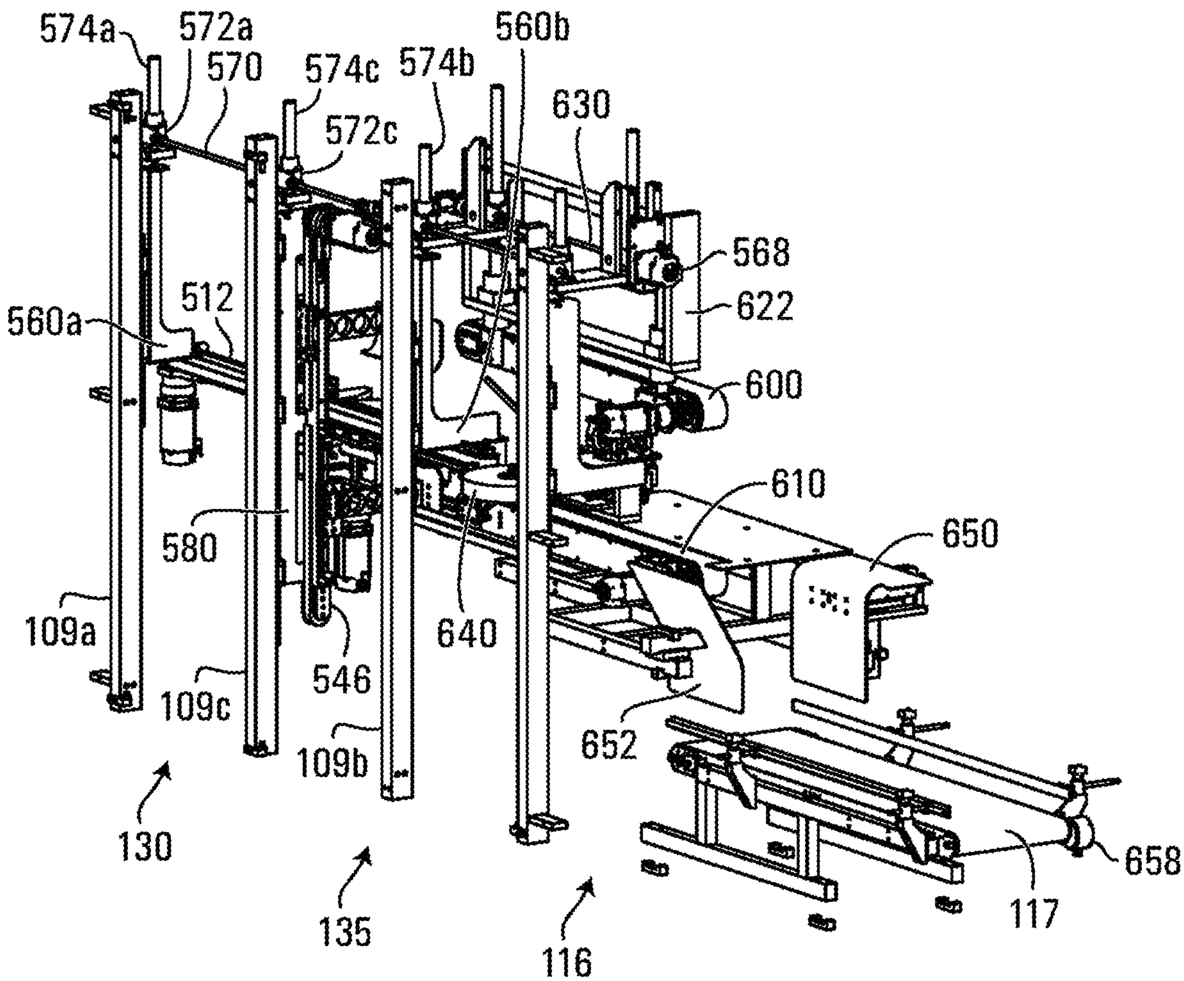

574a
572a
570
574c
572c
574b
560b
630
568
622
560a
512
600
610
650
580
640
109a
546
109c
652
109b
658
130
135
117
116

FIG. 15

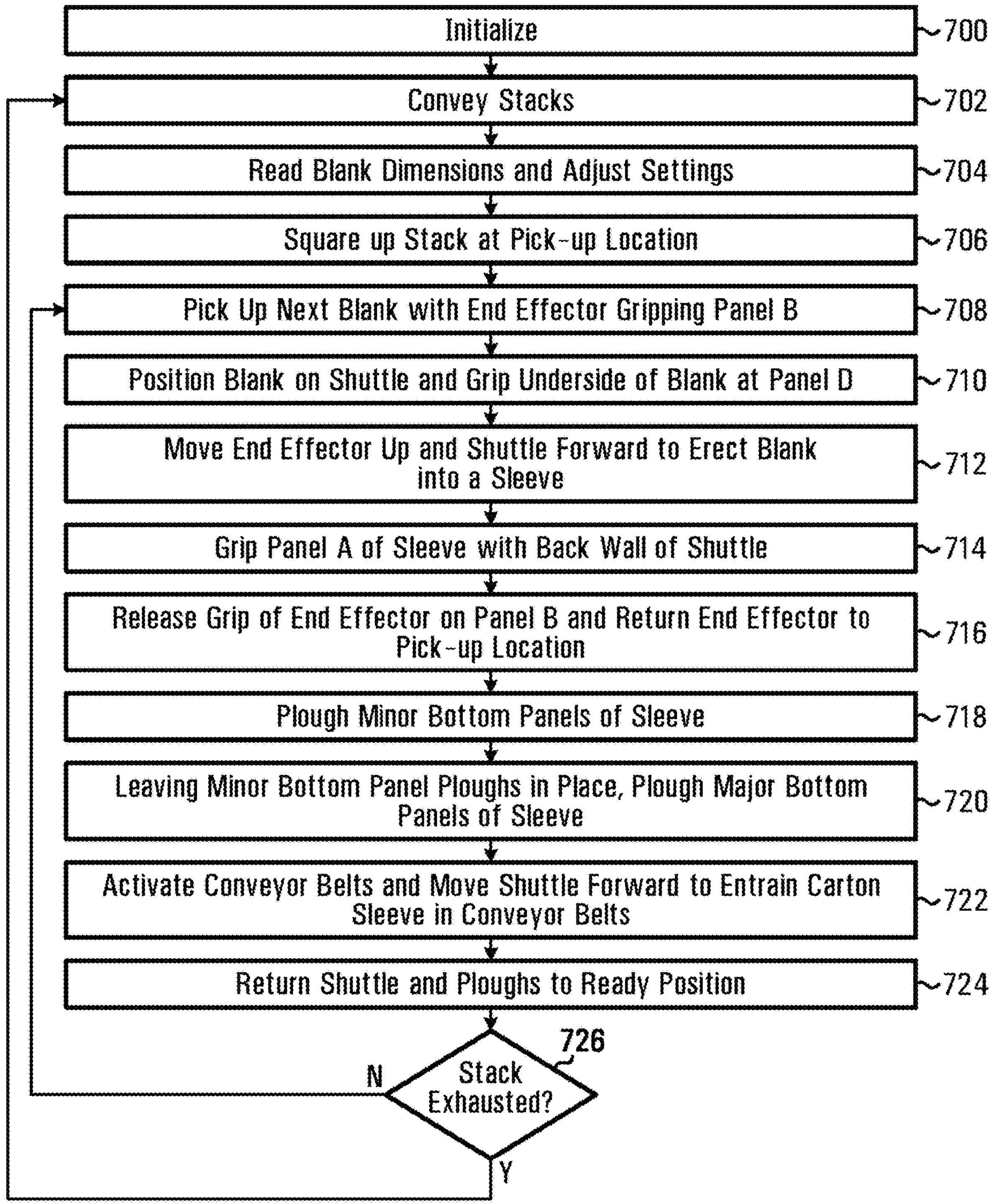

Initialize
700
Convey Stacks
702
Read Blank Dimensions and Adjust Settings
704
Square up Stack at Pick-up Location
706
Pick Up Next Blank with End Effector Gripping Panel B
708
Position Blank on Shuttle and Grip Underside of Blank at Panel D
710
Move End Effector Up and Shuttle Forward to Erect Blank into a Sleeve
712
Grip Panel A of Sleeve with Back Wall of Shuttle
714
Release Grip of End Effector on Panel B and Return End Effector to Pick-up Location
716
Plough Minor Bottom Panels of Sleeve
718
Leaving Minor Bottom Panel Ploughs in Place, Plough Major Bottom Panels of Sleeve
720
Activate Conveyor Belts and Move Shuttle Forward to Entrain Carton Sleeve in Conveyor Belts
722
Return Shuttle and Ploughs to Ready Position
724
Stack Exhausted?
726
N
Y

FIG. 16

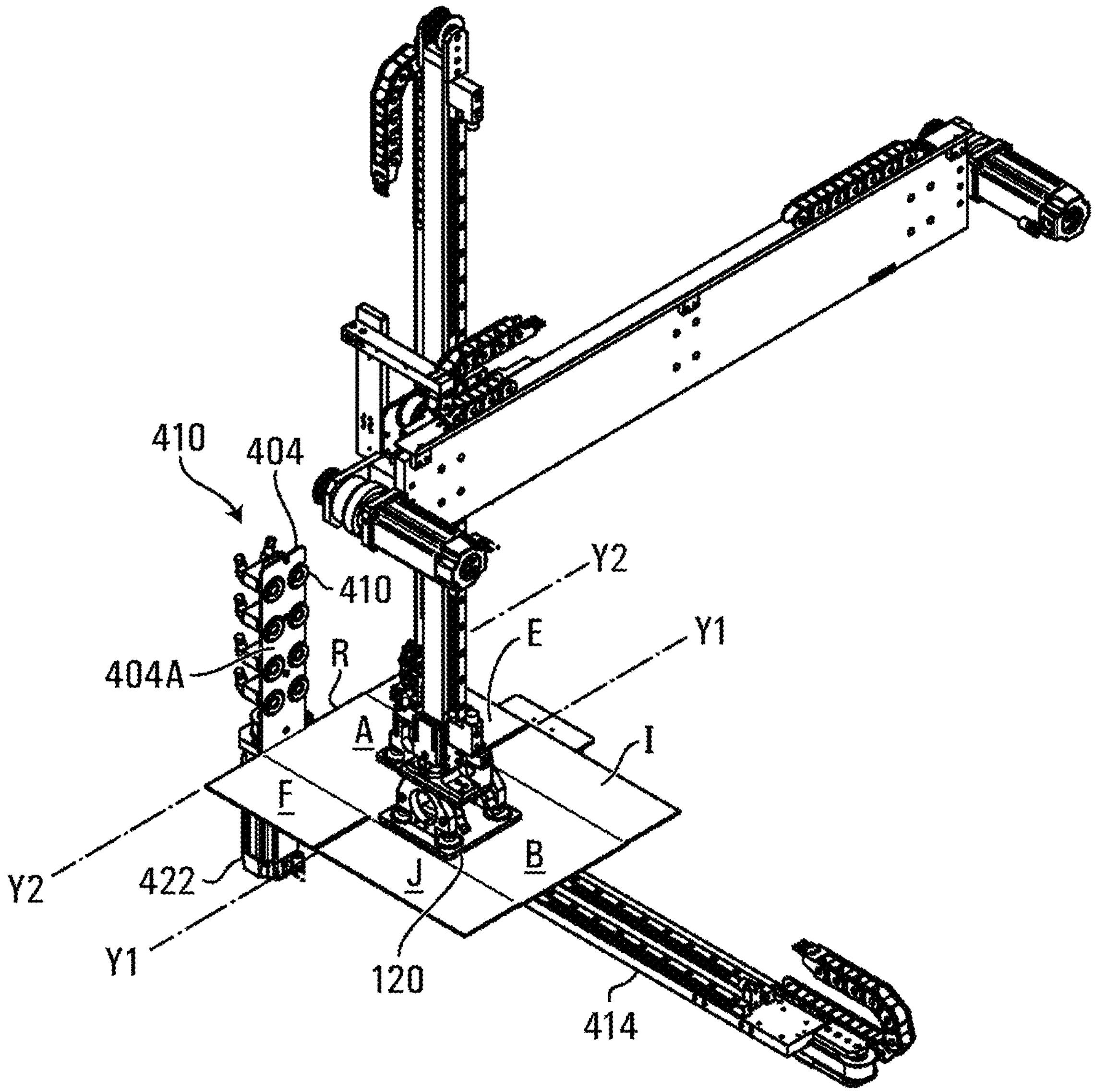



FIG. 17

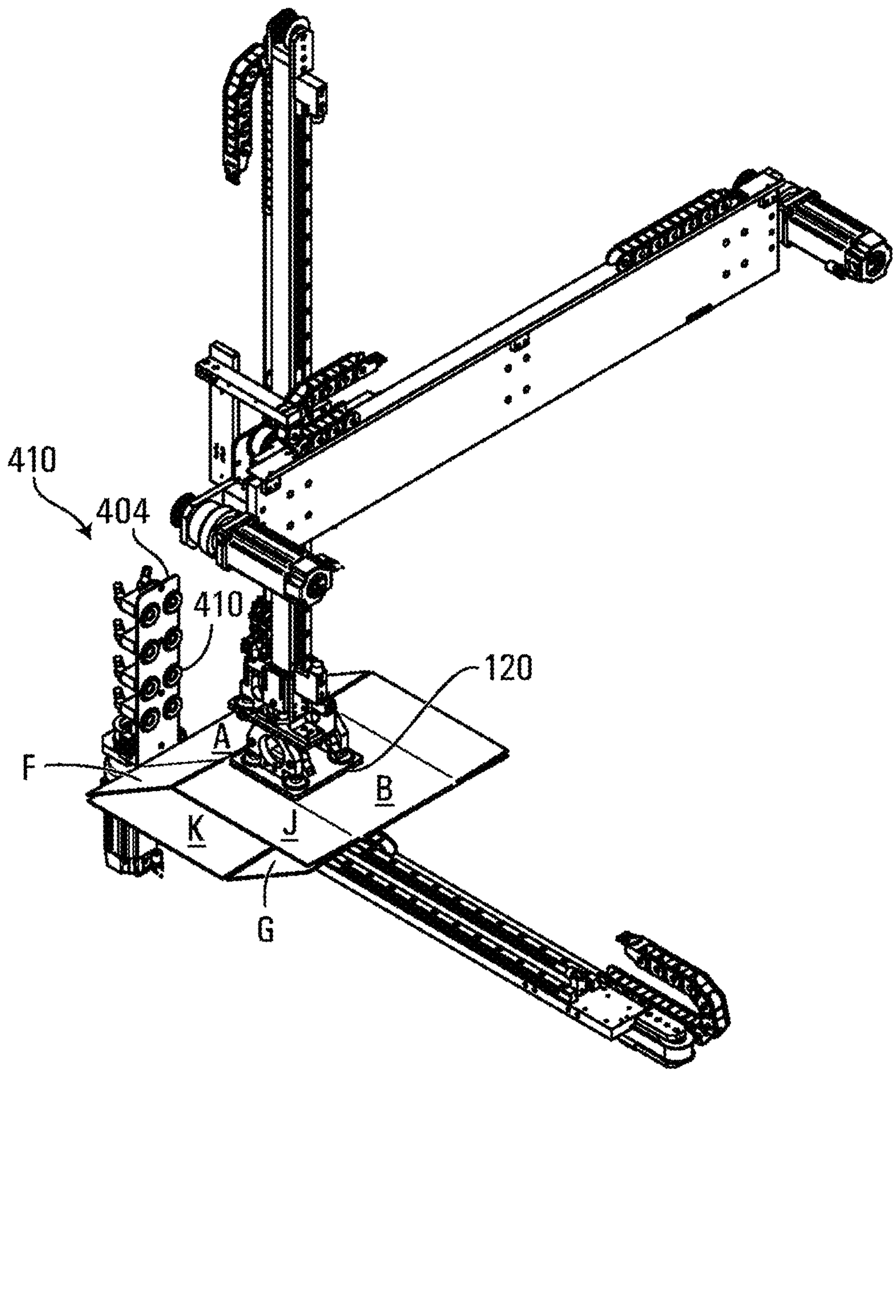



FIG. 18

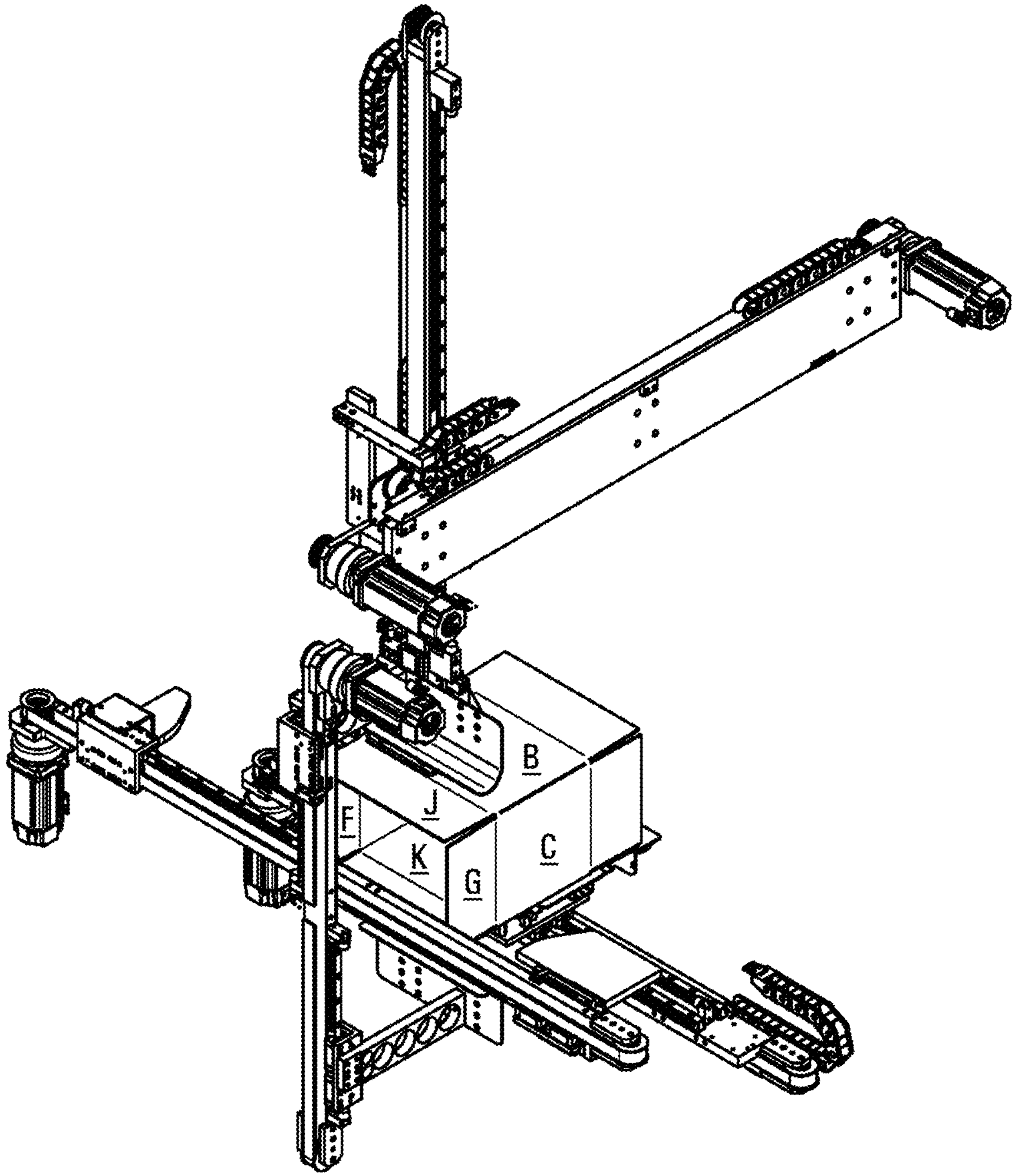



FIG. 19

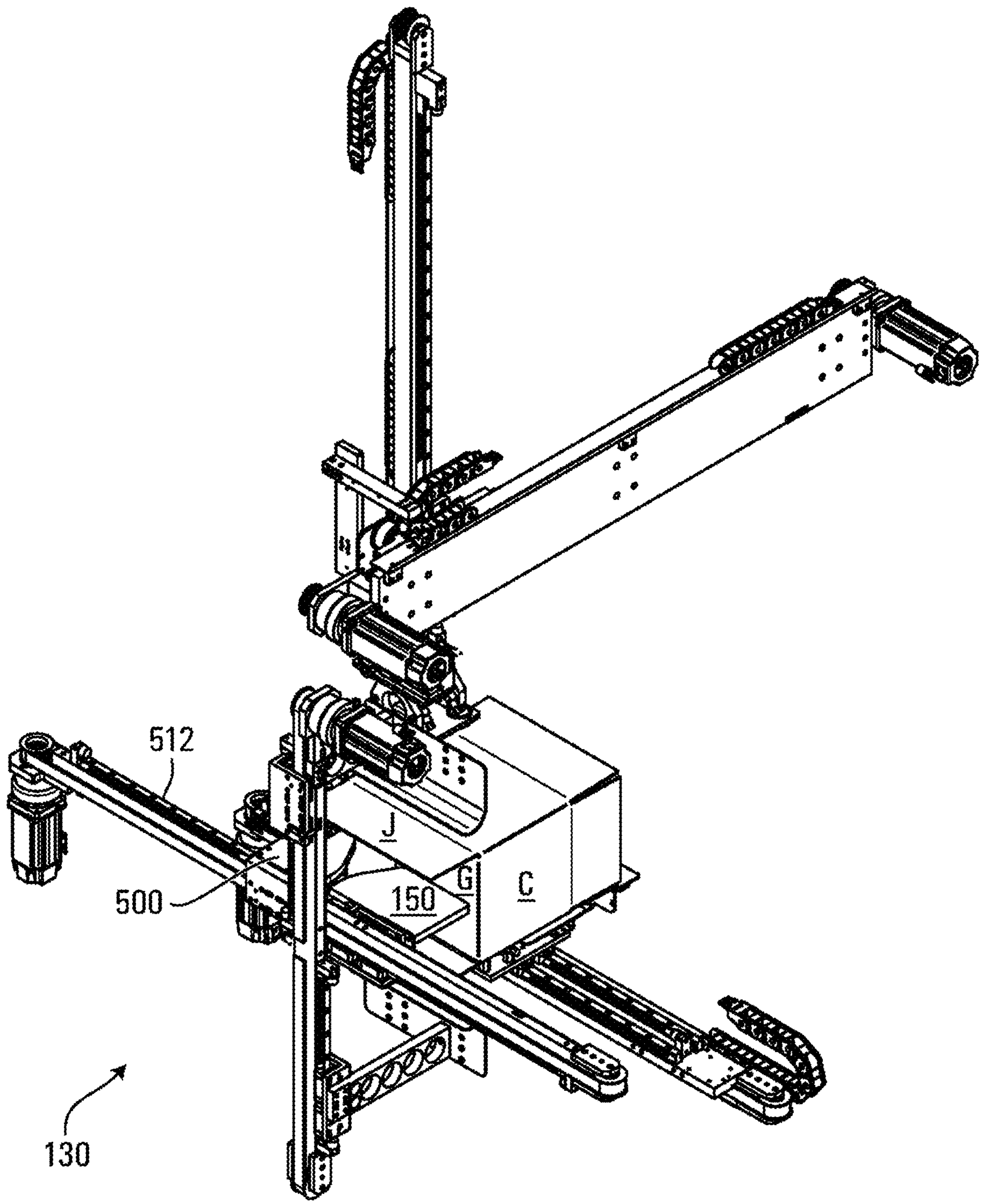



FIG. 20

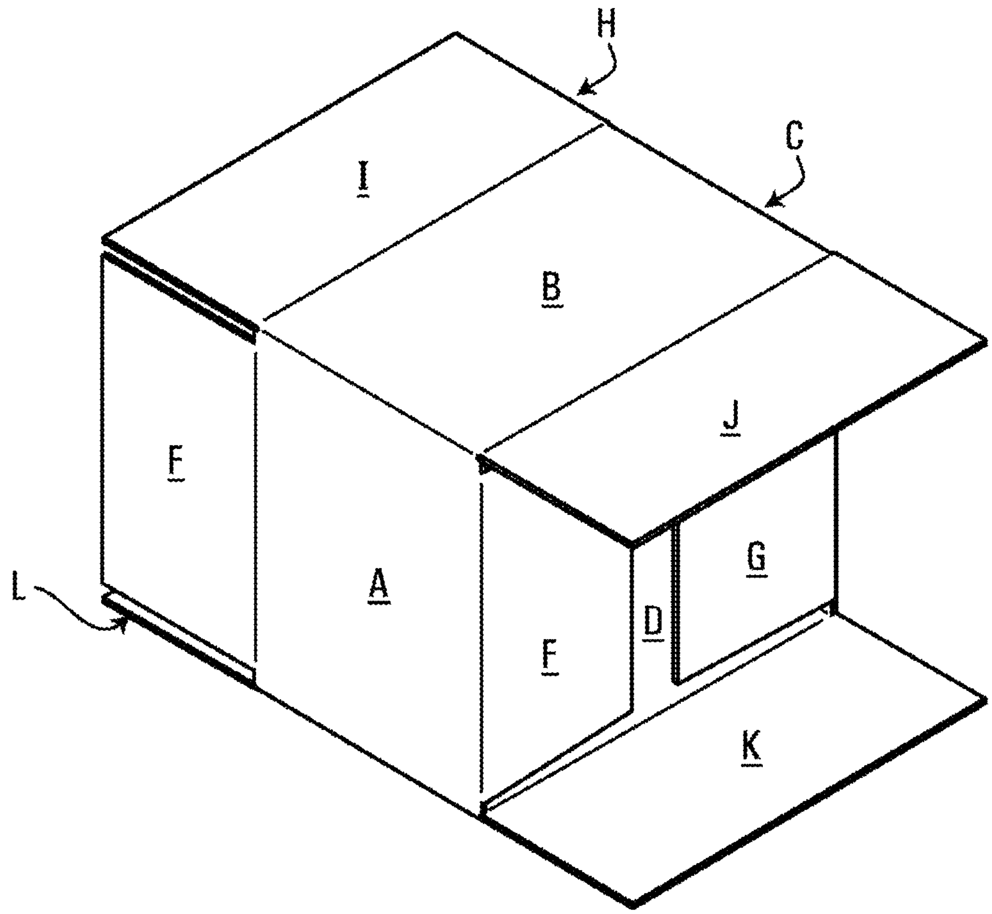



FIG. 21

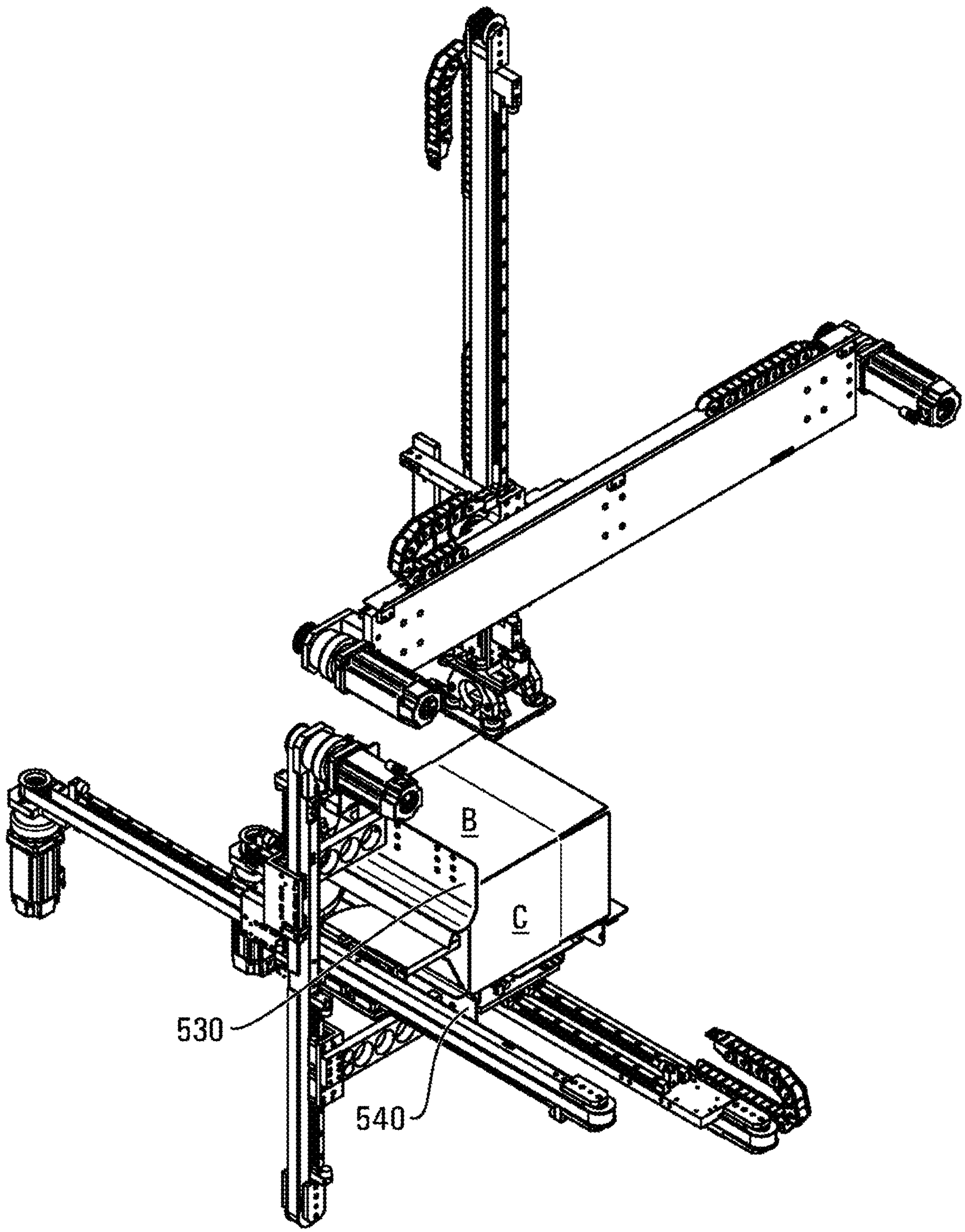



FIG. 22

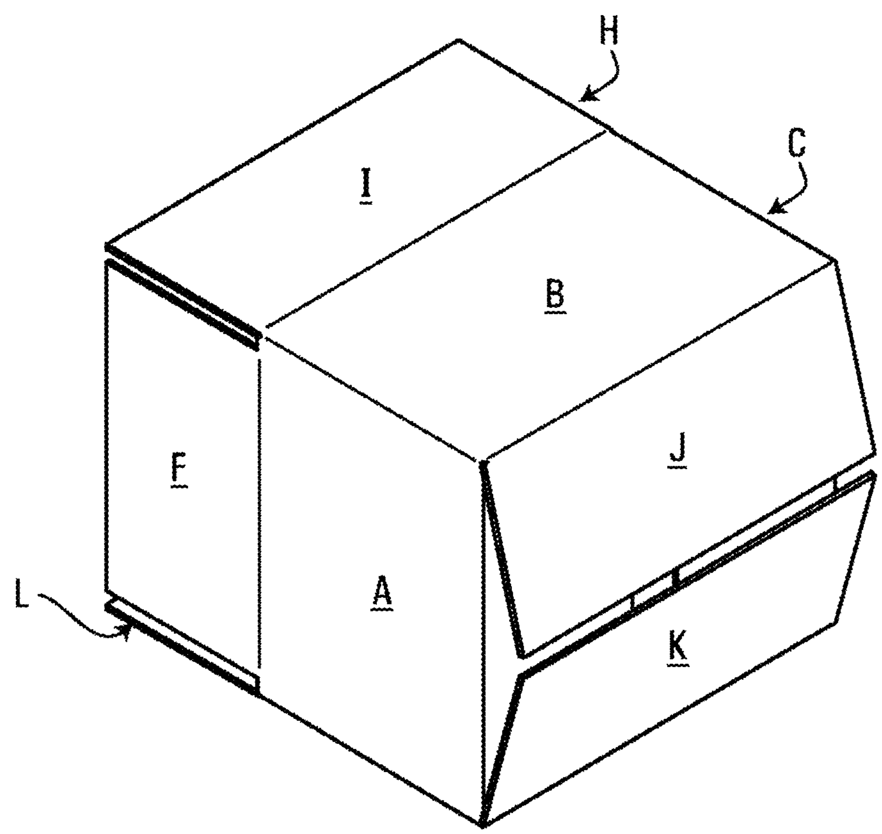



FIG. 23

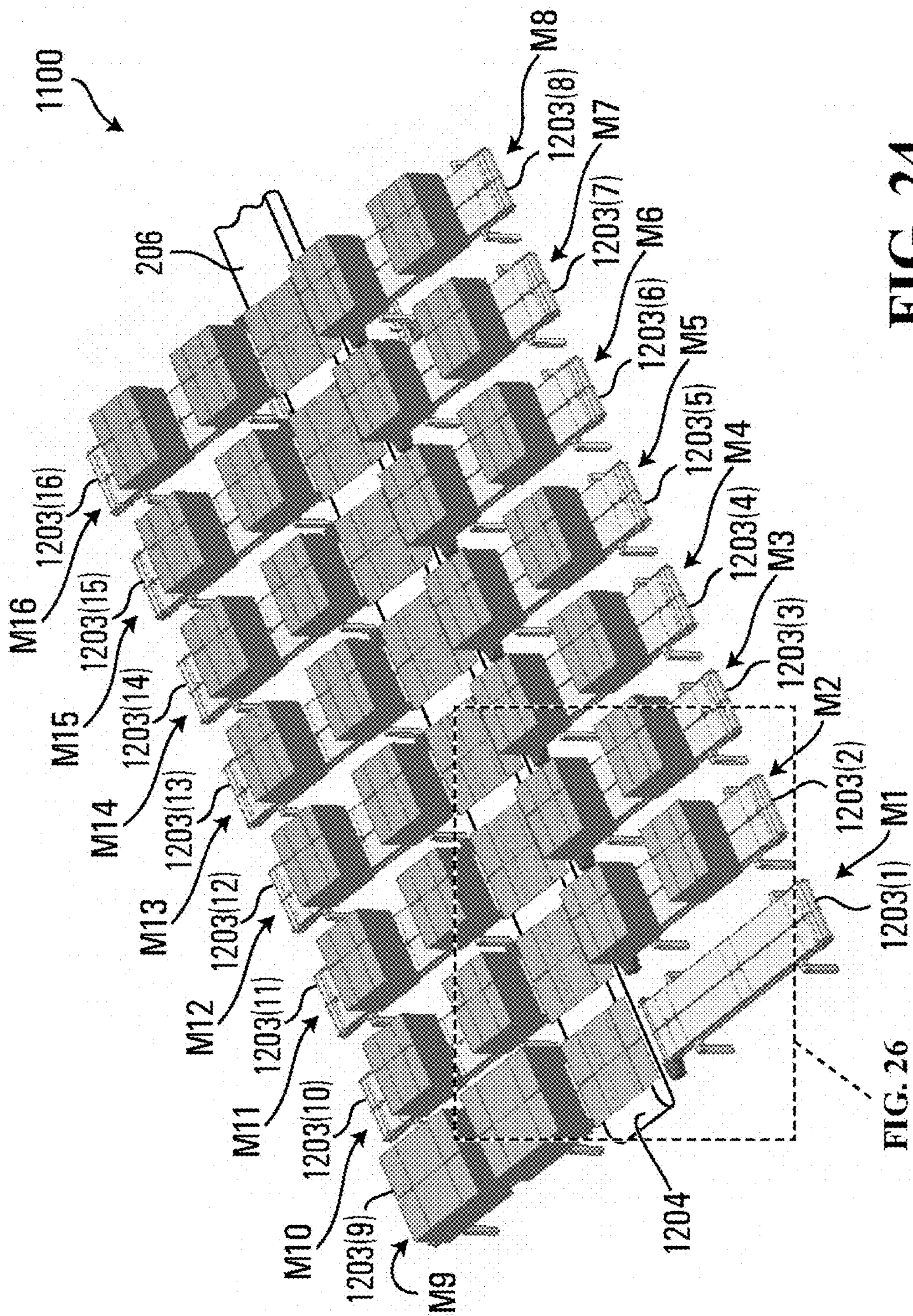

1100
206
M1
M2
M3
M4
M5
M6
M7
M8
M9
M10
M11
M12
M13
M14
M15
M16
1203(1)
1203(2)
1203(3)
1203(4)
1203(5)
1203(6)
1203(7)
1203(8)
1203(9)
1203(10)
1203(11)
1203(12)
1203(13)
1203(14)
1203(15)
1203(16)
1204
FIG. 26

FIG. 24

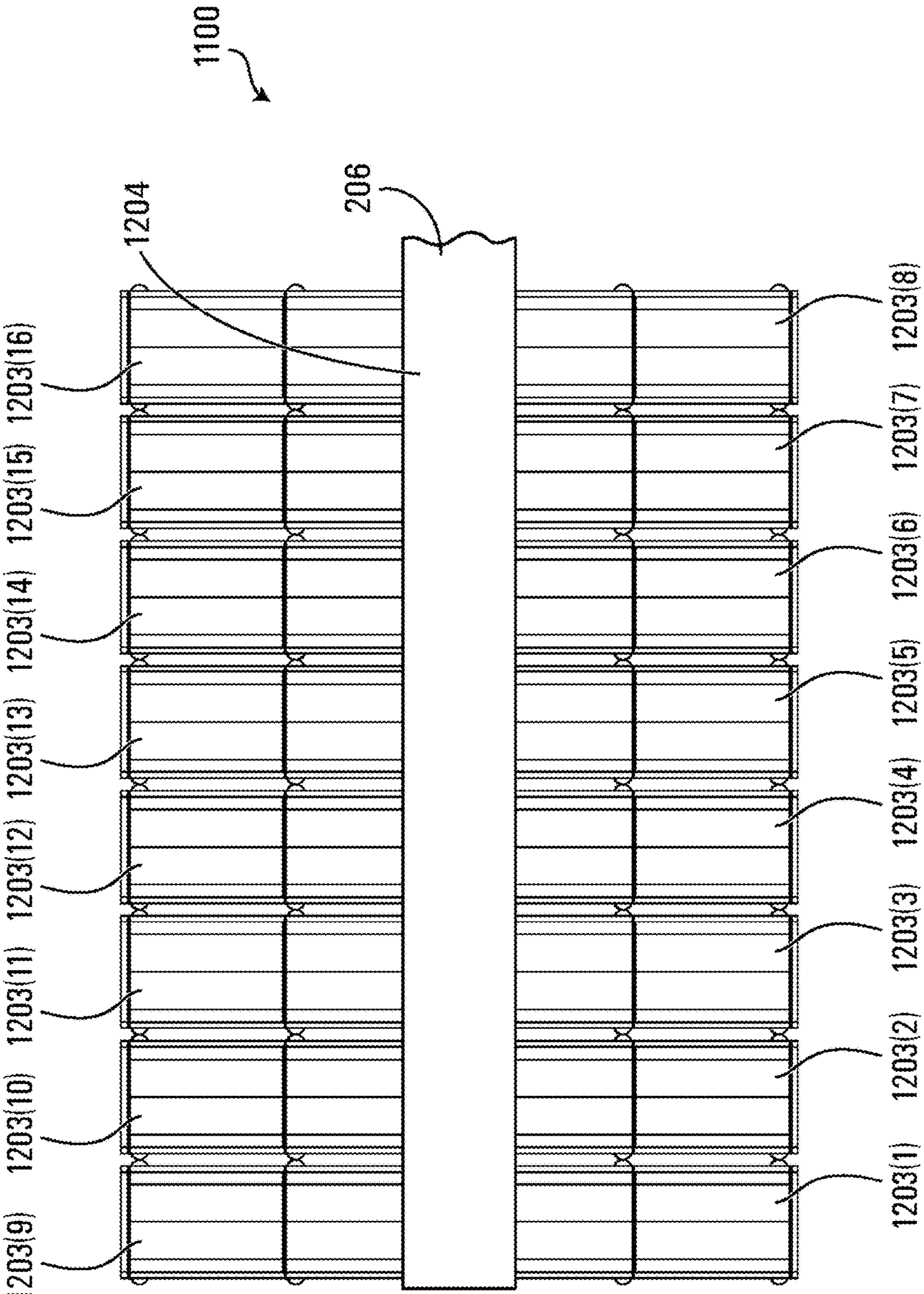

1100
206
1204
1203(16)
1203(15)
1203(14)
1203(13)
1203(12)
1203(11)
1203(10)
1203(9)
1203(8)
1203(7)
1203(6)
1203(5)
1203(4)
1203(3)
1203(2)
1203(1)

FIG. 25

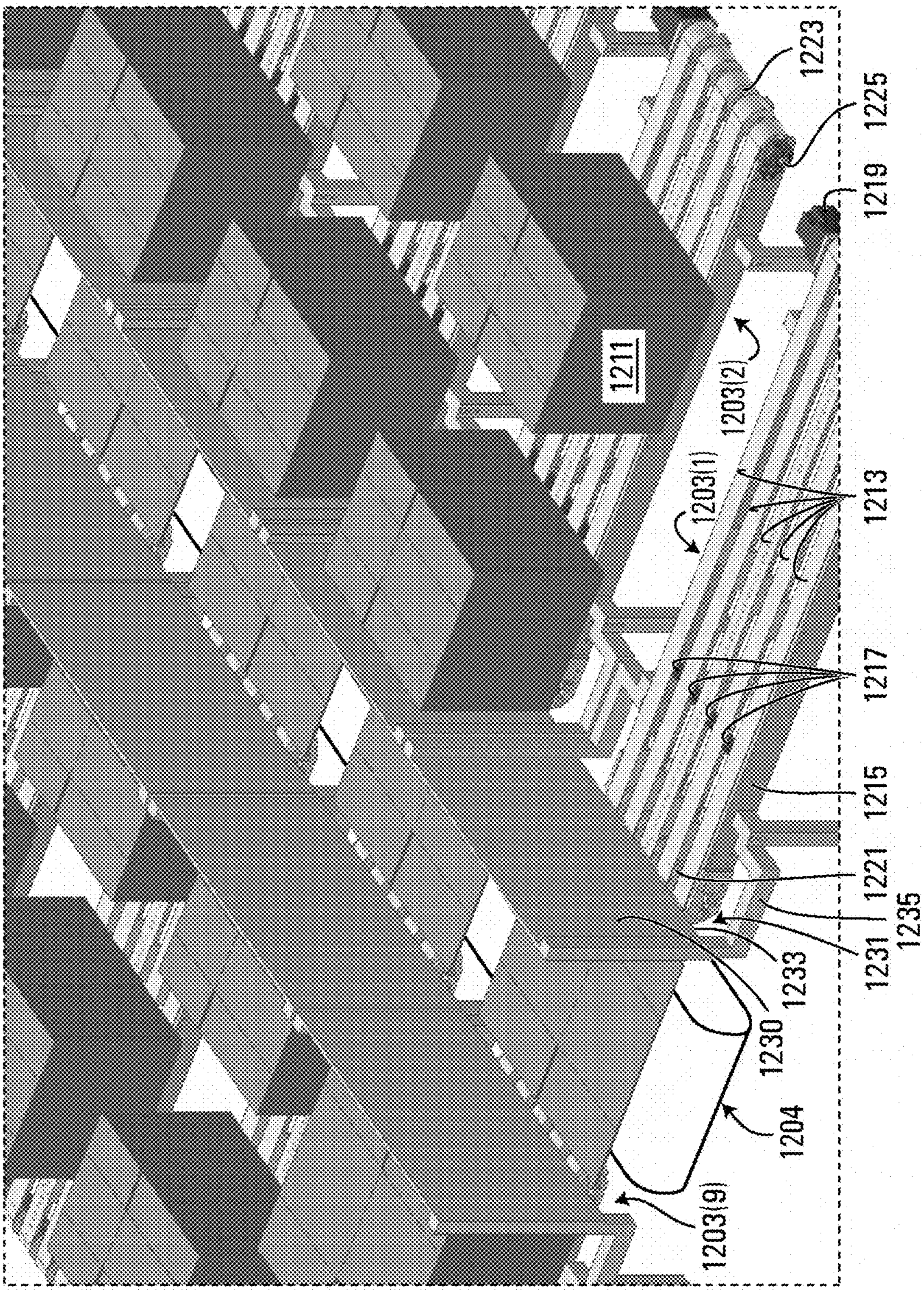

1223
1225
1219
1211
1203(2)
1203(1)
1213
1217
1215
1221
1235
1231
1233
1230
1204
1203(9)

FIG. 26

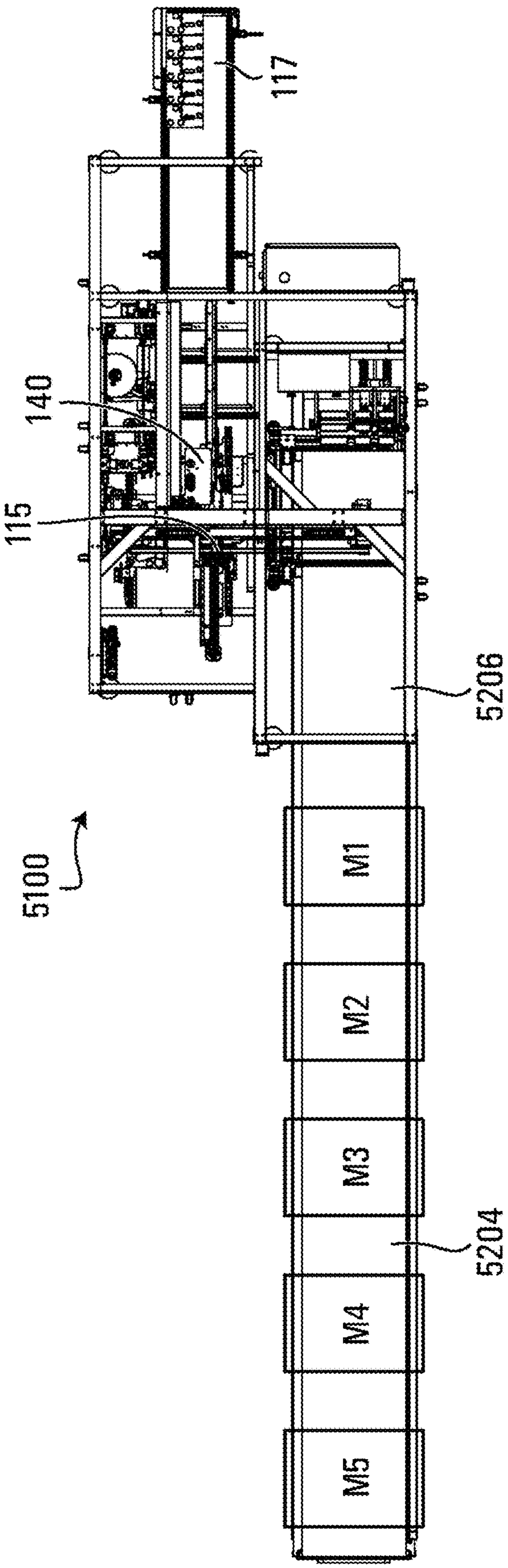
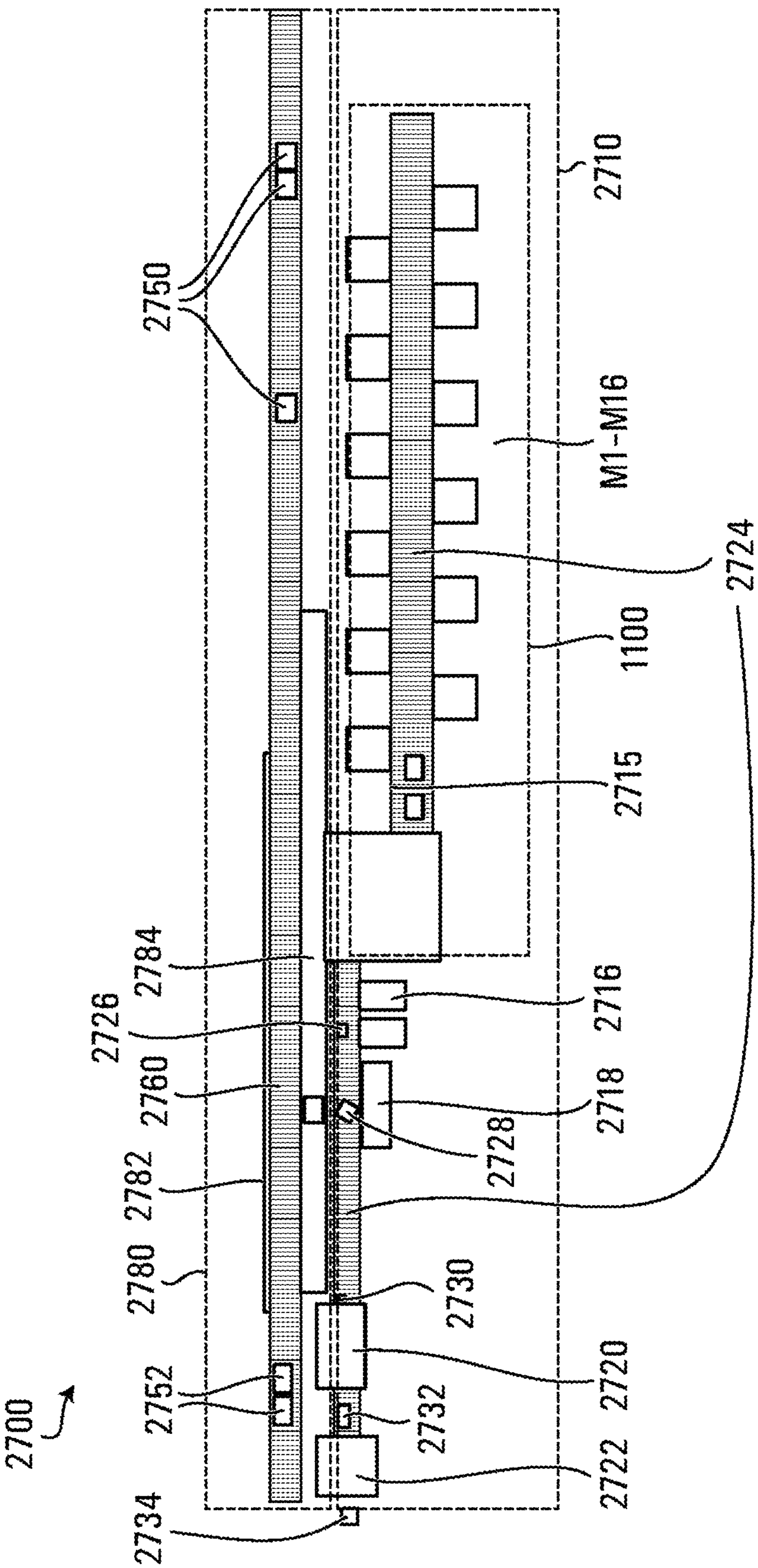



FIG. 26A



2700
2710
2750
M1-M16
2724
1100
2715
2784
2716
2726
2760
2718
2728
2782
2780
2730
2720
2752
2732
2722
2734


FIG. 27

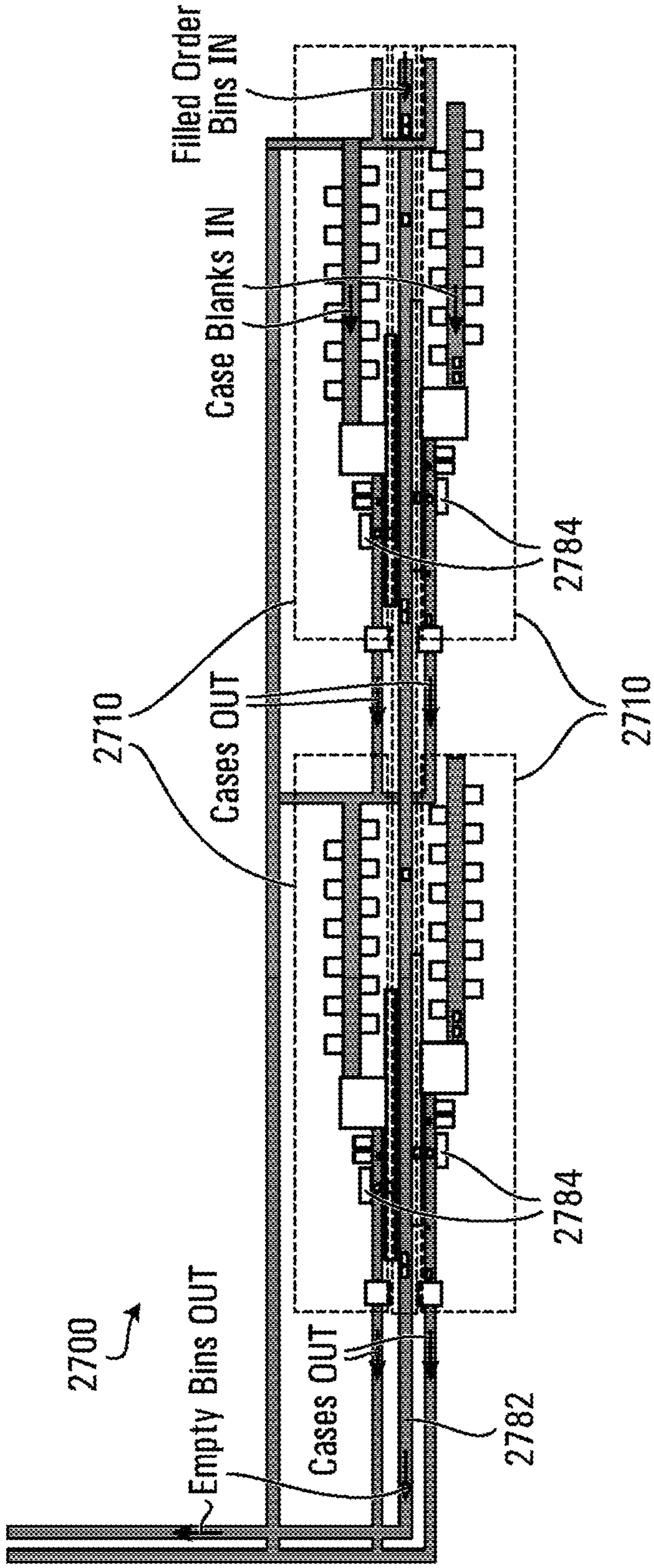

Filled Order Bins IN
Case Blanks IN
2784
2710
Cases OUT
2710
2784
2700
Empty Bins OUT
Cases OUT
2782

FIG. 28

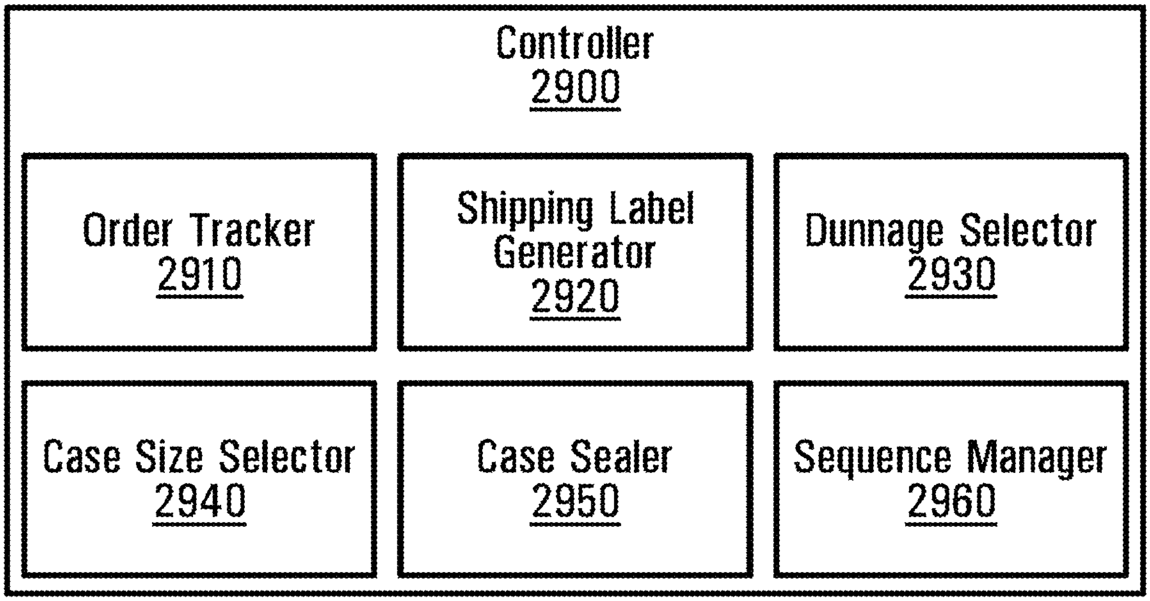

Controller
2900
Order Tracker
2910
Shipping Label Generator
2920
Dunnage Selector
2930
Case Size Selector
2940
Case Sealer
2950
Sequence Manager
2960

FIG. 29

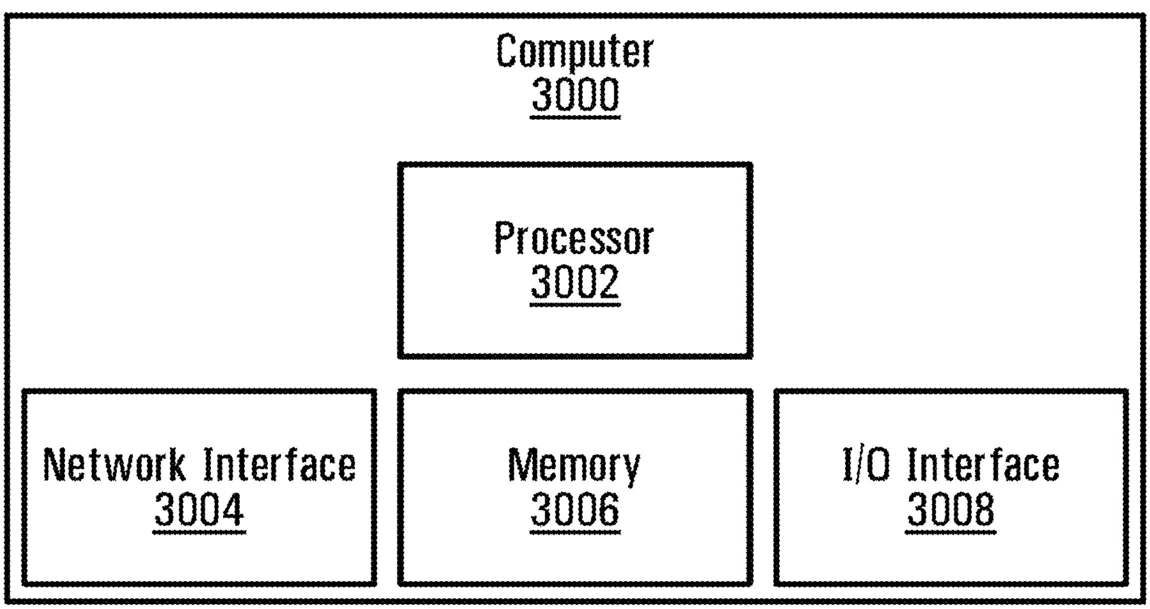

Computer
3000
Processor
3002
Network Interface
3004
Memory
3006
I/O Interface
3008

FIG. 30

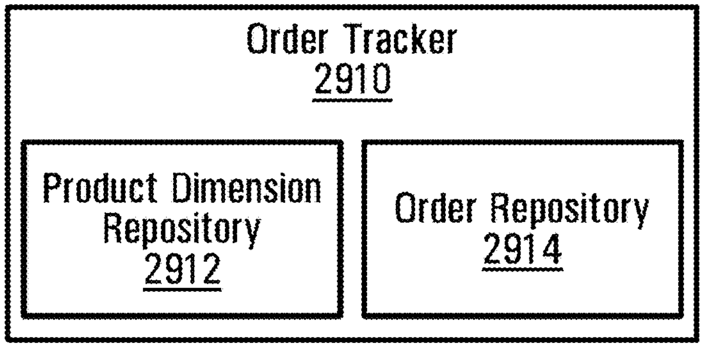



FIG. 31

2912

| Product_ID | Product_L | Product_W | Product_D |
|---|---|---|---|
| 20576 | 16.8 | 21.5 | 22.8 |
| 20027 | 19.4 | 21.2 | 15.2 |
| 99178 | 23.7 | 28.3 | 27.0 |
| 62060 | 29.9 | 19.1 | 10.1 |
| 46097 | 6.4 | 14.7 | 6.7 |

3206

3208

FIG. 32

2914

| Order ID | Bin ID | Product_IDs | Case Size | Dunnage_Type | Dunnage_Length | Packing Cell |
|---|---|---|---|---|---|---|
| 90001 | 9114 | 424234;<br>424234;<br>834588; | 5 | Bubble | 6.35 | 1 |
| 9000 | 9117 | 235873;<br>932293; | 7 | Paper | 2.73 | 6 |
| 90005 | 9118 | 578678 | 3 | Paper | 1.57 | 3 |
| 90006 | 9119 | 235238 | 8 | Paper | 3.47 | 4 |
| 90007 | 9120 | 667868;<br>281584;<br>273641; | 5 | Bubble | 4.41 | 5 |

3302 3304 3306 3308 3310 3312 3314

FIG. 33

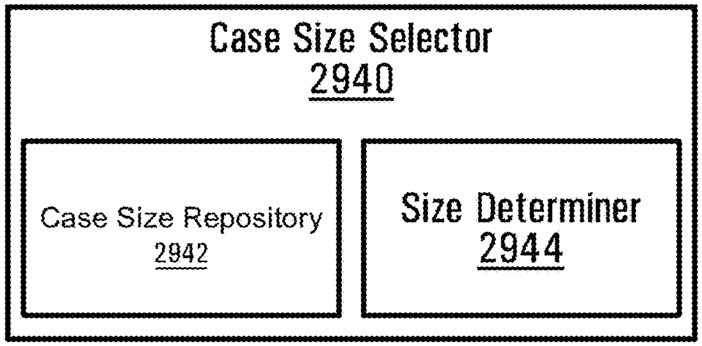



FIG. 34

2942

| Case Size ID | Total Product Vol Min. | Total Product Vol Max. | Height | Width | Depth | Packing Cell |
|---|---|---|---|---|---|---|
| 1 | 500 | 1000 | 10 | 10 | 10 | 1,2,3 |
| 2 | 1001 | 3375 | 15 | 15 | 15 | 2,3,4 |
| 3 | 3376 | 8000 | 20 | 20 | 20 | 1,3,4 |
| 4 | 8001 | 15625 | 25 | 25 | 25 | 1 |
| 5 | 15626 | 27000 | 30 | 30 | 30 | 4 |

3502 3504 3506 3208 3510

FIG. 35

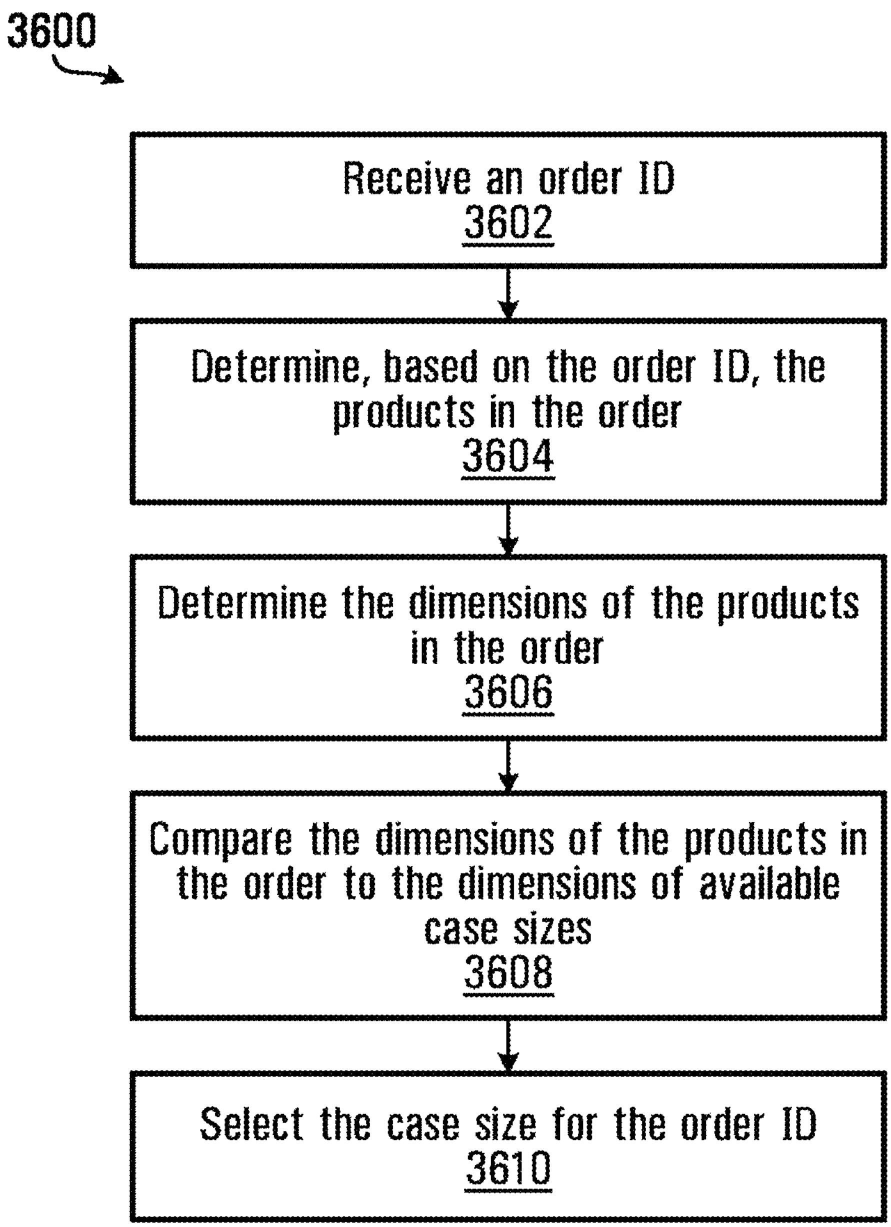

3600
Receive an order ID
3602
Determine, based on the order ID, the products in the order
3604
Determine the dimensions of the products in the order
3606
Compare the dimensions of the products in the order to the dimensions of available case sizes
3608
Select the case size for the order ID
3610

FIG. 36

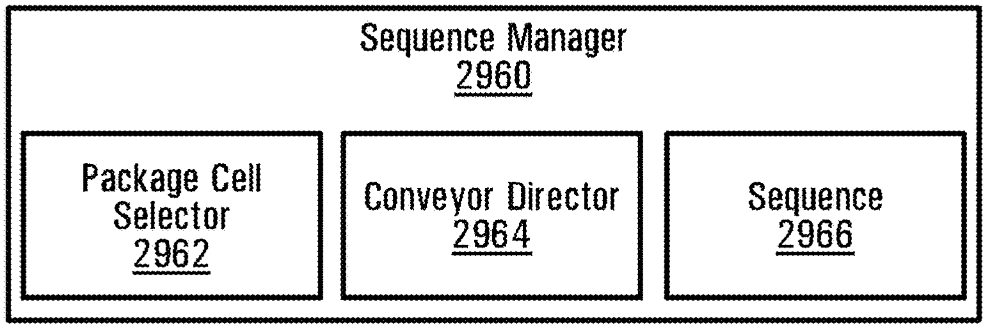



FIG. 37

2966

| Order ID | Bin ID | Case Size | Dunnage_Type | Dunnage_Length | Packing Cell |
|---|---|---|---|---|---|
| 90011 | 9124 | 2 | Paper | 6.34 | 1 |
| 90012 | 9127 | 3 | Paper | 3.47 | 1 |
| 90013 | 9128 | 3 | Paper | 9.38 | 1 |
| 90014 | 9129 | 1 | Paper | 2.73 | 1 |
| 90015 | 9120 | 4 | Paper | 1.57 | 1 |

3302 3304 3308 3310 3312 3314

FIG. 38

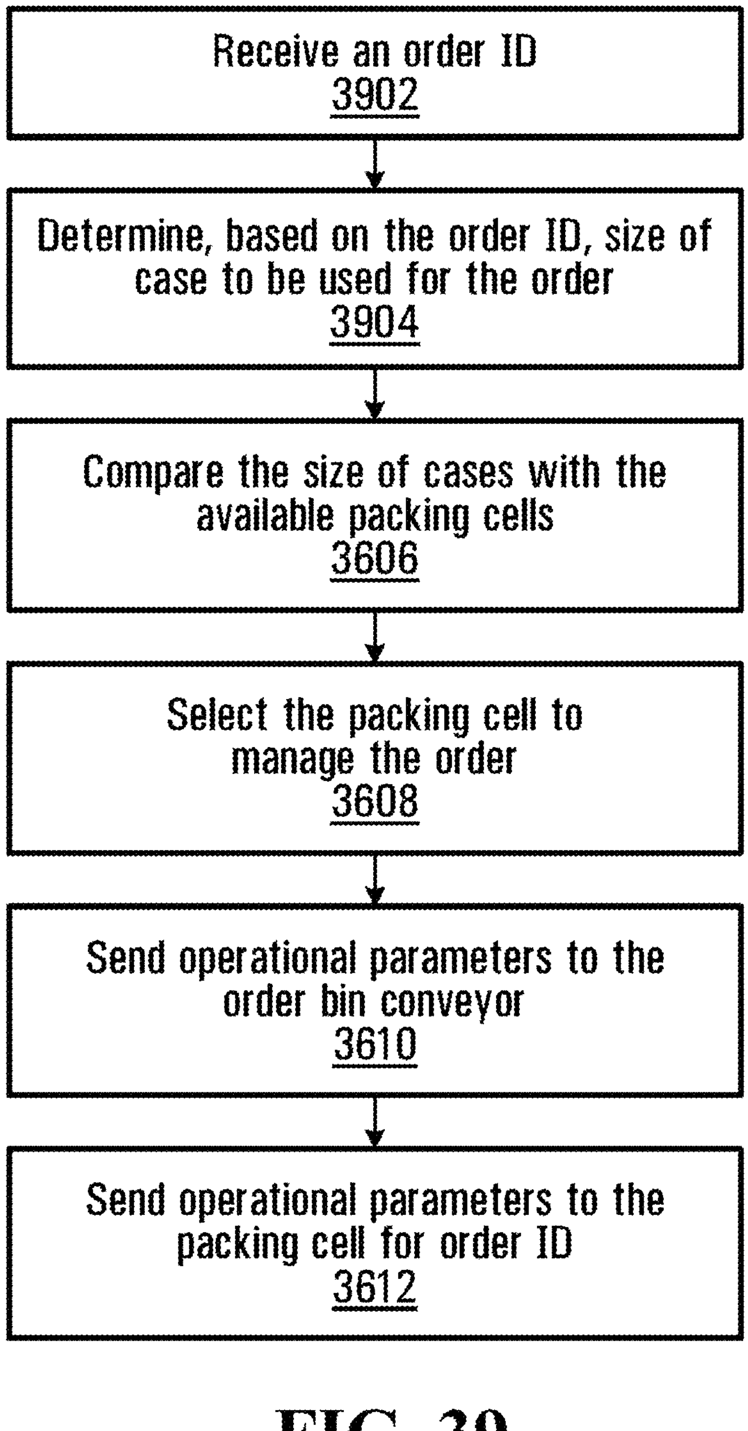

Receive an order ID
3902
Determine, based on the order ID, size of case to be used for the order
3904
Compare the size of cases with the available packing cells
3606
Select the packing cell to manage the order
3608
Send operational parameters to the order bin conveyor
3610
Send operational parameters to the packing cell for order ID
3612

FIG. 39

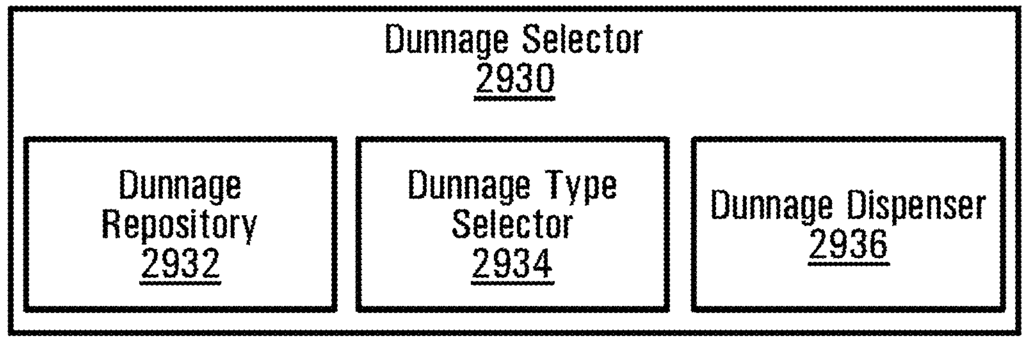

Dunnage Selector
2930
Dunnage Repository
2932
Dunnage Type Selector
2934
Dunnage Dispenser
2936

FIG. 40

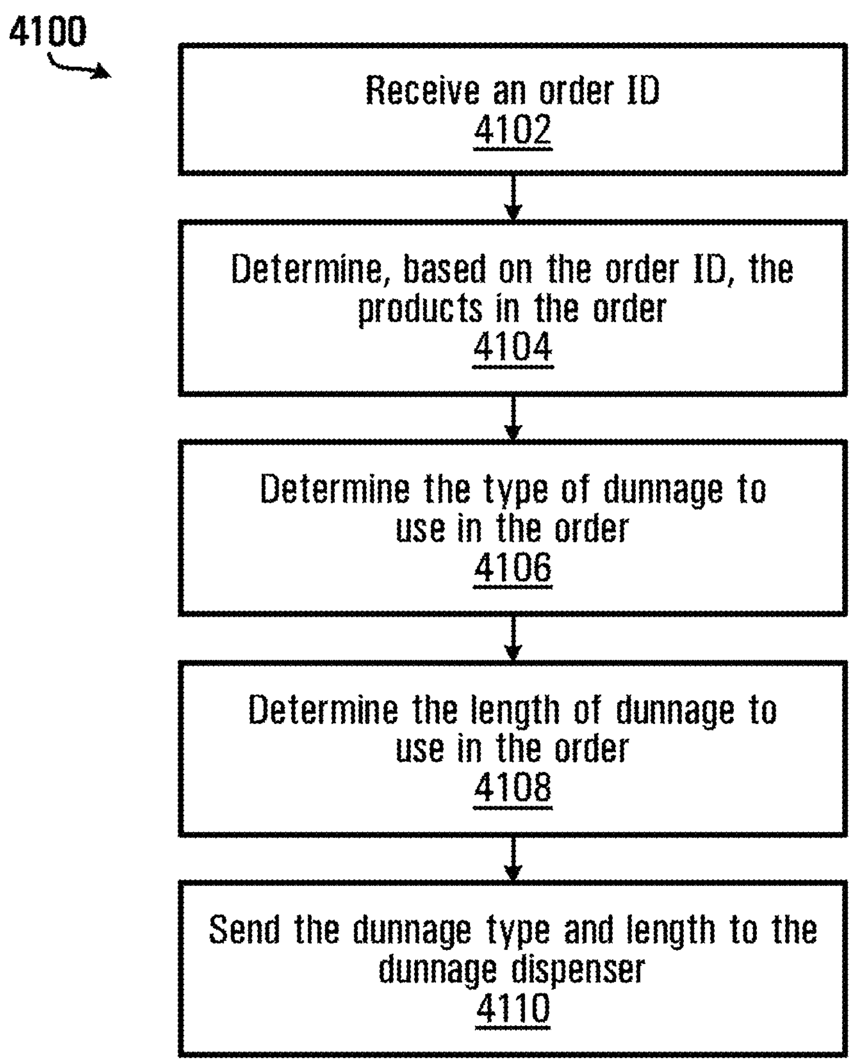

4100
Receive an order ID
4102
Determine, based on the order ID, the products in the order
4104
Determine the type of dunnage to use in the order
4106
Determine the length of dunnage to use in the order
4108
Send the dunnage type and length to the dunnage dispenser
4110

FIG. 41

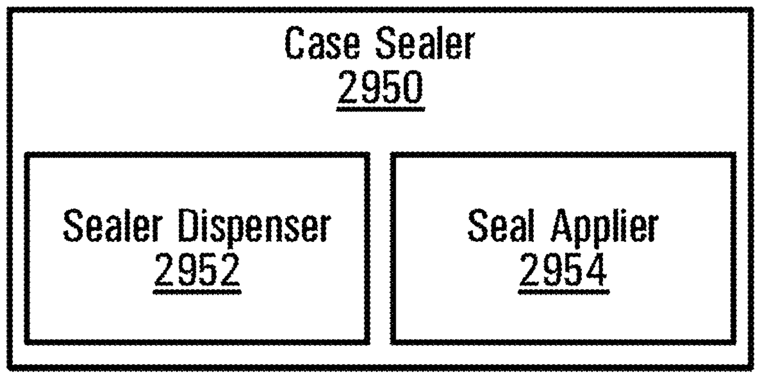

Case Sealer
2950
Sealer Dispenser
2952
Seal Applier
2954

FIG. 42

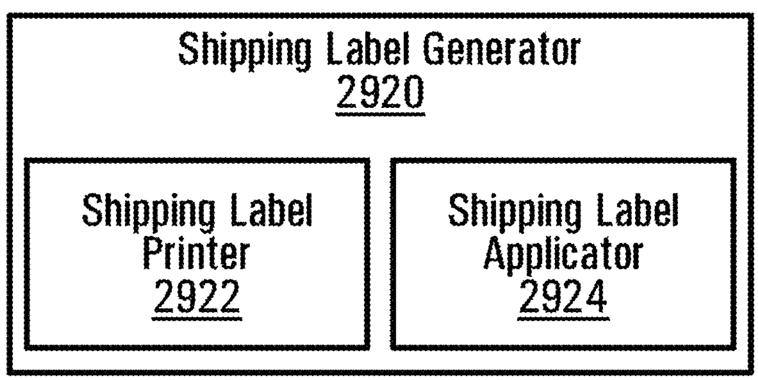

Shipping Label Generator
2920
Shipping Label
Printer
2922
Shipping Label
Applicator
2924

FIG. 43

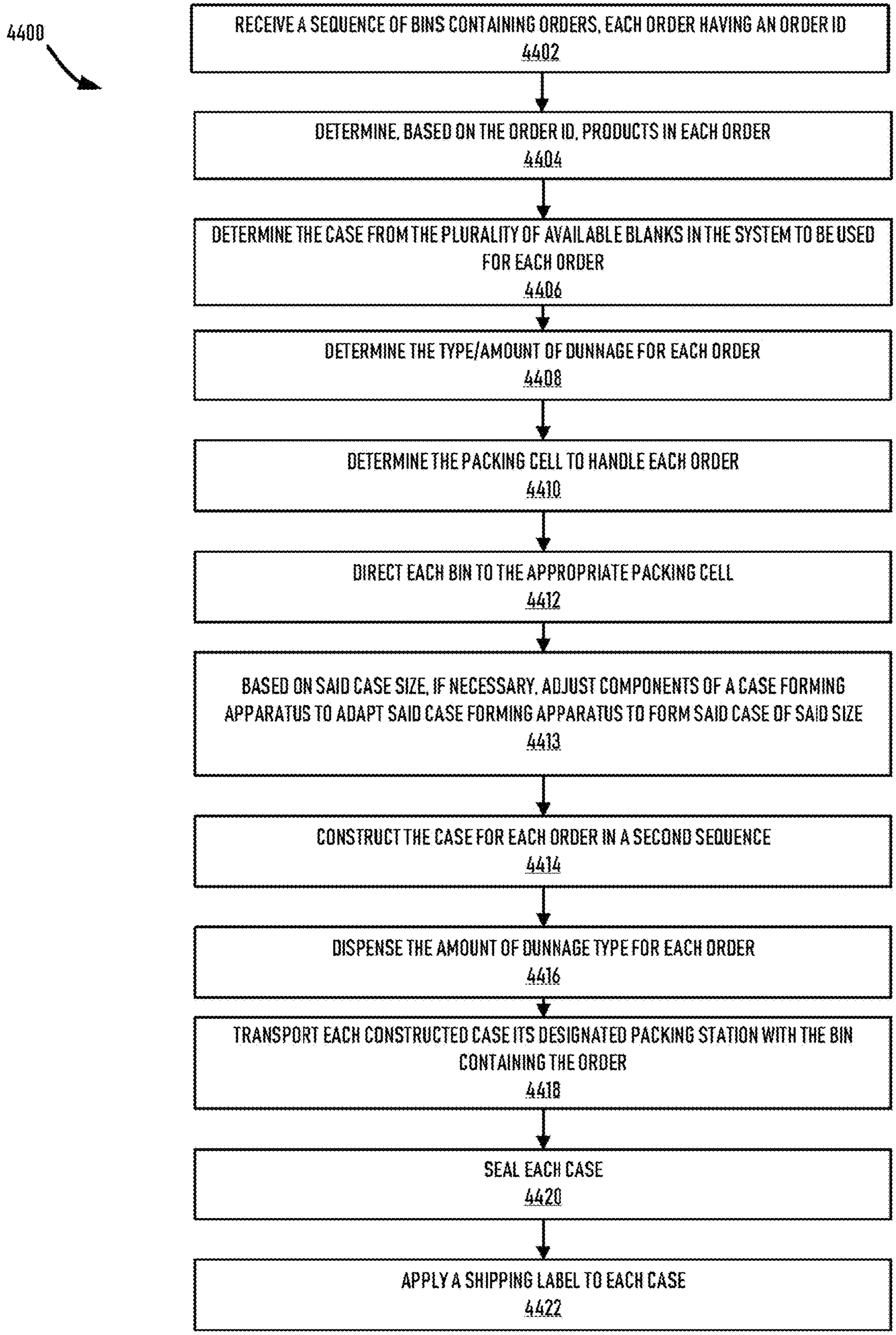

4400
RECEIVE A SEQUENCE OF BINS CONTAINING ORDERS, EACH ORDER HAVING AN ORDER ID
4402
DETERMINE, BASED ON THE ORDER ID, PRODUCTS IN EACH ORDER
4404
DETERMINE THE CASE FROM THE PLURALITY OF AVAILABLE BLANKS IN THE SYSTEM TO BE USED FOR EACH ORDER
4406
DETERMINE THE TYPE/AMOUNT OF DUNNAGE FOR EACH ORDER
4408
DETERMINE THE PACKING CELL TO HANDLE EACH ORDER
4410
DIRECT EACH BIN TO THE APPROPRIATE PACKING CELL
4412
BASED ON SAID CASE SIZE, IF NECESSARY, ADJUST COMPONENTS OF A CASE FORMING APPARATUS TO ADAPT SAID CASE FORMING APPARATUS TO FORM SAID CASE OF SAID SIZE
4413
CONSTRUCT THE CASE FOR EACH ORDER IN A SECOND SEQUENCE
4414
DISPENSE THE AMOUNT OF DUNNAGE TYPE FOR EACH ORDER
4416
TRANSPORT EACH CONSTRUCTED CASE ITS DESIGNATED PACKING STATION WITH THE BIN CONTAINING THE ORDER
4418
SEAL EACH CASE
4420
APPLY A SHIPPING LABEL TO EACH CASE
4422

FIG. 44

# METHOD AND APPARATUS FOR ERECTING CARTONS AND FOR ORDER FULFILMENT AND PACKING

## CROSS-REFERENCE TO RELATED APPLICATION

This application is related to U.S. application Ser. No. 16/230,979, filed on Dec. 21, 2018, the entire contents of which are hereby incorporated herein by reference. This application is a continuation-in-part of application Ser. No. 16/677,139 filed on Nov. 7, 2019, the entire contents of which hereby also incorporated herein by reference.

## FIELD

The present invention relates generally to methods and systems for forming containers and for order fulfilment and order packing.

## BACKGROUND

Containers are used to package many different kinds of items. One form of container used in the packaging industry is what is known generically as a "box" and it can be used to hold various items including products and sometimes other boxes containing products. Some in the packaging industry refer to boxes used to package one or more products as "cartons". Also in the industry there are containers/boxes that are known by some as "cases". Examples of cases include what are known as regular slotted cases ("RSC"). Another type of container is what is known as a "tray" which generally is formed only on five sides and has a permanently open top. Some types of trays are used to hold other boxes or cartons; some types of trays are used to hold products (e.g. trays are sometimes used to hold bottled water). In this patent document, including the claims, the words "carton" and "cartons" and "containers" are used collectively to refer to boxes, cartons, trays, and/or cases that can be used to package any type of items including products and other cartons.

Cartons come in many different configurations and are made from a wide variety of materials. However, many cartons are foldable and are formed from a flattened state—commonly called a carton blank. Cartons may be made from an assortment of foldable materials, including but not limited to cardboard, chipboard, paperboard, corrugated fibreboard, other types of corrugated materials, plastic materials, composite materials, and the like and possibly even combinations thereof.

In many known systems, carton blanks may be serially retrieved from a carton magazine, and reconfigured from a flattened state into an erected state, and placed in a slot on a carton conveyor. The erected carton may then be moved by the carton conveyor to a loading station where the carton may be filled with one or more items and then sealed.

To permit the carton blanks to be readily opened up into an erected state from a flattened state, the blanks may be held in the magazine in a generally completely flattened configuration and then can be folded and sealed such as by gluing or taping panels and/or flaps together to form an erected carton. Specialized apparatus that can handle only flat, unfolded and unsealed blanks for cartons are known.

However, some blanks are provided to users not in a flat, unfolded and unsealed form, but rather in what is known as a "knock-down" blank or "KD". A KD blank may be provided in a folded configuration and be partially glued or



otherwise sealed along one side seam thus being formed in a generally flattened tubular shape. Accordingly, each carton may require opposite panels to be pulled apart and reconfigured from a flattened tubular configuration to an open tubular configuration that is suitable for delivery to a carton conveyor. The carton blank may then have one side closed by folding and sealing the bottom flaps, and then be filled from the opposite side while on the carton conveyor. Also, any required additional flap folding and sealing such as with glue or tape can be carried out to enclose and completely close and seal the carton with one or more items contained therein. Alternately, for example the erected carton blank can be reoriented from a side orientation to an upright orientation with the opening facing upwards. The erected carton can then be moved to a loading station or loading system where it is top loaded with one or more items, such as products or other carton containing products. The top opening can then be closed by folding over and sealing the top flaps.

However, the forming of a carton ready to be filled with a product, using such a knock-down carton blank—i.e., a tubular carton blank that is flattened but partially glued along one side seam—has in the past involved quite complex machinery. Typically, tubular carton blanks are held in a magazine with the blanks being in an angled but generally downwardly disposed orientation. Another apparatus referred to as a carton erector or carton feeder fulfils the functions of retrieving the carton from the magazine, opening the flattened carton up into a generally tubular configuration, and then placing it on a carton conveyor. The carton feeder typically has suction cups and will move in a generally arcuate path between the various stations for retrieval, opening and discharge. Examples of such carton feeders are disclosed in U.S. Pat. No. 5,997,458 to Guttinger et al. issued Dec. 7, 1999, and U.S. Pat. No. 7,326,165 issued to Baclija et al. on Feb. 5, 2008, the contents of both of which are hereby incorporated herein in their entirety. Other similar types of carton erectors may retrieve blanks in series from a magazine using suctions cups, open the blanks using some other kind of mechanism such as carton breaker, and then feed the opened blanks to belt mechanisms which can pass the blanks to a carton conveyor to transport the blank. However, in such systems, difficulties arise in designing system components that can achieve a clean retrieval and handoff by the carton feeder/erectors apparatus.

In the formation of cartons from a corrugated or otherwise strengthened material such as a corrugated fibreboard material, it is also typically necessary as part of the forming process to fold over various parts of a blank made from a corrugated fibreboard material. However, current folding processes and machines are relatively complex.

Accordingly, an improved forming method and system is desirable which can readily form a container such as a carton from a generally flat blank.

## SUMMARY

In an aspect, there is provided an order packing system for orders containing at least one product, the system comprising: a first conveyer operable to transport bins to a packing station in a first sequence, each one of said bins containing an order comprising at least one product, a case construction apparatus, operable to erect cases from blanks of a plurality of sizes, a second conveyer operable to transport blanks to said case construction apparatus and to transport constructed cases to the packing station, a controller operable to: cause said second conveyor to transport blanks to said case construction apparatus in a second sequence, wherein sizes of constructed cases in said second sequence correspond to sizes of said at least one product in said first sequence, and cause the first and second conveyor to transport to the packing station each bin in the first sequence with its corresponding constructed case in the second sequence.

In another aspect, there is provided a method of packing product orders, said method comprising: (a) receiving a plurality of bins in a first sequence, wherein each bin comprises at least one product in an order; (b) accessing a next request from said queue; (c) determining a size for a case from said next request; (d) based on said size, automatically adjusting components of a case forming apparatus to adapt said case forming apparatus to form said case of said size; (e) transferring a case blank for said case of said size from a particular repository to said case forming apparatus, said particular repository holding case blanks for cases of said size; (f) operating said case forming apparatus to form said case from said case blank in a second sequence; (g) transporting said case to a packing station with the corresponding bin for the order; (h) until said queue is empty, repeating (b) to (g) for a request in said queue next following said next request.

In another aspect, there is provided an order packing system for orders containing at least one product, the system comprising: a first conveyer operable to transport bins to a packing station in a first sequence, each of said bins containing an order comprising at least one product, a case construction apparatus, operable to construct cases from blanks of a plurality of sizes; a second conveyer operable to transport constructed cases from said case construction apparatus to said packing station; a controller operable to: cause said case construction apparatus to construct cases in a second sequence and to cause said second conveyor to transport said constructed cases, in said second sequence to said packing station, wherein sizes of constructed cases in said second sequence correspond to the sizes of said at least one product in each of said bins in said first sequence, and cause the first and second conveyor to deliver each bin in the first sequence at the packing station with its corresponding constructed case in the second sequence, such that said orders in said bins in said first sequence can be transferred sequentially to corresponding constructed cases in said second sequence.

In another aspect, there is provided a packaging method, comprising: (a) delivering a plurality of bins in a first sequence to a packing station, wherein each bin contains an order of at least one product; (b) accessing a request from a queue of requests, said queue of requests being generated based on said first sequence; (c) determining a size for a case based on said request; (d) based on said size, automatically adjusting one or more components of a case forming apparatus to adapt said case forming apparatus to form said case of said size; (e) transferring a case blank for said case of said size from a particular blank repository to said case forming apparatus, said particular blank repository holding case blanks for cases of said size; (f) operating said case forming apparatus to form said case from said case blank; (g) repeating (b) to (g) for each request in said queue; to create a second sequence; (h) delivering said cases in said second sequence to said packing station with the corresponding bin for the order, such that said bins are delivered to said packing station in said first sequence, in a manner that enables said orders in said bins in said first sequence to be transferred sequentially to corresponding formed cases in said second sequence.

In another aspect, there is provided a method of erecting a first case from a first knock-down blank have a first length L**1** and after erecting said first case, erecting a second case from a second knock-down blank having a second length L**2** that is a different length than L**1**, said method comprising: conveying a first knock-down blank to a pick-up position wherein said front edge of said first knock down blank is proximate to or in abutment with a facing surface of a front edge guide located at a first position; gripping a top side panel of said first knock-down carton blank at said pick-up location with an end effector of a movement apparatus; translating said first knock-down carton blank with said movement apparatus from said pick-up location to a position over a shuttle base of a shuttle; lowering said first knock-down carton blank with said movement apparatus onto said shuttle base of said shuttle, such that a bottom side panel of said knock-down blank abuts said base; gripping said bottom side panel of said first blank with a gripper of said shuttle base; raising a top side panel of said first knock-down carton blank while advancing said shuttle from a first start position in a horizontal direction so as to open said first knock-down carton blank into a first carton sleeve; adjusting the longitudinal position of said front edge guide; conveying a second knock-down blank to a pick-up position wherein said front edge of said second knock down blank is proximate to or abuts with said facing surface of a front edge guide located at a second position that is different than the first position; gripping a top side panel of said second knock-down carton blank at said pick-up location with said end effector of a movement apparatus; translating said second knock-down carton blank with said movement apparatus from said pick-up location to a position over said shuttle; lowering said second knock-down carton blank with said movement apparatus onto said base of said shuttle bed, such that a bottom side panel of said second knock-down blank abuts said base; gripping said bottom side panel of said second blank with a gripper of said base; raising a top side panel of said second knock-down carton blank while advancing said shuttle from a second start position in said horizontal direction so as to open said second knock-down carton blank into a second carton sleeve.

In another aspect, there is provided a method of erecting a first case from a first knock-down blank have a first length L**1** and after erecting said first case, erecting a second case from a second knock-down blank having a second length L**2** that is a different length than L**1**; wherein said first blank has a crease line between a top side panel and a further side panel of said first knock down blank, wherein said further side panel is hingedly connected to said top side panel and to said bottom side panel of said first knock-down blank; wherein said second knock-down blank has a crease line between a top side panel and a further side panel of said second knock down blank, wherein said further side panel is hingedly connected to said top side panel and to said bottom side panel of said second knock-down blank; and wherein said method comprises: conveying a first knock-down blank to a pick-up position wherein said crease line of said first knock-down blank is aligned with a transverse axis; gripping a top side panel of said first knock-down carton blank at said pick-up location with an end effector of a movement apparatus; translating said first knock-down carton blank with said movement apparatus from said pick-up location to a position over said shuttle; vertically lowering said first knock-down carton blank with said movement apparatus onto said base of said shuttle bed, such that a bottom side panel of said knock-down blank abuts said base; gripping said bottom side panel of said first blank with a gripper of said base; raising a top side panel of said first knock-down carton blank while advancing said shuttle in a horizontal direction so as to open said first knock-down carton blank into a first carton sleeve; conveying a second knock-down blank to a pick-up position wherein said crease line of said second knock-down blank is aligned with said transverse axis; gripping a top side panel of said second knock-down carton blank at said pick-up location with said end effector of a movement apparatus; translating said second knock-down carton blank with said movement apparatus from said pick-up location to a position over said shuttle; vertically lowering said second knock-down carton blank with said movement apparatus onto said base of said shuttle bed, such that a bottom side panel of said second knock-down blank abuts said base; gripping said bottom side panel of said second blank with a gripper of said base; raising a top side panel of said second knock-down carton blank while advancing said shuttle in a horizontal direction so as to open said second knock-down carton blank into a second carton sleeve.

In another aspect, there is provided an apparatus for use in erecting a first case from a first knock-down blank have a first length L**1** and after erecting said first case, erecting a second case from a second knock-down blank having a second length L**2** that is a different length than L**1**, said apparatus comprising: a knock-down blank feeding apparatus operable to feed a first knock down blank and a second knock down blank to a pick up station; a shuttle having a bed with a horizontally extending base having base grippers; shuttle drive apparatus for driving said shuttle in a horizontal advancement direction; an end effector having end effector grippers; an end effector movement device for moving said end effector; a movable edge guide; a controller operatively associated with said movable edge guide, said shuttle drive apparatus, said end effector movement device and said grippers and configured to: operate said feeding apparatus to feed a first knock down blank to a pick-up position in which a leading edge abuts said movable edge guide; operate said movement device and said end effector to grip a top side panel of said first knock-down carton blank and move said first knock down blank and place said first knock-down carton blank on said horizontally extending base of said shuttle such that a bottom side panel of said first knock-down carton blank abuts said horizontally extending base; activate said base grippers to grip said bottom side panel of said first knock-down blank; operate said movement device to raise said top side panel of said first knock-down carton blank with said end effector while horizontally advancing said shuttle in order to open said first knock-down carton blank into a first carton sleeve; adjust the position of said movable edge guide; operate said feeding apparatus to feed a second knock down blank to a pick-up position in which a leading edge abuts said movable edge guide; operate said movement device and said end effector to grip a top side panel of said second knock-down carton blank and place said second knock-down carton blank on said horizontally extending base of said shuttle such that a bottom side panel of said second knock-down carton blank abuts said horizontally extending base; activate said base grippers to grip said bottom side panel of said second knock-down blank; operate said movement device to raise said top side panel of said second knock-down carton blank with said end effector while horizontally advancing said shuttle in order to open said second knock-down carton blank into a second carton sleeve.

In another aspect, there is provided a method for use in erecting a carton, comprising: (a) placing a knock-down carton blank on a base of a bed of a shuttle such that a bottom side panel of said knock-down carton blank abuts said base; (b) gripping said bottom side panel of said blank with a gripper of said base; (c) raising a top side panel of said knock-down carton blank while advancing said shuttle in a horizontal direction so as to open said knock-down carton blank into a carton sleeve.

In another aspect, there is provided an apparatus for use in erecting a carton, comprising: a shuttle having a bed with a horizontally extending base having base grippers; shuttle drive apparatus for driving said shuttle in a horizontal advancement direction; an end effector having end effector grippers; an end effector movement device for moving said end effector; a controller operatively associated with said shuttle drive apparatus, said end effector movement device and said grippers and configured to: operate said movement device and end effector to grip a top side panel of a knock-down carton blank and place said knock-down carton blank on said horizontally extending base of said shuttle such that a bottom side panel of said knock-down carton blank abuts said horizontally extending base; activate said base grippers to grip said bottom side panel of said blank; operate said movement device to raise said top side panel of said knock-down carton blank with said end effector while horizontally advancing said shuttle in order to open said knock-down carton blank into a carton sleeve.

Other aspects and features will become apparent to those of ordinary skill in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying Figures.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the Figures which illustrate example embodiments,

FIGS. **1** and **2** are top perspective views of a system made in accordance with an embodiment;

FIGS. **1**A to **1**E and **1**H, **1**I are various perspective views of parts of the system of FIG. **1**;

FIGS. **1**F and **1**G are plan views of the system of FIG. **1**;

FIG. **3** is a schematic control diagram;

FIG. **4**A is a plan view of one side of a knock-down blank that may be processed by the system;

FIG. **4**B is a perspective view an opposite side of the knock-down blank of FIG. **4**A;

FIG. **5** is a perspective view of a carton erected from the knock-down blank of FIGS. **4**A and **4**B;

FIG. **6** is a top perspective view of a portion of the system of FIGS. **1** and **2**;

FIG. **7** is a side view of the portion of FIG. **6**;

FIG. **8** is a top perspective view of another portion of the system of FIGS. **1** and **2**;

FIG. **9** is a bottom perspective view of the portion of FIG. **8**;

FIG. **10** is a top perspective view of another portion of the system of FIGS. **1** and **2**;

FIG. **11** is a bottom perspective view of the portion of FIG. **10**;

FIG. **12** is a top perspective view of another portion of the system of FIGS. **1** and **2**;

FIG. **13** is a bottom perspective view of the portion of FIG. **12**;

FIG. **14** is a top perspective view of another portion of the system of FIGS. **1** and **2**;

FIG. **15** is a bottom perspective view of the portion of FIG. **14**;

FIG. **16** is a flow diagram illustrating operation of a controller of the system of FIG. **1**;

FIGS. **17** to **20** and **22** are top perspective views of a portion of the system of FIGS. **1** and **2** illustrating erection of a knock-down blank into a carton;

FIGS. **21** and **23** are perspective views of a carton sleeve at different stages of being erected into a carton;

FIG. **24** is a perspective view of an input end of a system made in accordance with another embodiment;

FIG. **25** is a plan view of FIG. **24**;

FIG. **26** is a detail perspective view of a portion of FIG. **24**;

FIG. **26**A is a plan view of another alternate case forming system;

FIG. **27** is an example of an order packing system;

FIG. **28** is an example of an order packing system having multiple packing cells;

FIG. **29** is a block diagram of example hardware components of a control server;

FIG. **30** is software components of a control system;

FIG. **31** is software components of an order tracker;

FIG. **32** is an example product dimension repository;

FIG. **33** is an example order repository;

FIG. **34** is software components of a case size selector;

FIG. **35** is an example case size repository;

FIG. **36** is a flowchart showing an example method of use of the case size selector;

FIG. **37** is software components of a sequence manager;

FIG. **38** is an example sequence;

FIG. **39** is a flowchart showing an example method of use of the sequence manager;

FIG. **40** is software components of a dunnage selector;

FIG. **41** is a flowchart showing an example method of use of the dunnage selector;

FIG. **42** is software components of a case sealer;

FIG. **43** is software components of a shipping label generator; and

FIG. **44** is a flowchart showing an example method of packing orders.

## DETAILED DESCRIPTION

With reference initially to FIGS. **1** and **2**, in overview, a carton forming system **100** has a magazine **110** adapted to receive and hold a plurality of knock-down carton blanks **111** and an end effector **120** for retrieving the knock-down carton blanks from a pick-up area and placing them on a shuttle **140**. As will be described hereinafter, the end effector **120** and shuttle **140** co-operate to manipulate the knock-down blanks in such a way as to erect them into sleeves.

System **100** may also include a folding apparatus generally designated **130**, configured to fold one or more flaps of each sleeve, and a sealing station **135** at which flaps of the cartons are sealed. System **100** may also include a carton re-orienting station **116** and a carton discharge conveyor **117** for receiving and moving cartons away once they have been fully erected.

An example of a scheme for the power and data/communication configuration for system **100** is illustrated in FIG. **3**. The operation of the components of carton forming system **100**, and of system **100** as a whole, may be controlled by a programmable logic controller ("PLC") **132**. PLC **132** may be accessed by a human operator through a Human Machine Interface (HMI) module **133** secured to a frame **109** (FIG. **1**) of the system. HMI module **133** may be in electronic communication with PLC **132**. PLC **132** may be any suitable PLC and may for example include a unit chosen from the Logix 5000 series devices made by Allen-Bradley/Rockwell Automation, such as the ControlLogix 5561 device. HMI module **132** may be a Panelview part number 2711P-T15C4D1 module also made by Allen-Bradley/Rockwell Automation.

Electrical power can be supplied to PLC **132**/HMI **133**, and to all the various servo motors and DC motors that are described further herein. Compressed/pressurized air can also be supplied to the vacuum generators and pneumatic actuator through valve devices such as solenoid valves that are controlled by PLC **132**, all as described further herein. Servo motors may be connected to and in communication with servo drives that are in communication with and controlled by PLC **132**. Similarly, DC motors may be connected to DC motor drives that are in communication with and controlled by PLC **132**, again all as described further herein. Additionally, various other sensors are in communication with PLC **132** and may (although not shown) also be supplied with electrical power.

With reference now to FIGS. **4**A, **4**B, and **5**, an example of one kind of knock-down carton blank **111** that can be processed by system **100** to form a regular slotted case (RSC) is disclosed. Other types of knock-down carton blanks, and knock-down carton blanks of different sizes can also be processed by system **100**.

Each carton blank **111** may be generally initially formed and provided in a knock-down configuration—i.e., a flattened tubular configuration—as shown in FIGS. **4**A and **4**B. Each bank **111** has a height dimension "Ht"; a length dimension "L"; and a major panel Length "Q" (see FIG. **4**A). By inputting each of these three dimensions for a blank to be processed by system **100** into PLC **132**, PLC **132** can determine if the system **100** can process that size blank without the necessity for manual intervention to make an adjustment to one or more components of the system **100**. If PLC **132** determines that the adjustment can be made without human intervention, the PLC may make the necessary adjustments to positions and/or movements of at least some of the components forming system **100**.

Blank **111** may have opposed major side panels A and C integrally interconnected to a pair of opposed minor side panels B and D to form a sleeve, seen in FIG. **5**, when opened. An overlap strip of carton blank material may be provided between panel B and panel A that can be sealed by conventional means such as a suitable adhesive, to provide an overlapping seam joint in the vicinity of "P" (see FIG. **4**A). This seam joint at the overlap forms a knock-down carton blank in which the panels A, B, C and D are joined into a continuous blank that is of generally flattened tubular configuration, as shown in FIGS. **4**A and **4**B.

Also, as shown in FIGS. **4**A, **4**B and **5**, are major and minor end flaps E, H, L, I that are provided at one end of the respective major and minor side panels A-D. A second set of major and minor end flaps F, G, K and J are provided on the opposite, lower/bottom end of the major and minor side panels A-D. However, in other embodiments, cartons having other panel configurations can be formed. The panels and flaps are connected to adjacent flaps and/or panels by predetermined fold/crease lines as shown in FIGS. **4**A and **4**B. These fold/crease lines may for example be formed by a weakened area of material and/or the formation of a crease with a crease forming apparatus. The effect of the fold lines is such that one panel such as for example panel A can be rotated relative to an adjacent panel such as D or B along the fold lines. Flaps may also fold and rotate about fold lines that connect them to their respective panels.

As will be described hereinafter, carton blank **111** may be transformed from a knock-down blank (i.e., a generally flattened tubular configuration) to an open sleeve (open tubular configuration) and the flaps may be folded and sealed to form the desired erected carton configuration. System **100** is configured to deliver each carton with an upwardly facing opening suitable for top loading. In another embodiment, system **100** may be configured to deliver each carton with a sidewards facing opening suitable for side loading.

Carton blanks **111** may have flaps that provide material that can, in conjunction with a connection mechanism (such as for example with application of an adhesive, sealing tape or a mechanical connection such as is provided in so-called "Klick-lok™" carton blanks) interconnect flap surfaces, to join or otherwise interconnect, flaps to adjacent flaps (or in some embodiments flaps to panels), to hold the carton in its desired erected configuration.

Carton blanks **111** may be made of any suitable material (s) configured and adapted to permit the required folding/bending/displacement of the material to reach the desired configuration. Examples of suitable materials are chipboard, cardboard or creased corrugated fiber-board. It should be noted that the blank may be formed of a material which itself is rigid or semi-rigid, and not easily foldable but which is divided into separate panels and flaps separated by creases or hinge type mechanisms so that the carton can be erected and formed.

Turning now to the various portions of system **100**, with reference to FIG. **1** to **3**, magazine **110** may be configured to hold a plurality of vertically stacked knock-down carton blanks **111**, and be operable to move the stack of carton blanks **111** in a horizontal direction generally parallel to horizontal axis X under the control of PLC **132**, to a pick-up location where end effector **120** can retrieve cartons from the magazine.

Magazine **110** may comprise a single conveyor or other blank feed apparatus to deliver blanks to a pick-up location. In the illustrated embodiment, two conveyors are disclosed: an infeed conveyor **204** and an alignment conveyor **206**. Infeed conveyor **204** may be configured and operable to move a stack of blanks **111** from a stack input position (where a stack may be loaded onto conveyor **204** such as by human or robotic placement) to a position where the stack of blanks is transferred to a horizontally and transversely aligning, alignment conveyor **206**. Alignment conveyor **206** may be positioned downstream in relation to infeed conveyor **204** and be used to move the stack of blanks to the pick-up location. Magazine**110** may be loaded with, and initially hold, a large number of carton blanks **111** in vertical stacks, with the stacks resting on infeed conveyer **204**. A rear wall **202** mounted to frame **109** is configured to retain a stack from falling backwards when initially loaded on conveyor **204**. Rear wall **202** may have a generally planar, vertically and transversely oriented surface facing the stack of blanks **111**. Conveyor **204** may be of an appropriate length to be able to store a satisfactory number of stacks of blanks in series on conveyor **204**. PLC **132** can control the operation of conveyor **204** to move one stack at a time to the alignment conveyor **206**.

With infeed-conveyor having one or more stacks of blanks arranged longitudinally on infeed conveyor **204**, the stacks can be fed in turn onto alignment conveyor **206**. A sensor (not shown) may be provided in the vicinity of conveyor **204** to monitor whether there is a stack waiting on conveyor **204** and that sensor may be operable to send a warning signal to PLC **132** that can alert an operator that the magazine is low and needs to be replenished. The sensor may be a part number 42GRP-9000-QD made by Allen Bradley.

Of particular note, a plurality of stacks of blanks might be provided on conveyor **204** and each stack may be have associated information that can be read by an information reader **205** such as electronic or an optical reading device. For example, a bar code may be provided on each stack of blanks, such as on the top or bottom blank of the stack. The bar code may be read by a bar code reader associated with the infeed conveyor **204**. The bar code reader may be in communication with PLC **132**. The bar code may provide information indicative of a characteristic of the blanks in the stack. For example, the bar code may identify the size and/or type of blank in a particular stack. Other information indicators may be used such as for example RFID tags/chips and RFID readers. The information can then be automatically provided by the information reader to PLC **132** which can determine whether the current configuration of system **100** can handle the processing the particular type/size of blanks without having to make manual adjustments to any of the components. It is contemplated that within a certain range of types/sizes of blanks, system **100** is able to handle the processing of different types/sizes of blanks without manual adjustment of any components of system **100**. The bar code/RFID tag may provide the information about the dimensions of the blank as discussed above and then PLC **132** can determine adjustments, if any, that need to be made to (a) the components of the magazine; (b) the movement of the end effector **120**; (c) the movement of the shuttle **140**; and (d) at least some of the components of the folding apparatus **130** and some components at the sealing station **135** to be able to process a particular blank or a particular stack of blanks. The result is that system **100** may be able to automatically process at least some different types of blanks to form different cartons, without having to make manual operator adjustments to any components of system **100**.

The belt of infeed conveyor **204** may be driven by a suitable motor such as a DC motor or a variable frequency drive motor **291** (see FIG. **3**) controlled through a DC motor drive (all sold by Oriental under model AXH-5100-KC-30) by PLC **132**.

Once PLC **132** is given an instruction (such as by a human operator through HMI module **133**), infeed conveyor **204** may be activated to move a stack of blanks **111** horizontally downstream. PLC **132** can control motor **291** through the motor drive and thus conveyor **204** can be operated to move and transfer the stack towards and for transfer to the alignment conveyor **206**.

Stack alignment conveyer **206** may be driven by a motor **292** (FIG. **3**) that may be like motor **291** and with a corresponding motor drive. Motor **292** may also be controlled by PLC **132**. Conveyor **206** may be operated to move the stack of blanks **111** further horizontally until the front face of the stack abuts a planar front stop picket wall **218**.

The belts of conveyors **204** and **206** may be made from any suitable material such as for example Ropanyl.

A sensor **242** (FIG. **3**), such as an electronic eye model 42KL-D1LB-F4 made by ALLEN BRADLEY, may be located within the horizontal gap between conveyors **204** and **206**. Sensor **242** may be positioned and operable to detect the presence of the front edge of a stack of blanks as the stack of blanks begins to move over the gap between conveyors **202** and **206**. Upon detecting the front edge, sensor **242** may send a digital signal to PLC **132** (FIG. **3**) signalling that a stack has moved to a position where conveyor **206** can start to move. PLC **132** can then cause the motor **292** (FIG. **3**) for conveyor **206** to be activated. In this way, there can be a "hand-off" of the stack of blanks from infeed conveyor **204** to alignment conveyor **206**.

Once the rear edge of the stack of blanks **111** has passed the sensor **242** a signal may be sent to PLC **132** which can then respond by sending a signal to shut down the motor **291** (FIG. **3**) driving conveyor **204**. Conveyor **204** is then in a condition ready to be loaded with another stack of blanks **111**. Meanwhile conveyor **206** can continue to operate as it moves the stack of blanks **111** to the pick-up location.

The presence of a stack of blanks **111** at the pick-up location may be detected by a sensor **240** (FIG. **3**) that may be the same type of sensor as sensor **242**. The sensor **240** may detect the presence of the front edge of a stack of blanks at the pick-up location and may send a digital signal to PLC **132** signalling that a stack is at the pick-up location. At the pick-up location, the stack of blanks may be "squared up" and thereafter, once properly aligned, single carton blanks **111** may be retrieved in series from the stack of blanks **111** by engagement of the end effector **120** with the uppermost blank in the stack.

During movement of the stack of blanks **111** horizontally by conveyors **204** and **206**, the left hand side of the stack of blanks may be supported and guided by a left hand side wall **200** which is fixed to the frame **190**. Side wall **200** may be oriented generally vertically and may extend horizontally for substantially the full lengths of conveyors **204** and **206**.

The outer side of the magazine **110** adjacent conveyor **204** may be left open; however the outer side of conveyor **206** has a moveable outer guide wall **201**. The mounting arrangement for side wall **201** is illustrated in FIGS. **6** and **7**. Turning to these Figures, transverse bottom support plates **251** and **255** are supported on the factory floor spaced from, and parallel to, each other. Each of support plates **251**, **255** has mounted to a respective upper surface thereof tracks **253**, **257**. Side wall **201** is supported by connector blocks **267** which are slidably received on tracks **253**, **257**.

A drive mechanism in electronic communication with PLC **132** may be provided to drive side wall **201** on its tracks. Specifically, a servo motor **258** may be provided and be in electronic communication with PLC **132** through a servo drive (as seen in FIG. **3**). Examples that could be used are servo motor MPL-B1530U-VJ42AA made by ALLEN BRADLEY, in combination with servo drive 2094-BC01-MP5-S also made by ALLEN BRADLEY and gear head AE050-010 FOR MPL-A1520 made by Apex. The servo motor **258** may drive a shaft **262** to, in turn, drive an endless belt **264** attached to each of the blocks **267**. An encoder may be provided within or in association with servo drive motor **258** and the encoder may rotate in relation to the rotation of the shaft of the servo drive. The encoder may be in communication with, and provide signals to the servo drive which can then pass on the information to PLC **132**. Thus, PLC **132** may be able to determine the transverse position of side wall **201** and can operate the servo drive **258** to adjust the position of the side wall **201**. The particular type of encoder that may be used is known as an "absolute" encoder. Thus once the encoder is calibrated so that a position of the shaft **262** is "zeroed", then even if power is lost to system **100**, the encoder can maintain its zero position calibration.

During operation of system **100**, while side wall **200** is fixed, side wall **201** is moved laterally as part of a blank stack alignment procedure to provide for generally longitudinal alignment of the end edges of blanks **111** in the stack being prepared for processing as the stack is held between side walls **200** and **201**. Specifically, the PLC positions side wall **201** based on the height dimension Ht (FIG. **4**A) of the knock-down blanks in the stack being readied for processing as previously read by information reader **205**.

Side wall **201** has a lateral tamping apparatus **275** to tamp the blanks **111** in a direction toward the front picket wall **218** so as to align of the front and rear side edges of the blanks **111** in the stack. Tamping apparatus has a tamping plate **280** that rides in a longitudinal slot **272** in wall **201**. The end of tamping plate **280** which extends through the slot to the outside of wall **201** is joined to endless belt **276** that is driven by servo motor **278** under control of the PLC.

Tamping plate **280** that is located transversely inwardly of the inner surface of side wall **201**. Movement of endless belt **276** causes tamping plate **280** to engage the rear side edges of the blanks **111** in the stack to be processed with the consequence that, as the front edges of those blanks are pushed up against the inner surface of the front picket wall **218**, the front and rear edges of the blanks become laterally aligned. While a servo drive and belt combination is illustrated, other alignment devices, such as a pneumatic actuator with a piston attached to the tamping plate, could be used.

By operation of PLC **132**, suitable adjustment of outside wall **201** and tamping plate **280**, a stack of blanks **111** can be "squared-up" and precisely located at a pick-up location—that is, held against inside wall **200** and front picket wall **218**. Once in the pick-up location, the blanks are in the proper location for being engaged by the end effector **120**.

In particular, once the stack of blanks **111** have generally reached the pick-up location, PLC **132** can send a signal to drive mechanism **260** to cause the drive mechanism **260** to cause side wall **201** to move laterally inwards towards the side of stack of blanks **111**. PLC **132** will cause the drive mechanism **260** to move a sufficient distance to cause the edges of the blanks **111** to become in contact along their length with inner surface of longitudinally aligned inner surface of side wall **201**. However, PLC **132** will not cause side wall **201** to be moved to such an extent that it creates a force on the stack of blanks such that causes the blanks to buckle/be damaged if they are compressed to a significant extent between side walls **200** and **201**. PLC **132** determines how much to move side wall **201** towards side wall **200** by virtue of the carton size dimensions that have been input to the PLC, including dimension Ht (see FIG. **4**A). The wall **201** can be moved so as to apply a slight compression that can be fine-tuned such as by trial and error for different sized carton blanks. It should be noted that for many sized cartons, the manufacturers comply with industry standard carton sizes.

Once the longitudinal alignment has been effected by movement of side wall **201**, PLC **132** can cause actuator **276** to be activated to cause the vertical plate **280** to engage the rear edges of the blanks **111** in the stack. PLC **132** may cause the vertical plate **280** to move a sufficient distance to cause the rear edges of the blanks **111** to come in contact with inner surface of plate **280**. However, the vertical plate **280** is not moved to such an extent that it creates a force on the stack of blanks that would cause the blanks to buckle/be damaged if they are compressed too much between plate **280** and front picket wall **218**.

Thus, by way of review: The vertical tamping plate **280** can be adjusted by the PLC operating servo drive **278** in the X-direction so that when the vertical tamping plate **280** is retracted it is in the right position to push the blanks up against the front picket wall **218** (without squeezing them).

In review the tamping sequence for ensuring the blanks are properly squared up at the pick-up location steps include the following:

The right-hand-side magazine side guide wall **201** under control of PLC **132** expands wide enough to allow the stack of blanks to enter on alignment conveyor **206**, and clear tamping plate **280** even if the stack is misaligned and/or the blanks in the stack are not perfectly square with each other and in relation to the X-Y axes.

The conveyor **206** advances the stack of blanks **111** towards the front stop picket wall and such that the stack may abut the front stop picket wall **218**.

The side guide wall **201** may move inwardly to make contact with the side of the case stack and press the side wall **201** against the left hand side guide wall **200**. This aligns the cases so the side edges of blanks are aligned with each other and the longitudinal side wall of the walls **200** and **201**. This also brings the tamping plate in behind the stack of blanks.

The servo drive **278** may be activated to cause the tamping plate **280** to press the stack forward, thereby aligning the blanks in the stack so that their front and rear edges are vertically aligned with each other and with the inner face of the plate **280** and the inside surface of front wall **218**.

The blanks are then properly positioned so that the end effector can begin picking up blanks from the stack.

In order to pick-up blanks, the end effector may have one or more suction cups providing a suction force to a panel acting generally normal to the surface of the panel that is engaged, as described further below. Other types of suitable engagement devices might be employed.

Turning to FIGS. **8** and **9**, end effector **120** has a dedicated, independently driven and controlled movement apparatus **115** that allows end effector **120** to move in a plane defined by both vertical axis Z and horizontal axis Y in FIG. **8**. Thus, movement of the end effector **120** can only be in the vertical Z and horizontal Y directions (i.e. directions parallel to axes Z and Y in FIG. **8**)—the end effector cannot move in a horizontal X direction (i.e. a direction parallel to axis X in FIG. **8**). If the movement of the end effector **120** is restricted to only Z and Y directions, a moving apparatus can be constructed that is relatively less complex than if movement in all three directions is required.

Movement apparatus **115** includes a vertically oriented support tube **169** that may be generally rectangular in cross section to which end effector **120** is mounted by mounting blocks **190** so that end effector **120** moves in space with support tube **169**.

The support tube **169** is slidably mounted to a slide block **158** for vertical movement and slide block **158** is, in turn, mounted to a horizontal rail system for horizontal movement. More specifically, slide block **158** has a pair of spaced, longitudinally and horizontally extending short inner blocks, each one fitting on one longitudinally extending rail **160**, **162** that holds the blocks securely but allows blocks to slide horizontally relative to the rails. An example of a suitable rails system is the Bosch Rexroth ball rail system in which the rails are made from steel and the blocks have a race of ceramic balls inside allowing the block to slide on the rails. Rails **160**, **162** are generally oriented horizontally are attached to a horizontally extending beam **108** that is connected to frame **109**. Slide block **158** may be mounted to rails **160** or **162** for horizontal sliding movement along the rails. Slide block **158** has a rail system allow support tube **169** to be connected to it so as to be able to move vertically relative to slide block **158**. More specifically, a rail extends vertically along a back surface of tube **169** and is interconnected to a runner of slide block **158**. Again, a suitable rail system is the Bosch Rexroth ball rail system referenced above. Thus, support tube **169** can slide vertically relative to slide block **158** and will move horizontally with the slide block.

To drive the end effector **120** horizontally and vertically, a drive apparatus is provided which includes a left side drive motor **150** and a right side drive motor **154** (both of which may be servo motors such as the model MPL-B330P-MJ24AA made by Allen Bradley) mounted to either end of beam **108**. Servo drive **150** has a drive wheel **152** and servo drive **154** has a drive wheel **156**. Both servo motors **150** and **154** can be independently driven in both directions at varying speeds by PLC **132** (FIG. **3**) through servo drives. In this regard, both servo motors **150** and **154** may be provided with two separate ports, one for connection to a power line and the other for connection to a communication line to provide communication with the servo drive and PLC **132**. Servo motors **150**, **154** may also have a third input which may provide input for an electric braking mechanism. It should be noted that all of the servo motors described herein may be similarly equipped.

Four freely rotatable pulley wheels **155*a***, **155*c***, **155*d*** and **155*f*** are secured to the front face of the slider block **158** and a further freely rotatable pulley wheel **155*b*** is attached to the upper end of support tube **169**. One end of a drive belt **153**—that may for example be made from urethane with steel wires running through it—is fixedly attached to the bottom of support tube **169** by a belt block **159*b***. From there the belt extends upwardly to block pulley **155*f***, around the upper side of block pulley **155*f*** and then horizontally to servo drive wheel **152**. The belt loops around the servo drive wheel **152** and extends around the underside of pulley **155*a*** and then upwards to pulley **155*b***. From there belt extends around pulley **155*b***, downwards to block pulley **155*c***, around block pulley **155*c*** and then to servo drive wheel **156**. After passing around servo drive wheel **156**, belt **153** extends to the upper side of block pulley **155*d***. From block pulley **155*d***, belt **153** then extends vertically downwards to the bottom of the support tube **169** where it attached to the support tube by a belt block **159*a***. With this arrangement, by adjusting the relative rotations of servo drive wheels **152** and **156** through the operation of the servo motors **150** and **154**, the vertical position of support tube **169** relative to slide block **158** can be adjusted. Additionally, by adjusting the relative rotations of servo drive wheels **152** and **156**, the horizontal position of slide block **158** on rails **160**, **162** can be adjusted thus altering the horizontal position of support tube **169** and end effector **120**. It will thus be appreciated that by adjusting the direction and speeds of rotation of drive wheels **152**, **156** relative to each other the support tube **169** can be moved vertically and/or horizontally in space within the physical constraints imposed by among other things the position of the servo drive wheels **152** and **156**, the length of the belt **153**, and the length of support tube **169**. The following will be appreciated in particular:

(a) If wheels **152** and **156** both remain stationary then the position of support tube **169** will not be altered;

(b) If wheels **152** and **156** both rotate in the same clockwise direction and at the same speed relative to each other, then support tube **169** (and thus end effector **120**) will move horizontally from right to left;

(c) If wheels **152** and **156** both rotate in the same counter-clockwise direction and at the same speed relative to each other, then support tube **169** (and thus end effector **120**) will move horizontally from left to right;

(d) If wheel **152** rotates counter-clockwise, and wheel **156** rotates in opposite clockwise rotational directions, but both wheels rotate at the same rotational speed relative to each other, then support tube **169**, and thus end effector **120**, will move vertically downwardly;

(e) If wheel **152** rotates clockwise, and wheel **156** rotates in opposite counter-clockwise rotational directions, but both wheels rotate at the same rotational speed relative to each other, then plates **164**, **166** will move vertically upwardly.

It will be appreciated that if the speeds and directions of the two servo motors are varied in different manner, then the motion of the support tube **169** (and thus end effector **120**) can be created that has both a vertical component as well as a horizontal component. Thus any desired path within these two degrees of freedom (vertical in the Z direction and horizontal in the Y direction) can be created for support tube **169**—and thus for the end effector **120** (such as a path having curved path portions). Thus, by controlling the rotational direction and speed of the motors **150**, **154** independently of each other, PLC **132** can cause support tube **169** (and thus end effector **120**) to move along any path within these two degrees of freedom, within the physical constraints imposed by the spacing of the drive wheels **152**, **156** and pulley wheel **155***b*, and the bottom of support tube **169**.

An encoder may be provided for each of the servo drive motors **150** and **154** and the encoders may rotate in relation to the rotation of the respective drive wheels **152**, **156**. The encoders may be in communication with, and provide signals through the servo drives to PLC **132**. Thus PLC **132** can in real time know/determine/monitor the position of the belt **153** in space and thus will determine and know the position of the end effector **120** in space at any given time. The particular types of encoders that may be used are known as "absolute" encoders. Thus the system can be zeroed such that due to the calibration of both encoders of both servo drives **150** and **154**, the zero-zero position of the end effector in both Z and Y directions is set within PLC **132**. The zero-zero position can be set with the end effector at its most horizontally left and vertically raised position. PLC **132** can then substantially in real time, keep track of the position of the end effector **120** as it moves through the processing sequence for a blank **111**.

Also associated with moving apparatus **115** is a first, generally horizontally oriented caterpillar device **114** and a second generally vertically oriented caterpillar device **118**. Each of the caterpillars **114** and **118** have a hollow cavity housing hoses and wires carrying pressurized air/vacuum and electrical/communication wires. Caterpillar **114** allows such hoses and wires to move longitudinally as the support tube **169** and erector head **120***b* are moved longitudinally. Caterpillar **118** allows such hoses and wires to move vertically as the support tube **169** and erector head **120***b* are moved vertically. The caterpillars allow hoses and wires to supply end effector **120**. In this way both pressurized air/vacuum and/or electrical communication wires may be brought form locations external to the frame **109** onto the moving end effector **120**. An example of suitable caterpillar devices that could be employed is the E-Chain Cable Carrier System model #240-03-055-0 made by Ignus Inc. It should be noted that electrical communication between the PLC **132** and the end effector **120** could in other embodiments be accomplished using wireless technologies that are commercially available.

End effector **120** has a bottom suction plate **327** with a generally square shape and four peripheral flanged openings, each receiving a suction cup **312**. It should be noted that while many types of suction cups may be employed on the end effector, a preferred type of suction cup is the model B40.10.04AB made by Piab. Each suction cup **312** is connected to an outlet from a vacuum generator **330** (FIG. **3**). The vacuum generator may be any suitable vacuum generator device such as for example the model VCH12-016C made by Pisco. Vacuum generators each have an inlet interconnected to a hose (not shown) that can carry pressurized air from an air compressor or other vacuum source to the vacuum generator. The vacuum generator converts the pressurized air supplied to the inlet port into a vacuum at one of the outlet ports. That vacuum outlet port is interconnected to a suction cup **312** so that the suction cup can have a vacuum force. A solenoid valve device **340** (FIG. **3**) is interposed along the pressurized air channel running between each vacuum generator and the source of pressurized air. The solenoid valve device **340** may for example be a model CPE14-M1BH-5L-1/8 made by Festo. Valve device **340** is in electronic communication with PLC **132** and controlled by PLC **132**. In this way PLC **132** can turn on and off the supply of vacuum force to the suction cups **312**.

End effector **120** also has a reciprocating sensor rod **380** which, when not in contact with a carton blank, extends downwards through a central aperture in plate **327**, below the level of the plane of suction cups **312**. When the end effector **120** is brought vertically downwards to retrieve a blank on a stack of blanks **111** in magazine **110**, the erector head's movement just prior to suction cups **312** contacting with the upper surface of the blank will be generally vertically downwards. Prior to the suction cups **312** contacting the surface of a top panel of a blank, sensor rod **380** will impact the top panel and cause sensor rod **380**, which may be resiliently displaced due to a spring mechanism biasing the rod downwards, to be pushed upwards. This movement upwards of sensor rod **380** relative to plate **327** will cause a sensor (not shown) to be activated and send a signal to PLC **132**. The sensor may be an inductive proximity sensor where a metal cylinder fixed on the rod is sensed by the sensor's circuitry due to changes in the inductance of an induction loop inside the sensor. Such a sensor may be an 871FM-D8NP25-P3 sensor made by ALLEN BRADLEY. PLC **132**. When the PLC receives a signal from the sensor, it may respond to that signal by causing servo drives **150** and **154** to slow down so that the final few centimeters (e.g. 3.5 cm) of movement downwards towards contact between suction cups **312** and the top panel of the blank occurs at a much slower rate. The sensor also allows the PLC to know how much further vertically downwards end effector **120** must be lowered to establish proper contact between suction cups **312** and the top panel of the carton blank. It should also be noted that sensor rod **380** and its associated sensor device can also be used to ensure that PLC **132** is aware of whether, once a blank has been engaged, it remains engaged with the end effector **120** until it is intentionally released.

Turning to FIGS. **10** and **11**, shuttle **140** of system **100** has an L-shaped bed **400** with a horizontally extending base **402** and a vertically extending back wall **404**. The base has openings receiving suction cups **408** which are coupled to a solenoid controlled vacuum generator **332** (FIG. **3**). Similarly, back wall **404** has openings receiving suction cups **410** coupled to a solenoid controlled vacuum generator **334** (FIG. **3**). The shuttle rides on a horizontal rail **414** extending in the X-direction. Rail **414** is supported on the factory floor. The shuttle has a depending belt block **419** attached to an endless drive belt **416**. From the belt block, the drive belt extends along rail **414** to free-wheel **418** located at one end of rail **414**, around the free-wheel **418** and back along the rail **414** to the its other end where the belt passes around drive wheel **420** of a servo motor **422** and then returns along the rail **414** again to the belt block **419**. Given this arrangement, operating the servo motor in a counter-clockwise direction will move the shuttle in a downstream direction (toward the free-wheel **418**) and operating the servo motor in a clockwise direction will move the shuttle in an upstream direction (toward servo motor **422**).

FIGS. **12** and **13** detail folding apparatus **130**. Turning to these Figures, the folding apparatus has opposed horizontally reciprocating fin ploughs, namely an upstream fin plough **500** and a downstream fin plough **510**. These fins are slidably supported on a horizontal rail **512** that extends in the X-direction. A servo motor **514** is attached to the upstream end of rail **512** and a free-wheel **516** is attached to the downstream end of the rail. A continuous drive belt **520** runs around the drive wheel **524** of servo motor **514** and the free-wheel **516**. Upstream fin **500** has a back plate **526** which is attached to the drive belt and downstream fin **510** has a front plate **528** attached to the drive belt. With this arrangement, if the servo motor **514** is operated in a counter-clockwise direction, fins **500**, **510** move toward each other and when servo motor is operated in a clockwise direction, fins **500**, **510** move away from each other. The folding apparatus also has opposed vertically reciprocating folding ploughs, namely an upper plough **530** and a lower plough **540**. Each folding plough has a planar base terminating in a curved ploughing face. The ploughs **530**, **540** are mounted to the ends of respective support arms **532**, **542** and the arms are mounted to carriages **534**, **544** slidably supported on a vertical rail **546** (i.e., a rail extending in the Z-direction). A servo motor **554** is attached to the upper end of vertical rail **546** and a free-wheel **556** is attached to the lower end of the rail. A continuous drive belt **560** runs around the drive wheel **564** of the servo motor **554** and the free-wheel **556**. A back of the upper carriage **534** is attached to belt **560** and a front of lower carriage **544** is attached to the belt. With this arrangement, if the servo motor **554** is operated in a counter-clockwise direction, folding ploughs **530**, **540** move toward each other and if the servo motor is operated in a clockwise direction, folding ploughs **530**, **540** move away from each other.

Referencing FIGS. **1** and **15** along with FIGS. **12** and **13**, the horizontal rail **512** on which fins **500**, **510** run is attached at either end to the base of L-shaped supports **560***a*, **560***b*. The L-shaped supports ride in channels **562** of vertical ribs **109***a*, **109***b* of frame **109**. A servo motor **568** is geared to a common drive shaft **570** to turn pinions (not shown) inside hubs **572***a*, **572***b*. The pinions mesh with ring gear portions of shafts **574***a*, **574***b* in order to turn, and thereby adjust, the vertical position of the shafts. The shafts are rotatably connected to the top of L-shaped supports **560***a*, **560***b*. The result is that operation of the servo motor **568** in one rotational direction raises the L-shaped supports **560***a*, **560***b*—and therefore fins **500**, **510**—and operation of the servo motor **568** in the opposite rotational direction lowers the L-shaped supports **560***a*, **560***b*.

Similarly, vertical rail **546** on which folding ploughs **530**, **540** run via support arms **532**, **542** and carriages **534**, **544** is attached to a linear support **580** that rides in a channel of vertical rib **109***c* of frame **109**. Common drive shaft **570** also turns a pinion (not shown) inside hub **572***c* and this pinion meshes with a ring gear portion of shaft **574***c* in order to turn, and thereby adjust, the vertical position of shaft **574***c*. The shaft is rotatably connected to the top of linear support **580**. The result is that operation of the servo motor **568** in one rotational direction raises the linear support **580**—and therefore folding ploughs **530**, **540**—and operation of the servo motor **568** in the opposite rotational direction lowers the linear support **580**. Moreover, since all of supports **560***a*, **560***b*, and **580** are adjusted by common drive shaft **570**, these supports are all adjusted to the same vertical extent by operation of servo motor **568**.

Referring to FIGS. **1**, **14**, and **15** the sealing station **135** has a tape sealer **640** and flap folding rods **632** which are supported by fin supporting rail **512** and so move vertically with fins **500**, **510**. The sealing station also has a pair of opposed conveyor belts, upper conveyor belt **600** driven by servo motor **602** and lower conveyor belt **610** driven by servo motor **612**, with the tape sealer **640** disposed between the conveyor belts **600**, **610**. The lower conveyor belt **610** and a supporting platform **614** are supported by the factory floor. The upper conveyor belt is mounted to a sub-frame **622**. Servo motor **568** has a second drive shaft **630** that is operatively associated with a drive train (not shown) so that operation of the servo motor **568** adjusts the vertical position of sub-frame **622** and, therefore, the upper conveyor belt **600** with respect to the lower conveyor belt **610**. Moreover, it will be noted that drive shaft **630** and common drive shaft **570** are driven by the same servo motor, motor **568**, such that a vertical adjustment of upper conveyor belt **600** is mirrored by a vertical adjustment of fins **500**, **510** and ploughs **530**, **540**. However, the drive train is configured with a 2:1 drive ratio so that the drive shaft **630** rotates twice for any rotation of common drive shaft **570**. The result is that a vertical adjustment of n cm of the fins, folding ploughs, tape sealer and flap supporting rods results in a vertical adjustment of **2***n* cm of the upper conveyor belt **610**. This ensures that the centreline of a carton sleeve remains at the level of the fins and tape sealer for any position of the upper conveyor belt **600**.

The sealing station terminates at carton re-orienting station **116**. The carton re-orienting station has a pair of deflection plates **650**, **652** which re-orient a carton as it falls off the end of the sealing station to the discharge conveyor **117** from a position lying on its side at the sealing station **135** to an upright position on the discharge conveyor with its open top facing upwardly. The discharge conveyor **117** is a simple endless belt conveyor driven by a servo motor **658**.

A sensor **243** (FIG. **3**) such as an electronic eye model 42KL-P2LB-F4 made by ALLEN BRADLEY may be located at the input of the discharge conveyor. Sensor **243** may be positioned and operable to detect the presence or absence of an erected carton at the input to the discharge conveyor **117**. In this way, PLC **132** can be digitally signalled if an erected carton blank **111** remains at the input of the discharge conveyor such that another erected carton cannot be discharged. If so, the system **100** can be stopped by PLC **132** until any fault at discharge conveyor **117** can be rectified.

The overall operation of system **100** will now be described further in conjunction with FIG. **16**, which is a flow diagram of the sequence of operations of the PLC.

To prepare system **100** for operation, one or more stacks of knock-down carton blanks **111** may be placed at the input end of conveyor **204**. In this regard, it is assumed the blanks are placed on the conveyor **204** with panels A and B, and flaps E, F, I, and J facing up, as shown in FIG. **4**A, and the common edge of end flaps F and J facing side wall **200** as shown by the blank **111** in FIG. **1**. System **100** may then be activated, such as by PLC **132** being instructed through HMI **133** to commence the processing of blanks **111**. As an initial step PLC **132** may initialize the system by ensuring that all components are put in their "start" positions (step **700**). PLC **132** may then send an instruction to the drive motor of input conveyor **204** causing stack(s) of blanks **111** to be conveyed downstream in the X-direction (step **702**) toward an identification reader. An identifier on the first stack may then be read by the identification reader **205** which identifies the dimensions of the blanks in the first stack. With this information and in order to adapt system **100** to process blanks of the size in the first stack, the PLC adjusts the stroke of both the outer side wall **201** and the shuttle **140**, the path of end effector **120**, the vertical position of the folding fins **500**, **510**, the folding ploughs **530**, **540**, the tape sealer **640** and flap folding rods **632**, and upper conveyor **600** (step **704**).

Sometime prior to a stack of blanks reaching alignment conveyor **206**, the outer side guide wall **201** under control of PLC **132** will be driven by servo motor **260** to expand wide enough to allow the stack of blanks to enter alignment conveyor **206**, even if the stack is misaligned and/or the blanks in the stack are not perfectly square with each other. The stack(s) of blanks moves downstream, until the front edge of the (first) stack of blanks passes the downstream edge of conveyor **204** at which time sensor **242** sends a signal to PLC **132** indicating that the front edge of the stack has reached the input to alignment conveyor **206**. In response, PLC **132** may stop input conveyor **204** and send an instruction to the drive motor of alignment conveyor **206** to cause the stack of blanks **111** to move downstream towards end picket wall **218** of magazine **110**. Once the front edge of the stack of blanks **111** reaches end wall **218**, sensor **240** will send a signal to PLC **132** indicating that the front edge of the stack of blanks has reached end wall **218**. In response, PLC **132** can then move the outer side wall **201** inwardly to straighten the stack laterally and initiate the tamping sequence to "square up" the stack of blanks longitudinally, as detailed above (step **706**).

In review, the sequence for ensuring the blanks are properly squared up at the pick-up location may include the following steps. The side guide wall **201** moves inwardly to make contact with the side of the stack of blanks and press the stack against the left hand side guide wall **200**. This aligns the blanks so the lateral edges of the blanks are aligned with each other. This also moves the tamping plate **280** in behind the stack. The tamping plate **280** may then move forwardly to press the stack forward against the picket wall **218**, thereby aligning the blanks in the stack longitudinally so that their front and rear edges are vertically aligned with each other. The stack of blanks **111** is then properly positioned at the pick-up location so that the end effector **120** can begin picking up blanks from the stack.

End effector **120** will be positioned by the control of PLC **132** over movement apparatus **115**, at the zero position calibrated for the end effector **120**. PLC **132** may then cause servo motors **150** and **154** to be operated to achieve the following sequence of operations.

First the end effector **120** may be moved to the pick-up location as shown in FIG. **1** such that the end effector is directly over panel B of the top blank in the stack of blanks at the pick-up location.

As the end effector **120** is brought vertically downwards to retrieve the top blank on the stack of blanks **111** in magazine **110**, the end effector's movement just prior to suction cups **312** contacting with the upper surface of the blank will be generally vertically downwards. Prior to the suction cups **312** contacting the surface of a panel B of a blank, sensor rod **380** will contact the surface of panel B and be pushed upwardly. This upward movement of sensor rod **380** relative to plate **327** will cause a sensor to be activated and send a signal to PLC **132**. PLC **132** responds to that signal by causing servo drives **150** and **154** to slow down so that the final few centimeters (e.g. 3.5 cm) of movement downwards towards contact between cups **312** and the upper surface of panel B occurs at a much slower rate. Also, PLC knows how much further vertically downwards the end effector **120** must be lowered to establish proper contact between suction cups **312** and panel B. PLC **132** will then operate the valve device **330** on end effector **120** to cause suction force to be developed at suction cups **312**. Sensor rod **380** and its associated sensor device can also be used to ensure that PLC **132** is aware of whether, once a blank has been engaged in the magazine **110**, it remains engaged with end effector **120** until it is intentionally released.

With the end effector **120** in the pick-up location and the suction force being applied at suction cups **312**, the end effector **120** engages panel B of the top blank and then lifts the blank lift upwards (step **708**).

When the end effector **120** has reached a determined height it is moved laterally in the Y-direction until it is positioned over shuttle **140**.

Next, with reference to FIG. **17**, the end effector descends until the blank sits on the bed **400** of the shuttle with the hinge line R between side panel A and side panel D (FIG. 4B) positioned against the vertically extending back wall **404** of the shuttle **140**. The PLC then activates the suction cups **408** at the base **402** of the shuttle bed to grip the underside of the blank, and specifically side panel D of the blank (step **710**). Notably, side panel D, being the panel directly underneath side panel A in the knock-down blank, is not directly hinged to panel B, which panel is gripped by the end effector.

The end effector **120** is then raised vertically in the Z-direction while, simultaneously, the shuttle **140** is moved forwardly in the X-direction. In consequence of these operations, provided the simultaneous motions of the end effector and shuttle are appropriately co-ordinated, since underside panel D of the blank is gripped at the base of the shuttle and top panel B of the blank is gripped by the end effector, the blank begins to open up as illustrated in FIG. **18**.

The end effector **120** continues to move vertically upwardly and the shuttle simultaneously continues to move forwardly until the blank is fully erected into a carton sleeve as illustrated in FIG. **19**. The PLC will recognize this end point due to its knowledge of the dimensions of the sleeve. With the blank formed into a carton sleeve, panel A of the sleeve (seen in FIG. **18**) abuts the back wall **404** of the shuttle **140** (step **712**).

With panel A abutting the back wall **404** of the shuttle, the suction cups **410** of the back wall are activated so that panel A is gripped by the back wall **404** of the shuttle (step **714**). With both panels A and D held by the shuttle, the carton sleeve is held in its erect position without need of support from end effector **120**. Therefore, at this stage, the suctions cups **312** of the end effector **120** are de-activated and the end effector is moved away from the shuttle **140** back to the pick-up location (step **716**).

Next, with shuttle **140** held stationary, fin ploughs **500**, **510** are moved toward one another until they are adjacent one another as shown in FIG. **20** (step **718**). This has the effect of folding minor bottom end panels F and G of the carton sleeve inwardly, as shown in FIG. **21**. In this regard, it will be recalled that the vertical position of the fin ploughs **500**, **510** was set based on the size of the blank. This setting is so as to result in the fin ploughs contacting panels F and G at their midpoint.

With the shuttle remaining stationary and the fin ploughs remaining adjacent one another, the upper and lower ploughs **530**, **540** are next moved toward one another until these ploughs are positioned at a small stand off from fin ploughs **500**, **510** as shown in FIG. **22** (step **720**). This has the effect of folding major bottom flaps J and K of the carton sleeve inwardly, as shown in FIG. **23**.

Leaving all of the ploughs in place, the PLC next activates conveyor belts **600**, **610** and moves the shuttle **140** downstream until the belts frictionally grip side panels B and D of the carton sleeve and pull it downstream, extracting it from the ploughs (step **722**).

As the sleeve is pulled downstream from the ploughs **500**, **510**, **530**, **540**, the outside surface of major bottom flaps J and K are brought into contact with folding rods **632** which progressively complete the fold of flaps J and K. The carton sleeve is then pulled past taping sealer **640** by conveyor belts **600**, **610** at which sealer the seam between flaps J and K is taped in order to tape closed the bottom of the carton sleeve to form a carton. The carton is then ejected to the re-orienting station where it is deflected by deflector plates **650**, **652** as it falls onto the discharge conveyor **117** so that the bottom of the carton (i.e., flaps J and K) rest on the discharge conveyor. The discharge conveyor then conveys the carton to the output of system **100**.

Once the carton sleeve has moved downstream from the ploughs **500**, **510**, **530**, **540**, these ploughs are retracted from one another and the shuttle **140** is returned to its initial position in order to prepare system **100** for processing the next carton blank (step **724**); the end effector can then pick up the next blank in the stack (step **726**).

After exhausting the current stack of blanks, the next stack is conveyed to the information reader **205** and the PLC will read the dimensions of blanks in the next stack (step **726**). Thereafter, once the last blank in the current stack has moved downstream of the conveyor belts **600**, **610**, if the blanks in the next stack have different dimensions from the dimensions of blanks in the now exhausted stack, the PLC adjusts the stroke of the outer side wall **201** and the shuttle **140**, the path of end effector **120**, and the vertical position of the folding fins **500**, **510**, the folding ploughs **530**, **540**, tape sealer **640** with folding rods **632**, and upper conveyor **600**. System **100** is then readied to handle the next stack and it is moved to the pick-up location and the described processing operations repeated.

The system provides a relatively high processing capacity in part due to the relatively short "stroke" (i.e. longitudinal distance) that the end effector and shuttle must travel when carrying out the blank retrieval and erection. This means that the components do not have to travel such a great distance as in conventional carton erectors.

The system also has a relatively small footprint due to the U-shaped path provided for cartons blanks erected into cartons by the system. More specifically, incoming blanks are conveyed in an upstream X-direction to the pick-up location. These blanks are then conveyed in a Y (and Z) direction to the shuttle where they are then conveyed downstream in the X-direction.

Many variations of the embodiments described above are possible. By way of example the system may employ a second movement apparatus and end effector, identical in construction to movement apparatus **115** and end effector **120**, but a mirror image thereof. With such an arrangement, the two devices may be mounted side-by-side with the two end effectors operating in the same plane. Collisions between the two end effectors can be avoided by operating the two movement apparatus such that the two end effectors are always 180° out of phase with one another.

In another embodiment, as an alternate to magazine **110** in carton forming system **100** as described above, a modified carton forming system **1100** may have a plurality of magazines. FIGS. **24** and **25** illustrate the input end of such a modified system **1100** with a plurality of magazines M1-M**16** that feed to a common in-feed conveyor **1204**. The in-feed conveyor **1204** feeds to alignment conveyor **206**, and the remainder of the modified system, being identical to system **100**, is not illustrated.

Magazines M1-M**16** may each contain one or more stacks of product packaging, such as case blanks which each may generally be like blanks **111** processed by system **100**, with at least some of the magazines M1-M**16** containing different types/sizes and/or configurations of packaging/case blanks to other magazines. The size, configurations and types of case blanks (and the cases that can be formed therefrom) can vary to provide a range of case sizes, configurations and types that can be automatically processed by the system **1100** without the need for any manual intervention to modify any components of the system. PLC **132** of system **1100** may be programmed such that the particular dimensions/overall size/configuration (e.g. such as regular slotted carton or "RSC")/type of each of the blanks held in each one of the magazines M1-M**16** is stored in the memory of the PLC **132**.

Each magazine M1-M**16** may have its own blank transfer apparatus that may each include a transversely oriented magazine conveyor **1203**(**1**) to **1203**(**16**) respectively. Each conveyor **1203**(**1**) to **1203**(**16**) (referred to generically as a magazine conveyor **1203**) may be controlled by PLC **132**, such that a stack of blanks in each magazine M1-M**16** may be moved to a position adjacent a longitudinally oriented, central case blank in-feed conveyor **1204**. Each magazine M1-M**16** may have a transfer apparatus under the control of PLC **132** that is operable to extract and move a blank from a stack in the magazine M1-M**16** adjacent to in-feed conveyor **1204** and feed it onto central in-feed conveyor **1204** so that it may be transported.

With reference now to FIG. **26**, by way of representative example of the construction of a magazine, magazine conveyor **1203**(**1**) may include a frame **1215** that supports five, generally parallel, and spaced continuous belts **1213** that may be made of any suitable flexible material such as Ropanyl. The belts **1213** may each extend between rotatable idler wheels **1221** mounted on a freely rotatable shaft and rotatable drive wheels **1223**. Drive wheels **1223** may be mounted for rotation with and to a common drive shaft **1225** of a servo motor **1219** that may be interconnected via and in communication with a servo drive to the PLC **132** of system **1100**. Conveyor belts **1213** may each have an upper belt portion that together may support one or more stacks of blanks **1211** thereon. PLC **132** may give an instruction (such as by order fulfilment processor **1300**) to form a case, and if required, PLC **132** may cause upper belt portion of belt **214** to move towards in-feed conveyor **1204** by operation of servo motor **1219** rotating drive wheels **1223**. In this way belt **214** can, if necessary, move a stack of blanks **1211** to a position adjacent to the in-feed conveyor **1204**.

Positioned proximate the end of each magazine conveyor **1203** adjacent in-feed conveyor **1204** may be a vertically and longitudinally oriented plate **1230** (not shown in FIGS. **24** and **25**). Each plate **1230** may be supported by a plurality of plate support members **1235** that may be part of frame **1215**. A lower longitudinally extending edge **1233** of plate **1230** may be positioned so that only the bottom blank in a stack of blanks (i.e. the blank that is immediately above the upper portions of the belts) can pass through a slot provided beneath lower edge **1233** of plate **1230** and the horizontal plane formed by the upper surface of the upper portions of the belts **1213**. In this way, a slot **1231** can be provided that can permit a single blank at a time from the bottom of the stack to be pushed transversely through the slot and onto the in-feed conveyor **1204**.

A pushing mechanism may be provided to respond to signals from PLC **132** of the case former to push a blank in a magazine from the bottom of the stack though the slot **1204** and onto in-feed conveyor **1204**. The pushing mechanism may be any suitable type of device and may for example include a plurality of lugs **1217** located in the spaces between belts **1213**. The lugs may be driven in a cyclical path by a common type crank mechanism (not shown) that may include a common pneumatic or hydraulic cylinder with a piston controlled by PLC **132** by activating appropriate valves to suitably control the flow of pressurized air/hydraulic fluid to the cylinder. The cylinder may have a piston arm attached to a longitudinally oriented bar member that may be mounted for rotation. The crank mechanism may be configured to provide a path for the lugs **1217** that commences in a position behind the bottom blank in a stack, then moves transversely between the belts **1213** while engaging the rear side edge of the bottom blank thereby pushing the bottom blank through the slot **1231**. Once the crank mechanism reaches the end of the stroke, the lugs **1271** will descend downwards beneath the stack of blanks and move transversely in an opposite direction back to the starting position, while at the same time not engaging the next bottom blank on the stack and passing beneath the stack. The path returns the lugs **1217** back to the start position so that when signalled by PLC **132** to load another blank onto conveyor **1204**, the operation can be repeated.

In summary, PLC **132** can thus control motor **1219** and thus the movement of each conveyor **1203** as well as the movement of the lugs **1281**, and thus is able to selectively move and transfer a single blank at a time onto in-feed conveyor **1204** from any one of magazines M**1** to M**16**.

Therefore, unlike in system **100** where a stack of case blanks may be fed to the alignment conveyor **206** by in-feed conveyor **204**, in the modified system separate individual case blanks may be fed in series and longitudinally by in-feed conveyor **1204** to alignment conveyor **206**. The particular sequence/order of carton blanks that are placed onto in-feed conveyor **1204** of system **1100** may be determined and selected by PLC **132** such that case blanks may arrive at alignment conveyor **1206** in such a desired manner in which it is desired to process the blanks at least within system **1100**.

Further, PLC **132** may maintain in its memory records of case blanks that have been placed onto in-feed conveyor **1204**. For example, this information may include the type/size/configuration of the case blank and, where the system **1100** includes a labeller, the label information to be applied to the carton blank. A new record can be added each time a request for a new carton is received and, optionally, records can be removed once a carton has been formed (and labelled). Thus, such records may be organized and maintained in sequence in the memory of PLC **132** using a conventional shift registering technique. In this way, the record for the next carton blank scheduled to arrive at alignment conveyor **206** may be provided at the output of the shift registers as that carton blank arrives, and the type/configuration/size of that carton blank and the label information for that case blank may be determined from the provided output.

Once transferred from in-feed conveyor **1204** to alignment conveyor **206**, the alignment conveyor **206** may then under the control of PLC **132** move each blank sequentially to the pick-up location in the manner described previously with respect to system **100**. In this regard, conveyor **1204** may be constructed substantially like conveyor **204**.

A sensor (not shown) such as an electronic eye model 42KL-D1LB-F4 made by ALLEN BRADLEY, may be located within the horizontal gap between in-feed conveyor **1204** and alignment conveyor **206**. The sensor may be positioned and operable to detect the presence of the front edge of a blank as each blank in turn begins to move over the gap between the conveyors. Upon detecting the front edge, sensor may send a digital signal to PLC **132** signalling that a particular blank (the size/configuration/type of which PLC **132** is aware) has moved to a position where conveyor **206** can start to move. PLC **132** can then cause the motor for conveyor **206** to be activated to move the blank downstream. In this way, there can be a "hand-off" of each blank from in-feed conveyor **1204** to alignment conveyor **206**.

Once the rear edge of each blank passes the sensor, a signal may be sent to PLC **132** which can then respond by sending a signal to shut down the motor driving conveyor **1204**. Conveyor **1204** is then in a condition to await a further signal thereafter to feed the next blank in the series of blanks on the conveyor **1204** to alignment conveyor **206**. Meanwhile system **1100** can be operated to move the blank on alignment conveyor **206** to the pick-up location in the manner described in conjunction with system **100** so that processing of the blank can continue as described in conjunction with system **100**.

Optionally, PLC **132** may verify that the type/size/configuration of the case blank at the pick-up location matches the expected case blank. For example, the top surface of each case blank may include a bar code identifying its type/size/configuration, and this bar code may be read at the pick-up location by a suitably positioned bar code reader. The type/size/configuration of the case blank read from this bar code may be compared to the expected type/size/configuration of case blank, which may be determined from a record of the next scheduled case blank stored in memory of the PLC, as described above. Verification is successful when there is a match. When there is not a match, PLC **132** may issue a signal requesting manual operator intervention.

The system has been described as having a PLC. Optionally, any other suitable controller may be substituted, such as a programmed general purpose computer.

The carton blank, and resulting sleeve, has been described as being gripped with suction cups. Of course, any other suitable grippers may be employed

As noted above, it is contemplated that within a certain range of types/sizes/shapes of blanks, carton forming systems **100**/**1100** can process different types/sizes/shapes of blanks (within certain constraints/limits) without manual adjustment of any components of system **100**/**1100**. Also, it is contemplated that PLC **132** in systems **100**/**1100** may store information about the dimensions of different types/sizes/shapes of blanks **111** (eg. a height dimension "Ht"; a length dimension "L"; a major panel Length "Q" and also a case depth $D_p$—as shown in FIG. **4**A) and then PLC **132** can determine adjustments, if any, that need to be made to (a) the components of the magazine; (b) the movement of the end effector **120**; (c) the movement of the shuttle **140**; and (d) at least some of the components of the folding apparatus **130** and some components at the sealing station **135** to be able to process a particular blank. The result is that system **100** may be able to automatically process several different types of blanks to form different size/shape/type cartons, without having to make manual operator adjustments to any components of system **100**.

With reference to FIG. **4**A, it is contemplated that, by way of example only, that system **100** can process case blanks have the following ranges of dimensions:

Height Ht—in the range of 7" to 30" (17.78 cm to 76.2 cm)

Length L—in the range of 9" to 40" (22.86 cm to 101.6 cm)

Depth Dp—in the range of 4.5" to 20" (11.43 cm to 50.8 cm)

Major Panel Length Q—in the range of 4" to 20" (10.16 cm to 50.8 cm).

To further assist in the handling of case blanks **111** of different sizes/types/shapes, systems **100**/**1100** may include some additional features, as described hereinafter. With reference to FIGS. **1**A, **1**G and **1**I, a case blank **111**A is shown (FIGS. **1**A and **1**G) resting in a pick-up position on alignment conveyor **206**, with a leading edge **107**A defined by the aligned, front horizontal and transverse edges of top panels F, A and E and opposite bottom panels L, D, and K (see also corresponding edges **107** in FIGS. **4**A and **4**B). Leading transverse edge **107**A is proximate to, and preferably abuts up against the facing surfaces of picket wall **218** such that leading transverse edge **107**A is substantially aligned with a transverse horizontal axis $Y\mathbf{2}_A$ which extends along the facing surfaces of front picket wall **218** (also referred to herein as blank front edge guide **218**). Axis $Y\mathbf{2}_A$ also continues to run transversely and horizontally parallel to axis Y through system **100** including, preferably, along the forward facing surface **404**A (FIGS. **1**G and **17**) of back wall **404** of shuttle **140** when the shuttle is in the longitudinal start position before it commences its advancement to open the case blank—in the manner as described above. As an aside, it should be noted that some aspects of system **100** at the pick-up location area are shown in isolation in FIG. **1**A-C, **1**H-I, for clarity.

The adjacent inner horizontal and transverse edges of upper panels F, A and E and respective adjacent upper panels J, B, and I, form a transverse horizontal crease line that is substantially aligned with a transverse horizontal axis $Y\mathbf{1}_A$ which runs transversely and horizontally, and parallel to axis $Y\mathbf{2}_A$ through system **100**. A corresponding, but slightly lower, axis $Y\mathbf{1}_A'$ (that is vertically aligned with and parallel to axis $Y\mathbf{1}_A$ also runs through inner horizontal and transverse edges of opposite lower panels L, D, and D and respective adjacent lower panels H, C, and G to form a corresponding lower crease line. These two crease lines typically will lie in the same vertical and transverse plane. Axis $Y\mathbf{1}_A$ and axis $Y\mathbf{2}_A$ are separated by a distance $X_{YA}$ (FIG. **1**G).

By contrast, with reference to FIGS. **1**B, **1**H and **1**F, a blank **111**B (which has generally smaller dimensions than blank **111**A—including a length $L_B$ that is shorter than length $L_A$, and which may also have a height Ht that is shorter than height Ht of blank **111**A) is shown resting in a pick-up position on conveyor **206**, with a leading transverse edge **107**B defined by the aligned, front edges of panels I, B and J. Leading transverse edge **107**B of blank **111**B is also positioned proximate to, and preferably is in abutment with the facing surfaces of picket wall **218** such that leading edge **107**B is substantially aligned with a transverse horizontal axis $Y\mathbf{2}_B$ which extends along the forward edge surfaces of front picket wall **218**. Axis $Y\mathbf{2}_B$ also continues to run transversely and horizontally parallel to axis Y through system **100** including also preferably, along the front surface of back wall **404** of shuttle **140**, when in the longitudinal start position before it commences its advancement to open the second case blank—as described aboveAxis $Y\mathbf{1}_B$ and axis $Y\mathbf{2}_b$ are separated by a distance $X_{YB}$ (FIG. **1**F). Distance $X_{YB}$ is shorter than distance $X_{YA}$.

The adjacent inner horizontal and transverse edges of upper panels F, A and E and respective adjacent upper panels J, B and I, form a transverse crease line that is substantially aligned with a transverse horizontal axis $Y\mathbf{1}_B$ which runs transversely and horizontally and parallel to axis Y and to axis $Y\mathbf{2}_B$ through system **100**. A corresponding, but slightly lower, axis $Y\mathbf{1}_B'$ (that is vertically aligned with and parallel to axis $Y\mathbf{1}_B$ also runs through inner horizontal and transverse edges of opposite lower panels L, D, and K, and respective adjacent lower panels H, C and G to form another transverse crease line. These two crease lines typically will lie in the same vertical and transverse plane.

During the operation of system **100** in processing blanks having different lengths $L_A$, $L_B$, the longitudinal axes $Y\mathbf{1}_A$ and $Y\mathbf{1}_B$ of the two differently sized blanks **111**A, **111**B are co-linear (the crease lines in both blanks run along the same transverse line/axis—or at least run in the same vertical transverse plane). Similarly, the longitudinal axes $Y\mathbf{1}_A'$ and $Y\mathbf{1}_B'$ of the two differently sized blanks **111**A, **111**B are co-linear (the crease lines may also run along the same transverse line/axis—or at least run in the same vertical transverse plane). Thus, in system **100**, no matter what length L of case blank that is being processed, a transverse and vertical plane through the crease lines between panels I, B and J and respective adjacent panels E, A and F remains in a constant longitudinal (ie. X direction) position, and similarly, a transverse and vertical plane through the crease lines between panels L, D and K, and respective adjacent panels H, C and G will also typically remain in a constant longitudinal (ie. X direction) position.

It will be appreciated however, that in system **100**, for blanks **111**A, **111**B, with different lengths L, the transverse axes $Y\mathbf{2}_A$ and $Y\mathbf{2}_B$ will not be not co-linear (eg. the front edges of the case blanks do not run along the same line/axis parallel to axis Y or through the same vertical and transverse plane). Therefore, in system **100**, if the length L of a case blank that is being erected during operation, changes from case blank to the next case blank, the transverse axis Y**2** at the front edge of panels E, A and F will be in a different longitudinal (ie. X direction) position.

When end effector **120** is positioned by the control of PLC **132** at the pick-up location (such as shown in FIG. **1**G) the end effector is located directly over panel B of a blank **111**A and preferably right behind, or a short distance behind, in the X direction, the crease line axis $Y\mathbf{1}_A$ and when, when end effector **120** is positioned by the control of PLC **132** at the pick-up location (such as shown in FIG. **1**G) the end effector is directly over panel B of a blank **111** B the end effector **120** will be the distance in the X direction behind the crease line axis $Y\mathbf{1}_B$.

Therefore, in order to accommodate case blanks of different lengths L, the forward-facing surfaces of front picket wall/front edge guide **218**, and typically also the start position of the front surface **404**A of back wall **404** of shuttle **140** will have to be moved to corresponding different longitudinal start positions. Adjustment of the start position of shuttle **140** can be controlled by PLC **132**, and the corresponding stroke of shuttle **140** may also be adjusted by PLC **132**.

In order to provide a corresponding varying, appropriate pick-up positions of case blank **111**A and case blank **111**B, on conveyor **206**, the longitudinal (ie. in direction of axis X) position of picket wall/front edge guide **218**, must also be adjusted by PLC **132**. Accordingly, a longitudinal, picket wall movement mechanism **241** may be provided in system

100. Picket wall movement mechanism **241** may be controlled by PLC **132** which can adjust the longitudinal position of picket wall **218** to provide a proper pick up position for a case blank on conveyor **206**, to ensure that the crease line between panels I, B and J and respective adjacent panels E, A and F (eg. axes $Y1_A$ and $Y1_B$) will be in the same longitudinal (X axis) position through system **100**, regardless of the length L of case blank **111** that is being processed at any particular time by system **100**). Thus, when end effector **120** is positioned by the control of PLC **132** at the pick-up location (such as shown in FIG. **1**G) the end effector is directly over panel B of a blank **111**A a short distance in the X direction behind the crease line axis $Y1_A$ and when, when end effector **120** is positioned by the control of PLC **132** at the pick-up location (such as shown in FIG. **1**G) the end effector is directly over panel B of a blank **111**B the end effector **120** will be the same short distance in the X direction behind the crease line axis $Y1_B$.

It should be noted that if the height Ht of the cases also vary (such as between case blank **111**A and case blank **111**B) the transverse, pick-up position of the end effector **120** on the blank while on conveyor **206**, and the transverse, lowering down position of the end effector for lowering the blank onto the base **402** of shuttle **140**, may vary in the transverse direction (Y direction) by PLC **132** so that the end effector **120** is properly positioned transversely at both the pick-up, and lowering, of the blank. When picking up a blank, the end effector **120** may be positioned movement apparatus **115** directly over the central area in the transverse position in the Y direction of panel B, dependent upon the height Ht of the respective blank **111**A, **111**B—which may vary between blank **111**A and blank **111**B. PLC **132** can also adjust the transverse movement of movement apparatus **115** so that when the end effector **120** descends towards the base **402** of bed **400** of shuttle **140** such that the front edge **107** is positioned against the vertically extending back wall **404** of the shuttle **140**, the end effector will be generally directly above the base **402** and the blank properly positioned transversely on the bed **402**.

With reference also to FIGS. **1**C, **1**D and **1**E, picket wall **218** may be supported by a support frame generally designated **243**. Support frame **243** has lower longitudinal members **243***a* which may rest on a plurality of transverse rollers **277** that are supported on a sub-frame **221**. Support frame **243** is also mounted to a slidable carriage **245**. Carriage **245** may be operable to ride/slide on a pair of horizontal, longitudinally extending rails **247** extending in the X-direction. Rails **247** may be supported by a sub-frame **249** on the factory floor. Carriage **245** may have a depending belt block **261** attached to an endless drive belt **263** From the belt block **261**, the drive belt extends along rails **247** to free-wheel **265** device located at one end of rails **247**, around the free-wheel device **265** and back along the rails **247** to the its other end where the belt passes around drive wheel of a servo motor **273** and then returns along the rails **247** again to the belt block **261**. According to some embodiments, as shown in FIG. **1**C, the drive belt may include an acme screw arrangement. According to other embodiments, screw type actuators may be alternatively implemented with drive belts for high-speed actuations. Given this arrangement, PLC **132** may operate the servo motor **273** to move the belt block **261**, and thus carriage **245** and also picket wall **218** (which is supported in such movement by support frame **243** riding on rollers **277**) such that picket fence **218** can be moved in forward/backward directions (in the X direction) in order to properly position the picket wall **218** in the correct longitudinal position for the particular sized case blank to be processed and erected into a case. Thus PLC **132** can adjust the longitudinal positions of both picket wall **218** and shuttle **140**, to accommodate changes in the lengths L of the case blanks that are being fed in series by conveyor **206** to the pick-up location.

In yet another embodiment, as shown schematically in FIG. **26**A, a system **5100** is depicted schematically in which system **5100** is constructed substantially the same as systems **100**/**1100**, except as described hereinafter. In system **5100**, a plurality of magazines M**1**-M**5** may be supported by one or more frame structures above a common in-feed conveyor **5204** (which may be constructed generally like in-feed conveyor **204**, including as depicted in FIGS. **24**, **25** and **26**). Magazines M**1**-M**5** may be arranged in spaced longitudinal relation to each other vertically above in-feed conveyor **5204**. In-feed conveyor **1204** feeds an alignment conveyor **5206** (which may be like alignment conveyor **206** described above), and except as described herein, the remainder of the modified system **5100**, may be the same as systems **100**/**1100**.

Magazines M**1**-M**15** may each contain one or more stacks of product packaging, such as case blanks which each may generally be like blanks **111** processed by system **100**, with at least some and possibly each of the magazines M**1**-M**15** containing different types/sizes and/or configurations of packaging/case blanks compared to other magazines. The size, configurations and types of case blanks (and the cases that can be formed therefrom) can vary to provide a range of case sizes, configurations and types that can be automatically processed by the system **5100** without the need for any manual intervention to modify any components of the system. PLC **132** of system **5100** may be programmed such that the particular dimensions/overall size/configuration (e.g. such as regular slotted carton or "RSC")/type of each of the blanks held in each one of the magazines M**1**-M**5** is stored in the memory of the PLC **132**.

Each magazine M**1**-M**5** may provide a vertical stack of case blanks above infeed conveyor **5204** and be operable to dispense single case blanks on demand under the control of PLC **132**, in a flattened orientation onto infeed conveyor **5204**. An example arrangement of a suitable type of vertical case dispensing magazine, is the magazine that forms part of the 310E case erector made by Wepackit Inc. of Orangeville, Ontario, Canada (http://www.wepackitmachinery.com/310E/310E.pdf).

PLC **132** may give an instruction to form a case, and if required, PLC **132** may cause one of magazines M**1**-M**5** to dispense a blank of an appropriate configuration/size onto in-feed conveyor **5204** for delivery to alignment conveyor **5206**. PLC **132** is able to selectively move and transfer a single blank at a time onto in-feed conveyor **5204** from any one of magazines M**1** to M**5**. Therefore, separate individual case blanks may be fed in series and longitudinally in a desired sequence by in-feed conveyor **5204** to alignment conveyor **5206**. The particular sequence/order of carton blanks that are placed onto in-feed conveyor **5204** of system **5100** may be determined and selected by PLC **132** or another control system as described hereinafter, such that case blanks may arrive at alignment conveyor **5206** in such a desired sequence in which it is desired to process the blanks within system **5100**.

PLC **132** may maintain in its memory records of the sequence of case blanks that have been placed onto in-feed conveyor **5204**. For example, this information may include the type/size/configuration of the case blank and, where the system **5100** includes a labeller, the label information to be applied to the carton blank. A new record can be added each time a request for a new carton is received and, optionally, records can be removed once a carton has been formed (and labelled). Thus, such records may be organized and maintained in sequence in the memory of PLC **132** using a conventional shift registering technique. In this way, the record for the next carton blank scheduled to arrive at alignment conveyor **5206** may be provided at the output of the shift registers as that carton blank arrives, and the type/configuration/size of that carton blank and the label information for that case blank may be determined from the provided output.

Once transferred from in-feed conveyor **5204** to alignment conveyor **5206**, the alignment conveyor **5206** may then under the control of PLC **132** move each blank sequentially to the pick-up location in the manner described previously with respect to systems **100** and **1100**. In this regard, conveyors **5204** and **5206** may be constructed substantially like conveyor **204/1204** and **206**.

As described above, a sensor (not shown) such as an electronic eye model 42KL-D1LB-F4 made by ALLEN BRADLEY, may be located within the horizontal gap between in-feed conveyor **5204** and alignment conveyor **5206**. The sensor may be positioned and operable to detect the presence of the front edge of a blank as each blank in turn begins to move over the gap between the conveyors. Upon detecting the front edge, sensor may send a digital signal to PLC **132** signalling that a particular blank (the size/configuration/type of which PLC **132** is aware) has moved to a position where conveyor **5206** can start to move. PLC **132** can then cause the motor for conveyor **5206** to be activated to move the blank downstream. In this way, there can be a "hand-off" of each blank from in-feed conveyor **5204** to alignment conveyor **5206**.

Once the rear edge of each blank passes the sensor, a signal may be sent to PLC **132** which can then respond by sending a signal to shut down the motor driving conveyor **5204**. Conveyor **5204** is then in a condition to await a further signal thereafter to feed the next blank in the series of blanks on the conveyor **5204** to alignment conveyor **5206**. Meanwhile system **5100** can be operated to move the blank on alignment conveyor **5206** to the pick-up location in the manner described in conjunction with system **100** so that processing of the blank can continue as described in conjunction with system **5100**.

Optionally, and as in the system described above, in system **5100**, PLC **132** may verify that the type/size/configuration of the case blank at the pick-up location matches the expected case blank. For example, the top surface of each case blank may include a bar code identifying its type/size/configuration, and this bar code may be read at the pick-up location by a suitably positioned bar code reader. The type/size/configuration of the case blank read from this bar code may be compared to the expected type/size/configuration of case blank, which may be determined from a record of the next scheduled case blank stored in memory of the PLC, as described above. Verification is successful when there is a match. When there is not a match, PLC **132** may issue a signal requesting manual operator intervention.

It may also be observed in FIG. **26**A that the overall configuration of system **5100** provides for a generally S-shaped path (or, if mirrored, a Z-shape) for case blanks through system **5100**. More specifically, incoming blanks are conveyed in a downstream X-axis direction to the pick-up location. These blanks are then conveyed in a perpendicular Y-axis direction to the shuttle where they are then conveyed again downstream in the same X-axis direction. Such an S-shaped configuration may be suitable when system **5100** is integrated into a larger system, such as a pack line system as described hereinafter, of which system **5100** is only a part.

The generally S-shaped path may be achieved by generally reversing the orientation of shuttle **140** and its components (on an X direction axis), including L-shaped bed **400** with its horizontally extending base **402** and vertically extending back wall **404** such that the shuttle is oriented in a the same downstream—X axis—direction as infeed conveyor **5204** and alignment conveyor **5206**. Additionally, end effector **120** may be positioned so as to engage on a top surface of panel A,—so that during that during opening of the case blank **111**, the shuttle **120** will push against the rearward edges of panels J, B and I, while end effector **120** lifts panel vertically, causing panel B to rotate from a horizontal orientation to a vertical orientation (See FIGS. **4**A and **4**B). Alternatively, each blank **111** may be fed to the alignment conveyor in an opposite direction (ie. so that panels J, B and I are leading panels and panels F, A and E are the trailing panels). Thus, the end effector **120** may then pick up the case blank **111** on panel B and the shuttle **120** will push against the rearward edges of panels F, A and E, while end effector **120** lifts panel B vertically, causing panel A to rotate from a horizontal orientation to a vertical orientation. In each such arrangement, the transverse axis through the crease lines Y1 of the panels will remain the same longitudinal position during operation, regardless of the length of the case blank **111**.

System **5100** may also have its a folding apparatus generally designated **130**, configured to fold one or more flaps of each sleeve, and a sealing station **135** at which flaps of the cartons are sealed arranged in an opposite direction. System **100** may also include a carton re-orienting station **116** and a carton discharge conveyor **117** arranged in an opposite longitudinal direction—as shown. Thus, system **5100** is operable to feed an erected case to a carton re-orienting station **116** and a carton discharge conveyor **117** which are also oriented in the same downstream—longitudinal X-axis—direction from the case erecting station, as depicted in FIG. **26**A.

The use of carton forming systems **1100/5100** described above, have the ability to process a relatively large number of different size case blanks from a relatively small footprint on a factory floor. By moving case blanks in their flattened configuration, on conveyor systems to the end effector **120** where they are translated transversely, also in their flattened state, and only opened in the combined movements of the shuttle and the end effector, provides a very technically efficient mechanism for erecting cases of different sizes. It will be noted that several steps of the case forming process are able to be performed at the same time (in parallel to each other). For example, the systems may be configured such that infeed and alignment conveyors may be moving to the pick-up position one case blank, while another case blank is being moved transversely by the end effector (of the end effector is at least being moved), while an erected case is completing its sealing/labelling steps. The result is that it is believed that systems **100/1100/5100** may be able to process in the order of at least 20-30 cases per minute.

According to another embodiment, the carton forming system **100** or modified carton forming systems **1100/5100** can be very effectively used in an order packing system. FIG. **27** depicts an example of such an order packing system **2700**. The order packing system comprises an order staging subsystem **2780** and a packing cell **2710**. Although a single packing cell **2710** is shown, embodiments may include multiple packing cells.

Order staging subsystem **2780** carries a sequence of individual orders of products to be packaged and shipped. In the depicted example, each order of products is held in a container, e.g. a resuable bin. Order staging subsystem **2780** transports orders of products to a packing position **2718** at which products may be packed for shipping. Specifically, order staging subsystem comprises an order bin conveyor **2782** for carrying filled order bins **2750** to packing position **2760** and carrying out, from the packing position **2760**, empty order bins **2752**. In the depicted example, a branch conveyor **2784** is provided, onto which filled order bins **2750** may be diverted for packing at packing cell **2710**.

The order bin conveyor **2782** according to some embodiments may be a series of sub-conveyors. The conveyor has multiple input and output points such that bins may be introduced to or removed from the conveyor at multiple locations. An exchange mechanism including one or more diverters may be provided, such that a path for each bin may be defined by selectively operating the mechanism. The order bin conveyor **2782**, according to some embodiments, may be configured to orient or tilt a filled order bin **2750** to a specific angle.

The packing cell **2710** comprises the modified case forming system **1100** or **5100**, a dunnage dispenser **2716**, a packing station **2718**, a case sealer **2720**, and a case labeller **2722**. These components of the packing cell **2710** are connected by a case conveyor **2724**.

Modified case forming system **1100** or **5100** receives blanks **111** from case blank magazine M1-M16 by way of case conveyor **2724**, and forms erected cases **2726** from the blanks **111** in the same manner as systems **100**, **1100** and **5100** as described above.

Modified case forming system **1100** or **5100**, according to some embodiments, is configured to construct cases of different sizes, from the blanks **111** of different sizes. The modified case forming system **1100** or **5100** can receive an instruction of the size of the case to construct from the blank **111**, and may if necessary, modify its construction mechanism as described hereinbefore to construct the case to said size.

Erected cases are transported by case conveyor **2724** to dunnage dispenser **2716** to receive dunnage. Dunnage can be generally defined as packing material to protect products during shipping. For example, types of dunnage include bubble wrap, packing peanuts, paper or corrugated cardboard inserts. Dunnage dispenser **2716** may include any mechanisms suitable for providing dunnage of one or more types. For example, dunnage dispenser **2716** may include one or more of: rolls for dispensing wrap such as bubble wrap, or hoppers for dispensing particles such as packing peanuts. At dunnage dispenser **2716**, according to some embodiments, the type of dunnage, the length or amount of dunnage are selected, and the dunnage is dispensed into the constructed case.

Next, cases with dunnage **2728** are transported by case conveyor **2724** to the packing station **2718** to become packed cases **2730**.

At packing station **2718**, products from a bin **2750** at packing position **2760** are removed from the bin and placed into the constructed case with dunnage **2728**. Products may be manually transferred from filled order bin **2750** to the constructed and dunned case **2728** by a human operator, or automatically transferred by a suitable machine, or a combination thereof. In an example, the products may be transferred by a mechatronic system including a robotic arm.

After being packed at packing station **2718**, the packed cases **2730** are transported by case conveyor **2724** to sealing station **2720** to be closed and sealed. Sealing station **2720** is configured to control the selection, dispensing, and application of the sealing material. For example, a type of tape may be selected and applied to a case. Sealing station **2720**, according to some embodiments, may be a robotic articulated arm, or any other electromechanical device that can apply the seal to the box. According to some embodiments, sealing station **2720** can include individual or combined electromechanical systems for dispensing of a sealing material and the application of the sealing material to a case.

Sealed cases **2732** are transported over a case conveyor **2724** to label station **2722** to be labelled for shipment. Cases outputted from label station **2722** are completed cases **2734**, ready for postal/courier distribution. The label station is configured to generate the shipping label, print the shipping label, and apply the shipping label. A shipping label can include information such as the postal address, and the method of shipping to be applied to the case. According to some embodiments, shipping information may be encoded in a barcode or any other encoded visual data structure. label station **2722**, may be a robotic articulated arm, or any other electromechanical device that can apply the shipping label to the case. According to some embodiments, label station **2722** can include individual or combined electromechanical systems for printing the shipping label and the application of the shipping label to a case.

The order bin conveyer **2782** and the case conveyor **2724** are configured to deliver to the packing station **2718** the bins and constructed cases in corresponding sequences. That is, a case may be selected for each order, based on the physical size or weight of the products in the order. As will be described in greater detail, the sequence of orders and cases presented at packing station **2718** may be matched to one another such that a case that corresponds to the size of each order is brought to the packing station along with the bin containing that order.

As shown, a sequence or queue of order bins is formed on branch conveyor **2784** by diverting bins from the order bin conveyor **2782**. The sequence of bins are positioned so that the bin at the front of the sequence located proximate packing position **2760**. Similarly, a sequence or queue of constructed cases is formed on the case conveyor **2724** approaching the packing position **2760**. Each case in the sequence of cases corresponds to a filled order bin **2750** containing products. The size of the case constructed in the sequence of cases is based on the products in the corresponding filled order bin **2750**.

In some embodiments, the order packing system may include multiple packing cells. As shown in in FIG. **28**, the order packing system **2700** comprises four packing cells **2710**. However, any number of packing cells may be present, subject to space and logistical limitations. As depicted, the four packing cells are commonly fed by a single order bin conveyor **2782**. However, in other embodiments, multiple separate order bin conveyors may be provided.

Increasing the number of packing cells **2710** may enable greater throughput of orders through the system. Further, the plurality of packing cells **2710** may enable optimization through configuration of the individual packing cells. For example, when multiple packing cells **2710** are present, a greater range of case and dunnage types and sizes may be accommodated. For example, certain packing cells **2710** may only have case blanks **111** corresponding to smaller cases, to be used for order bins that contain smaller products.

Order staging subsystem **2780**, according to some embodiments, may further include branch conveyers **2784** to feed the various packing cells **2710**. The order staging subsystem **2780** and packing cell **2710** may also use the branch conveyor **2784** and the order bin conveyor **2782** to transport the empty bins for reuse, and the case conveyor **2724** to transport the completed orders (i.e. with a constructed case from a selected blank, filled with dunnage and products, sealed and labelled) towards an output for delivery to a customer.

According to some embodiments, order bin conveyor **2782** may orient the bins at an angle for easy unloading of the contents from the bin. For example, bins may be oriented with an opening facing packing position **2760**.

Order staging subsystem **2780**, branch conveyors **2784** and packing cells **2710**, may be controlled by a control system **2900**. For example, the control system may dictate any of the speed and position of orders and cases within the system, and the sequences of order bins and cases that are presented at packing location **2760** of any given packing cell.

Control system **2900** may be implemented in any combination of programmable logic controllers (PLCs) and computing devices such as PCs. Each PLC **132** associated with a particular carton forming system **100**, **1100**, **5100** can form part of control system **2900**.

FIG. **29** is a block diagram of example hardware components of control server **2900**. Control server **2900** may be hosted on a computer **3000** including processor **3002**, network interface **3004**, a suitable combination of persistent storage memory **3006**, random access memory and read only memory and one or more I/O interfaces **3008**. Processor **3002** may be an Intel **x86**, PowerPC, ARM processor or the like. Network interface **3004** interconnects control server **2900** to a network (not shown). Memory **3006** may be organized using a conventional filesystem. Control server **2900** may include input and output peripherals interconnected to control server **2900** by one or more I/O interfaces **3008**. These peripherals may include a keyboard, display, mouse and one or more devices such as DVD drives, USB ports and the like for reading computer-readable storage media. Software components exemplary of embodiments of the present invention may be loaded into memory **3006** over network interface **3004** or from one or more peripheral devices.

FIG. **30** depicts a simplified organization of example software components stored at a computing device of control system **2900**. The control server **2900** can include functional modules to control individual components of the packing cell. As depicted, the modules include order tracker **2910**, shipping label generator **2920**, dunnage selector **2930**, case size selector **2940**, case sealer **2950** and sequence manager **2960**, each are able to interface with the components of packing cell **2710** and order staging subsystem **2780** via one or more PLCs (such as PLC **132**) to cause physical operations to occur as described herein. Further, the software components are able communicate with each other and to access any appropriate database required to complete the functions as will be described. For example, the software components may be configured to communicate with each other via individual function calls between software components or requests to access the information stored at locations in a memory **3006**.

Order tracker **2910** maintains records of orders being fulfilled and details, e.g. physical dimensions, of products within such orders. As shown in FIG. **31**, the order tracker includes a product dimension repository **2912** (e.g. a database or database table) and order repository **2914** (e.g. a database or database table). Order repository **2914** functions to keep a record of all orders in the system. An order includes at least one product, and can comprise multiple products to be shipped to a location. The order repository **2914** may also include the shipping address to send the order to, or may link to another table including shipping addresses, according to some embodiments. The product dimensions repository **2914** can include the dimensions of each product, such as height, width, and depth. Individual products may have a unique SKU ID number associated with them. According to some embodiments, the database is stored locally in memory **3006**. According to other embodiments, this database is stored in a memory accessible on another server by way of a network. According to some embodiments, the order tracker **2910** further includes weights for each product and an indication of the product fragility.

FIG. **32** is an example of a product dimension repository **2912** stored in the order tracker **2910**, made up of information about the products in the order and their dimensions. As depicted, product dimension repository **2912** is a database table. The product dimension repository **2912** comprises products each having a unique product ID **3206**. Each product **3206** has dimensions **3208**. The product dimension repository **2912** would have entries for each possible product that could be used in orders within the order fulfilment system **2700**.

Order tracker **2910** also includes an order repository **2914**, stored as a table to track a sequence of orders having an order ID **3302**, wherein each order corresponds to an individual bin containing at least one product **3306**. Each product **3306** corresponds to a product that can be found in product dimensions **2912**. Each individual bin may be tracked using an individual bin ID **3304**. The order database, as will be described later, can also keep track of the case size **3308** selected to be constructed from the case construction apparatus, the dunnage type **3310** to be used in packing the case, the dunnage length **3312** to be used when packing the case, and the specific packing cell **3314** that the bin will be transported to. The case size **3308**, dunnage type **3310**, dunnage length **3312**, and packing cell **3314** can serve as operational parameters delivered to order staging subsystem **2780** and a packing cell **2710**.

As will be apparent, product dimension repository **2912** and order repository **2914** may be linked tables within a database schema of order tracker **2910**.

Case size selector **2940**, as shown in FIG. **34** comprises a case size repository **2942** and size determiner **2944**. In operation, case size repository **2942** comprises a database of available case sizes and the volume of the constructed case, along with the packing cell **2710** that includes blanks for the case size. Size determiner **2944** receives an input comprising an order ID **3302**, including the product IDs **3306** and the individual product dimensions **3208**, and calculates a volume for the order. Based on the order volume, the most appropriate case size is selected for use for the order.

FIG. **35** is an example of case size repository **2942**. As depicted, case size repository **2942** is a database table. Each case size is identifiable by a unique case size ID **3502**. For each case size ID **3502**, case dimensions **3508** for height, width, and depth are defined. Optionally, additional capacity parameters may be recorded. For example, as shown, case size table **2942** includes a volume minimum **3504** and volume maximum **3506**. Additionally or alternatively, other suitable parameters could be recorded such as minimum and maximum order weights. Case size repository **2942** further includes an indicator **3510** of which packing cells **2710** includes blanks in magazines M1-M16 corresponding to the case size having ID **3502**.

FIG. **36** is an example method **3600** for the use of the case size selector **2940**. First, at block **3602**, an order ID **3302** is received. The order ID **3302** may be a unique identifier for an individual order such as, for example, a purchase of products from an online marketplace. The order ID **3302** can be used to query a database stored in a memory in a network for additional information.

At block **3604**, the products in the order are determined, based on the order ID **3302**. This may be done, for example, by querying order repository **2914** (FIG. **33**) stored in a memory on a network to return all product IDs **3306** for the individual order ID **3302**.

At block **3606**, the dimensions of the products in the order are determined. This may be done, for example, by performing a lookup in product dimension repository **2912** (FIG. **32**) to return the dimensions **3208** for each individual product ID **3206** in for the product IDs **3306** associated with individual order ID **3302**.

At block **3608**, a query of case size table **2941** (FIG. **35**) is performed to identify candidate case types, namely, those case types that are capable of holding the products in the order. In an example, the dimensions of the products in the order are compared with the dimensions of available case sizes. Candidate cases may, for example, be those with length, width and height greater than the largest product in the order. Candidate cases may be filtered according to other capacity values. For example, according to some embodiments, a total volume of the products in the order is calculated and compared that to the total volume available in all cases in case size repository **2942**. Cases with internal volume less than the total volume of products in the order, or with internal volume less than a defined multiple of the total product volume (e.g. 1.5×) may be eliminated as candidates. According to other embodiments the individual product dimensions are compared to those of cases in case size repository **2942**.

Finally, at block **3610**, the case size for the order ID **3302** is selected. According to some embodiments, the candidate case with the smallest internal volume is selected as the generated case size to use for the order. According to other embodiments, the case size selected as the case size for the order ID **3302** is the case in case size repository **2942** with the smallest maximum dimension, i.e. the smallest length, weight or height.

An example approach for selecting case size is disclosed in U.S. Pat. No. 6,876,958 to Chowdhury et al., issued to assignee New Breed Corporation on Apr. 5, 2005 (hereinafter, "Chowdhury"), the contents of which is hereby incorporated by reference herein in its entirety. In particular, Chowdhury's product packaging utility processes each order placed by a customer to automatically identify, from available case types/sizes/configurations, a type/size/configuration of suitable case (or cases) suitable for packaging the products in the order. Chowdhury's a product packaging utility identifies/determine suitable case(s) according to an algorithm/function that accesses and uses one or more electronically-stored characteristics of each product in the order (e.g., dimensions, weight, etc.) and one or more electronically-stored characteristics of available case types (e.g., dimensions, size, configuration, type, maximum volume that can be held, maximum weight that can be held, etc.). This algorithm identifies suitable cases such that a minimum number of cases and the smallest size cases suitable for packaging the products in the order may be provided. Thus, identification of suitable case types/sizes/configurations can be optimized to provide an optimal case type/size/configuration which minimizes packaging material used and to minimize empty space in cases, and a case identified as suitable may be referred to as an "optimal" case. It will be appreciated that identification of suitable case types/sizes/configurations may also be identified or optimized according other pre-defined criteria. The case identification algorithm of Chowdhury's product packaging utility may also take into account other factors and constraints such as, e.g., the availability of each type/size/configuration of case, the maximum fill ratio of each type/size/configuration of case, the maximum number of products that can be placed into each type/size/configuration of case, and whether certain products are pre-packaged together and therefore must be placed in the same case. Thus, using Chowhury's product packaging utility, case size selector **2940** may process a customer order for specific products by accessing information in it memory and utilizing an algorithm/function to identify a suitable case (or cases) for packaging those products from a plurality of available cases.

It should be noted that the size of the case may be the overall internal available volume of the case in which items may be held. The size may also be the specific dimensions of the case. The type of case may include the reference to what material the blanks is made from (e.g. paperboard or corrugated cardboard). Its configuration may an indication of it being a top opening case which is generally cuboid in shape when closed, or another configuration such as a regular slotted case, etc.

Chowdhury's product packaging utility may also generate, for each case of a particular type/size/configuration identified to fulfil an order, a packing list indicating the order in which each of the products is to be preferably placed into the case, as well as placement information indicating where each product is to be preferable placed in the case. For example, this placement information may be expressed using coordinates (e.g., 0, 0, 0) in a coordinates system defined for the case and/or descriptors of locations in the case (e.g., front, right hand side, second layer, etc.). Thus, when order the case size selector **2940** includes a product packaging utility such as Chowdhury's product packaging utility, case size selector **2940** may generate a packing list and/or placement information for each identified case. Case size selector **2940** may also generate a diagram illustrating a desired optimal physical arrangement of the products in each case. Such a diagram may be readily generated using placement coordinates for each product, as provided by Chowdhury's product packaging utility.

The generated case size can be inputted as an operational parameter to one of packing cells **2710**, wherein the selected case size corresponds to a case blank **111** stored in one of the associated magazines **M1**-**M16**. The generated case size can be recorded in the corresponding record of order repository **3300**.

FIG. **37** shows sequence manager **2960**, comprising a packing cell selector **2962**, conveyor director **2964**, and sequence **2966**. The packing cell selector **2962** functions to select, based on the case size or any other optimization algorithm, the appropriate packing cell **2710** to manage the order fulfilment. Sequence manager **2960**, using the packing cell selector **2962**, will generate and modify a sequence **2966** of cases constructed in the packing cell **2710**. The conveyor director **2964**, based on input from the packing cell selector **2962**, will supply operational signals to conveyors (such as order bin conveyor **2782** and case conveyor **2762**) to transport the blanks from case magazine **M1**-**M16** in sequence **2966** to the appropriate packing cell **2710**. In operation, the filled order bin **2750** will be directed towards the packing cell **2710**, where each corresponding case will transported by the conveyor **2762** to the packing station **2718**.

The conveyor director can define a path, i.e. a set of conveyors to be traversed for the case or bin to take to reach the appropriate packing cell. At intersections of conveyors, the system may include a diverter mechanism, to divert a bin or case from one conveyor path to a next conveyor path.

FIG. **38** is an example of sequence **2966** for a chosen packing cell **3314** managed by the sequence manager **2960**. As depicted, the sequence **2966** is a list to track the filled order bins **2750**, and the properties of the corresponding erected case **2726**. Sequence manager **2960** will generate an individual sequence **2966** for each packing cell **2710** in the order packing system **2700**. The sequence **2966** may be linked to product dimension repository **2912** and order repository **2914** within a database schema of order tracker **2910**.

As new orders **3302** having bins **3304** enter the order packing system **2700**, the sequence manager **2960** can add the order **3302** to the sequence **2966** for the chosen packing cell **3314**. As completed cases **2734** and empty order bins **2752** leave the chosen packing cell **3314**, sequence manager **2960** can remove the order **3302** from the sequence **2966**. In the same order as the sequence **2966**, the filled order bins **2750** will be delivered by order staging subsystem **2780** to the chosen packing cell **3314**. Similarly, in the same order as the sequence **2966**, the chosen packing cell **3314** will be given operational parameters for the order **3302**, such as case size **3308**, dunnage type **3310**, dunnage length **3312**.

FIG. **39** is an example method **3900** for the use of the sequence manager **2960**.

At block **3902**, an order ID **3302** corresponding to a filled bin on order bin conveyor **2782** is selected.

Next, at block **3904**, the size of case to be used for the order is determined. This can be done using a case size selector **2940** and the method as shown in FIG. **36**.

Next, at block **3906**, the case size for the order from block **3904** is compared with the cases available at each of packing cells **2710**. This can be done by case size repository **2942** (FIG. **35**) across the different packing cells **2710**. The packing cells **2710** that have magazines containing blanks for the case size determined from block **3904** are identified.

Next, at block **3908**, a packing cell **2710** to handle the order is selected. According to embodiments where there are multiple packing cells **2710**, it is possible that the different packing cells **2710** may be configured based on specific sizes of cases (i.e. a specific packing cell **2710** for smaller cases, and a specific packing cell **2710** for larger cases). Alternatively, in other non-limiting embodiments, the packing cell **2710** selected may be random or evenly distributed.

Next, at block **3910**, parameters are sent to the order bin conveyor to direct the filled order bin to the selected packing cell **2710** selected at block **3908**. The individual path for the bin across the conveyors will be defined and any instructions for intersection conveyors or diverter mechanisms may also be defined and communicated.

Finally, at block **3912**, operational parameters are sent to the packing cell **2710** for the order ID **3302**. This can include the case size to construct as determined in block **3904**, among any other operational parameters.

FIG. **40** shows components of the dunnage selector **2930**. Dunnage selector **2930** includes a dunnage repository **2932**, a dunnage type selector **2934** and dunnage dispenser **2936**. In operation, an order ID **3302** is provided to dunnage selector **2930**. Based on order information such as product dimensions **3208**, weights and fragility, a type of dunnage and quantity of dunnage is determined, then dispensed. Examples of dunnage types include bubble wrap, packing peanuts, or loose paper. In some embodiments, dunnage types or quantities may be selected based on customer preference in addition to the product information (such as size or weight). For example paper dunnage may be selected for orders by customers who have expressed a preference for eco-friendly packaging.

The dunnage repository **2932** stores the types of dunnage available to be dispensed, and quantity increments in which it may be dispensed. For example, packing peanuts may be dispensed in defined volume increments and bubble wrap may be dispensed in discrete sheet sizes. Dunnage type selector **2924**, based on the information in the order tracker **2910**, determines the type and length to be dispensed by the dunnage dispenser **2926** of a packing cell **2710**. Determinations by the dunnage selector **2930** can be passed as operational parameters to a packing cell **2710**.

FIG. **41** is an example method **4100** for the use of the dunnage selector **2930**.

At block **4102**, an order ID **3302** is received.

At block **4104**, the products in the order are determined, based on the order ID **3302**. This may be done, for example, by querying a database stored in a memory on a network to return all products IDs **3306** associated with the individual order ID **3302**. Individual products, as shown in FIG. **32**, may themselves have unique identifiers **3206** and individually recorded dimensions **3208**. In some embodiments, blocks **4102**, **4104** may be performed based on a single instruction message received by dunnage selector **2930**. For example, the instruction message may include order ID **3302** along with all of the corresponding record of order repository **3300**. Alternatively, an instruction received at **4102** may include only an order ID **3302** and dunnage selector may responsively query for product information from order repository **3300**.

At block **4106**, the type of dunnage to use in the order is determined. Examples of dunnage types include bubble wrap, packing peanuts, or loose paper. Dunnage types may be selected based on the product information (such as size or weight), or based on information stored in the database about a user who has made the order, for example that they would prefer an eco-friendly dunnage type.

At block **4108**, the quantity (e.g. length or volume) of dunnage to use in the order is determined. According to some embodiments, quantity of dunnage to use in the order may be a function of the empty space left in the case, including the space occupied by the products in the order.

Finally, at block **4110**, instructions are sent to the packing cell **2710** for the order ID **3302**. This can instruct the packing cell **2710** that for each case in the sequence of constructed cases, to dispense the amount and type of dunnage determined by the method **4100**.

Case sealer **2950**, as shown in FIG. **42**, operates to seal the constructed cases once they have been filled at packing station **2718**. Case sealer **2950** includes sealer dispenser **2952** and seal applier **2954**. In operation, seal dispenser **2952** will dispense the appropriate amount of sealing material (such as tape, for example) for the seal applier **2952** to apply to the constructed case.

Case sealer **2950**, in operation, will receive an order ID **3302**. The order ID **3302** can be used to query a database stored in a memory in a network for additional information. The database can include product information such as weight, or a case size previously determined for the order. Based on this information, case sealer will determine the appropriate amount of sealing material to dispense. For example, based on the order ID **3302**, the case sealer **2950** can determine that the box has a depth of 50 cm, and then instruct the seal dispenser **2952** to dispense 50 cm of tape for the seal applier **2854** to apply.

Shipping label generator **2920**, as shown in FIG. **43**, operates to print and apply shipping labels to the sealed cases for shipping. Shipping label generator **2920** includes shipping label printer **2922** and shipping label applicator **2924**. In operation, shipping label printer **2922** will print the necessary details, for example a shipping address or bar code, for an order to a paper or sticker that can be applied to the case. Shipping label applicator **2924** will take the printed shipping label and apply the label to the sealed case.

Shipping label generator **2920**, in operation, will receive an order ID **3302**. The order ID **3302** can be used to query a database stored in a memory (such as the repositories in order tracker **2910**) in a network for additional information. The database can include information such as shipping address, shipping type, and any information. Based on this information, shipping label printer **2922** will print the appropriate label for the shipping label applicator **2924** to apply to the case.

FIG. **44** is an example method **4400** of packing product orders. The method includes receiving a sequence of bins **4402**, determining the products in the order **4404**, determining the case to be used for the order **4406**, determining the dunnage for the order **4408**, determining the packing cell for the order **4410**, directing the bin to the packing cell **4412**, constructing the case for each order **4414**, dispensing the dunnage for each order **4416**, transporting the case to the packing station **4418**, sealing the case **4420**, and applying a shipping label to the case **4422**.

At block **4402**, a unique sequence of bins containing orders, each order having order ID **3302**, are received via order bin conveyor **2782**. By querying a database with this order ID **3302**, one can determine information about the order, for example the products in the order, their dimensions, their weight, the shipping address for the order, etc.

Accordingly, at block **4404**, based on the product ID, products in the order are determined. This can be done by querying a database or repository (such as those in order tracker **2910**) for the products in each order.

Next, at block **4406**, based on the products in the order, a case from a magazine of blanks is selected for use with the order. This can be done by a case size selector **2940** as described above with reference to the method of FIG. **36**. The case size selector **2940** will determine, based on the products in the order determined at block **4404**, and the available case sizes to case constructors in packing cells **2710**, the appropriate case size to be constructed for the order.

Next, at block **4408**, the type and length of dunnage are selected. This can be done by dunnage selector **2930** as described above with reference to the method of FIG. **41**. The available case volume from the case determined at block **4406**, along with the fragility and weight of the products in the order are considered when selecting the type and amount of dunnage to dispense.

Next, at block **4410**, based on the size of case, type of dunnage, and any optimization algorithm, a packing cell **2710** is selected by the sequence manager **2960** for fulfilling the order as described above with reference to the method of FIG. **39**. For example, if the size of cases in only available at a specific packing cell **2710**, this will be the packing cell **2710** selected.

The determinations of steps **4406**, **4408**, and **4410**, may be given to the order bin conveyor **2782**, case conveyor **2724**, and packing cell **2710** as operational parameters.

At block **4412**, each bin is directed to the appropriate packing cell **2710**. According to embodiments where order bin conveyor **2782** comprises multiple sub-conveyors, the path instructions and diversion mechanisms will be defined for delivering the bin to the packing cell **2710**. The bins will be delivered in a sequence.

At block **4413**, if necessary, components of the modified case forming system **1100** or **5100** are adjusted to adapt the modified case forming system **1100** or **5100** to form the case of the appropriate size. It is noted that components of the modified case forming system **1100** or **5100** may not need to be adjusted in all situations, for example when selected case size is the same or similar to the size of the case most recently constructed prior to the selected case size in the sequence.

According to some embodiments, at block **4413**, a position of an alignment component of a case blank alignment device is set so that when said case blank abuts said alignment component, said case blank has a predetermined position.

Additionally or alternatively, at block **4413**, based on said size of said case, a stroke of a second alignment component may be adjusted. The first alignment component, according to some embodiments, is a laterally moveable first side guide for abutting a first side of said case blank in order to set a predetermined lateral position of said case blank and wherein the second alignment component is a laterally moveable second side guide for urging said case blank into abutment with said first side guide.

Next, at block **4414**, modified case forming system **1100** or **5100** will construct a sequence of cases. The sequence of cases corresponds to the bins being delivered from block **4412**. That is, for each order at a particular packing cell **2710**, a corresponding case will be constructed of the size determined at block **4406**. In operation, a blank will be transported by a conveyor from a magazine storing a plurality of case blanks to a case construction apparatus able to construct cases of various sizes.

Next, at block **4416**, the length of dunnage type is dispensed for each order. The case is transported from case construction apparatus to a dunnage dispenser. The length and type of dunnage dispensed into a constructed case will correspond to that determined at block **4408**.

At block **4418**, the cases is transported to a packing station with the bin containing the order that corresponds to the case. At the packing station, products are transferred from the bin to the constructed case. According to some embodiments, product transfer can be done by a person. According to other embodiments, product transfer can be done by a robotic device.

Next, at block **4420**, each case is transported to a case sealer, configured to seal the case with the appropriate amount and type of sealer. The type of seal can be determined based on the case size.

Finally, at block **4422**, a shipping label is applied to each case. The shipping label can include information such as the shipping address, a barcode, and any other information required to ship the case.

Of course, the above described embodiments are intended to be illustrative only and in no way limiting. The described embodiments of carrying out the invention are susceptible to many modifications of form, arrangement of parts, details and order of operation. The invention, rather, is intended to encompass all such modification within its scope, as defined by the claims.

When introducing elements of the present invention or the embodiments thereof, the articles "a," "an," "the," and "said" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements.

The invention claimed is:

1. An order packing system for orders containing at least one product, the system comprising:

a first conveyer sub-system operable to transport a plurality of bins to a packing station in a first sequence, each one of said plurality of bins containing an order comprising at least one product, said at least one product in the order in each bin of said plurality of bins being transferred into a constructed case of a plurality of constructed cases at said packing station, and wherein at least one bin of said plurality of bins contains an order comprising a plurality of products;

a case construction apparatus, operable to erect cases from blanks of a plurality of sizes to form said plurality of constructed cases,

a second conveyer sub-system operable to transport blanks to said case construction apparatus so that said construction apparatus can form said plurality of constructed cases, and to transport said plurality of constructed cases to the packing station,

a controller operable to:

cause said second conveyor sub-system to transport blanks to said case construction apparatus in a second sequence, wherein sizes of said plurality of constructed cases in said second sequence correspond to sizes of said at least one product in said first sequence, and

cause the first and second conveyor sub-systems to transport to the packing station each bin of the plurality of bins in the first sequence with a corresponding constructed case of the plurality of cases in the second sequence.

2. The system of claim 1, wherein the case construction apparatus comprises:

a plurality of magazines, each of said plurality of magazines holding a case blank that can be formed into a case of a different configuration; and

an erecting apparatus operable to erect any of said case blank from each of said plurality of magazines into a plurality of cases of different configurations.

3. The system of claim 2, wherein the case construction apparatus further comprises a case sealer to seal the bottom of the erected case blanks.

4. The system of claim 1, further comprising a dunnage dispenser situated between the case construction apparatus and the packing station operable to dispense dunnage into the constructed cases.

5. The system of claim 1, further comprising a case sealer situated after the packing station operable to seal the top of the constructed cases.

6. The system of claim 1, further comprising a shipping labelling situated after the packing station operable to affix a shipping label to the constructed cases.

7. The system of claim 1, wherein the controller is further configured to manage the first sequence and second sequence based on a database of orders stored in a memory on a server.

8. The system of claim 1, further comprising a branch conveyor sub-system operable to divert a bin to the packing station.

9. A system as claimed in claim 1, wherein said system is operable to perform a method of packing product orders, said method comprising:

(a) receiving said plurality of bins in said first sequence, wherein each bin comprises said at least one product in said order;

(b) accessing a next request from a queue;

(c) determining a size for a case from said next request;

(d) based on said size, automatically adjusting components of a case forming apparatus to adapt said case forming apparatus to form said case of said size;

(e) transferring a case blank for said case of said size from a particular repository to said case forming apparatus, said particular repository holding case blanks for cases of said size;

(f) operating said case forming apparatus to form said case from said case blank in second sequence;

(g) transporting said case to a packing station with the corresponding bin for the order;

(h) until said queue is empty, repeating (b) to (g) for a request in said queue next following said next request.

10. The method of claim 9 wherein (d) comprises, based on said size of said case, setting a position of an alignment component of a case blank alignment device so that when said case blank abuts said alignment component, said case blank has a predetermined position.

11. The method of claim 10 wherein said alignment component is a first alignment component and wherein (d) further comprises, based on said size of said case, adjusting a stroke of a second alignment component opposed to said first alignment component.

12. The method of claim 11 wherein said first alignment component is a laterally moveable first side guide for abutting a first side of said case blank in order to set a predetermined lateral position of said case blank and wherein said second alignment component is a laterally moveable second side guide for urging said case blank into abutment with said first side guide.

13. The method of claim 9 further comprising, prior to (e), based on said size of said case, identifying from amongst a plurality of repositories of case blanks, each having case blanks of a different size such that any given repository has case blanks for cases of a single size, said particular repository.

14. The method of claim 9 wherein each said next request comprises a data structure, said data structure storing an indication of said size for said case.

15. The method of claim 14 further comprising, based on said size, adjusting a movement profile of a case erecting component of said case forming apparatus.

16. The method of claim 15 further comprising referencing said data structure and labeling said case or said case blank with a label having information from said data structure.

17. The method of claim 16 wherein said data structure stores an identification of products to be loaded into said case and an arrangement and packing order of said products to be loaded into said case, and wherein said labeling comprises labeling such that said label identifies said size of said case, said products to be loaded into said case, and said arrangement and packing order.

18. The method of claim 13 further comprising automatically adjusting a position of sealing components of a case sealing device to adapt said case sealing device to seal said case of said size.

19. The method of claim 18 wherein said case is labelled with a label indicating said size and further comprising reading said label to identify said size and wherein said adjusting said position of sealing components of said case sealing device is based on said case size read from said label.

20. An order packing system as claimed in claim 1, wherein:

said second conveyor sub-system comprises a first conveyor section operable to transport blanks to said case construction apparatus and said second conveyor sub-system comprises a second conveyer section operable to transport constructed cases from said case construction apparatus to said packing station;

said controller operable to:

cause said case construction apparatus to construct said plurality of constructed cases in said second sequence and to cause said second section of said second conveyor sub-system to transport said plurality of constructed cases, in said second sequence to said packing station, wherein sizes of constructed cases in said second sequence correspond to the sizes of said at least one product in each of said bins in said first sequence, and

cause the first and second conveyor sub-systems to deliver each bin in the first sequence at the packing station with its corresponding constructed case in the second sequence, such that said orders in said bins in said first sequence can be transferred sequentially to corresponding constructed cases in said second sequence.

21. The order packing system of claim 20, wherein:

said first sequence is a selected subset of a plurality of bins on said first conveyor sub-system;

said first conveyor sub-system is operable to transport other bins of said plurality of bins to another packing station;

and further comprising:

another case construction apparatus, operable to construct cases from blanks of a plurality of sizes; and

a third conveyor sub-system operable to transport constructed cases from said another case construction apparatus to said another packing station.

22. The system of claim 21, wherein the case construction apparatus further comprises:

a case sealer to seal the bottom of the erected case blanks.

23. The system of claim 20, further comprising:

a dunnage dispenser situated between the case construction apparatus and the packing station operable to dispense dunnage into the constructed cases.

24. The system of claim 20, further comprising:

a case sealer situated after the packing station operable to seal the top of the constructed cases.

25. The system of claim 20, further comprising:

a shipping labelling situated after the packing station operable to affix a shipping label to the constructed cases.

26. The system of claim 20, wherein the controller is further configured to:

manage the first sequence and second sequence based on a database of orders stored in a memory on a server.

27. The system of claim 20, further comprising a branch conveyor sub-system operable to divert a bin to the packing station.

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