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(54) **METHOD AND APPARATUS FOR FORMING CONTAINERS**

(52) **U.S. Cl.**
CPC *B31B 50/28* (2017.08); *B31B 50/64* (2017.08); *B31B 50/006* (2017.08)

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(57) **ABSTRACT**

(21) Appl. No.: **18/244,803**

(22) Filed: **Sep. 11, 2023**

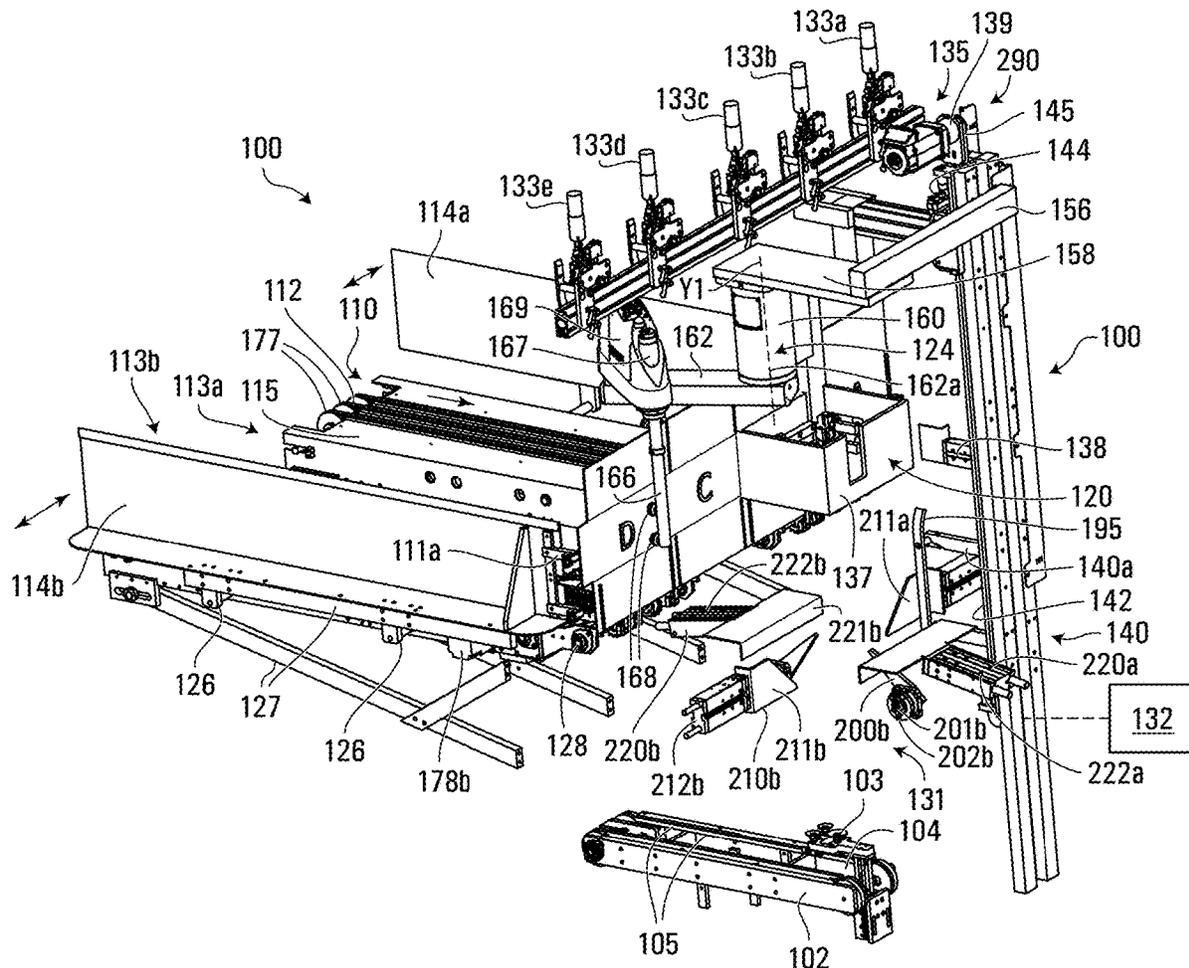
Related U.S. Application Data

(63) Continuation of application No. 16/853,471, filed on Apr. 20, 2020, now Pat. No. 11,772,352.

Publication Classification

(51) **Int. Cl.**
B31B 50/28 (2006.01)
B31B 50/64 (2006.01)

A method and apparatus are disclosed for forming containers. The containers may be cans, including composite cans. The apparatus may include a cylindrical mandrel and a blank may be formed into a cylindrical tube around the mandrel. Rotational apparatuses may engage portions of a blank that may be in a flat configuration and may rotate the portions around the outward cylindrical surface of the mandrel. Free edges of the tubular blank may be sealed by a sealing strip that may be T-shaped in cross section. A cup may be installed in an end opening, such as a bottom end, of the cylindrical tube. The cup may be sealed in the end opening by a seaming apparatus.



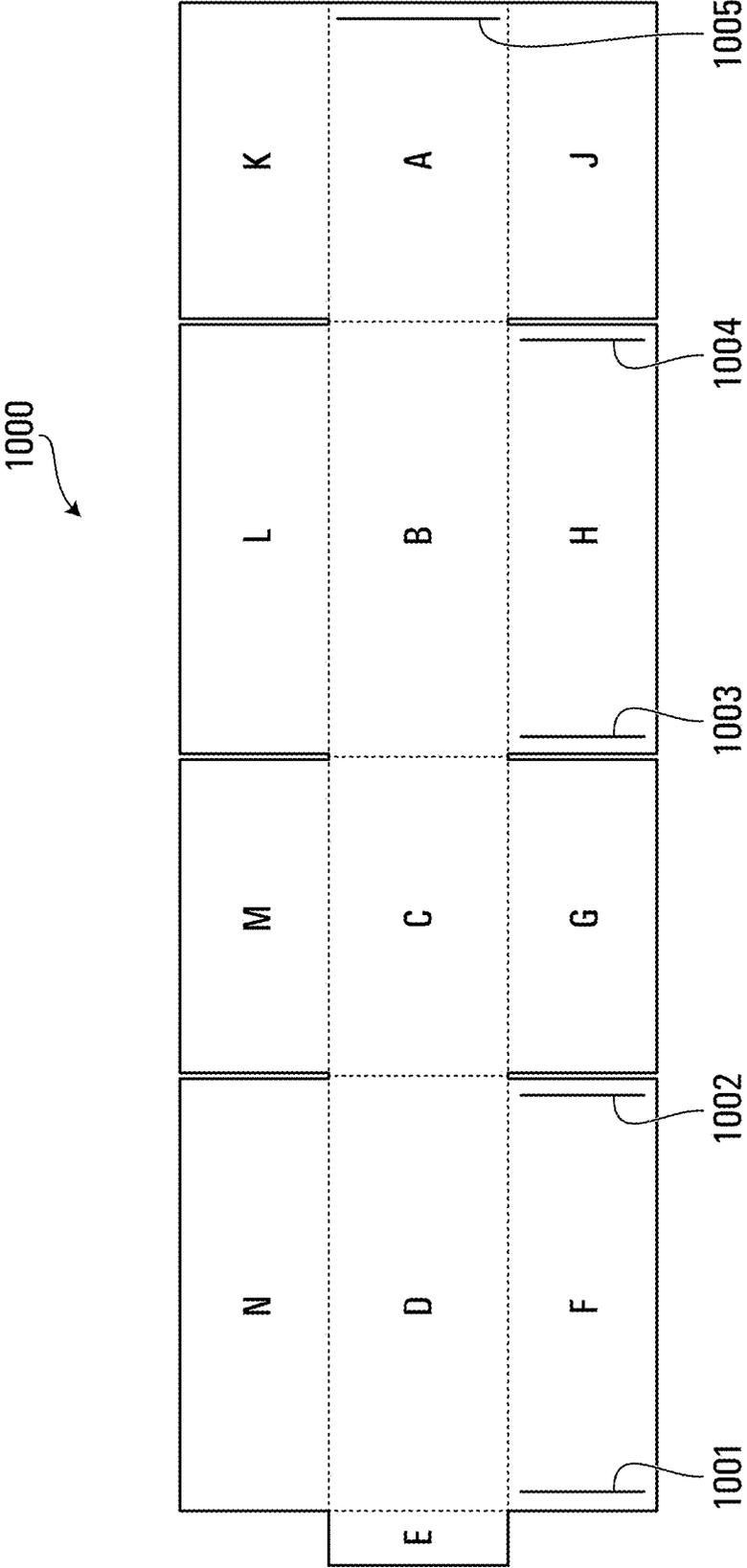


FIG. 1

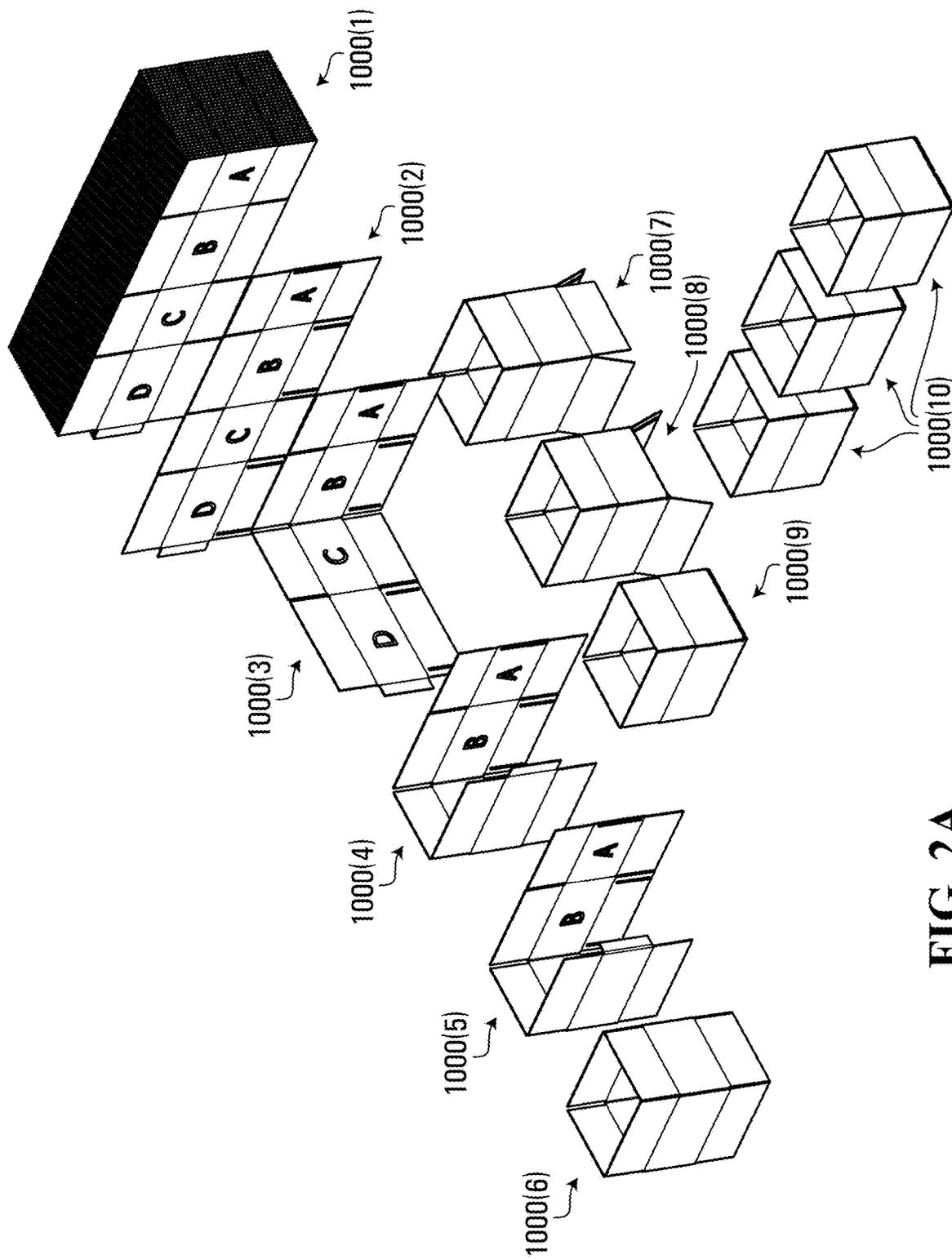


FIG. 2A

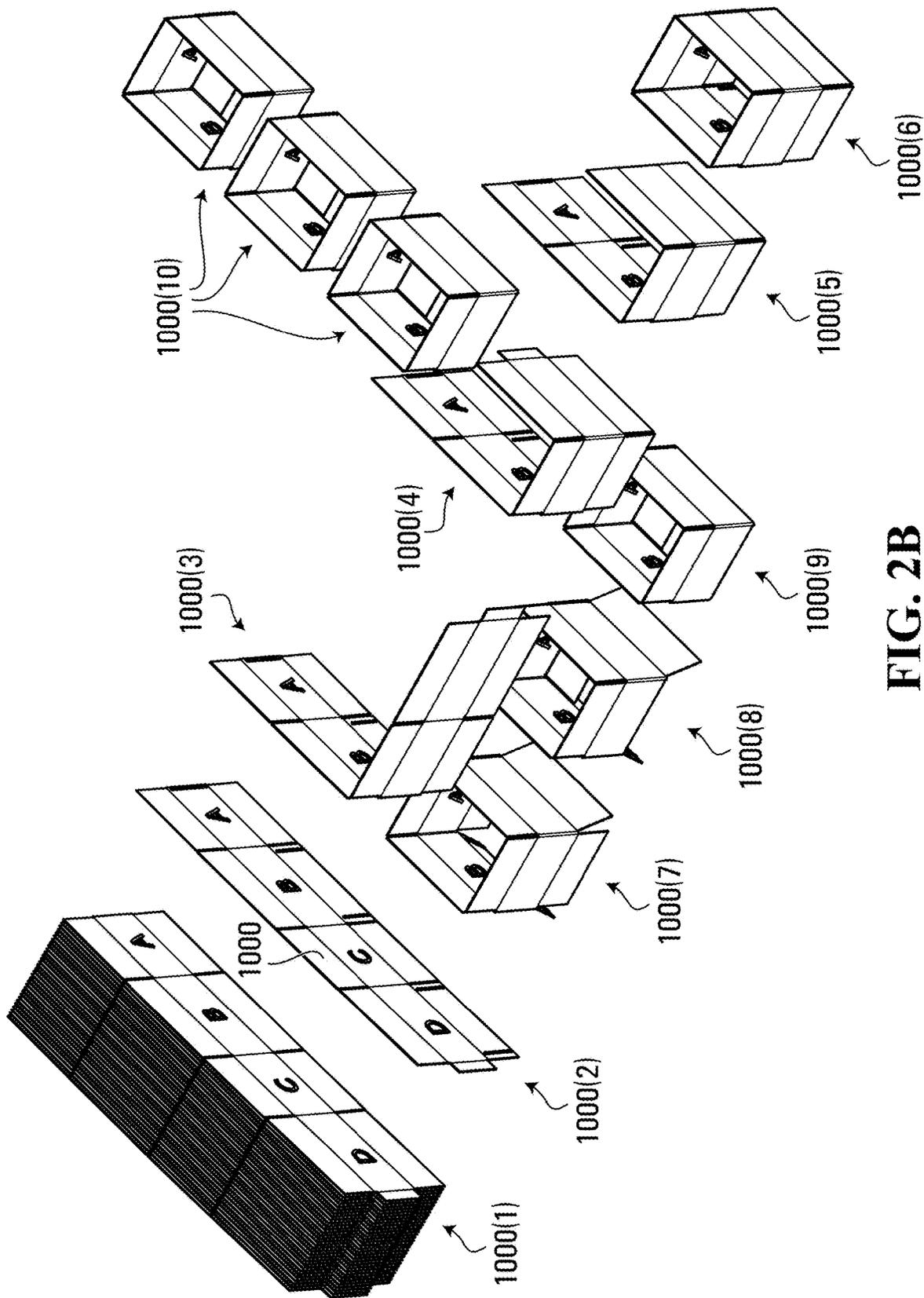


FIG. 2B

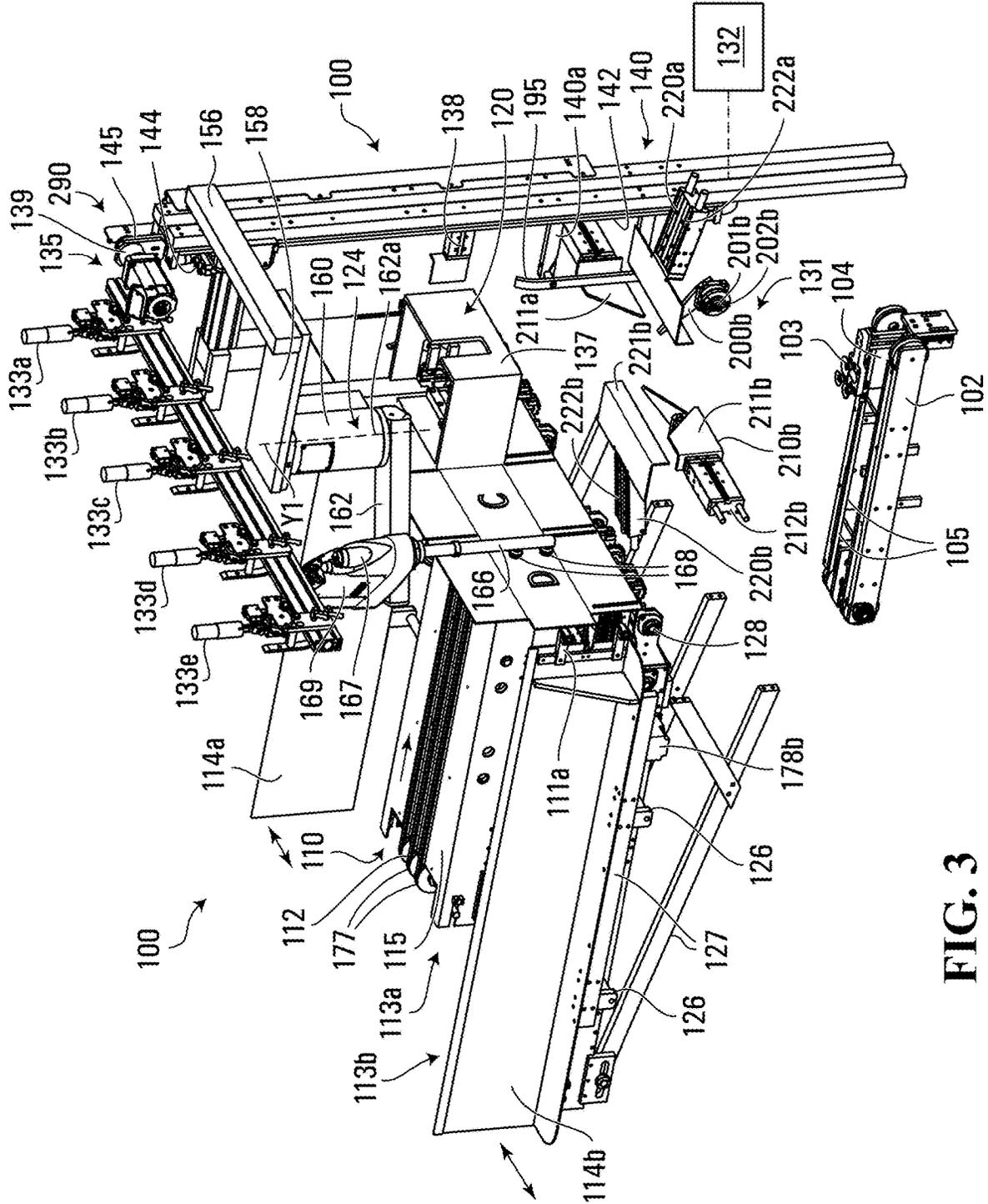


FIG. 3

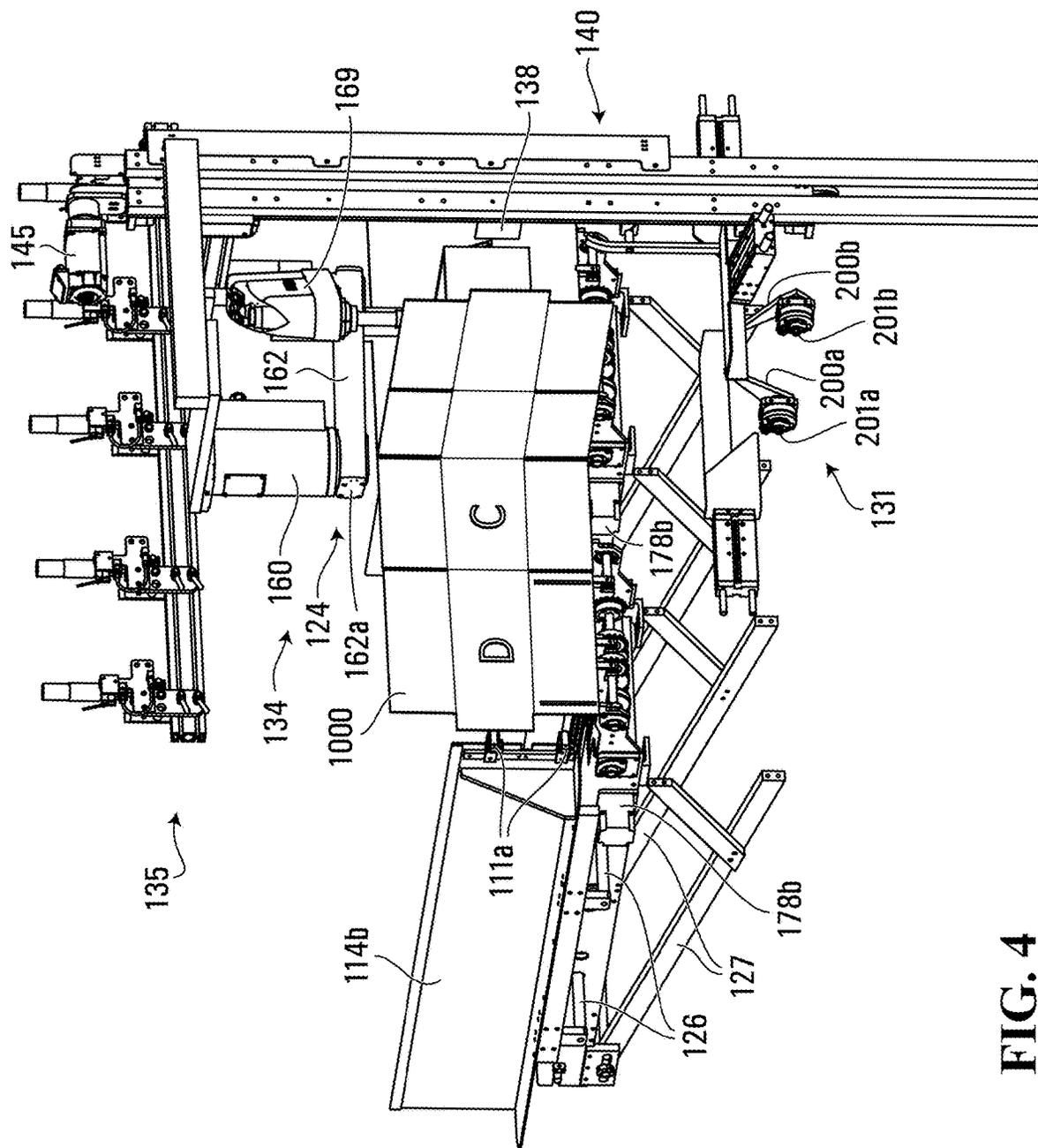


FIG. 4

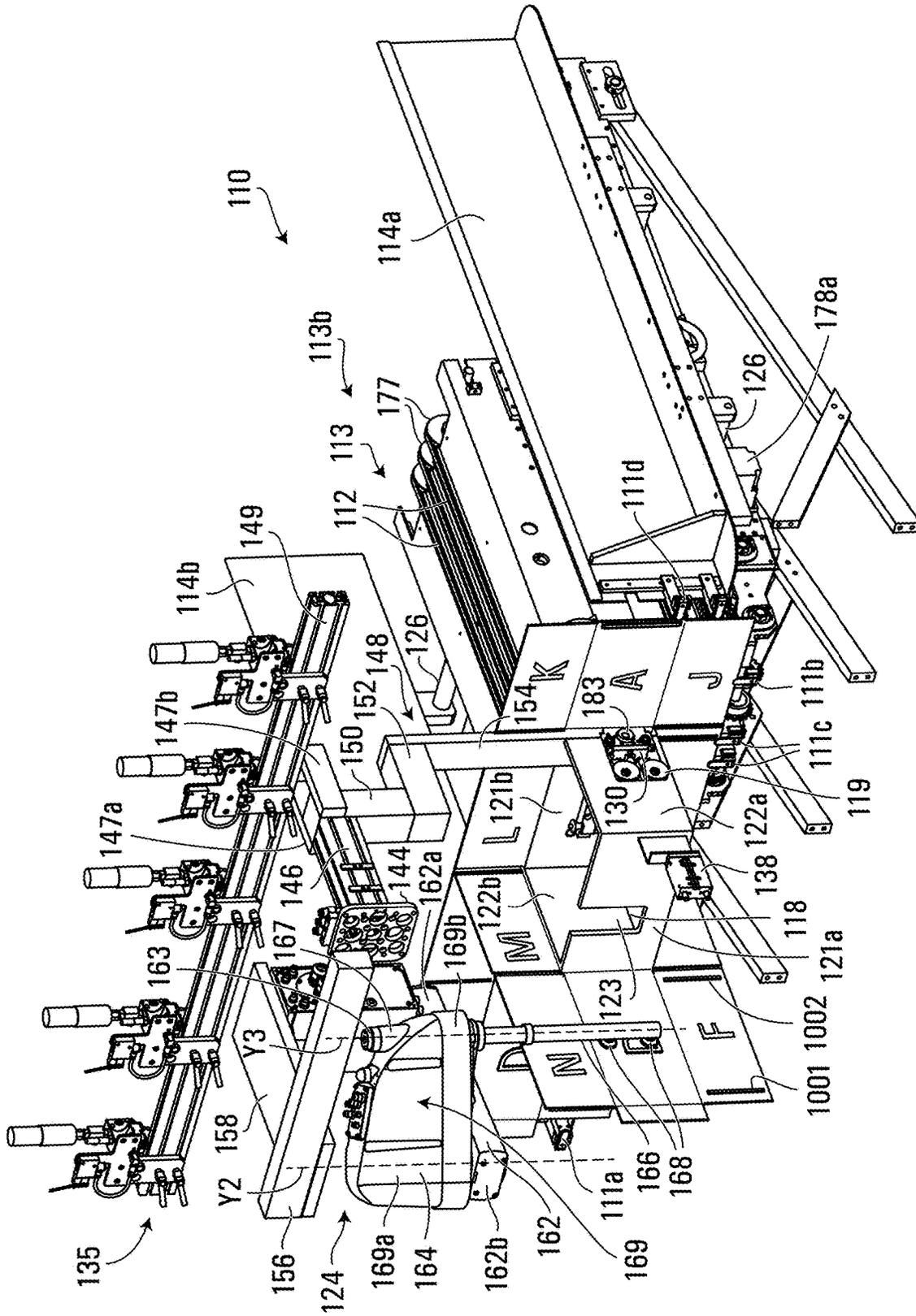


FIG. 5

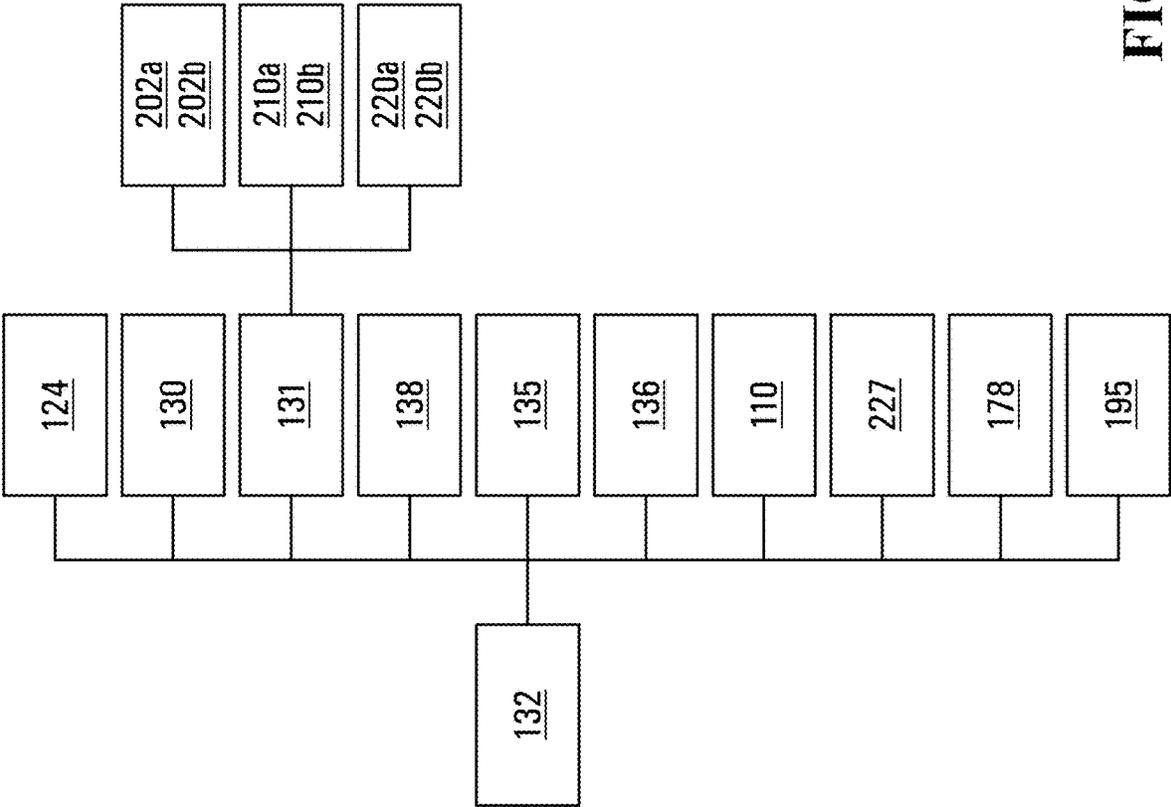


FIG. 5A

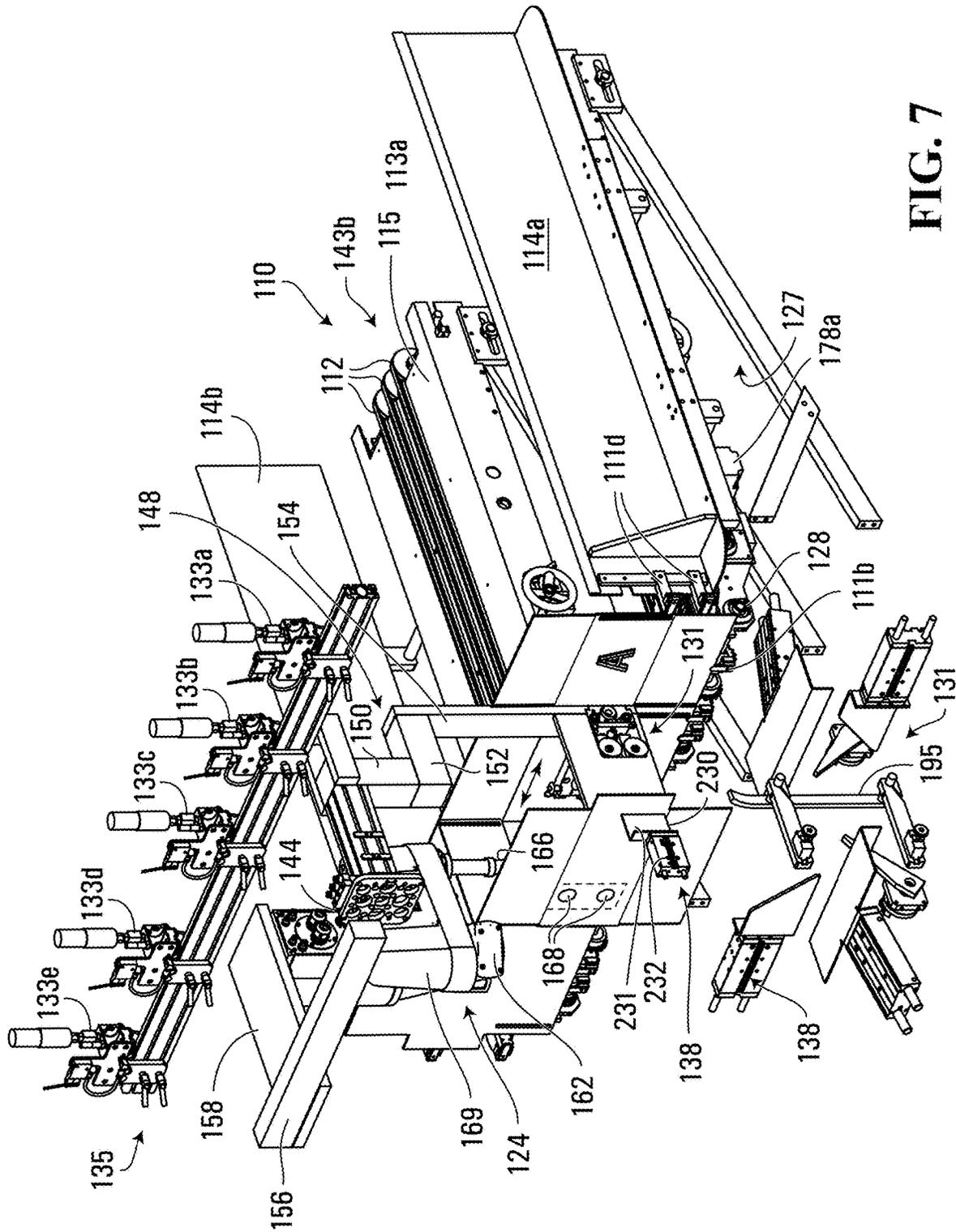
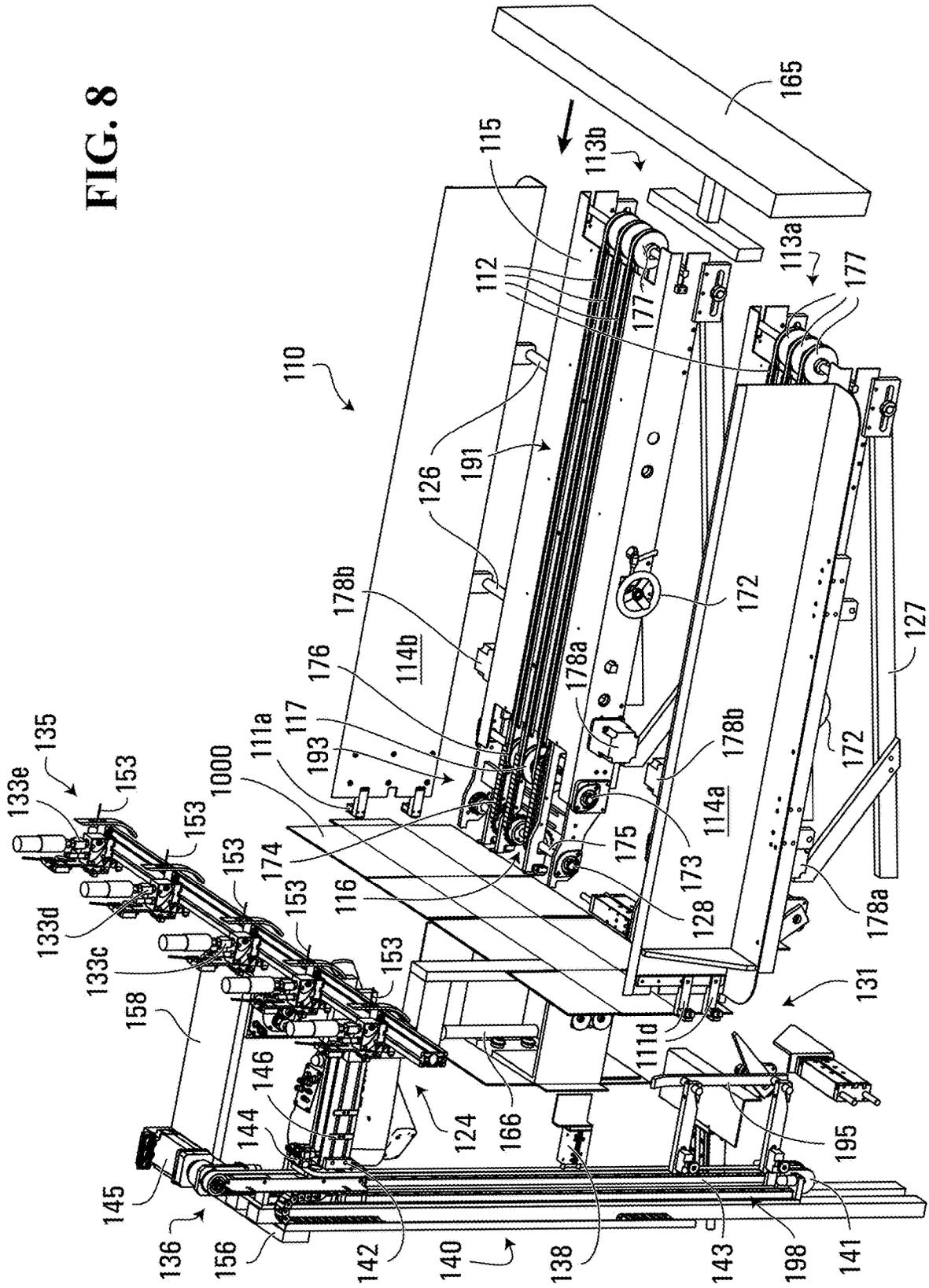


FIG. 7

FIG. 8



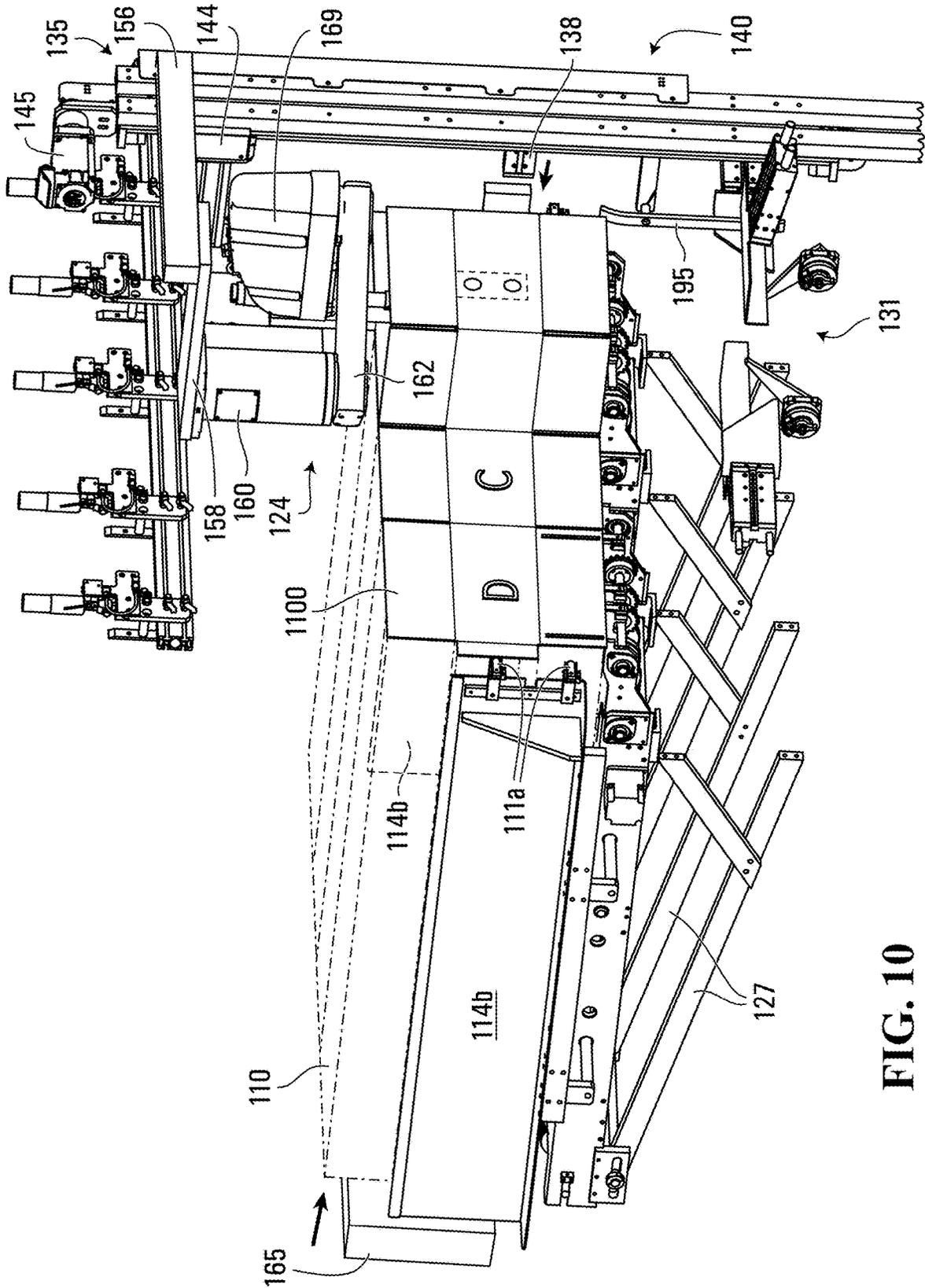


FIG. 10

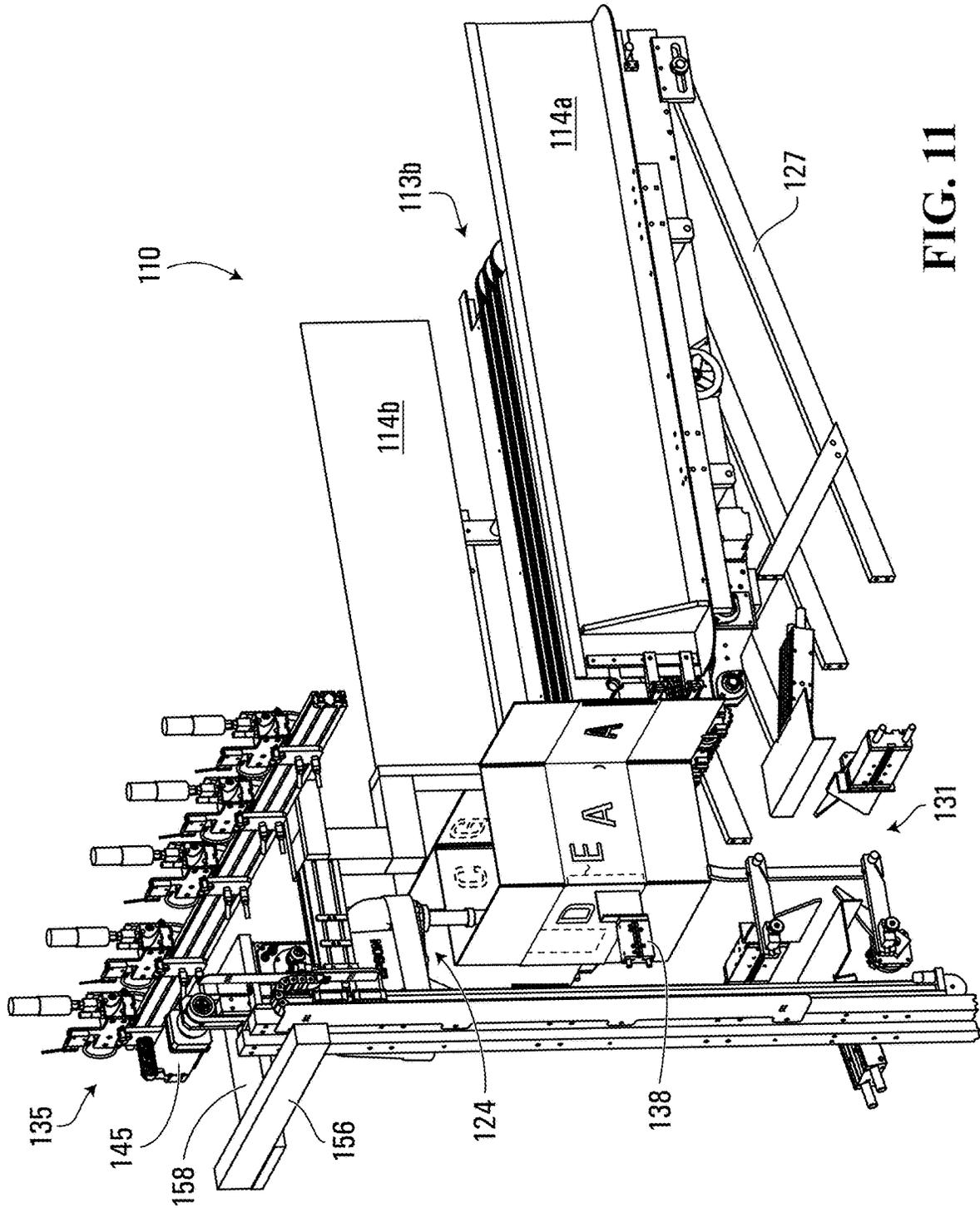


FIG. 11

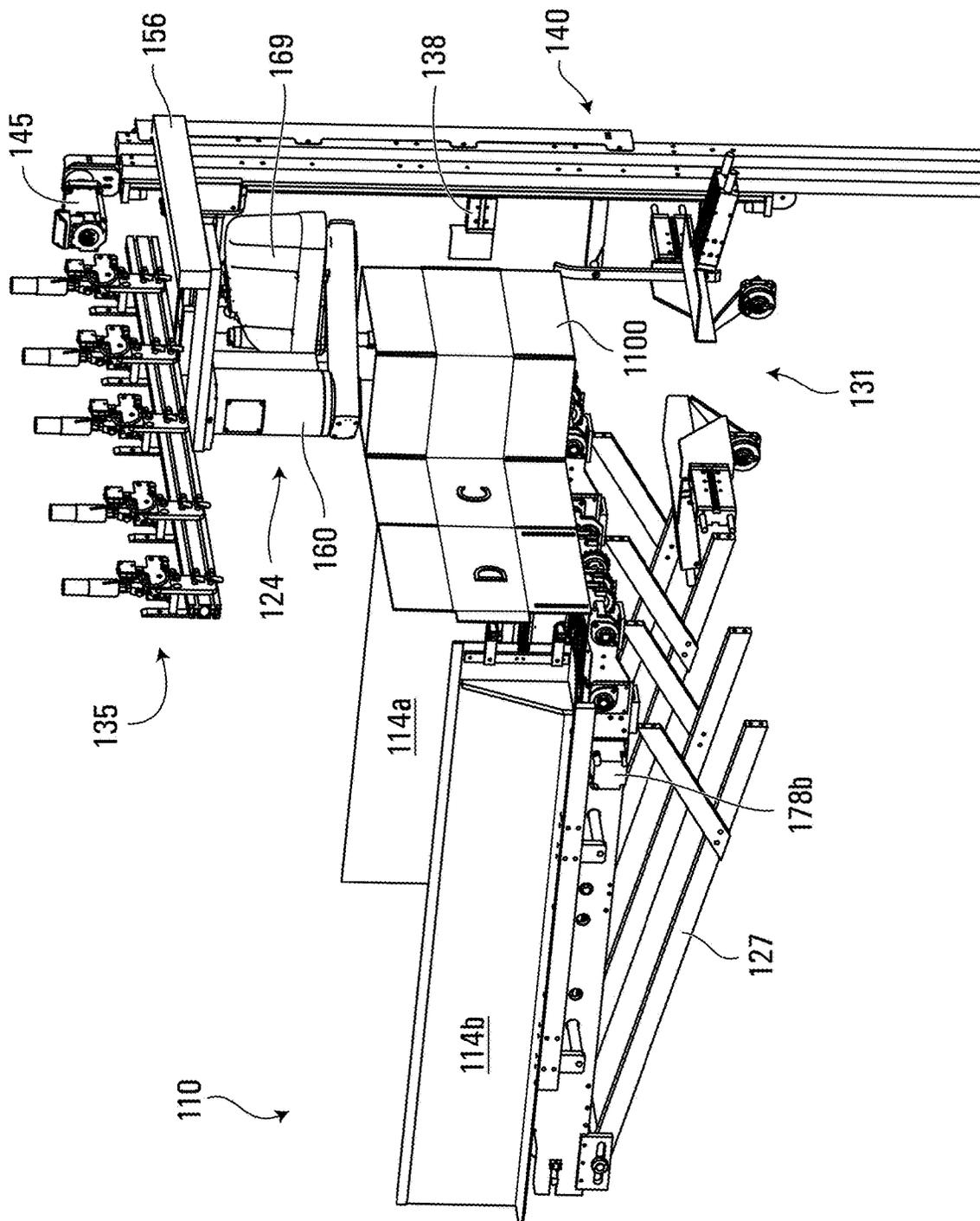


FIG. 12

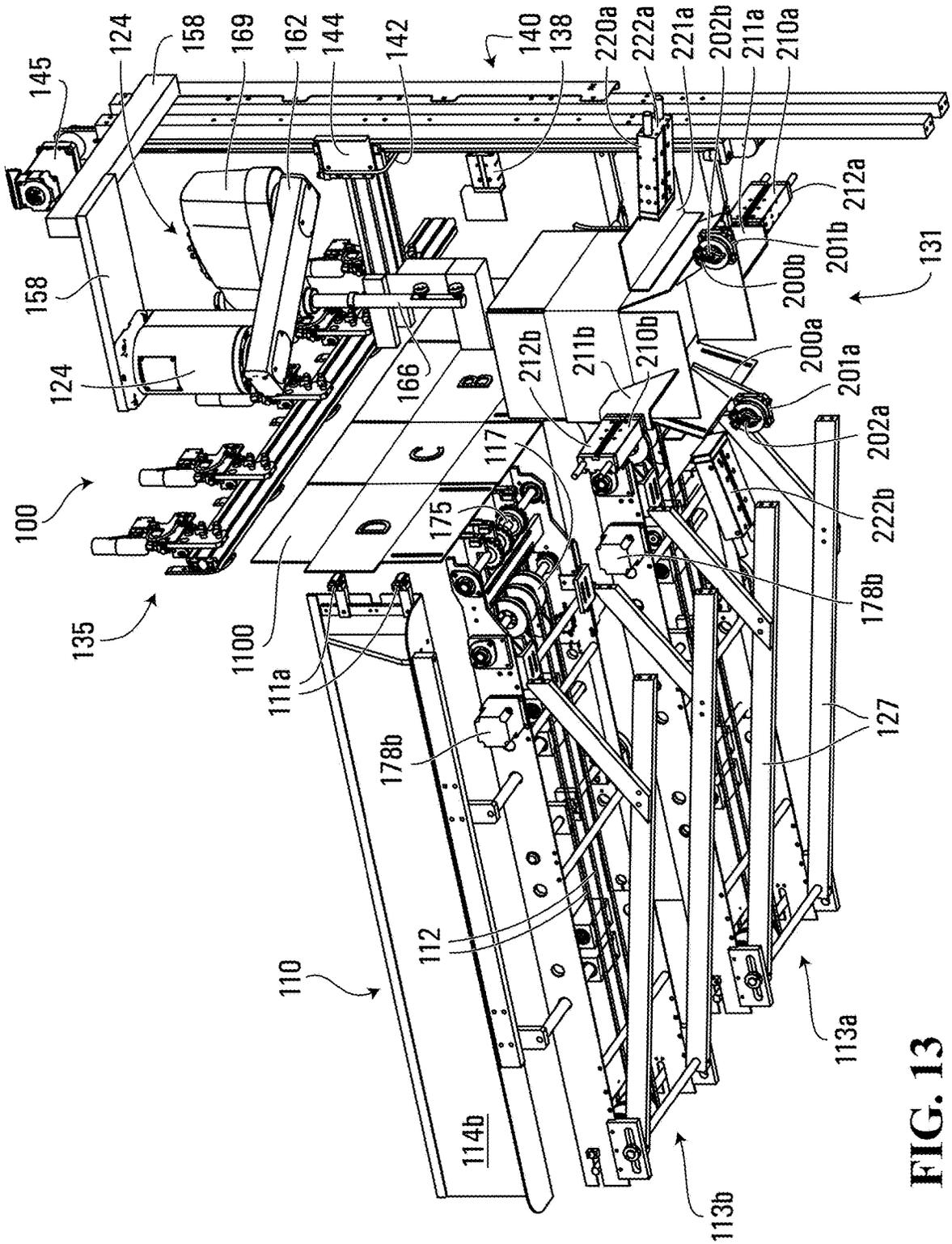


FIG. 13

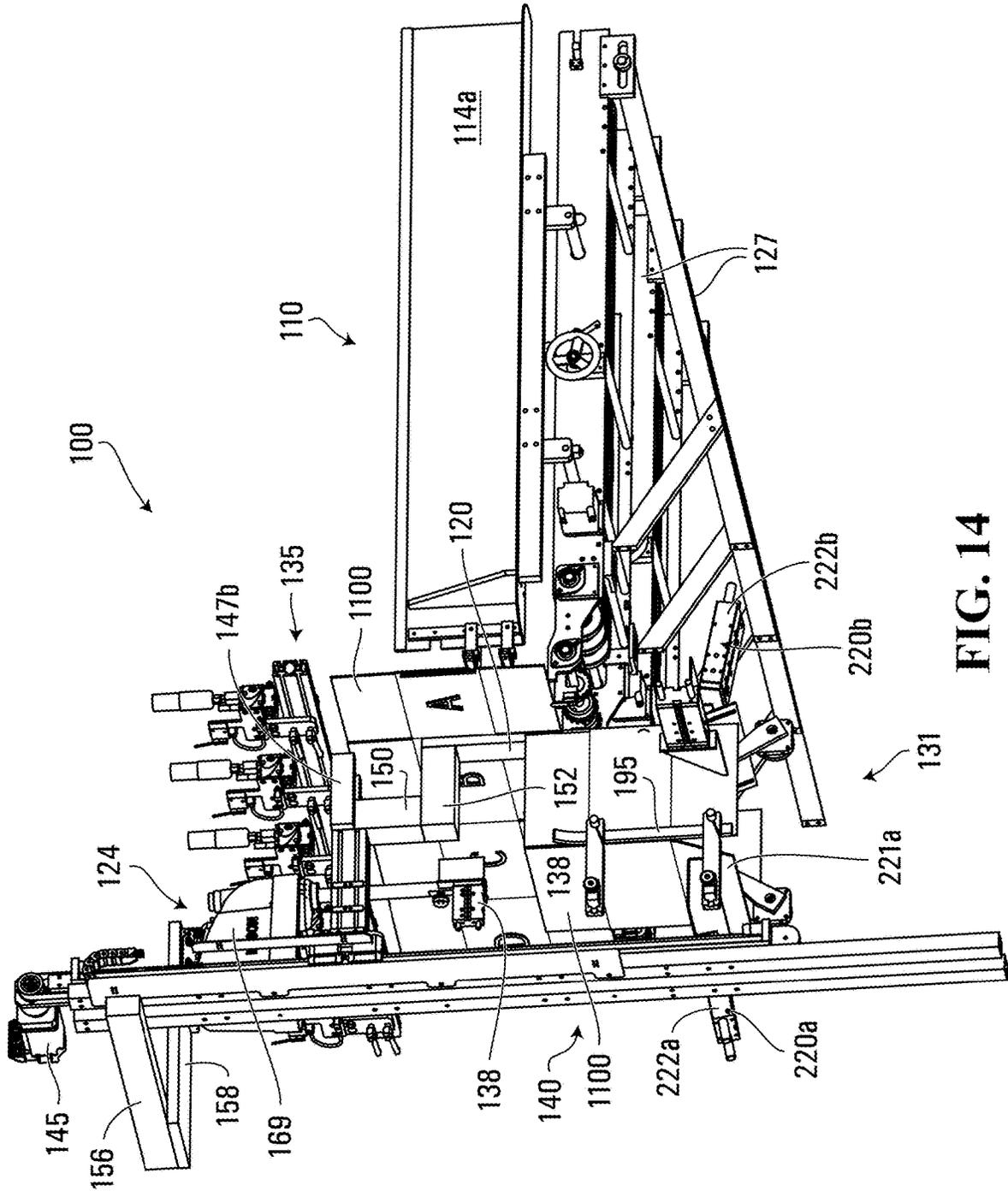


FIG. 14

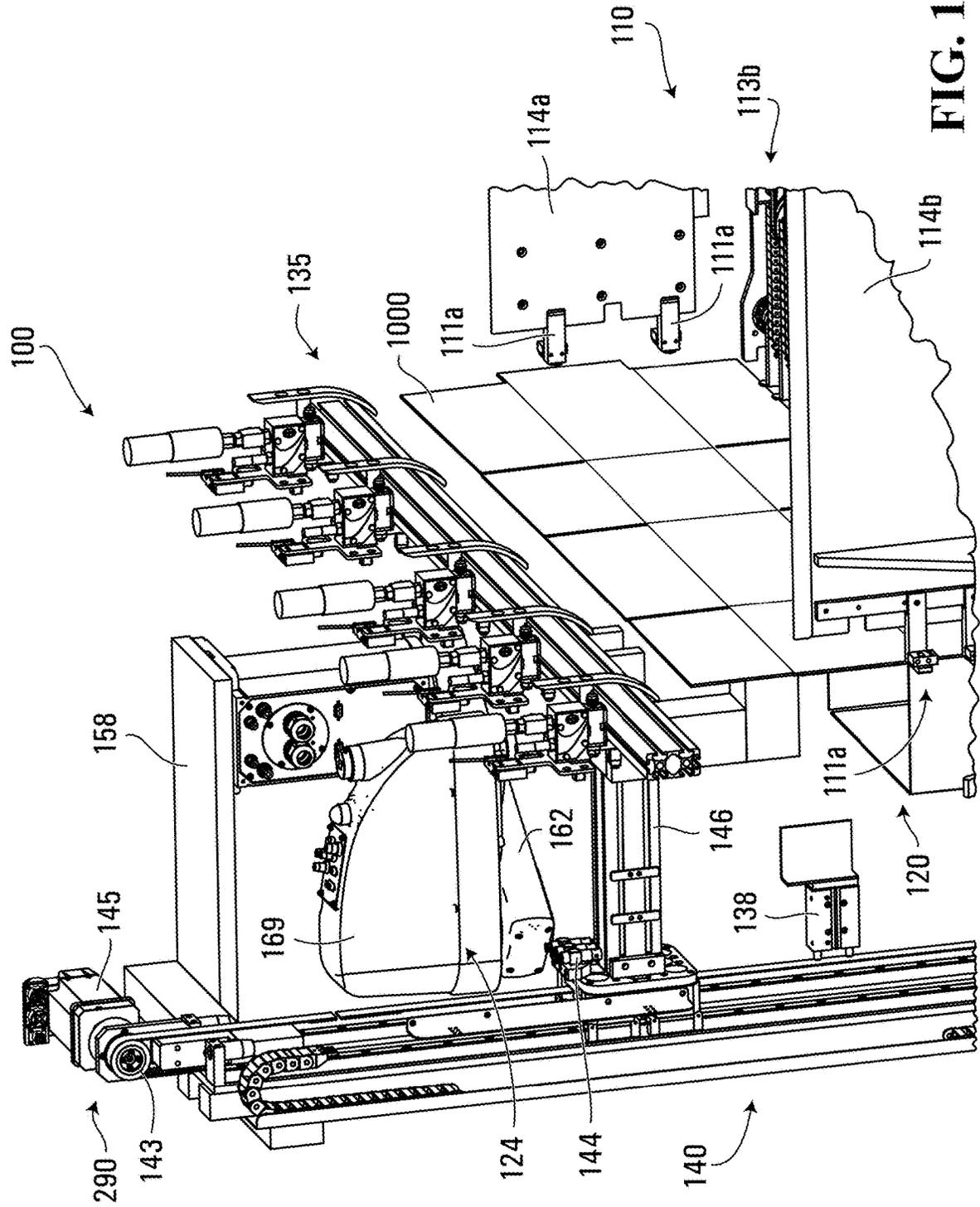


FIG. 15

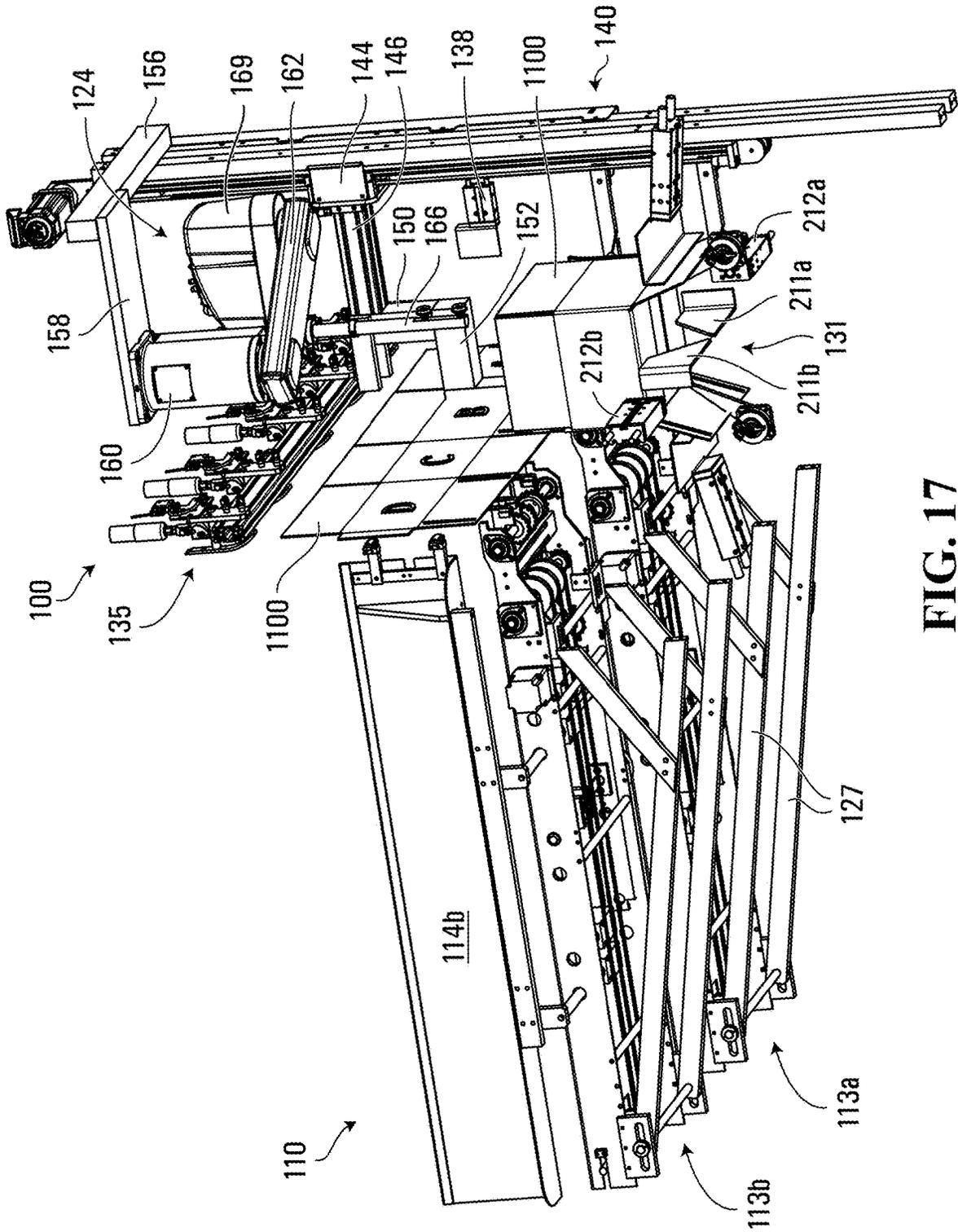


FIG. 17

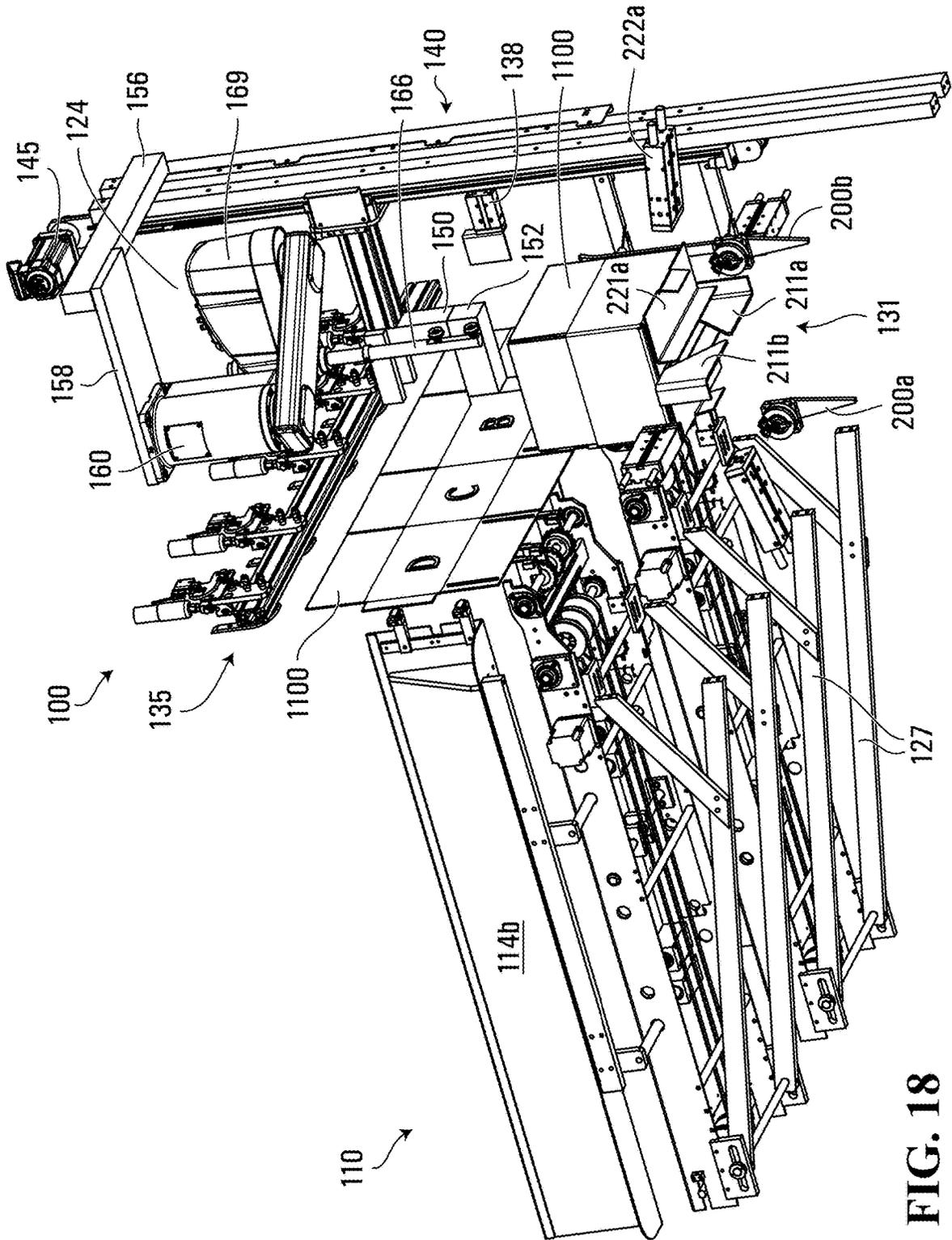


FIG. 18

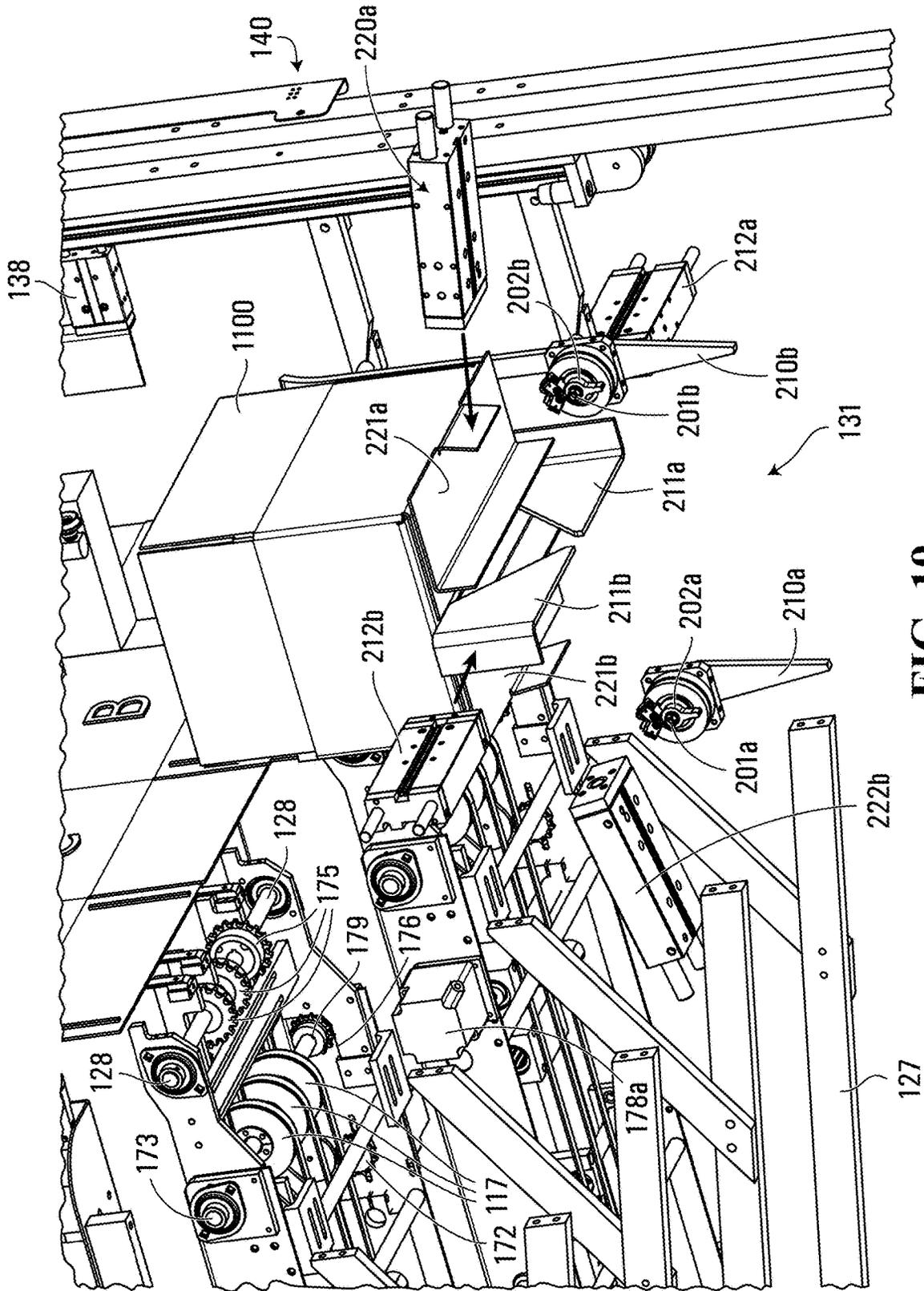


FIG. 19

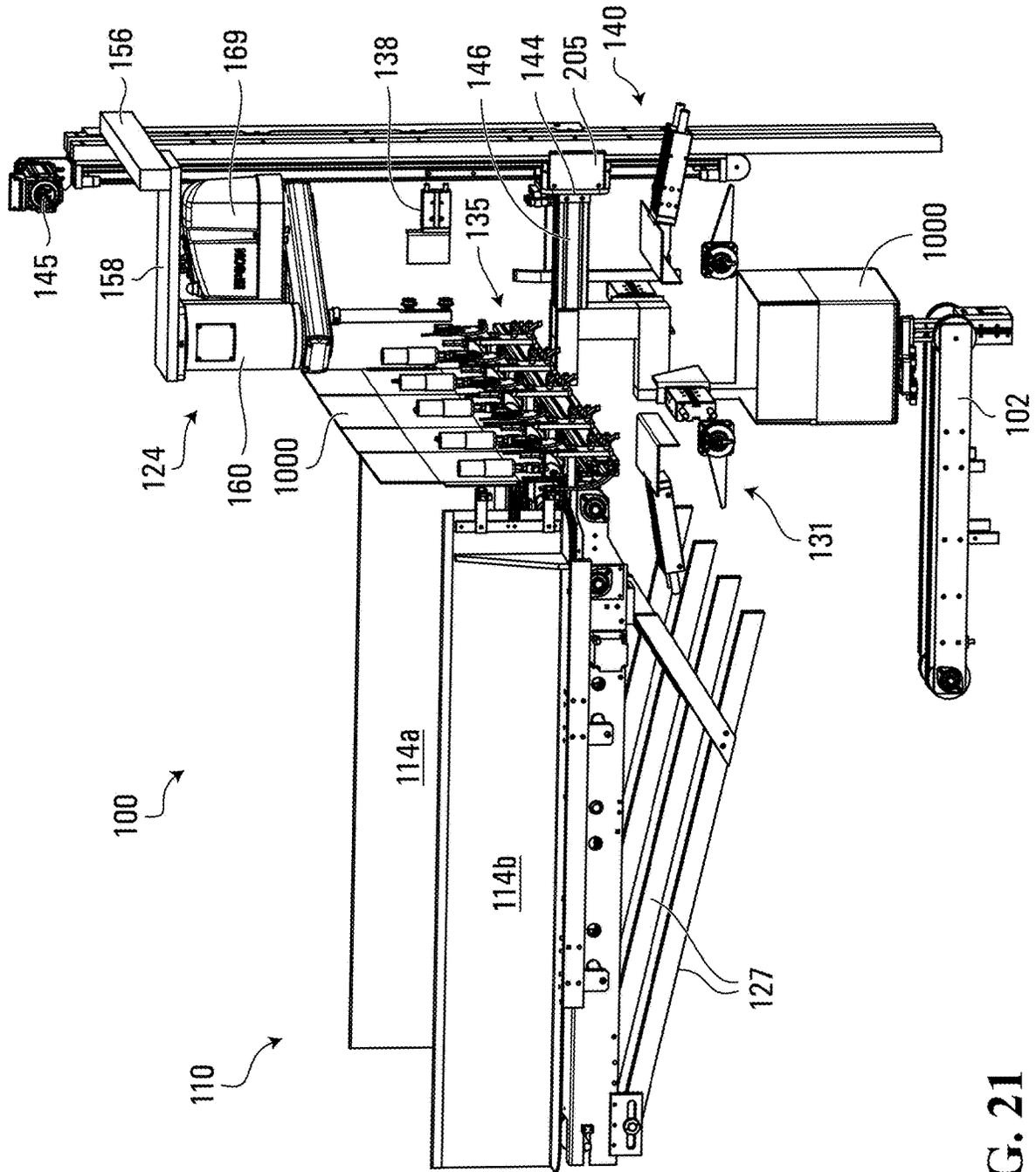


FIG. 21

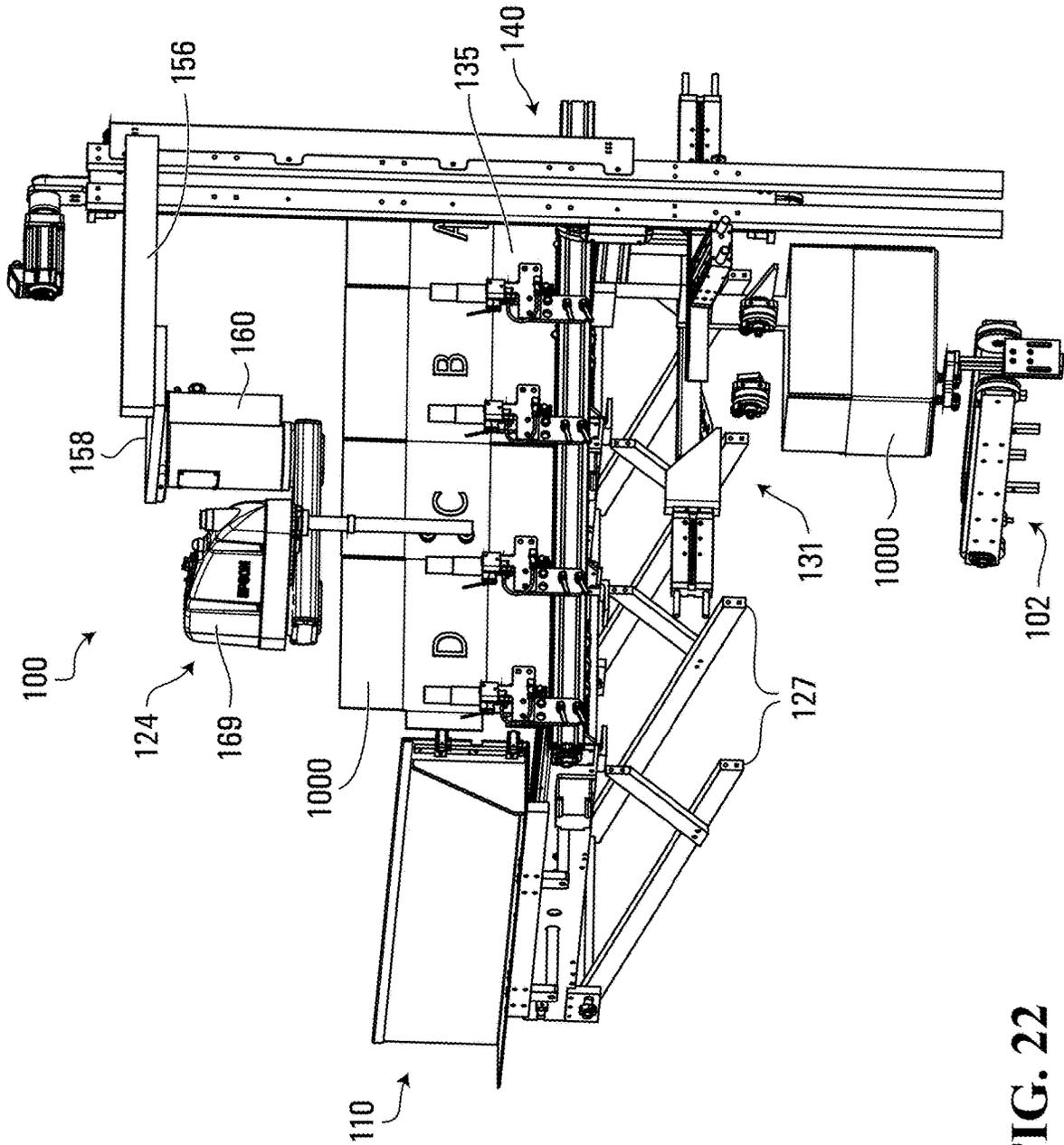


FIG. 22

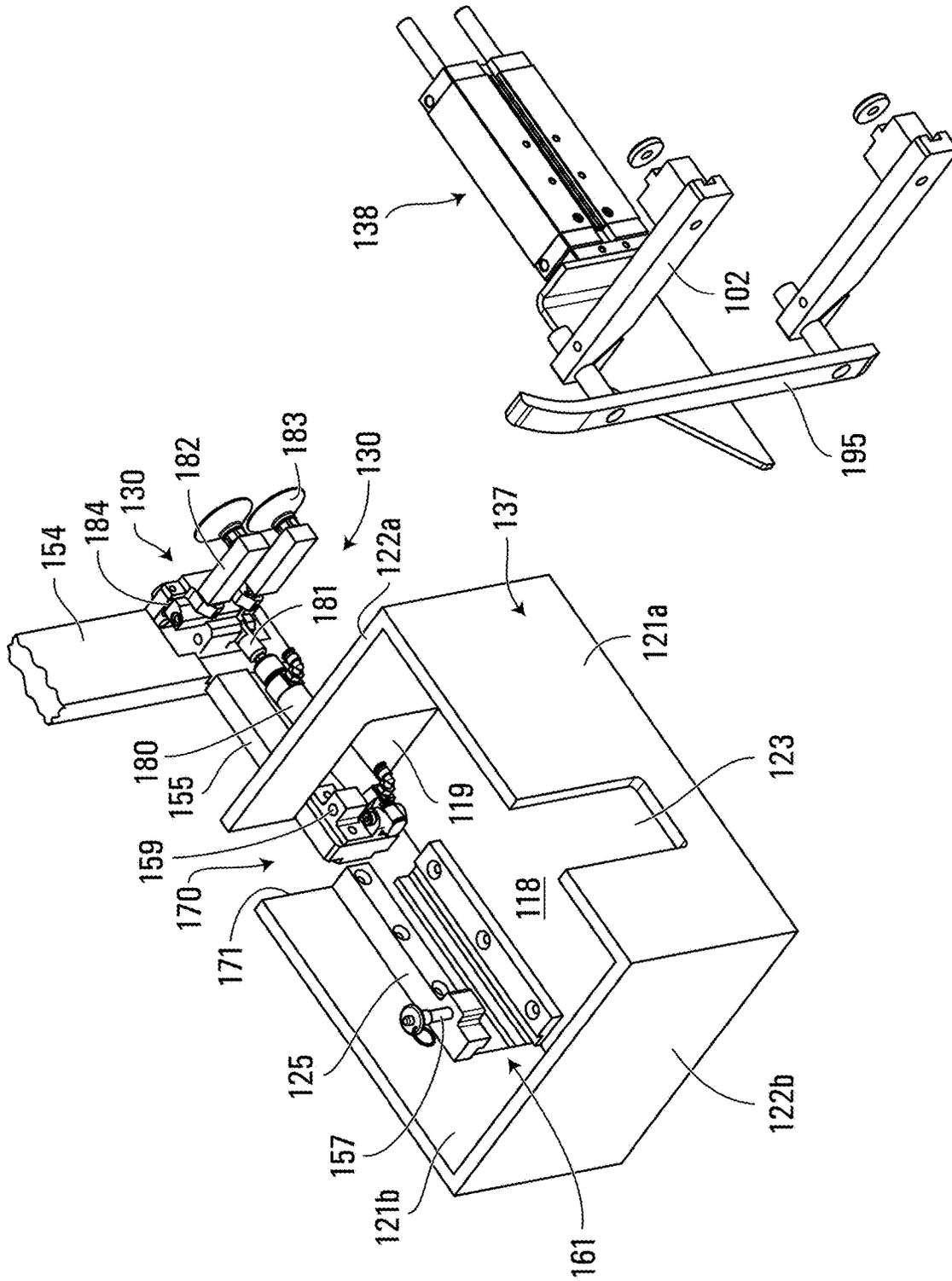


FIG. 23

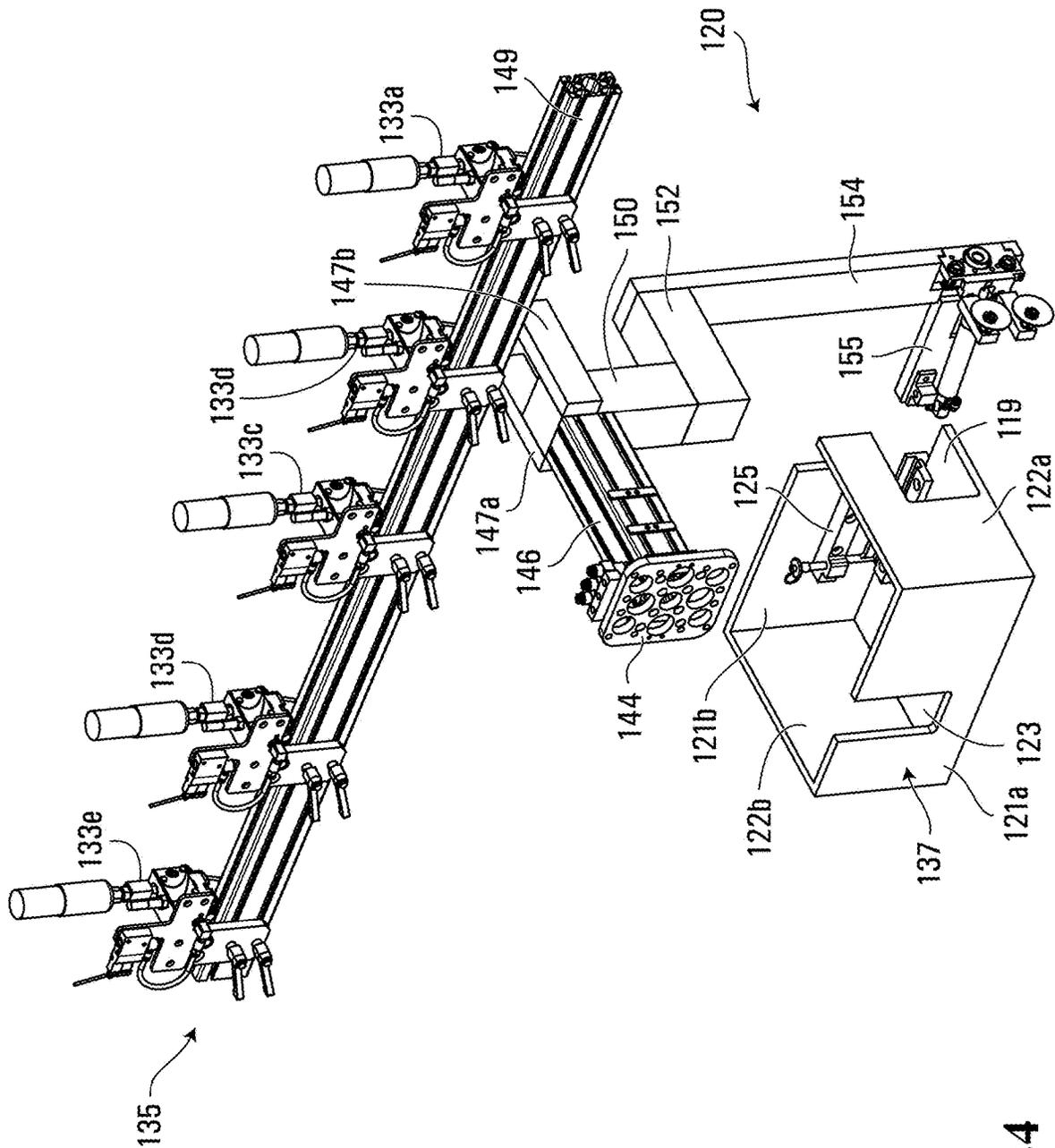


FIG. 24

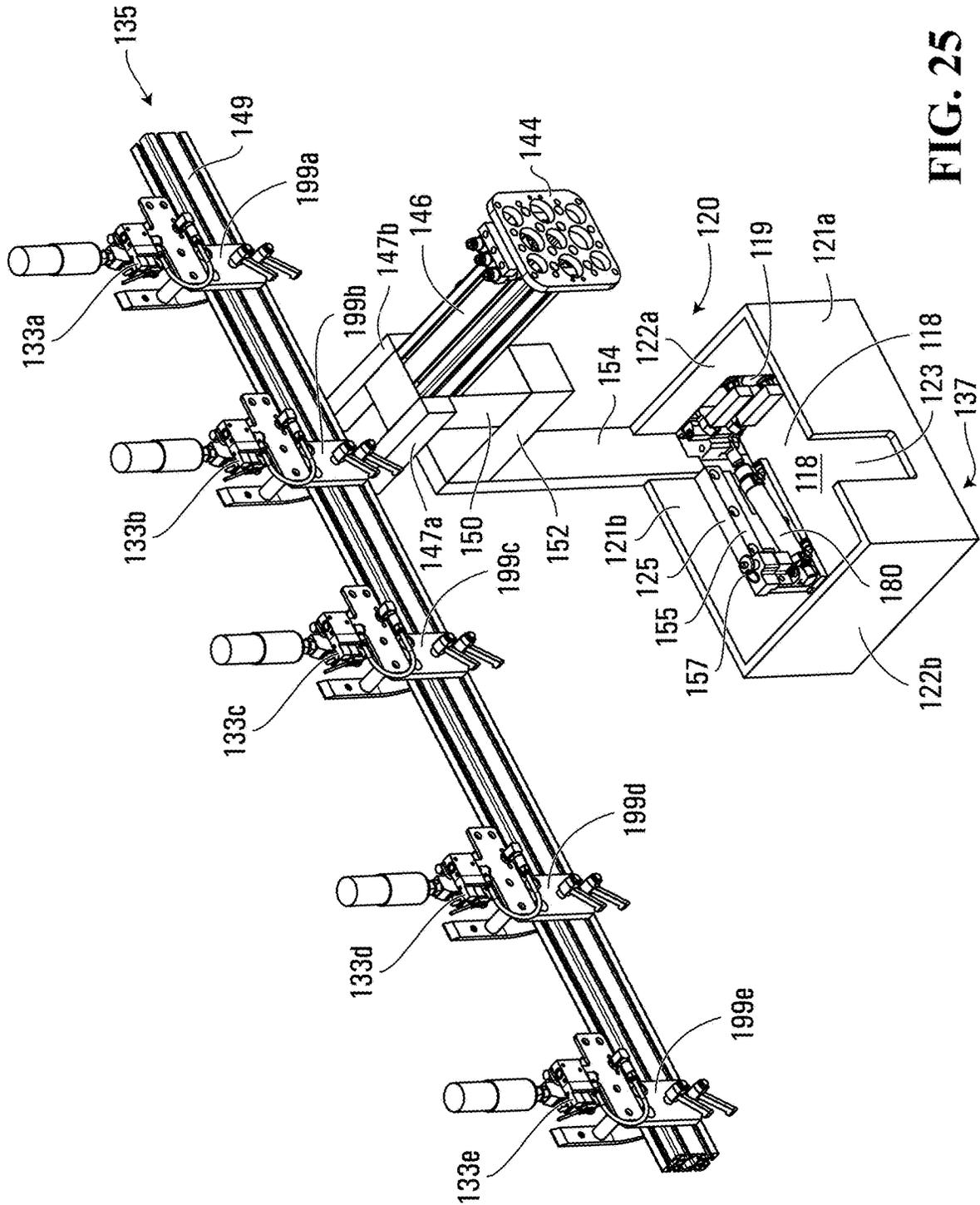


FIG. 25

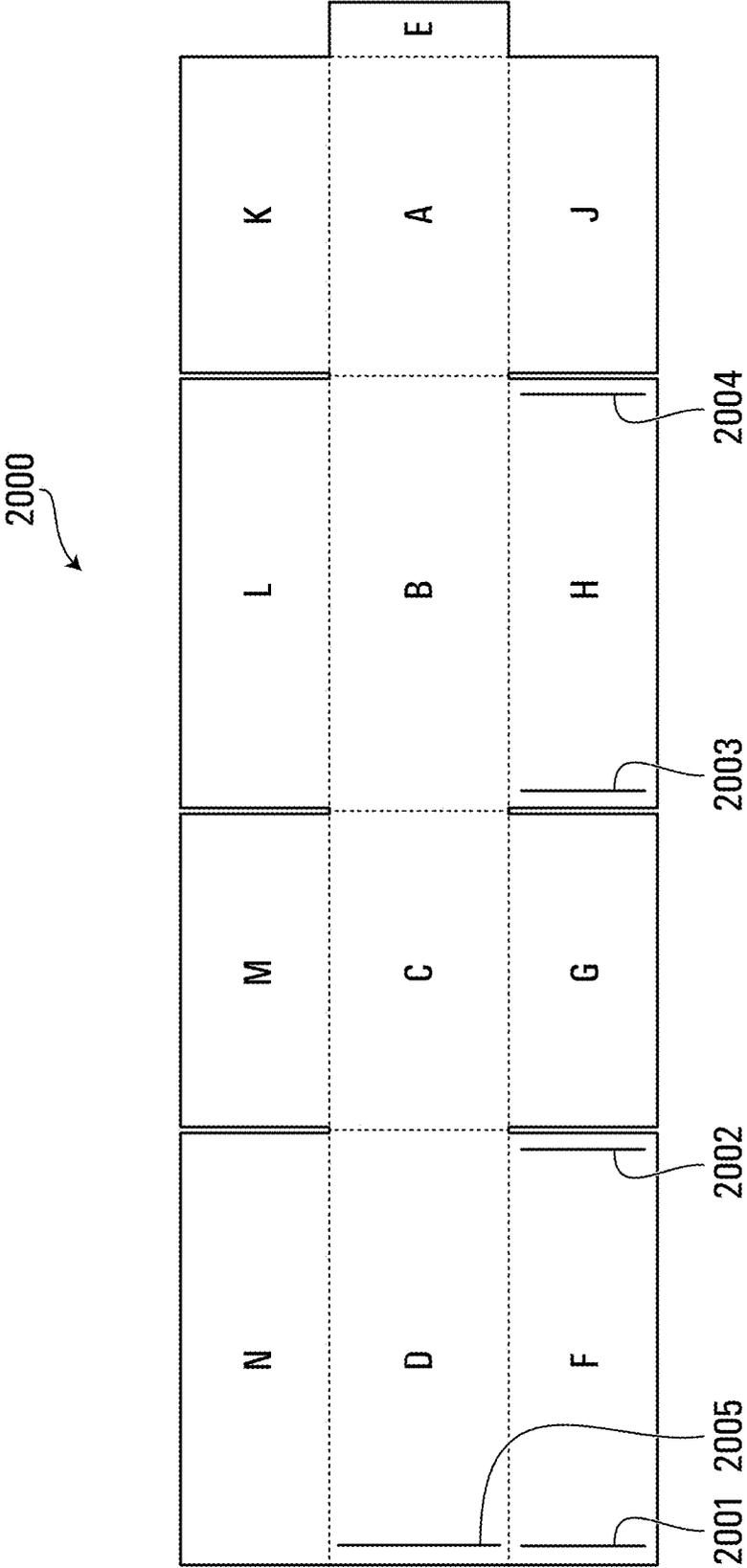


FIG. 26

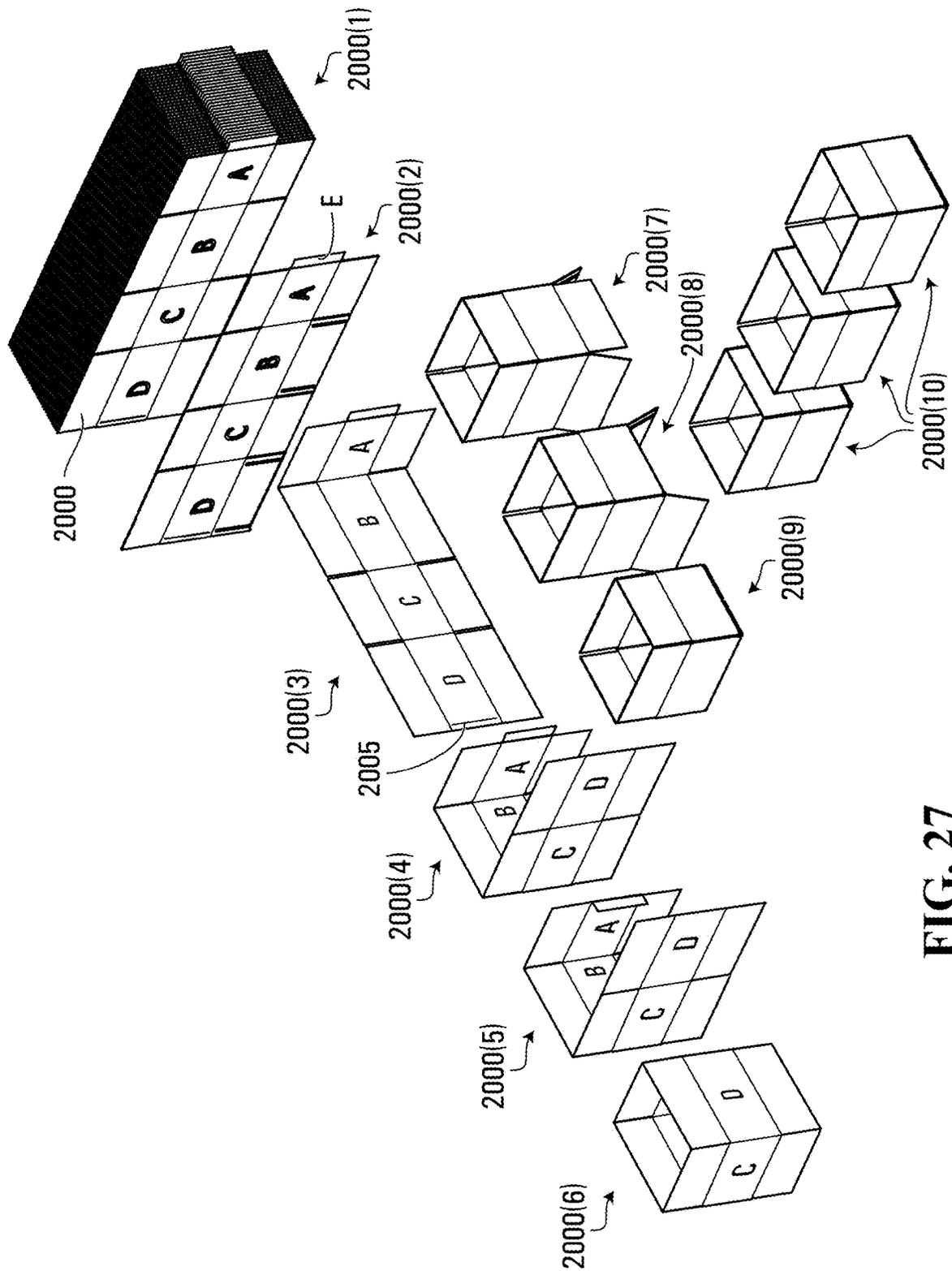


FIG. 27

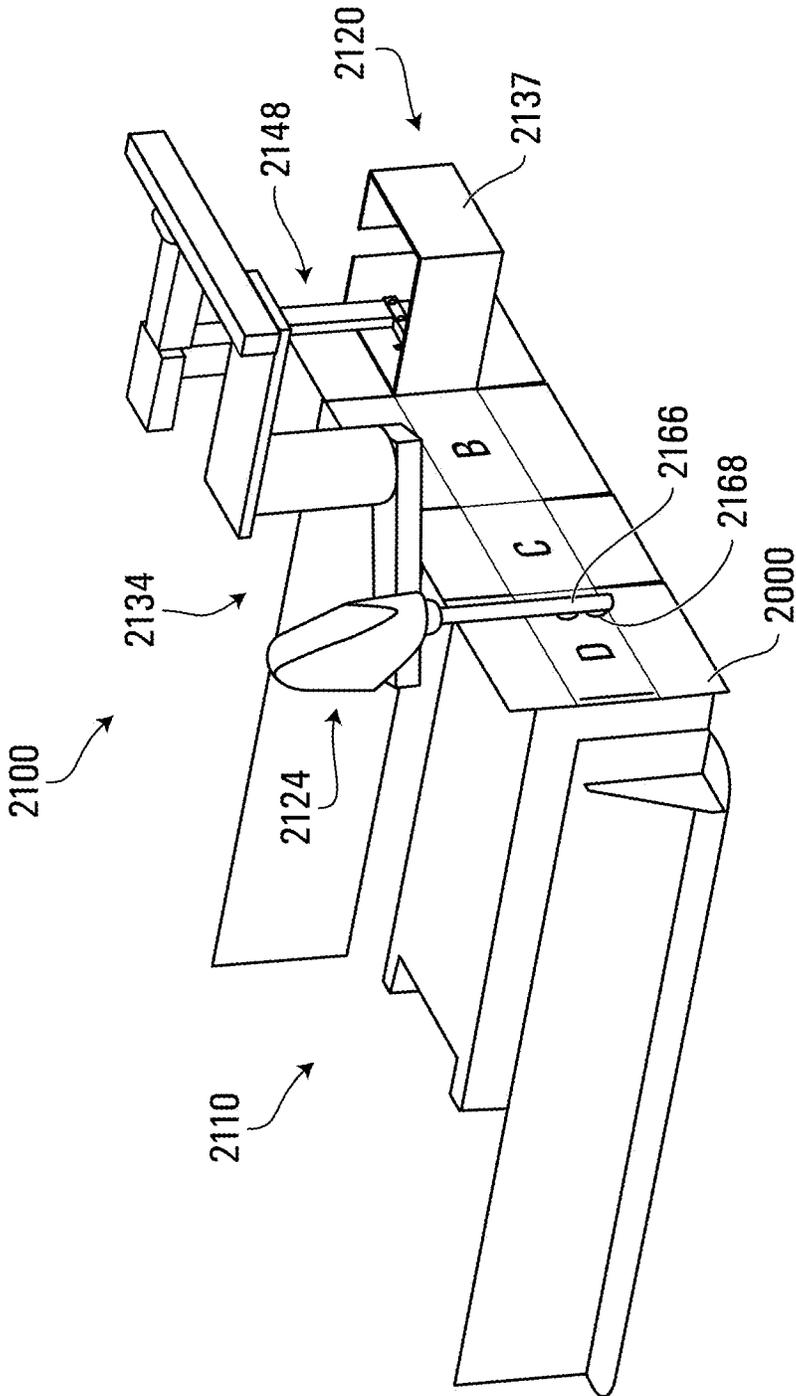


FIG. 28

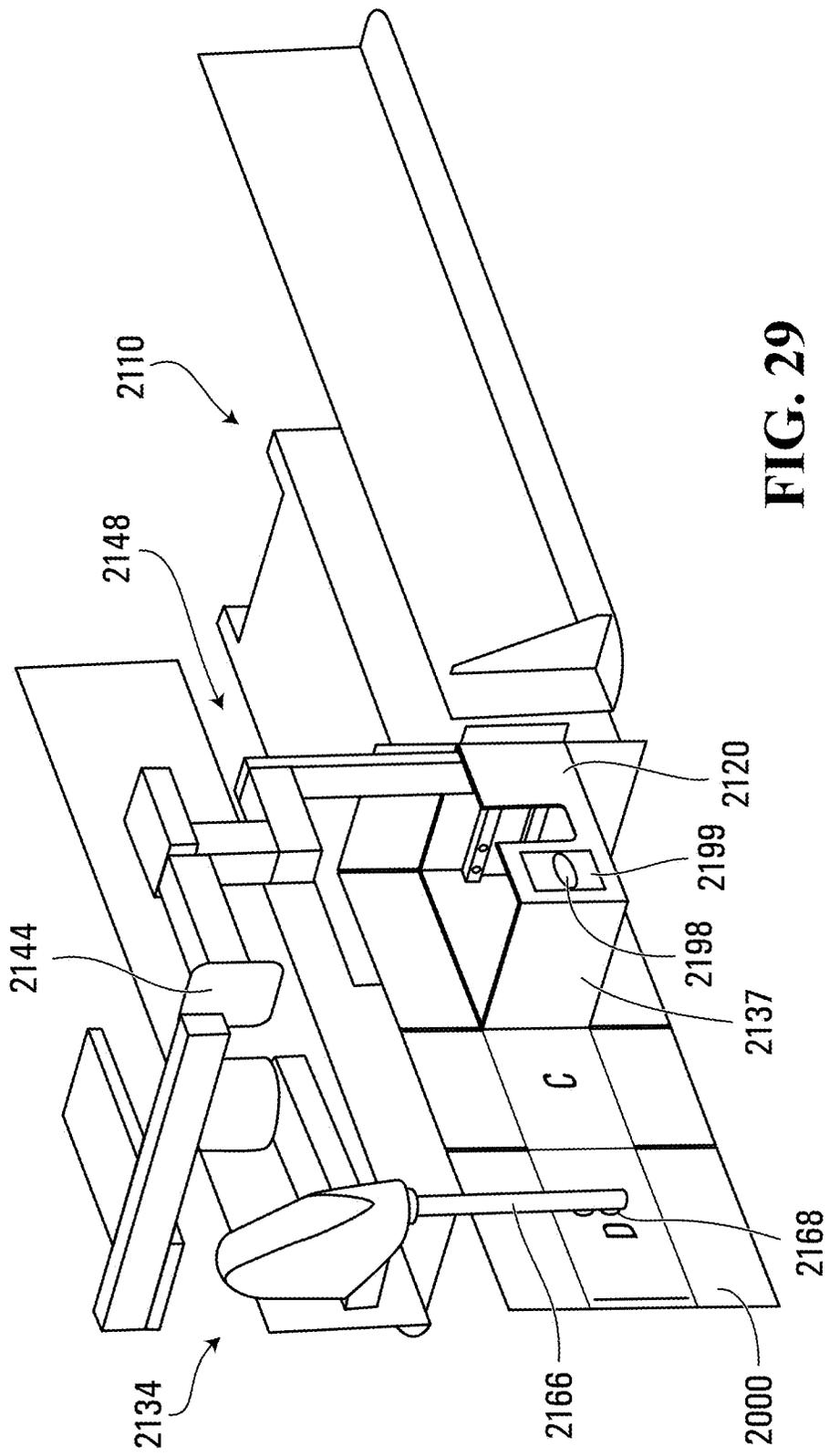


FIG. 29

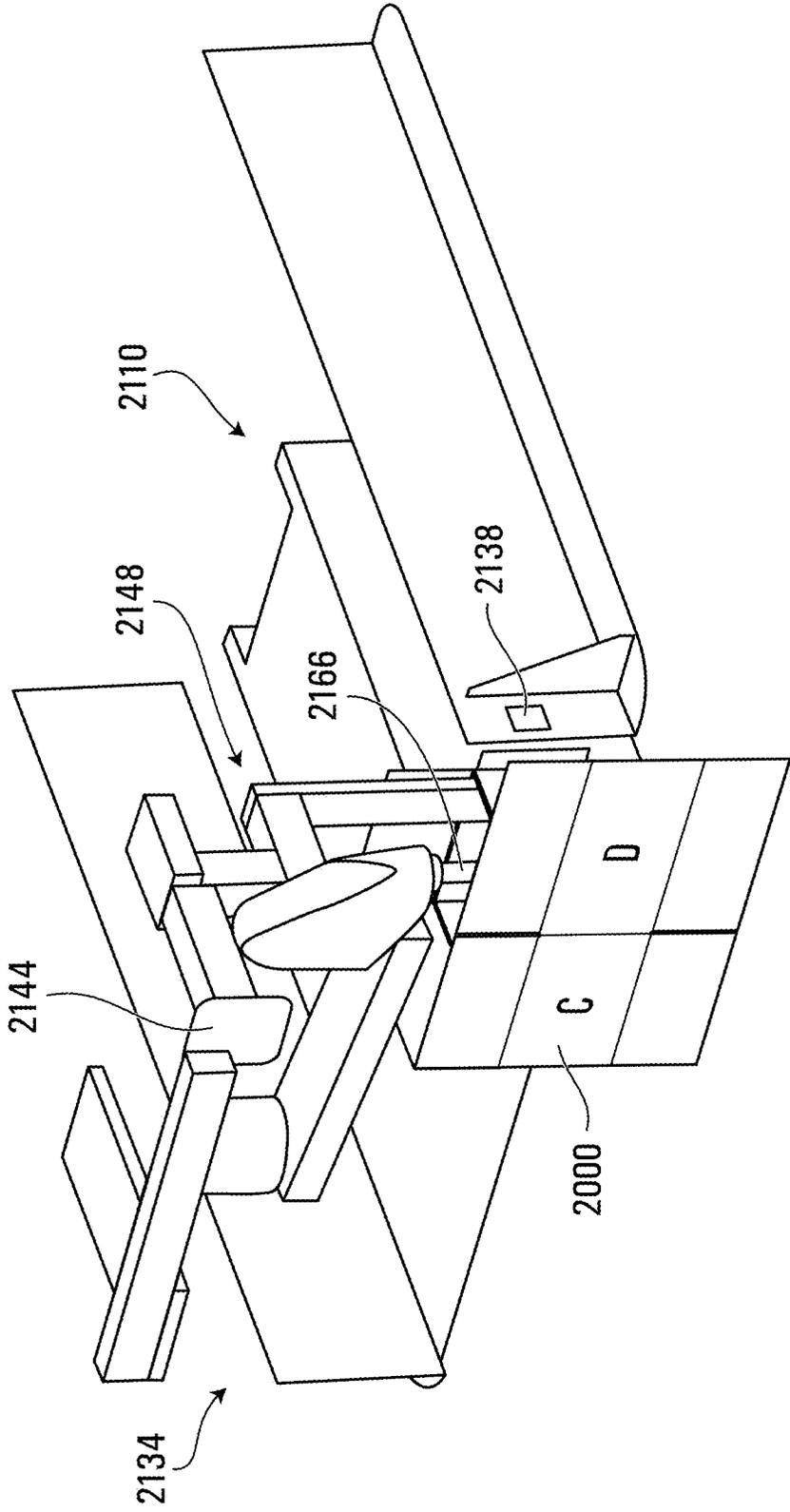


FIG. 30

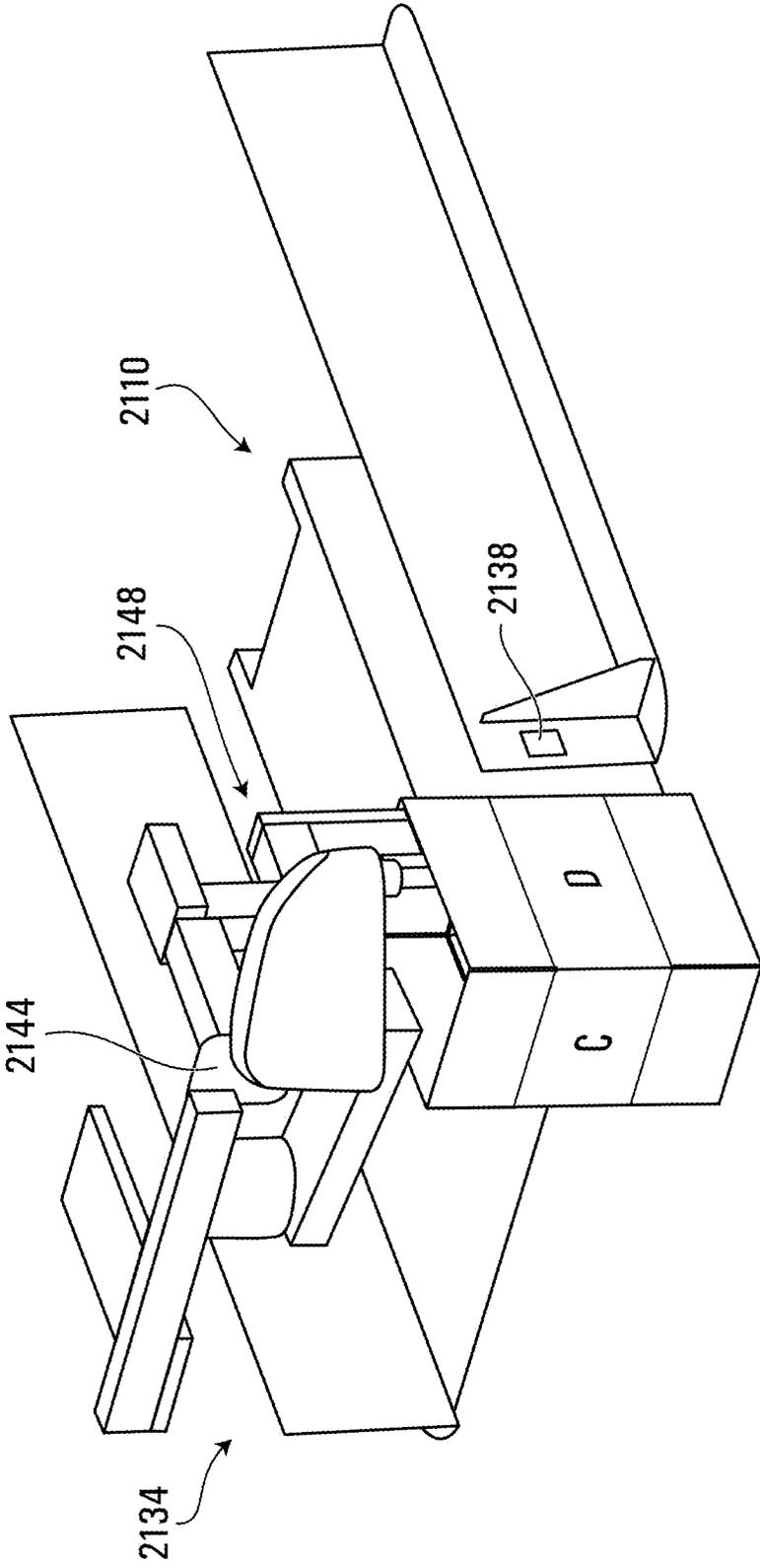


FIG. 31

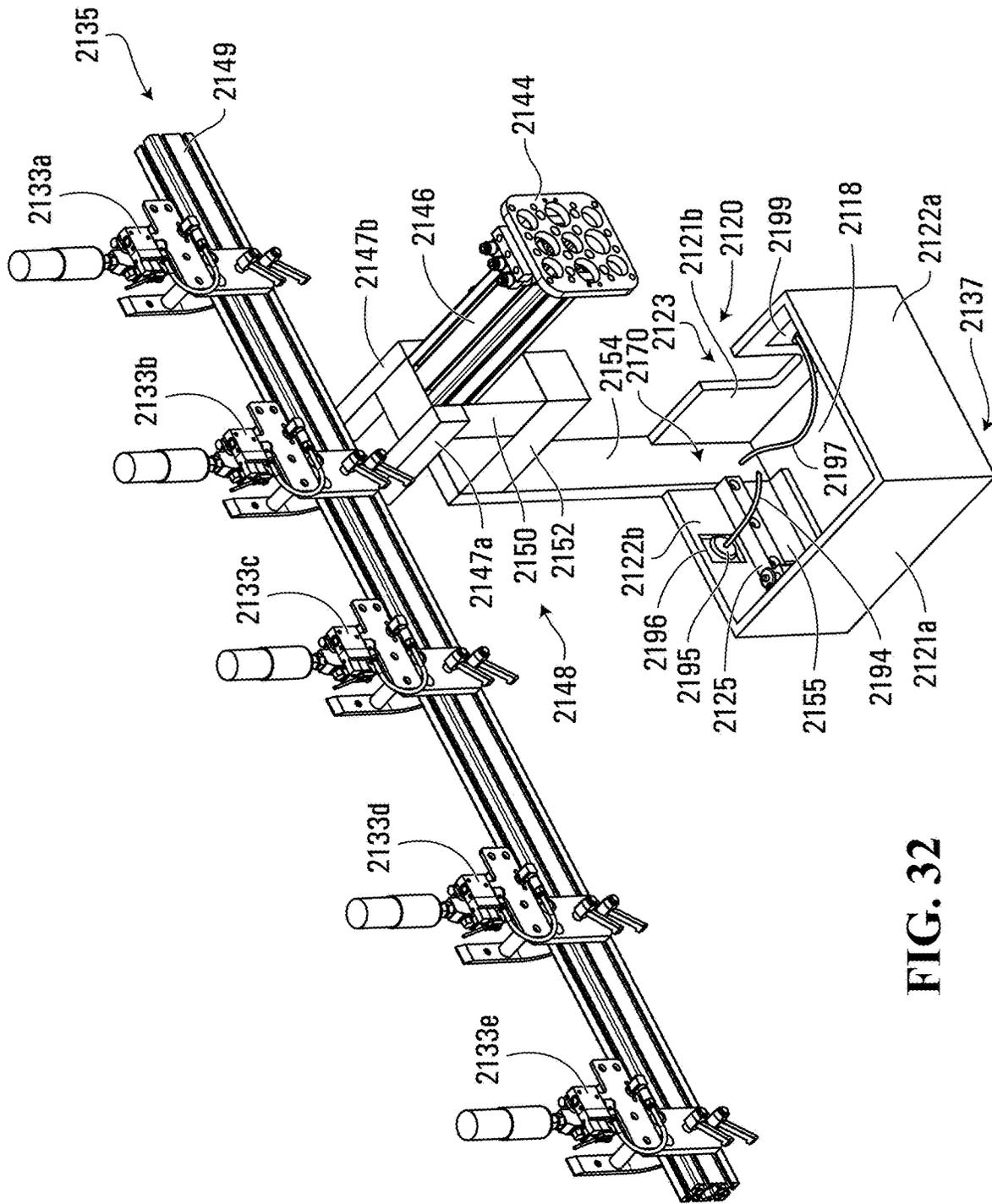


FIG. 32

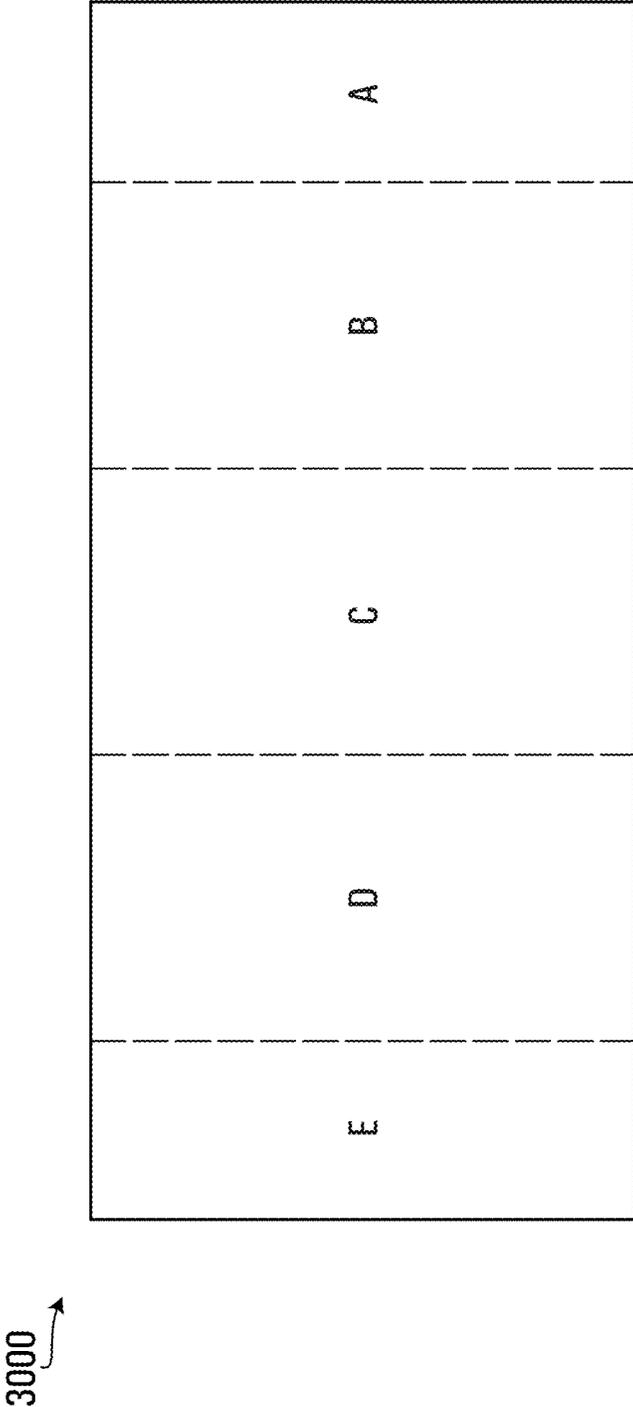


FIG. 33

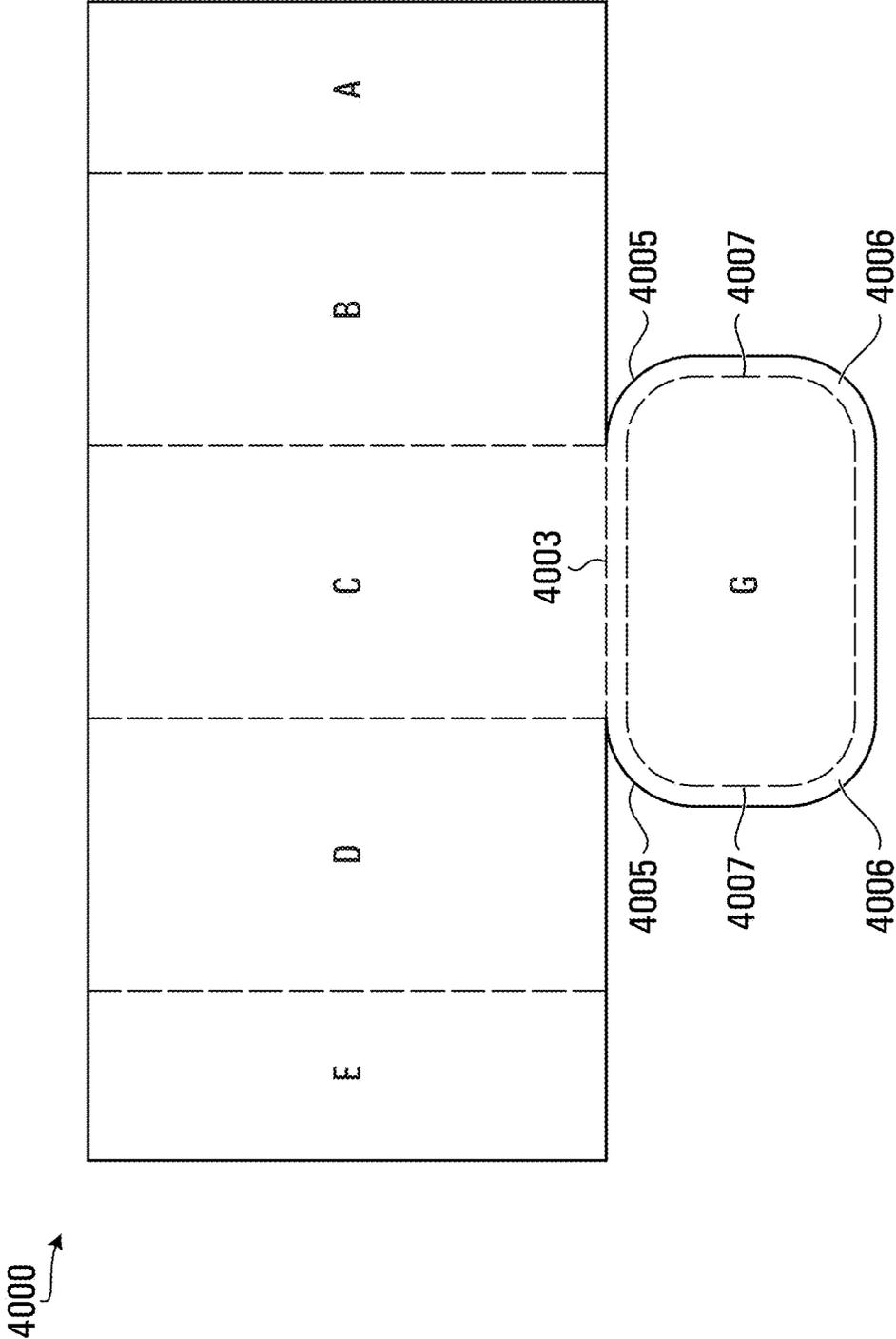


FIG. 33A

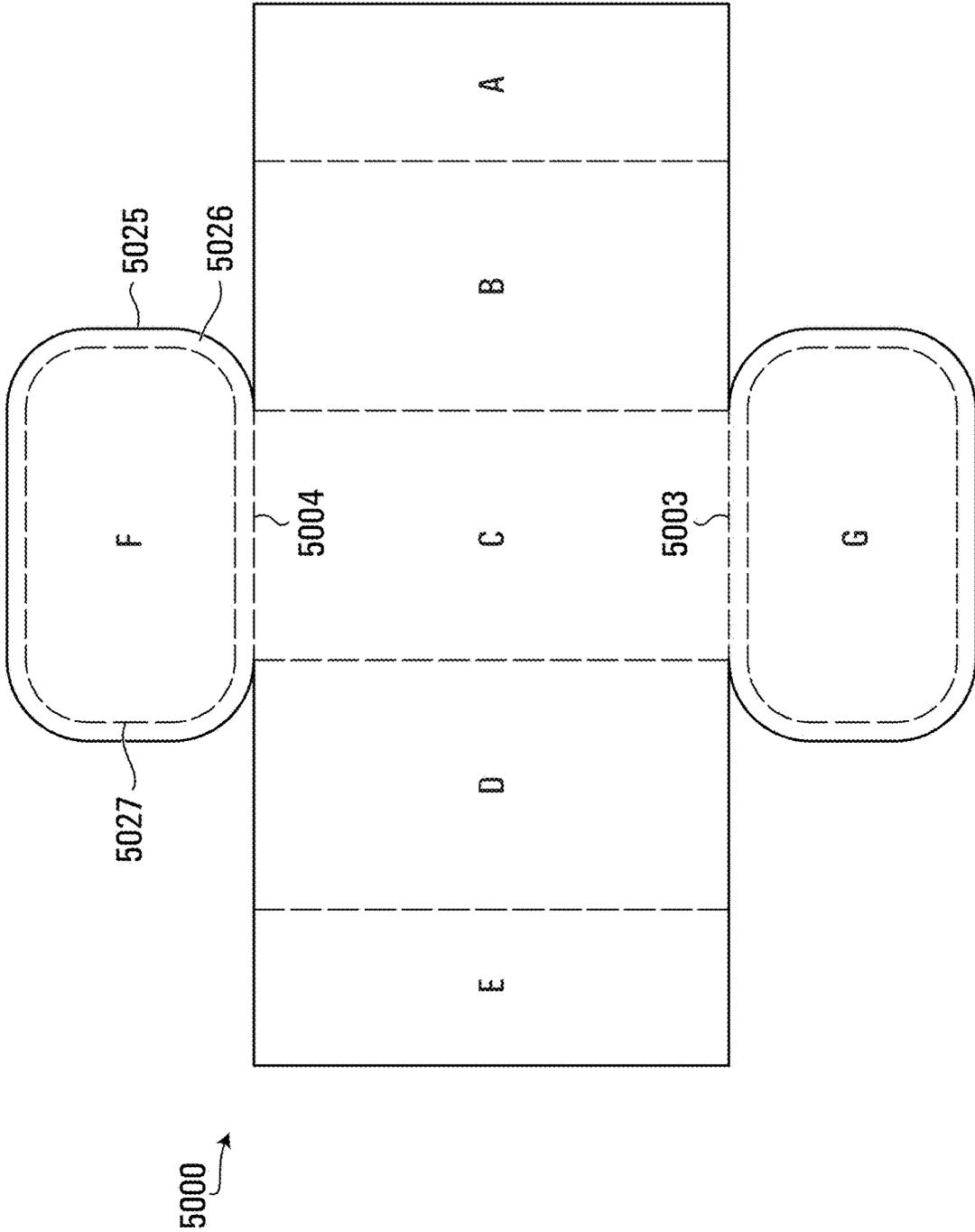


FIG. 33B

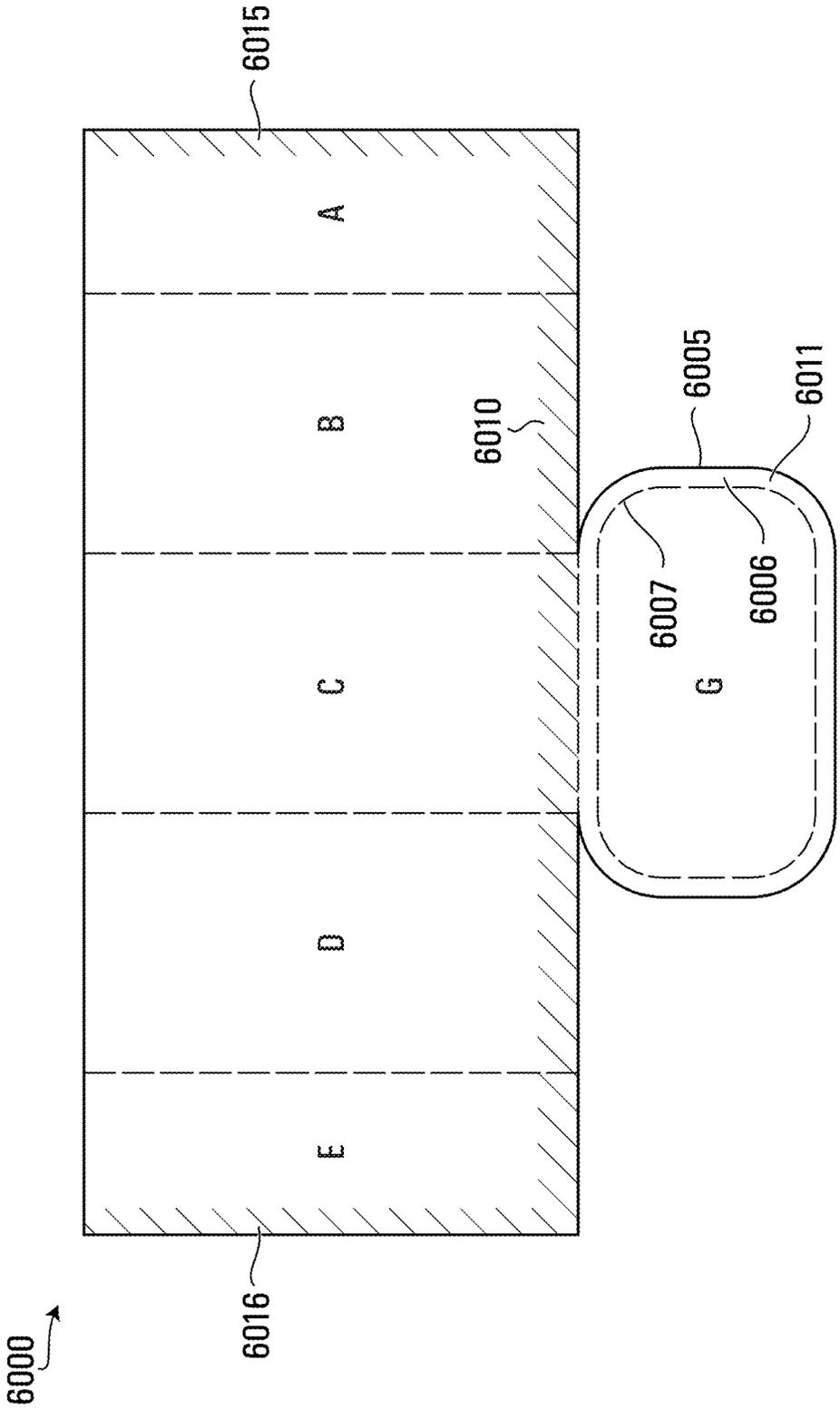


FIG. 33C

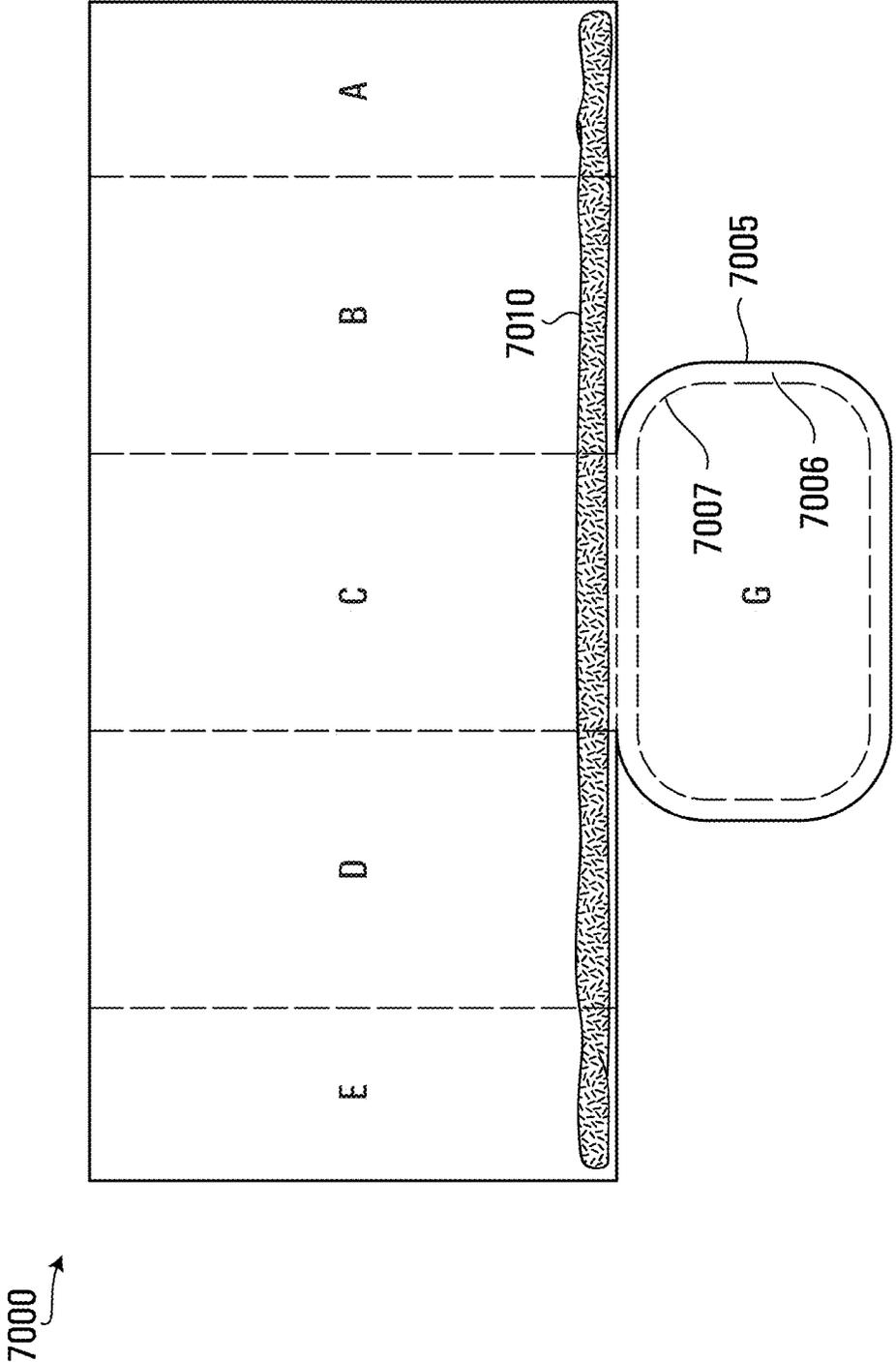


FIG. 33D

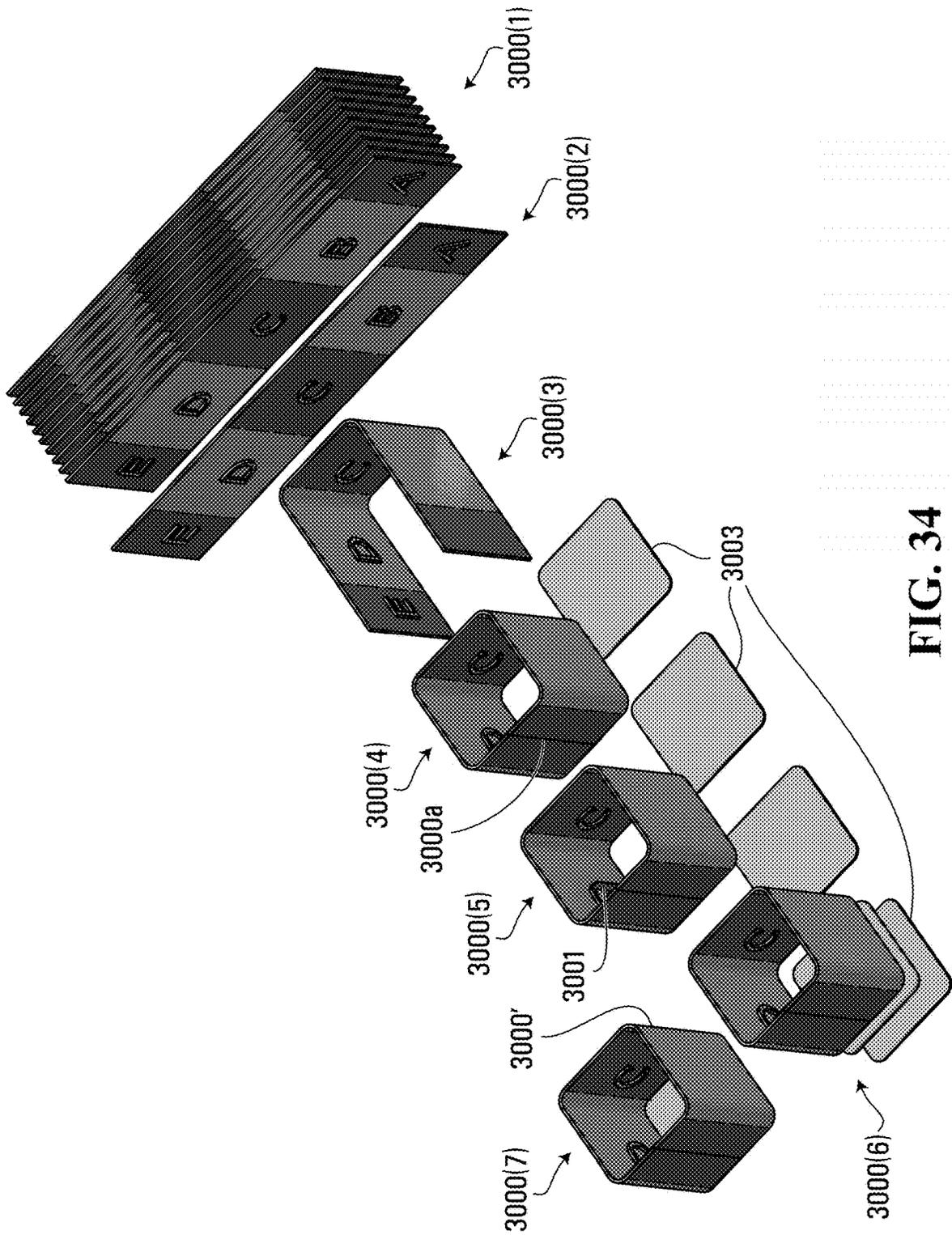


FIG. 34

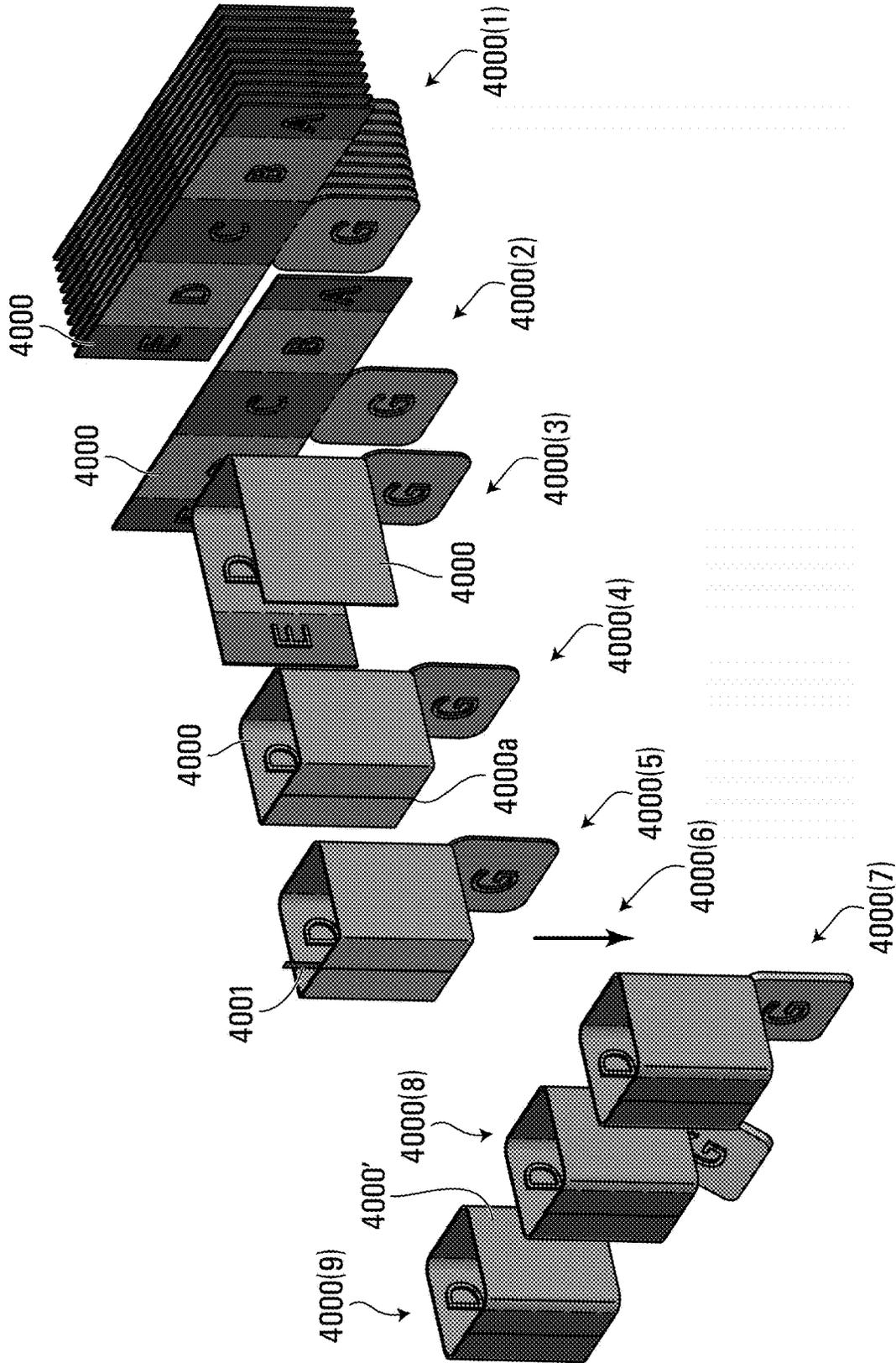


FIG. 35

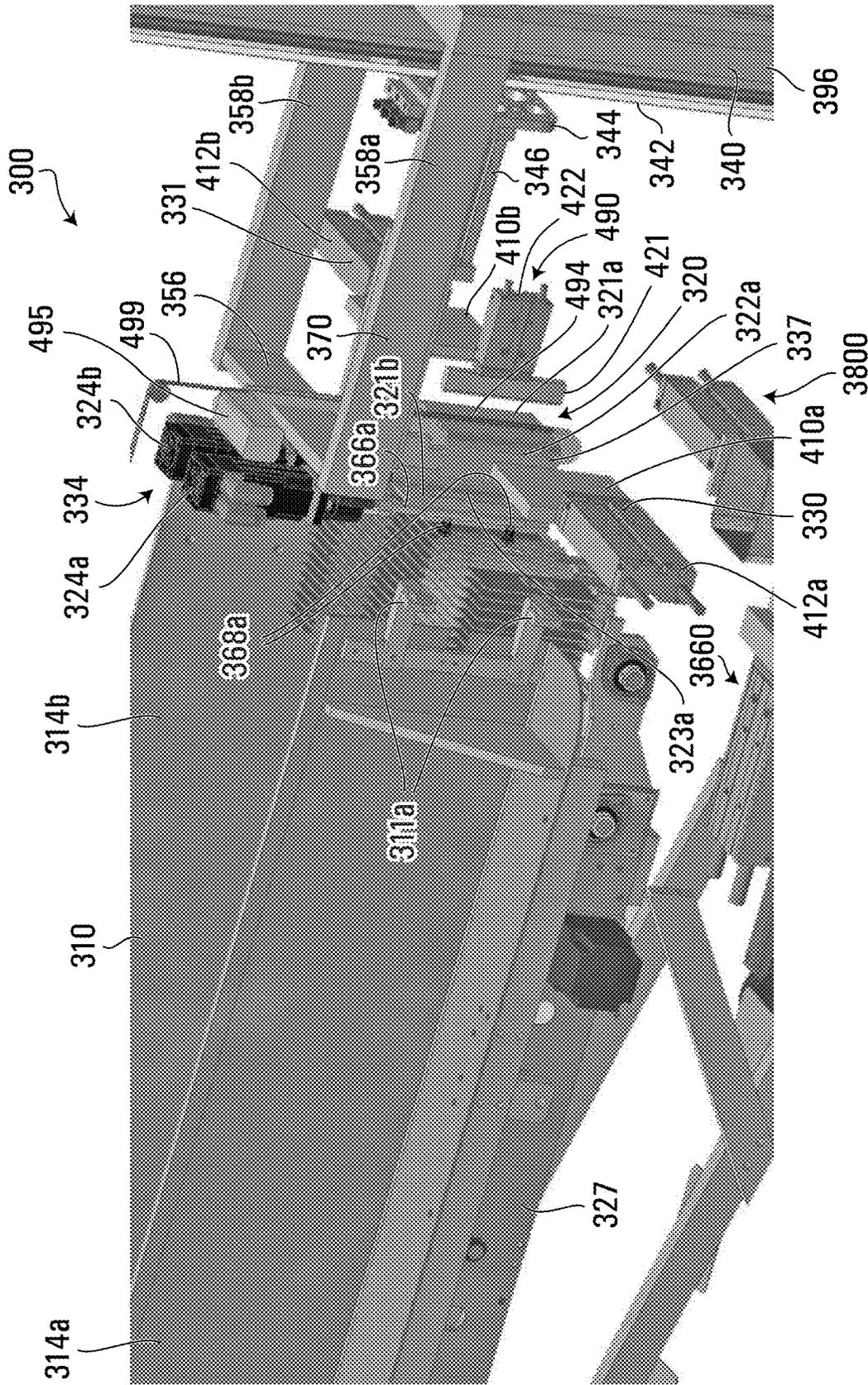


FIG. 36

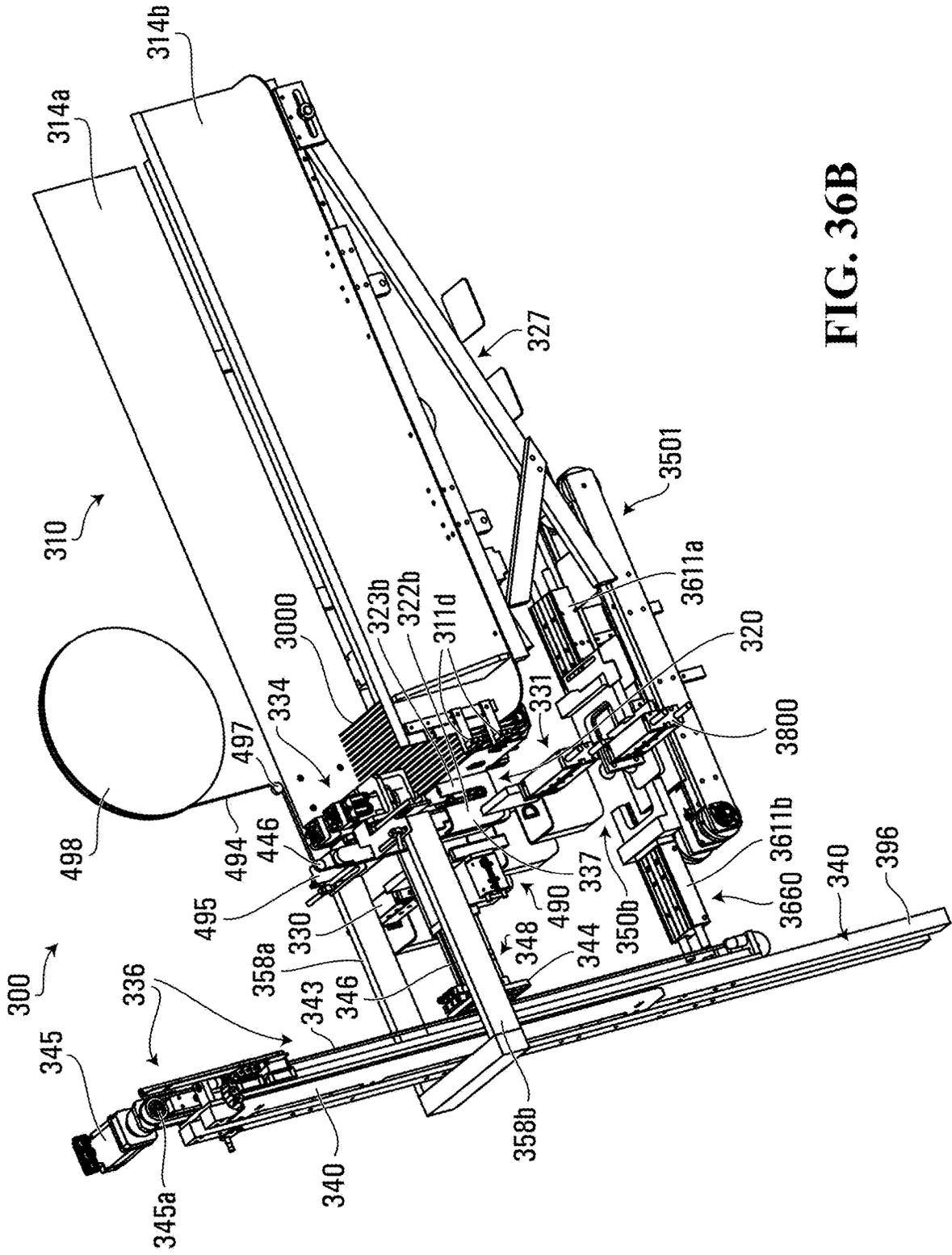


FIG. 36B

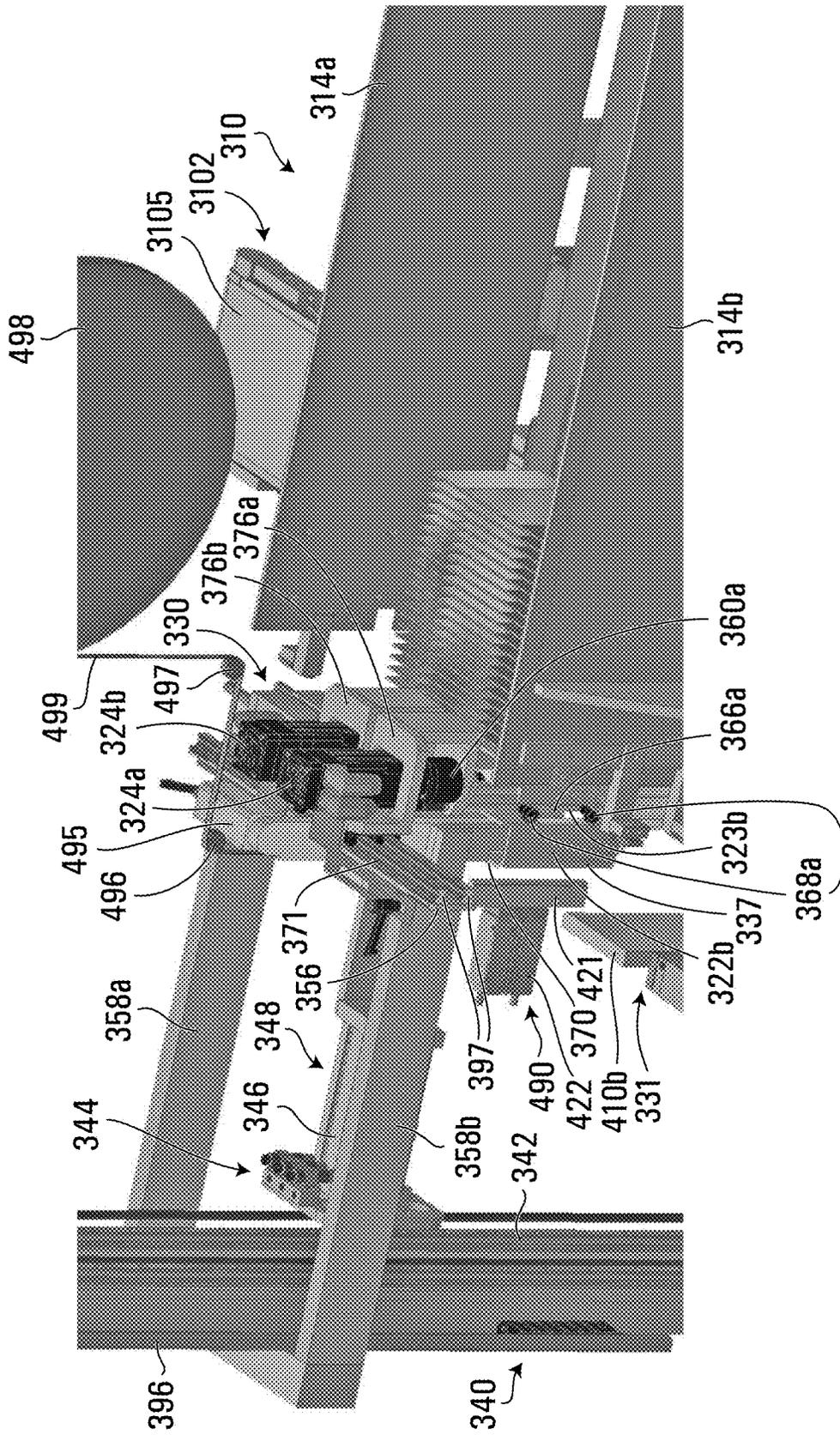


FIG. 36C

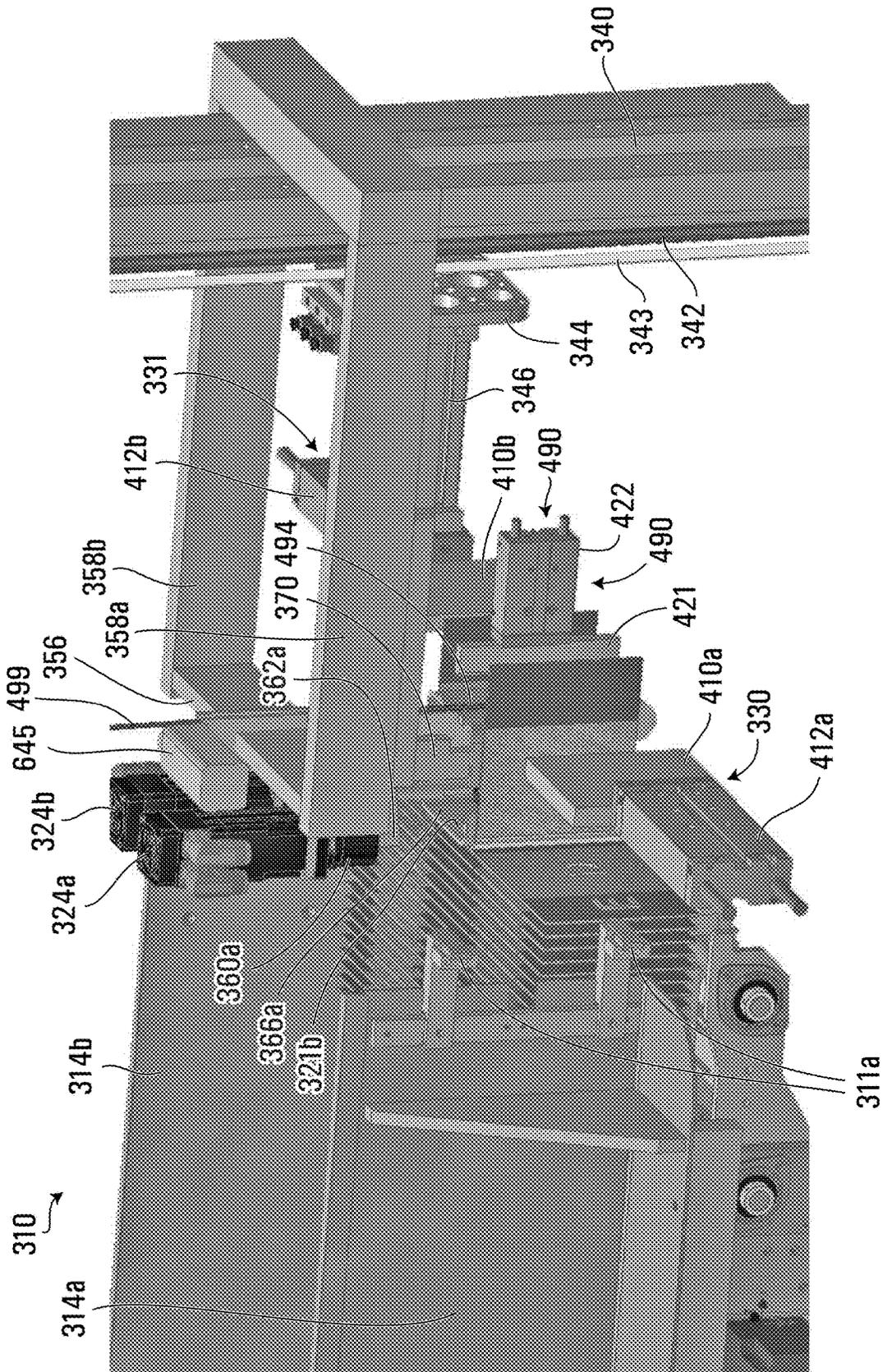


FIG. 38

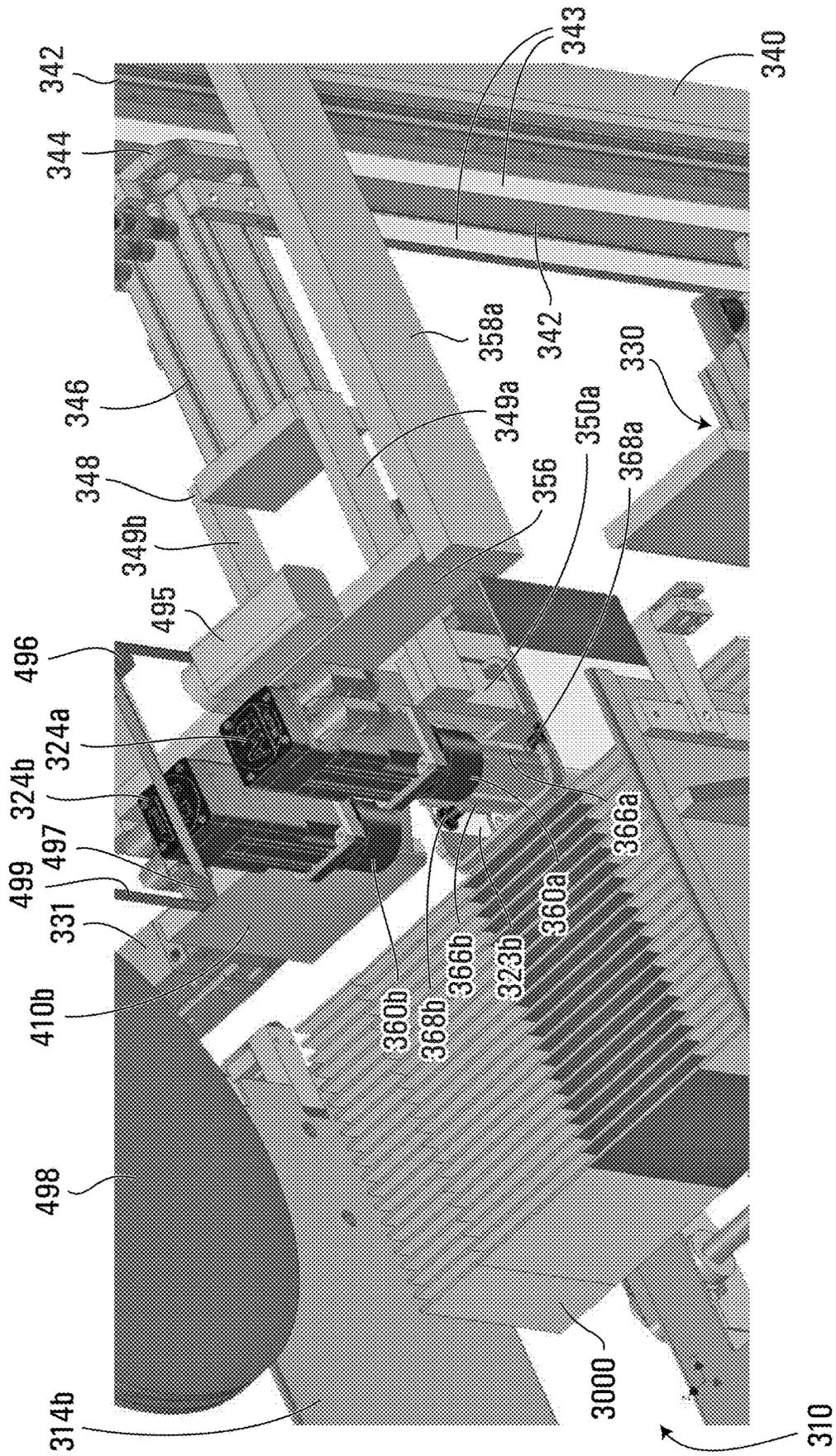


FIG. 39

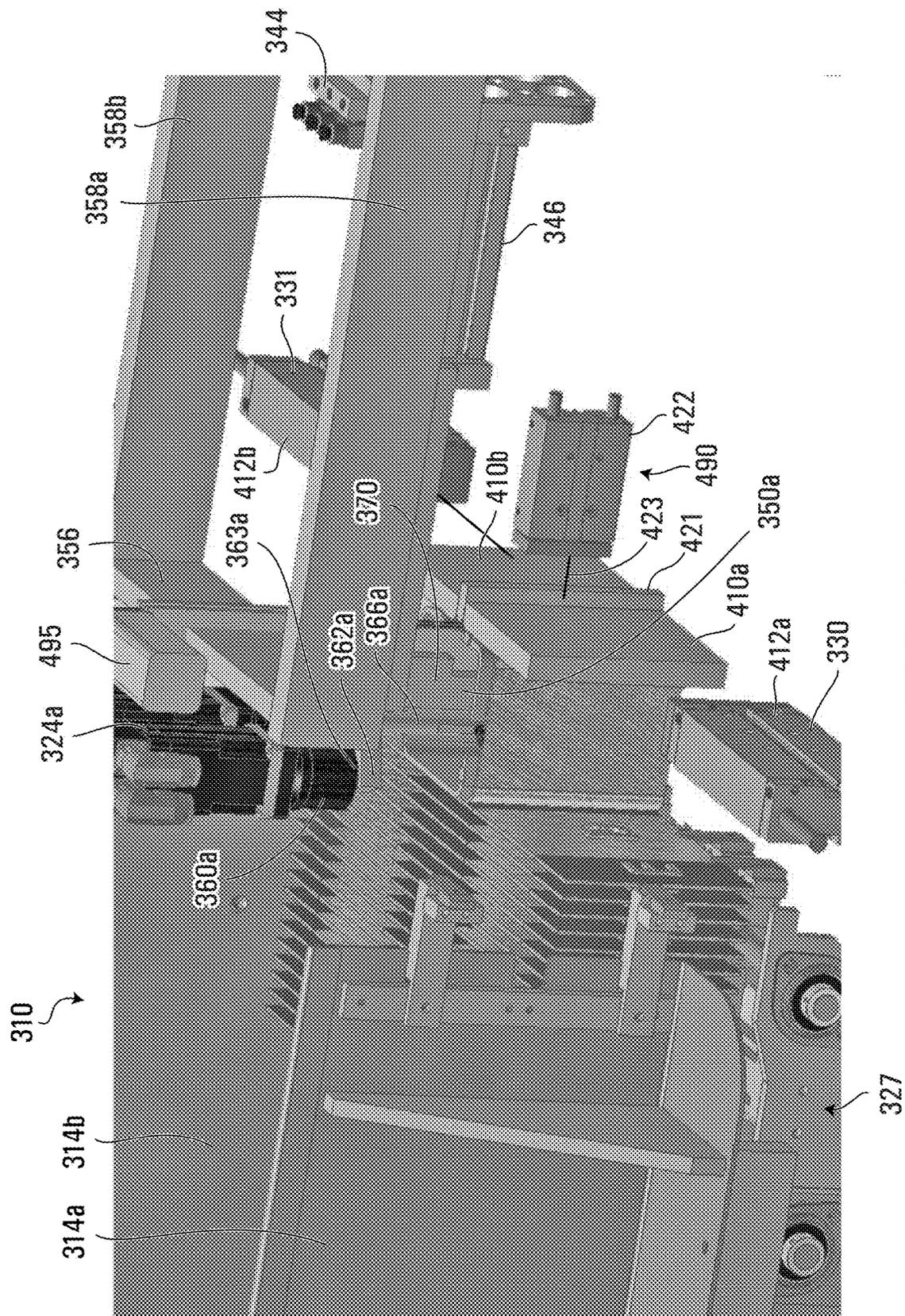


FIG. 41

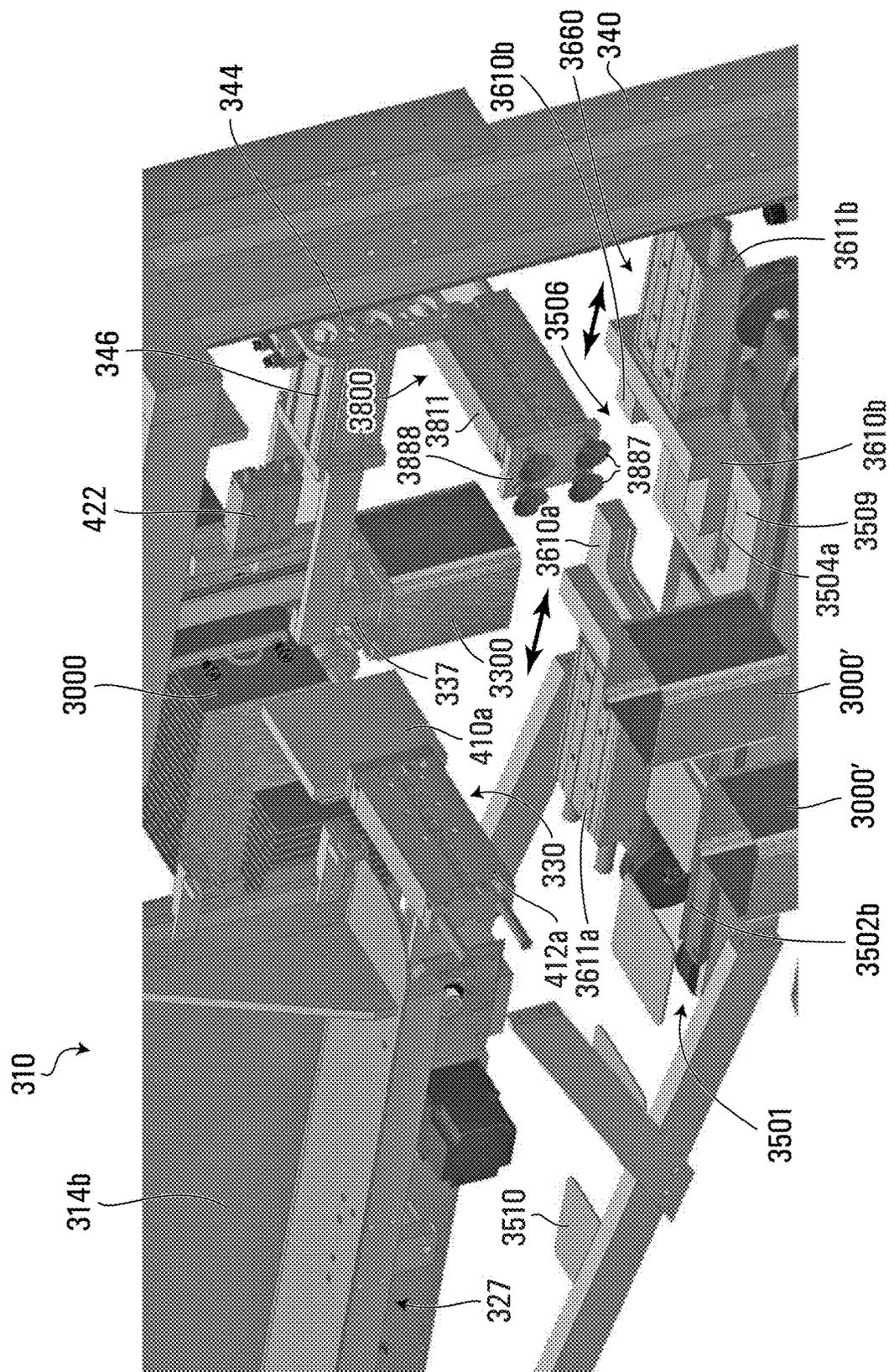


FIG. 42

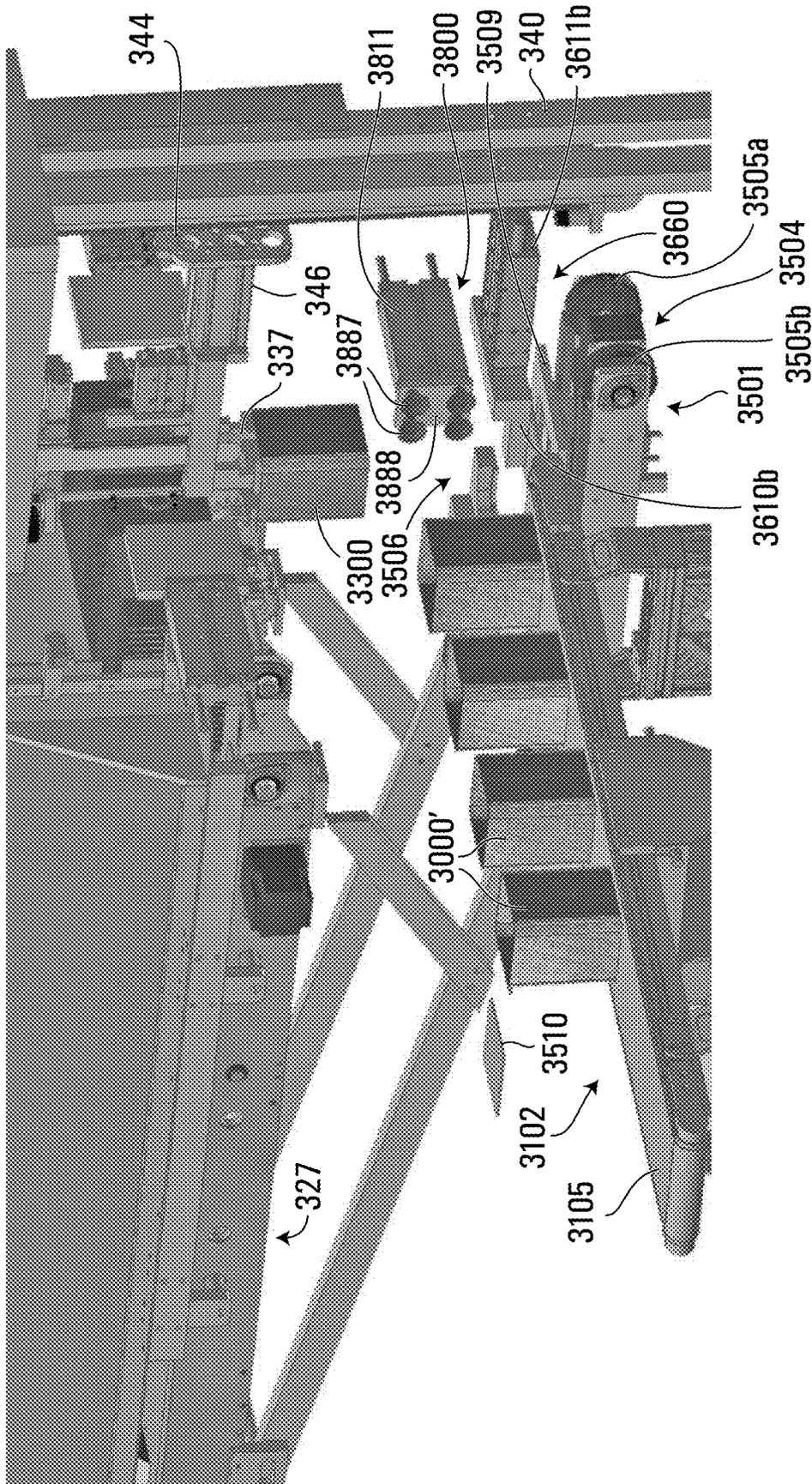


FIG. 43

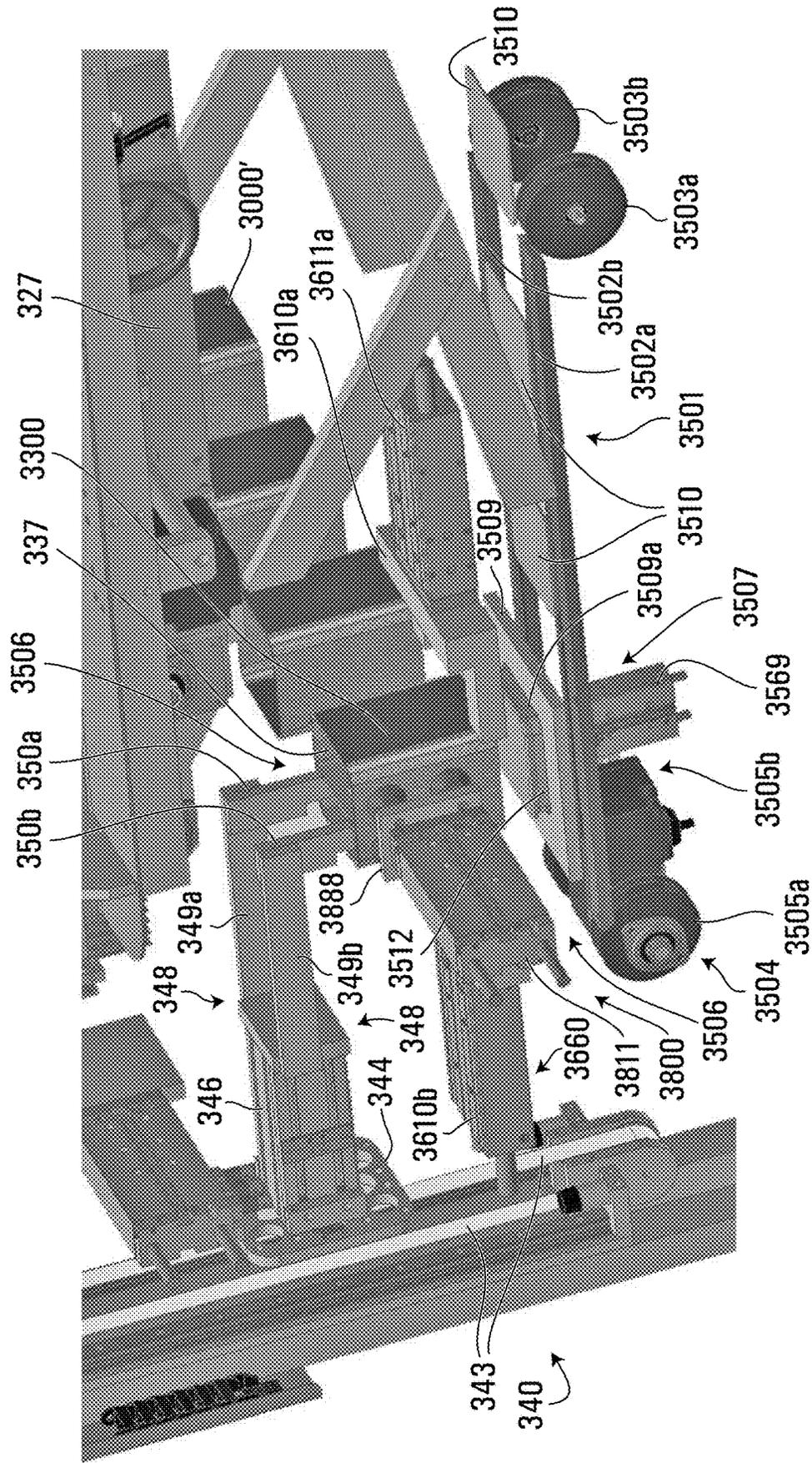


FIG. 44

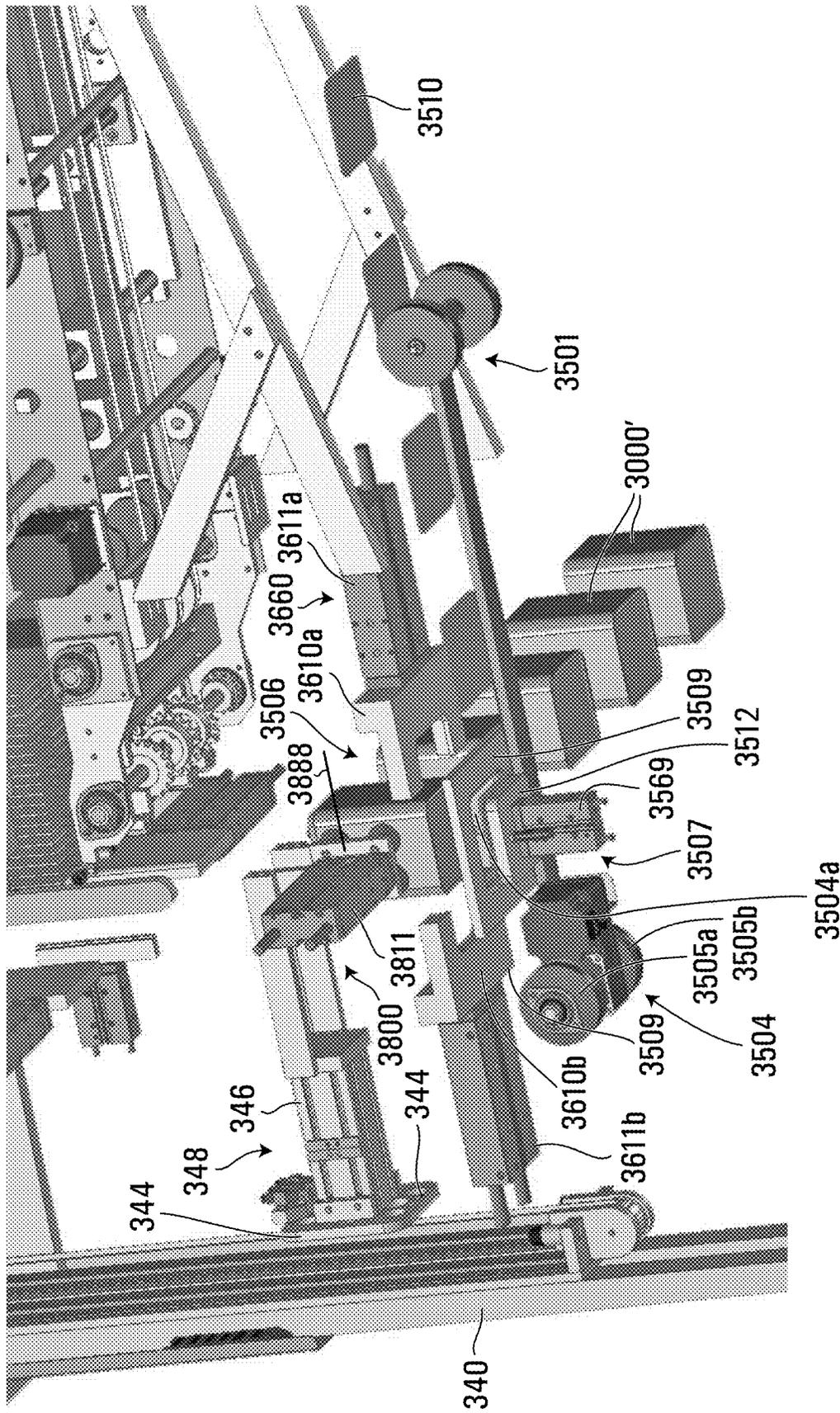


FIG. 45

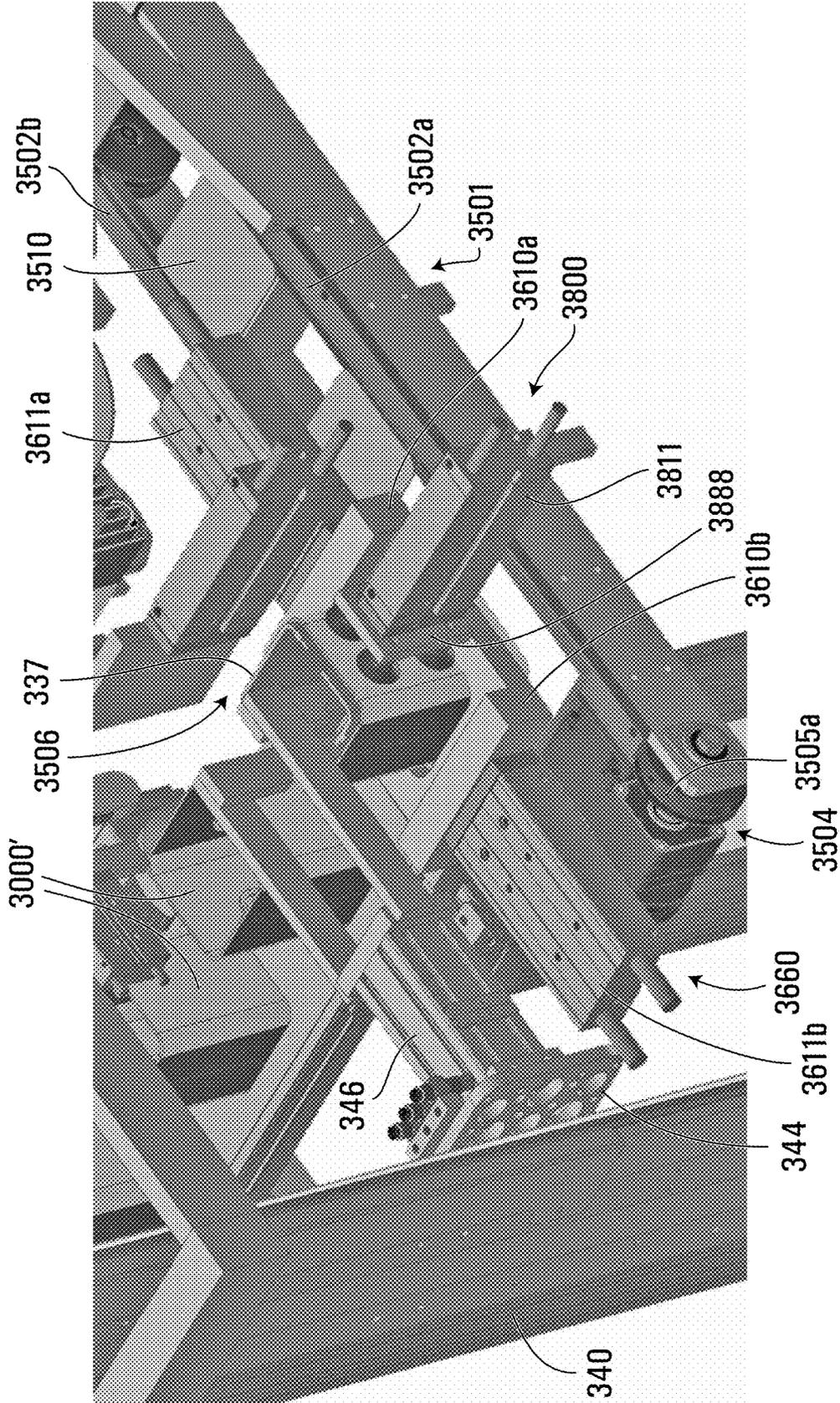


FIG. 47

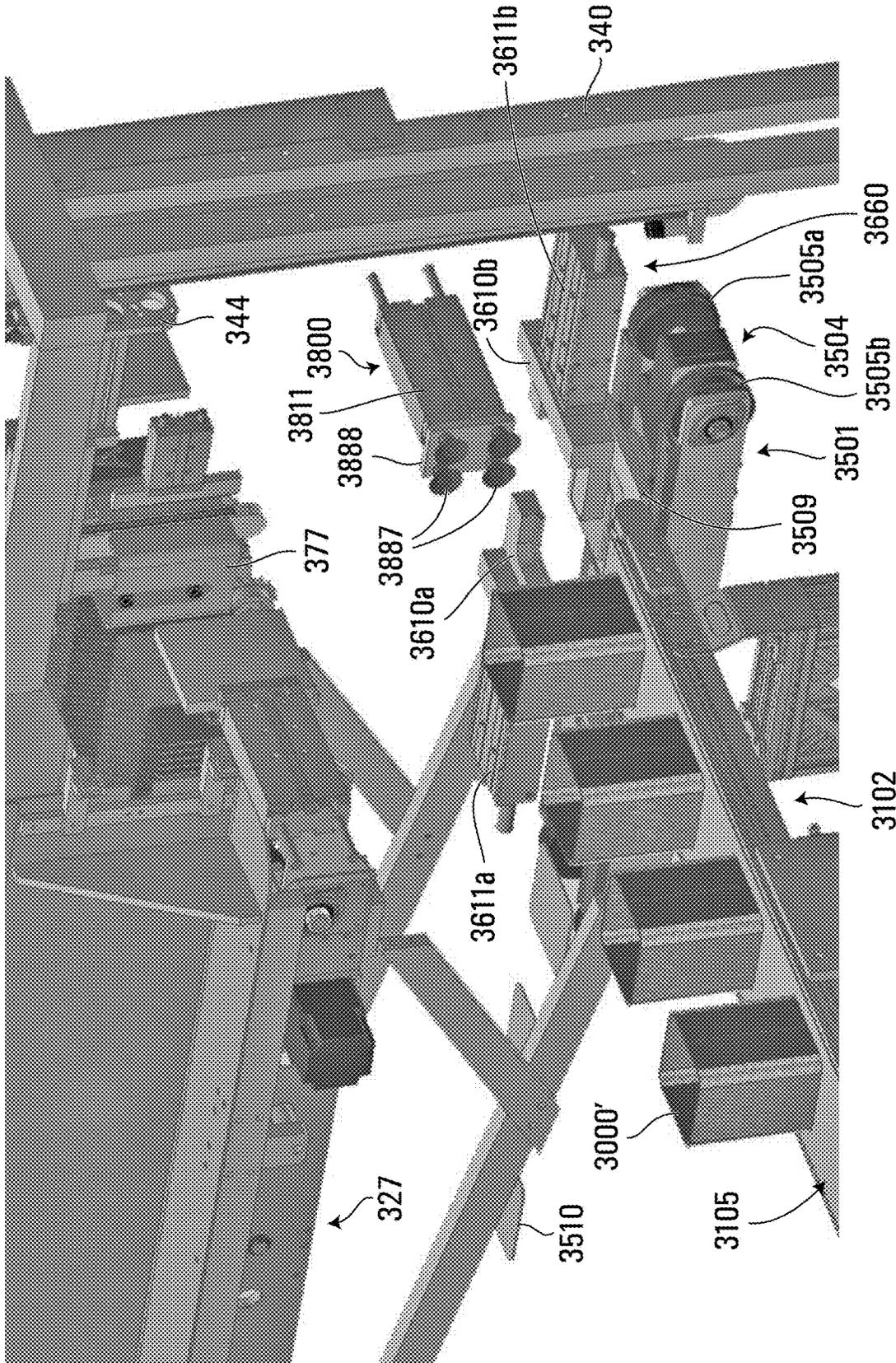


FIG. 50

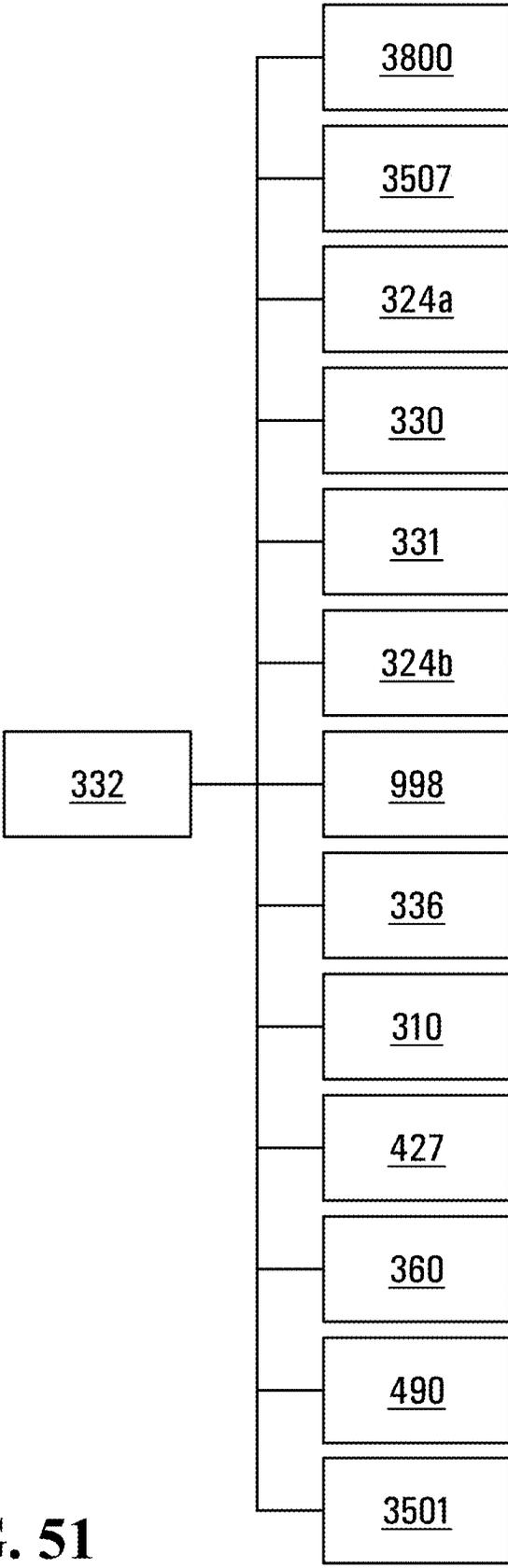


FIG. 51

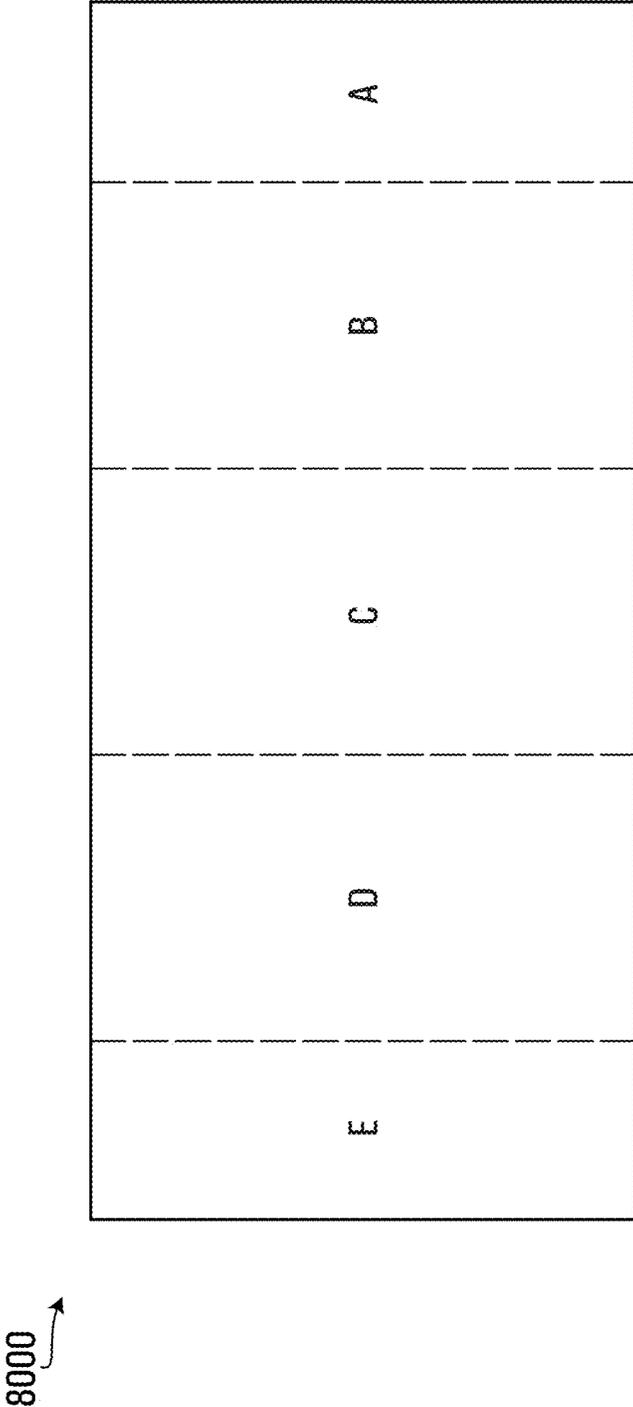


FIG. 52

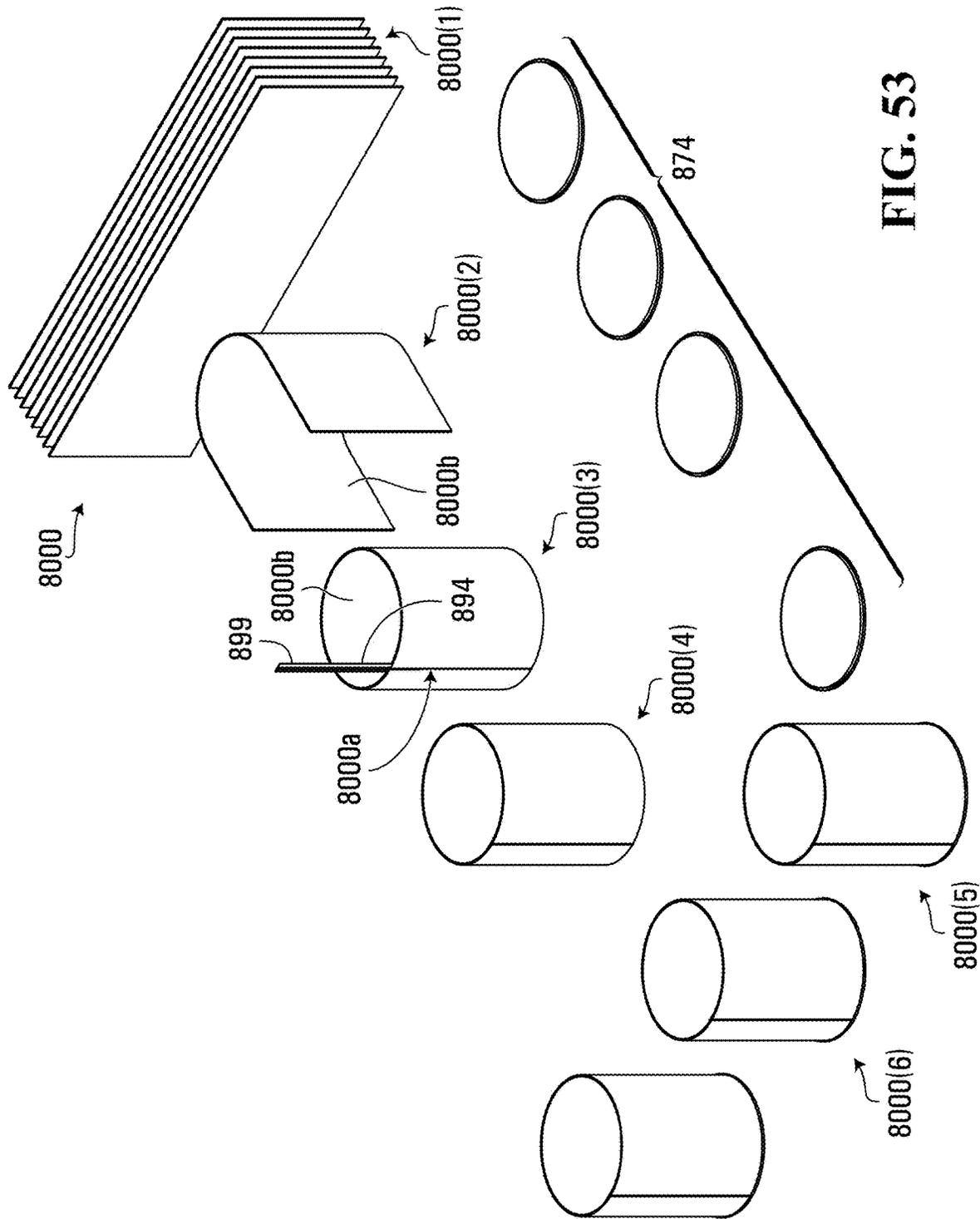


FIG. 53

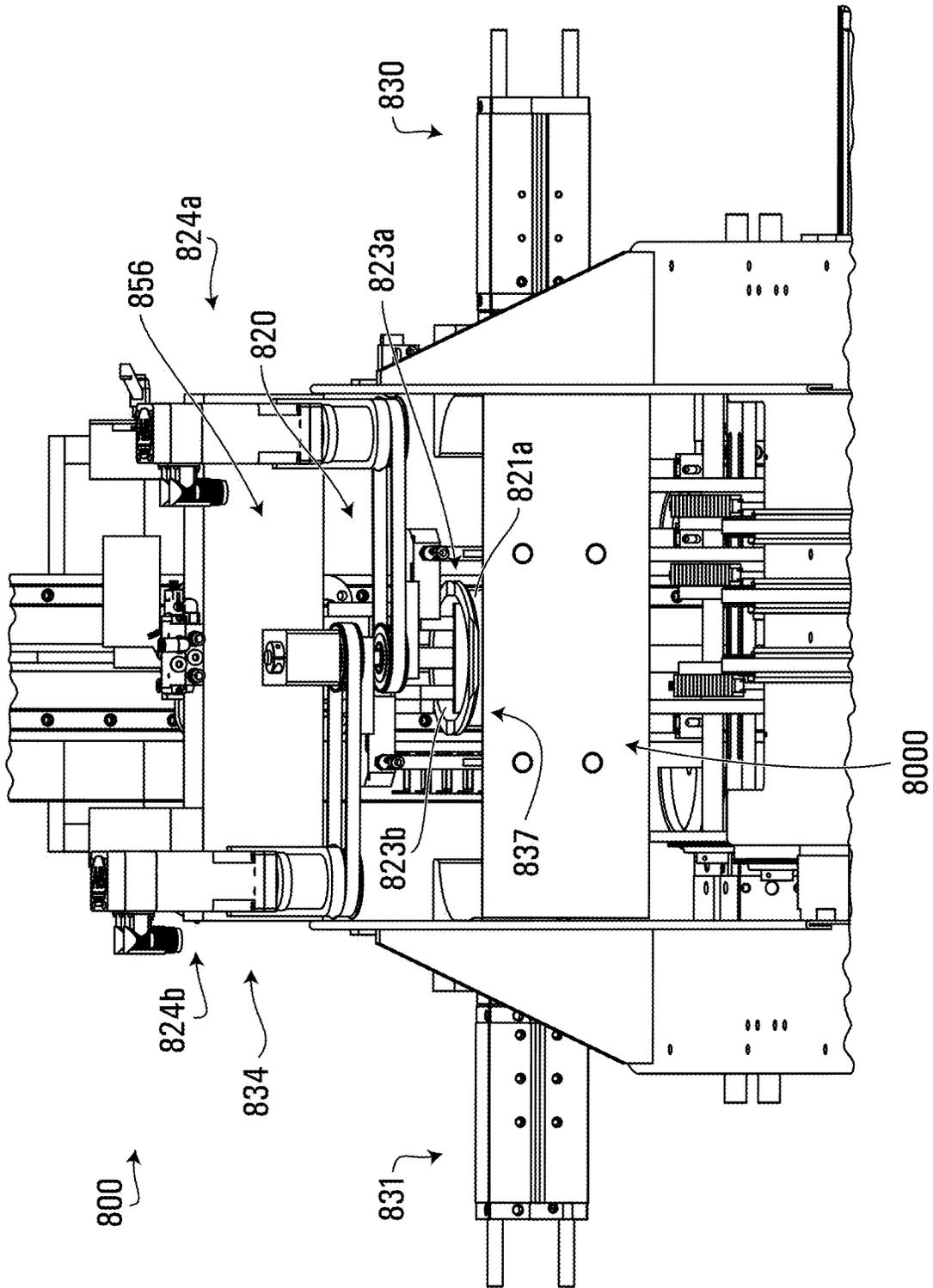


FIG. 56

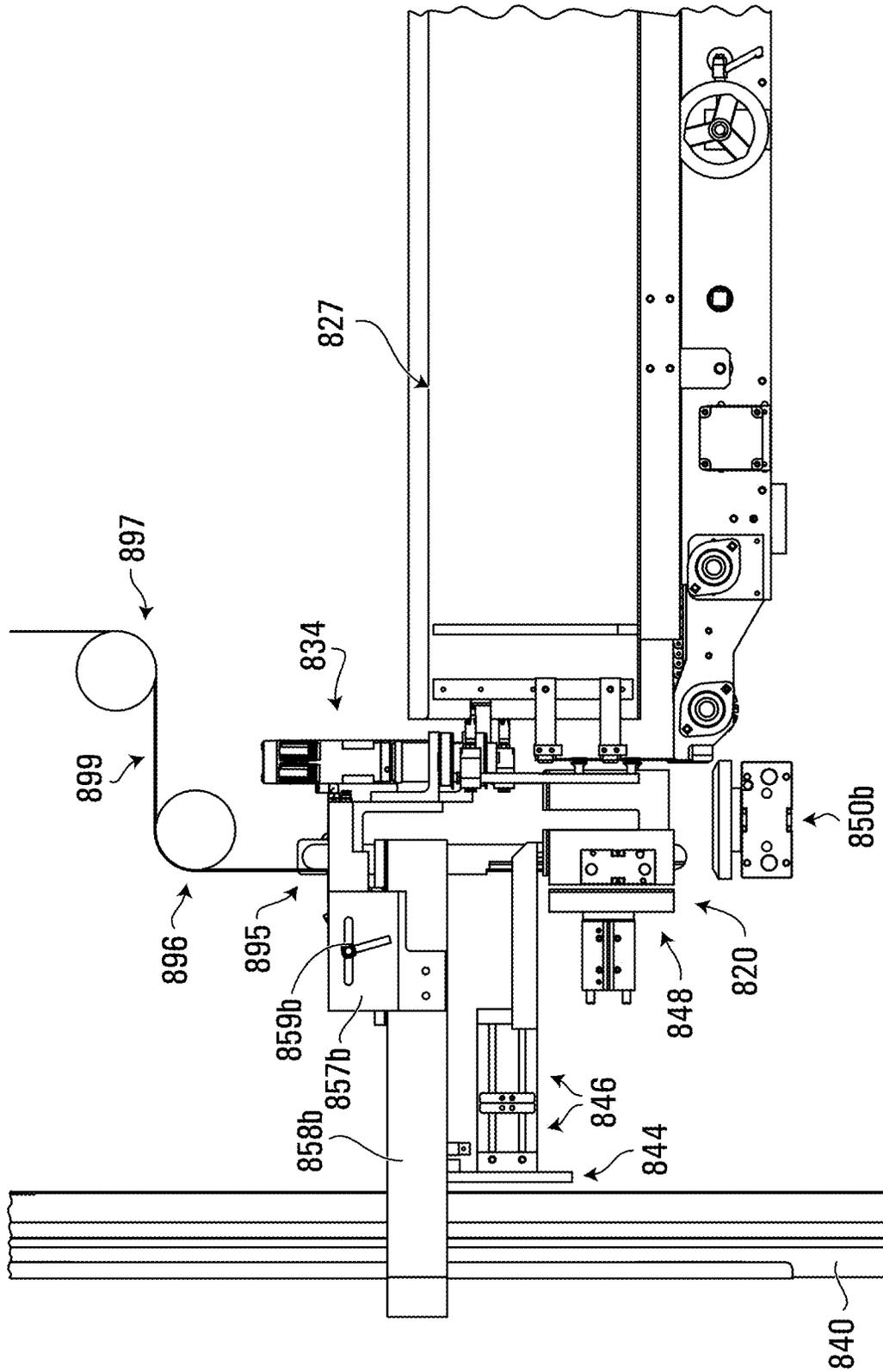


FIG. 57

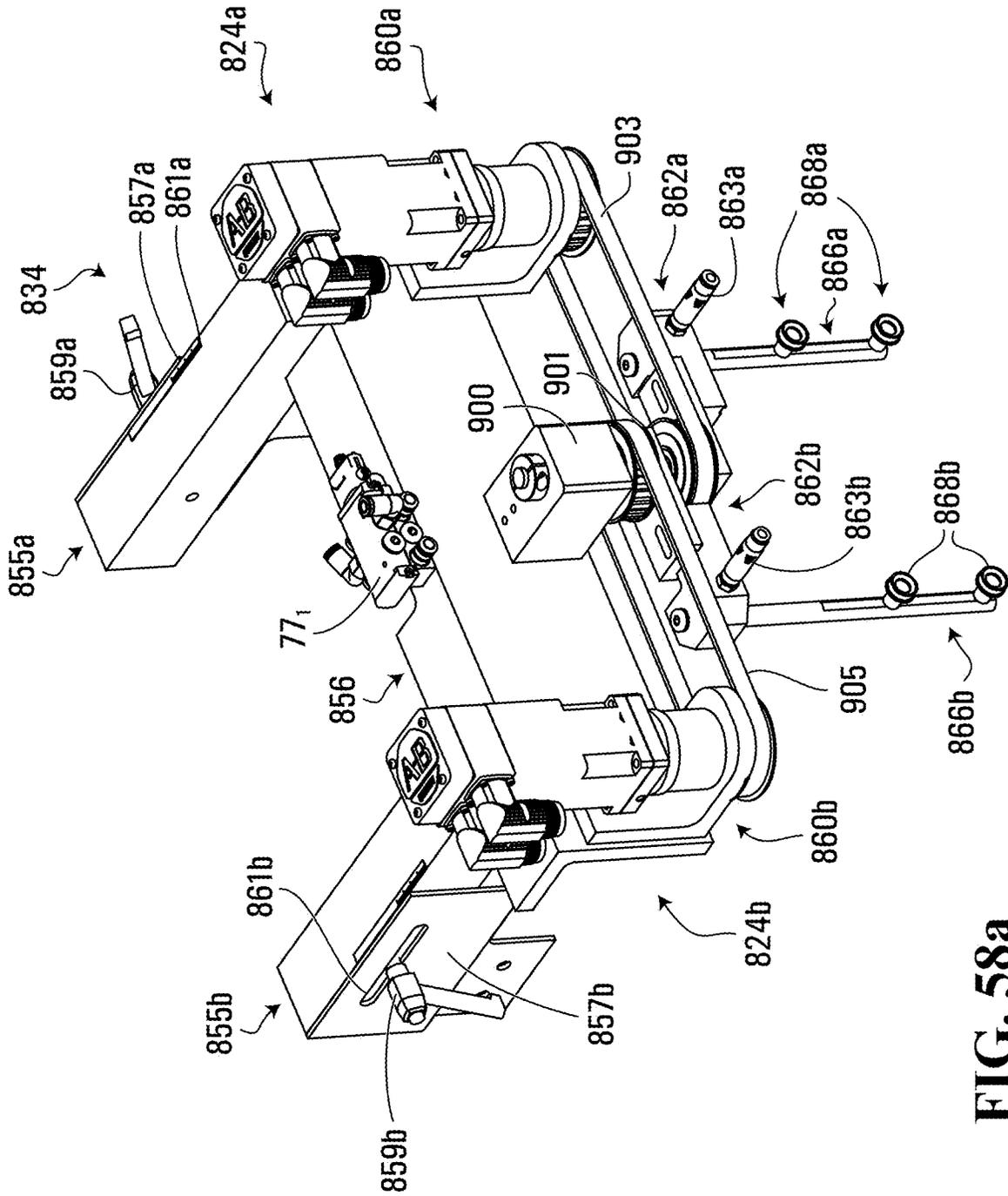


FIG. 58a

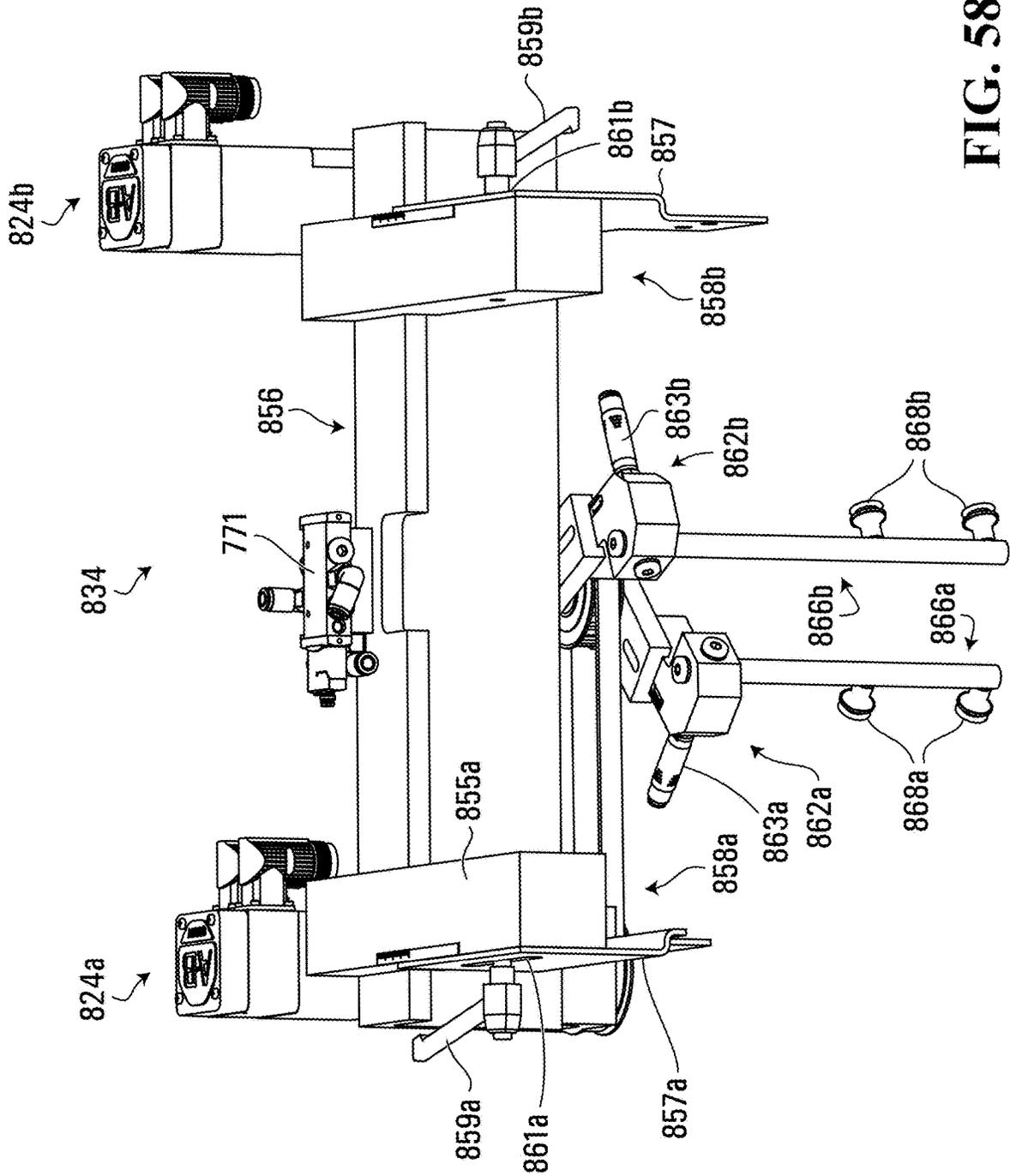


FIG. 58b

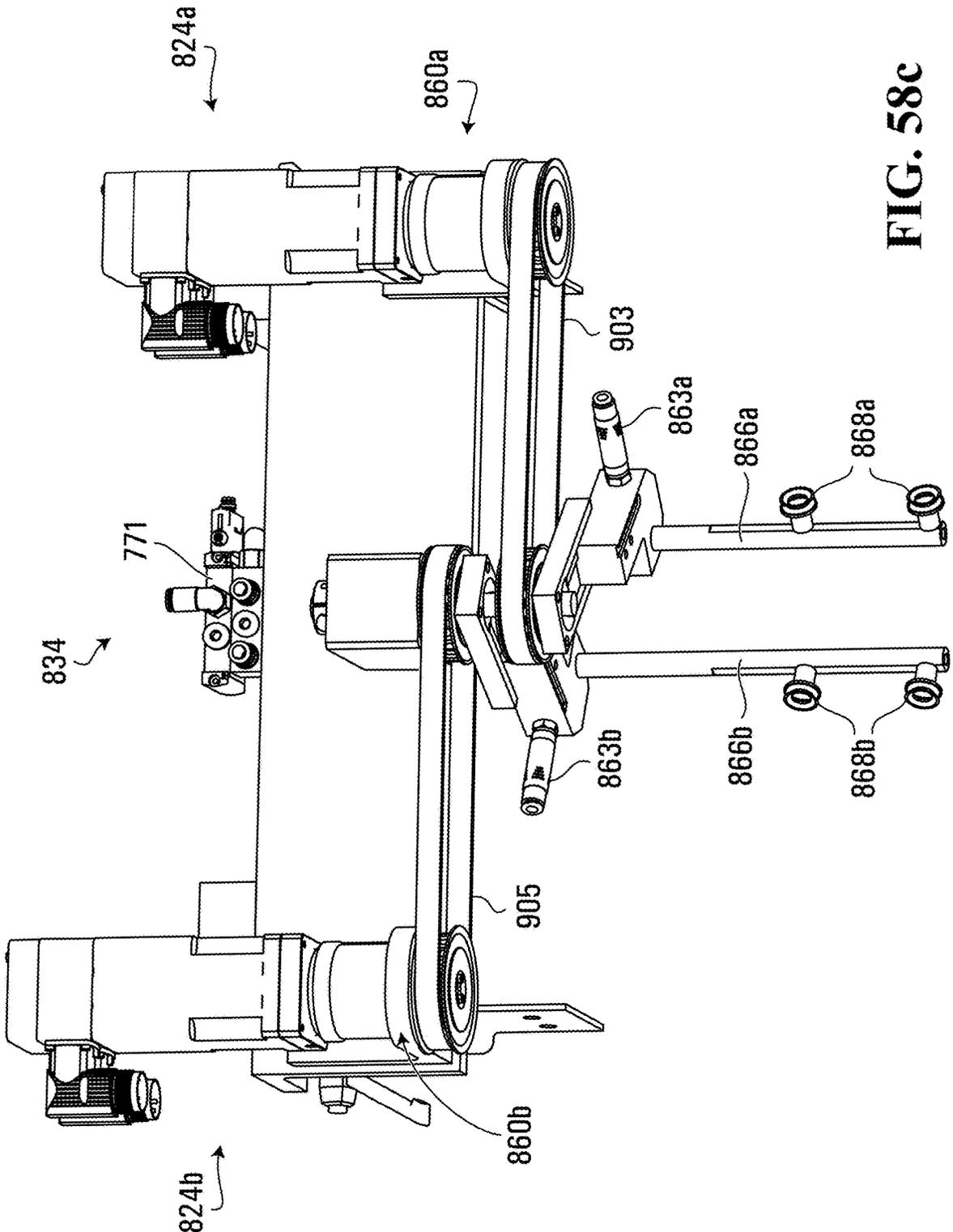


FIG. 58c

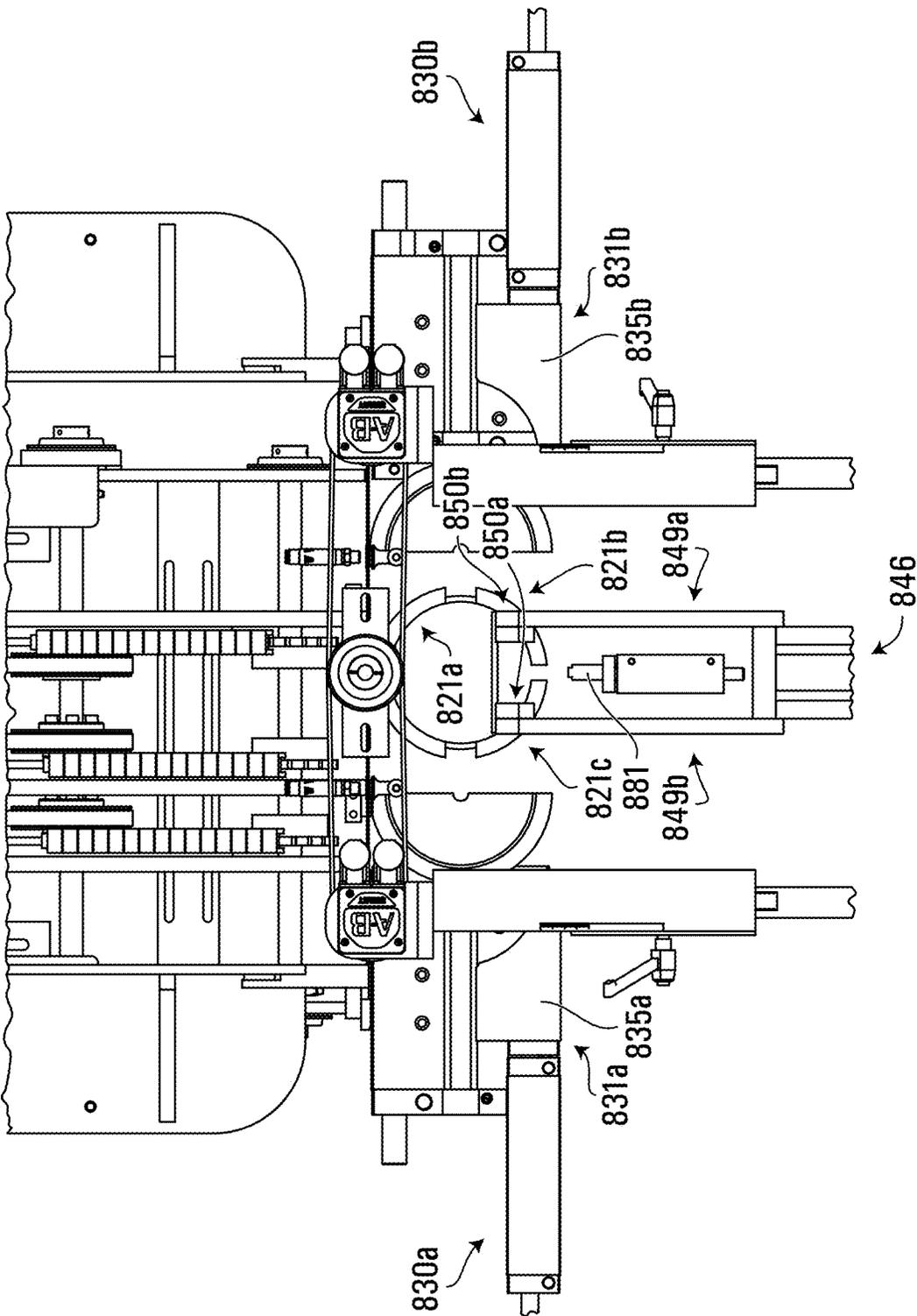


FIG. 60

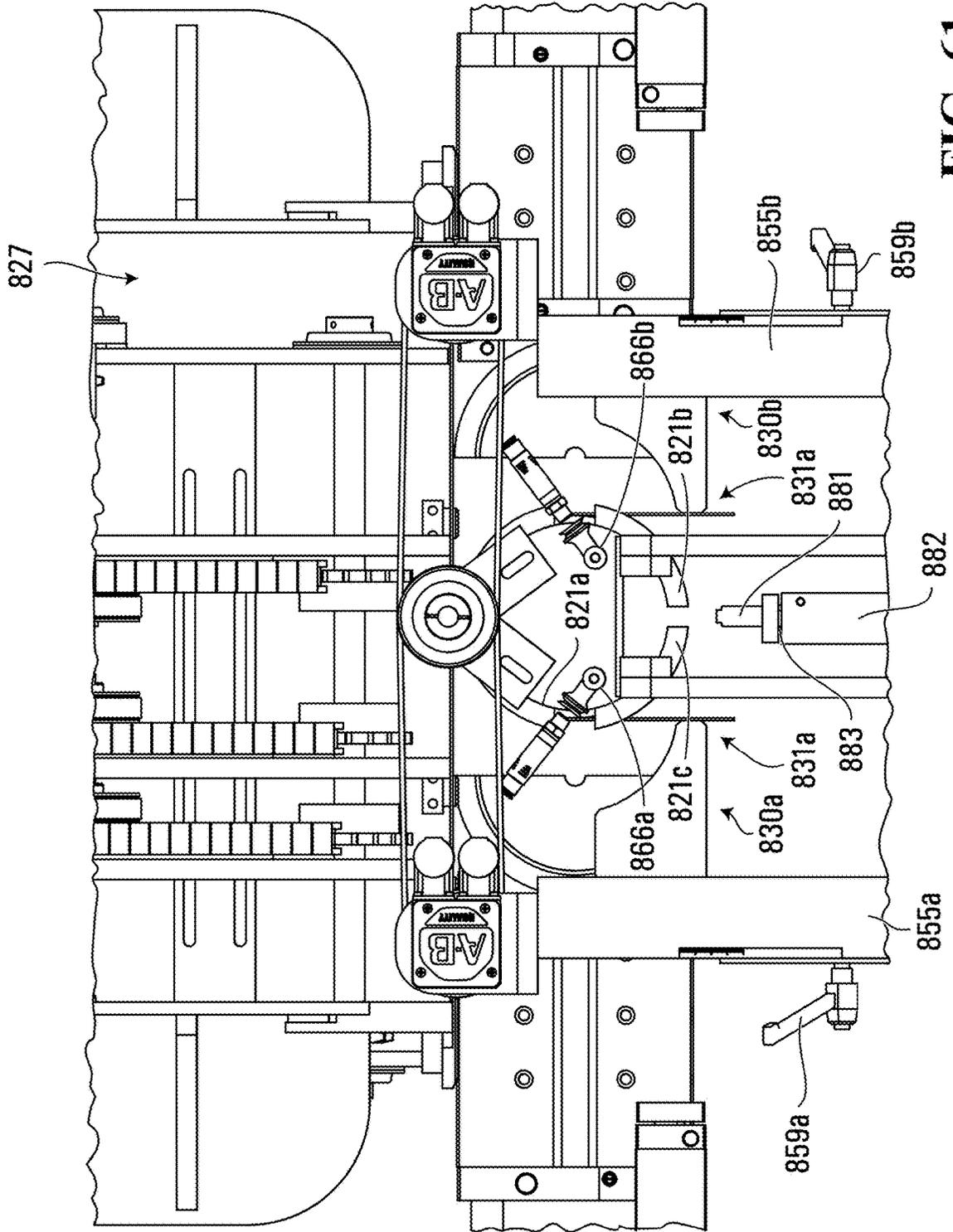


FIG. 61

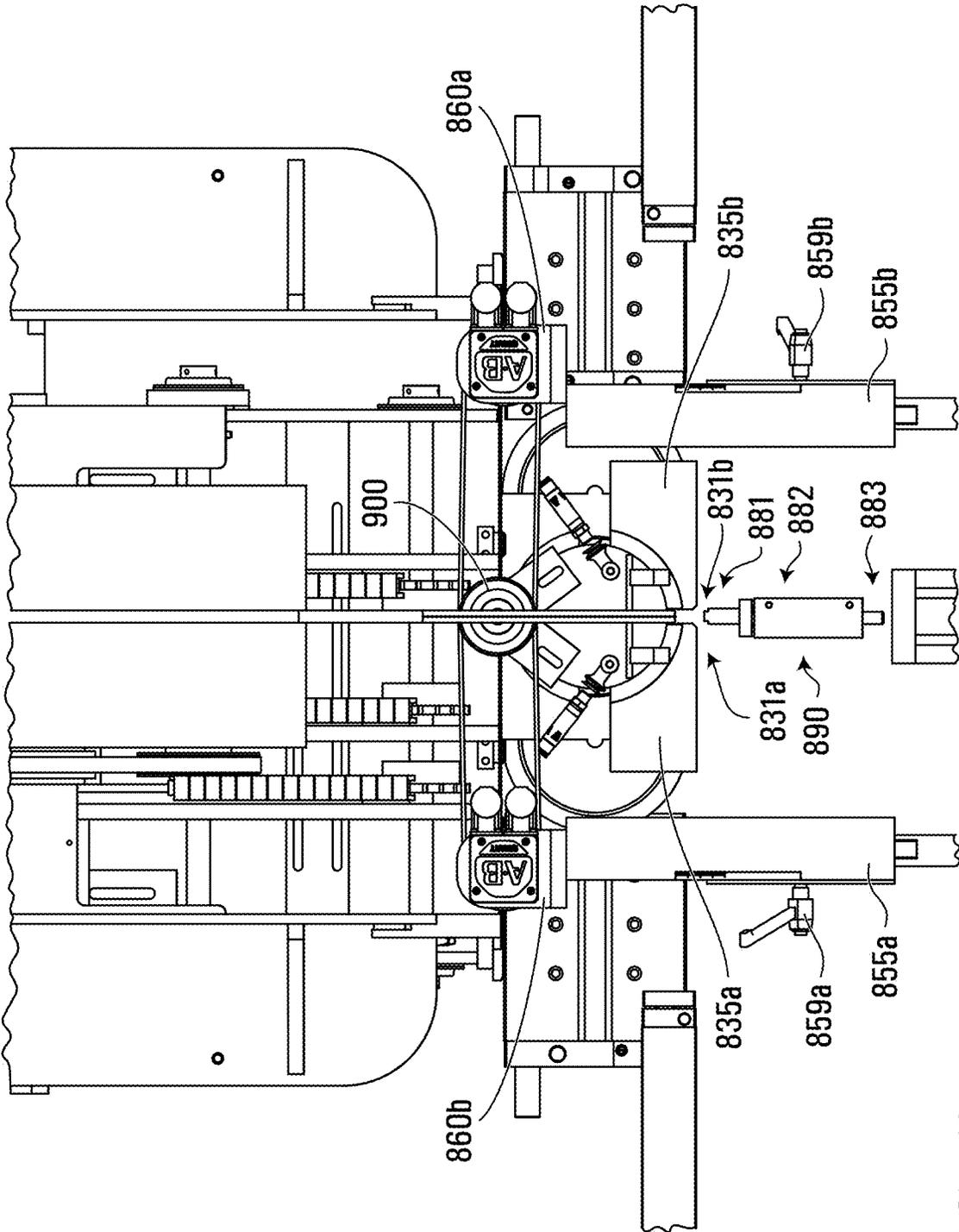


FIG. 62

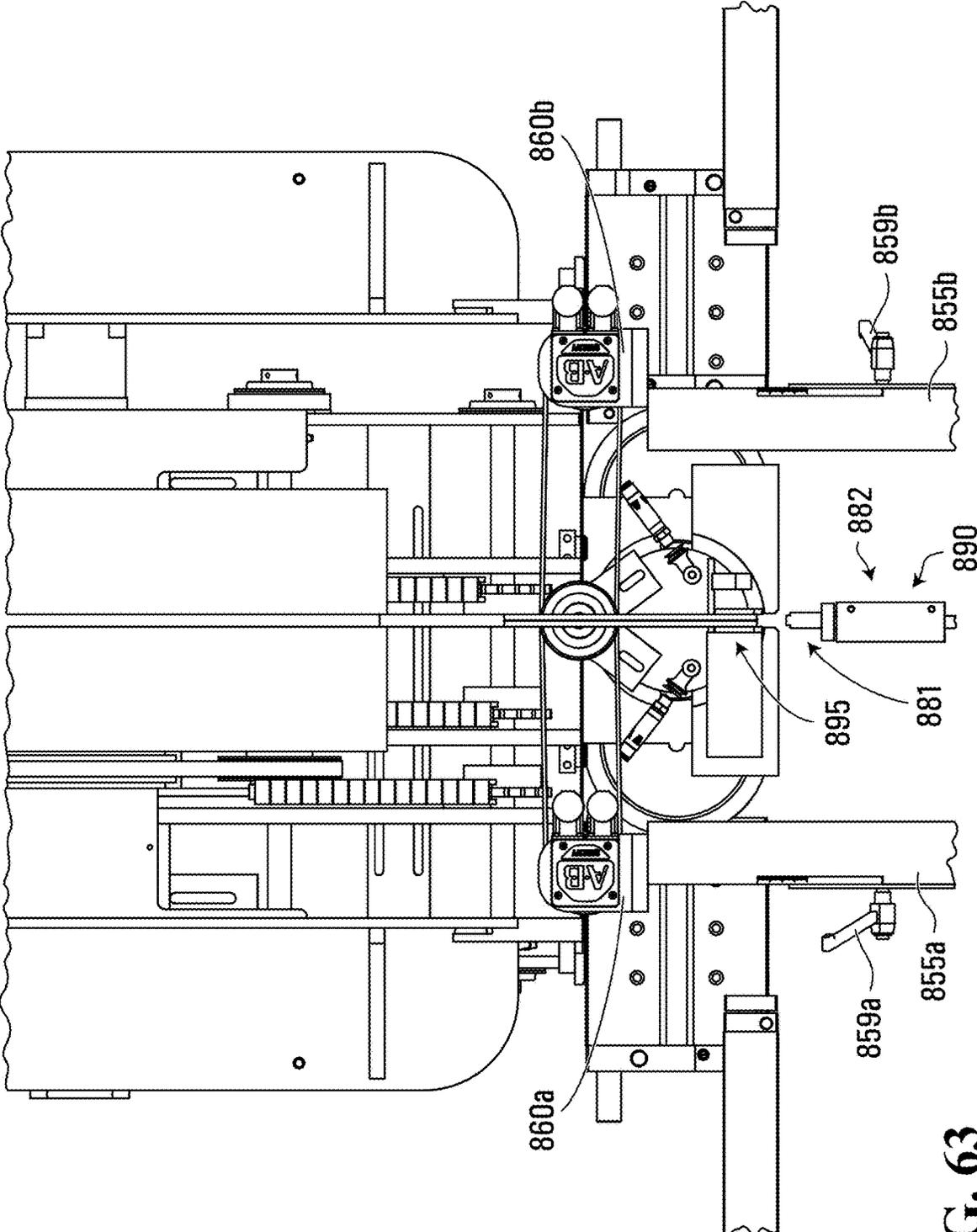


FIG. 63

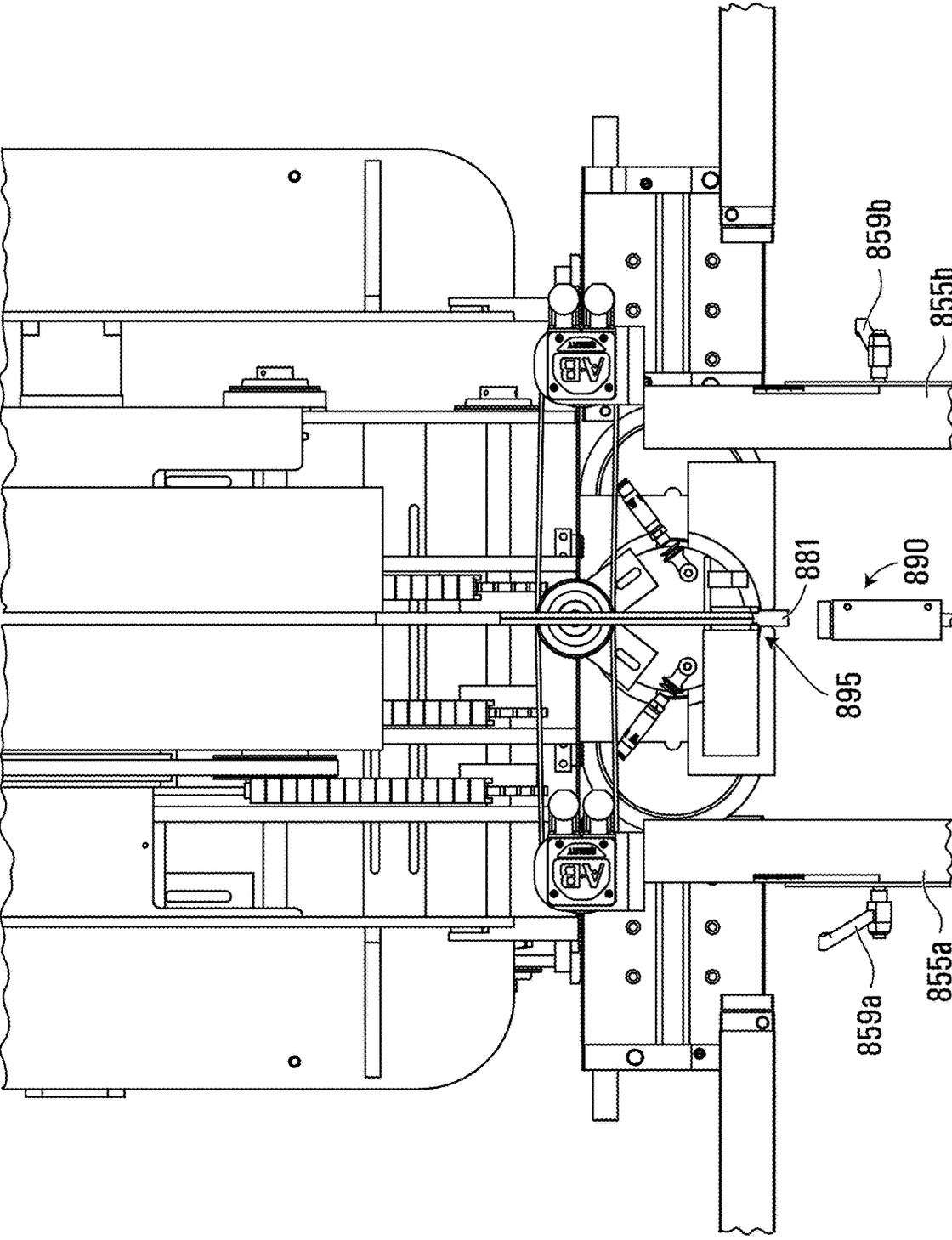


FIG. 64

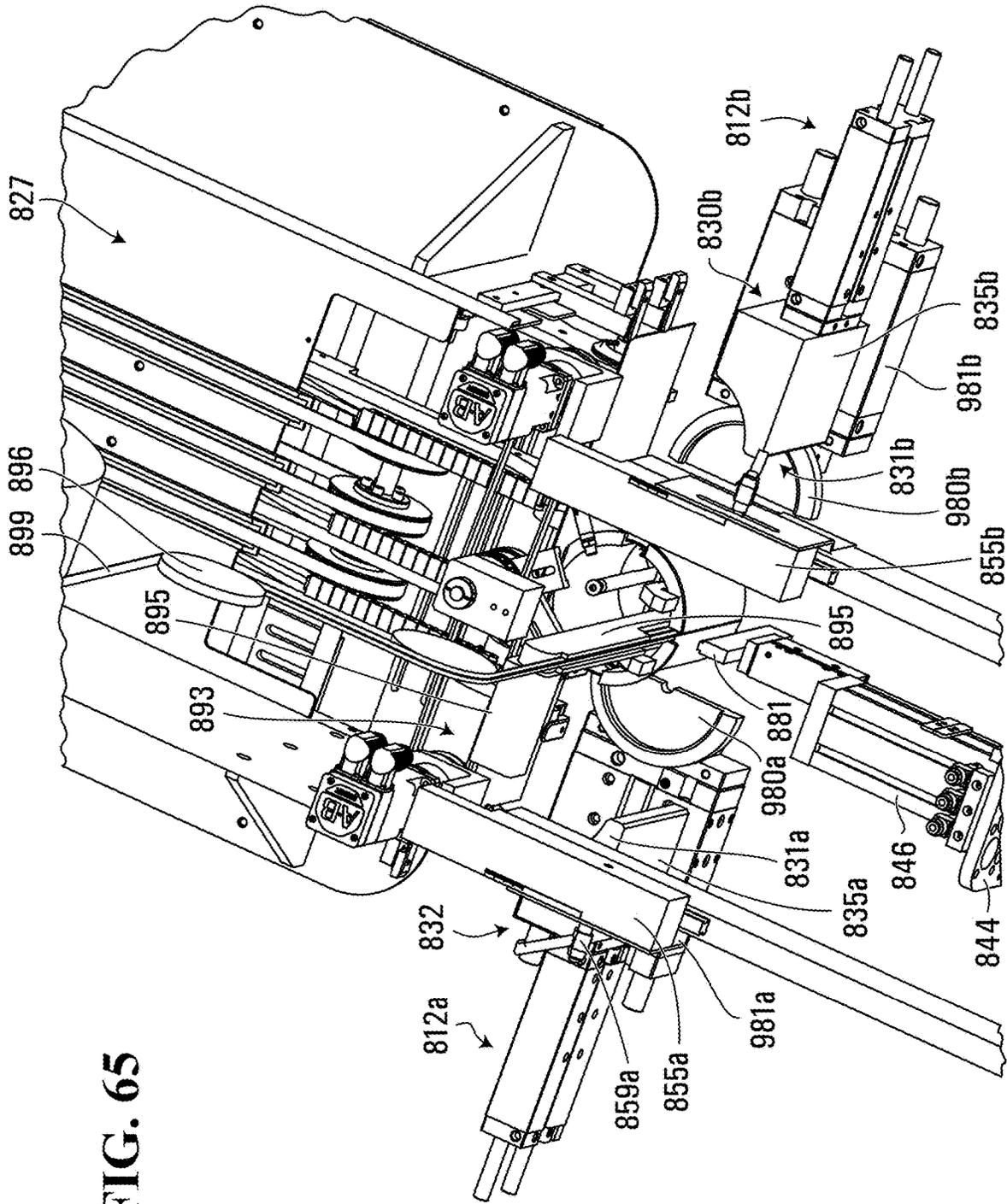


FIG. 65

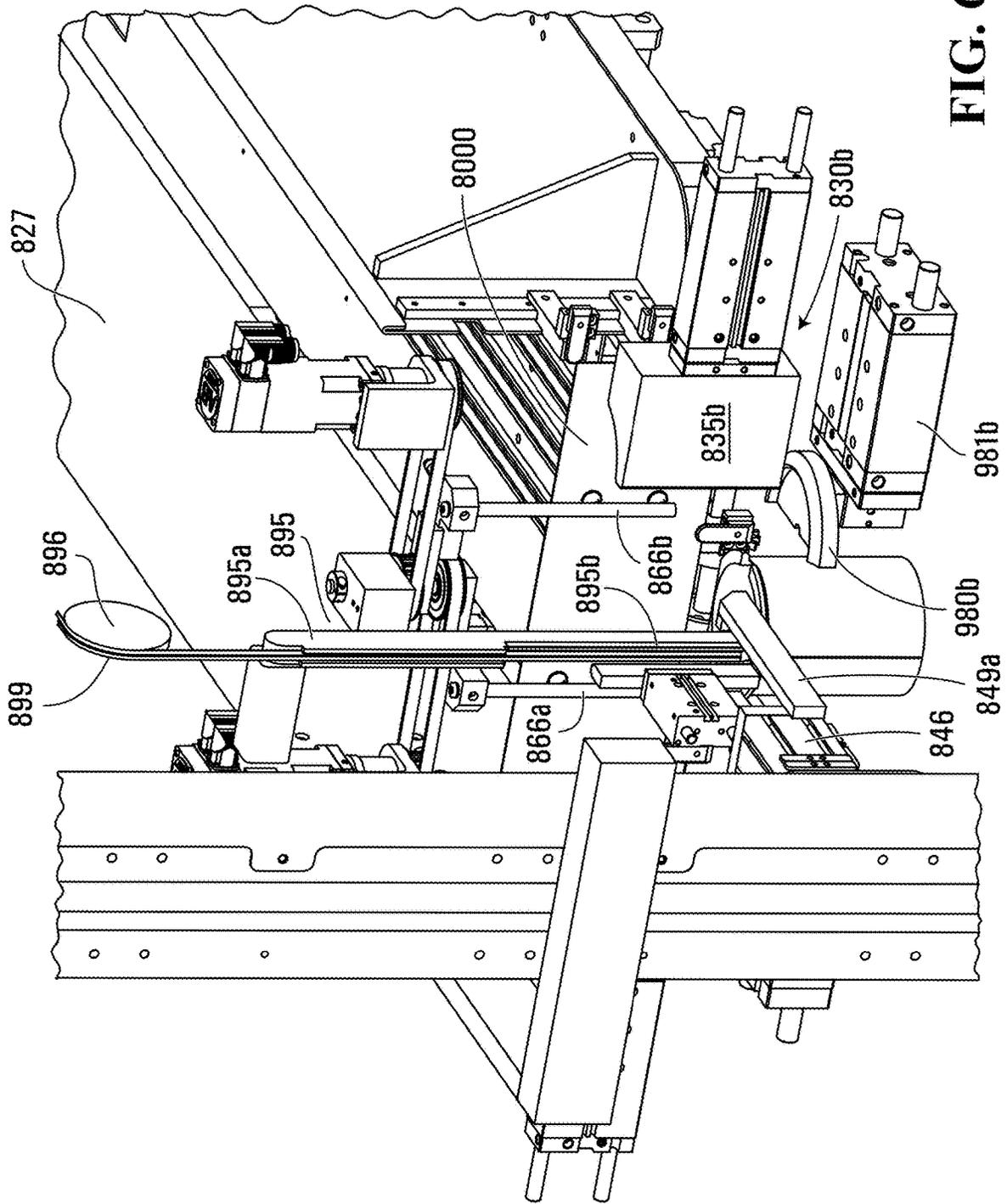


FIG. 66a

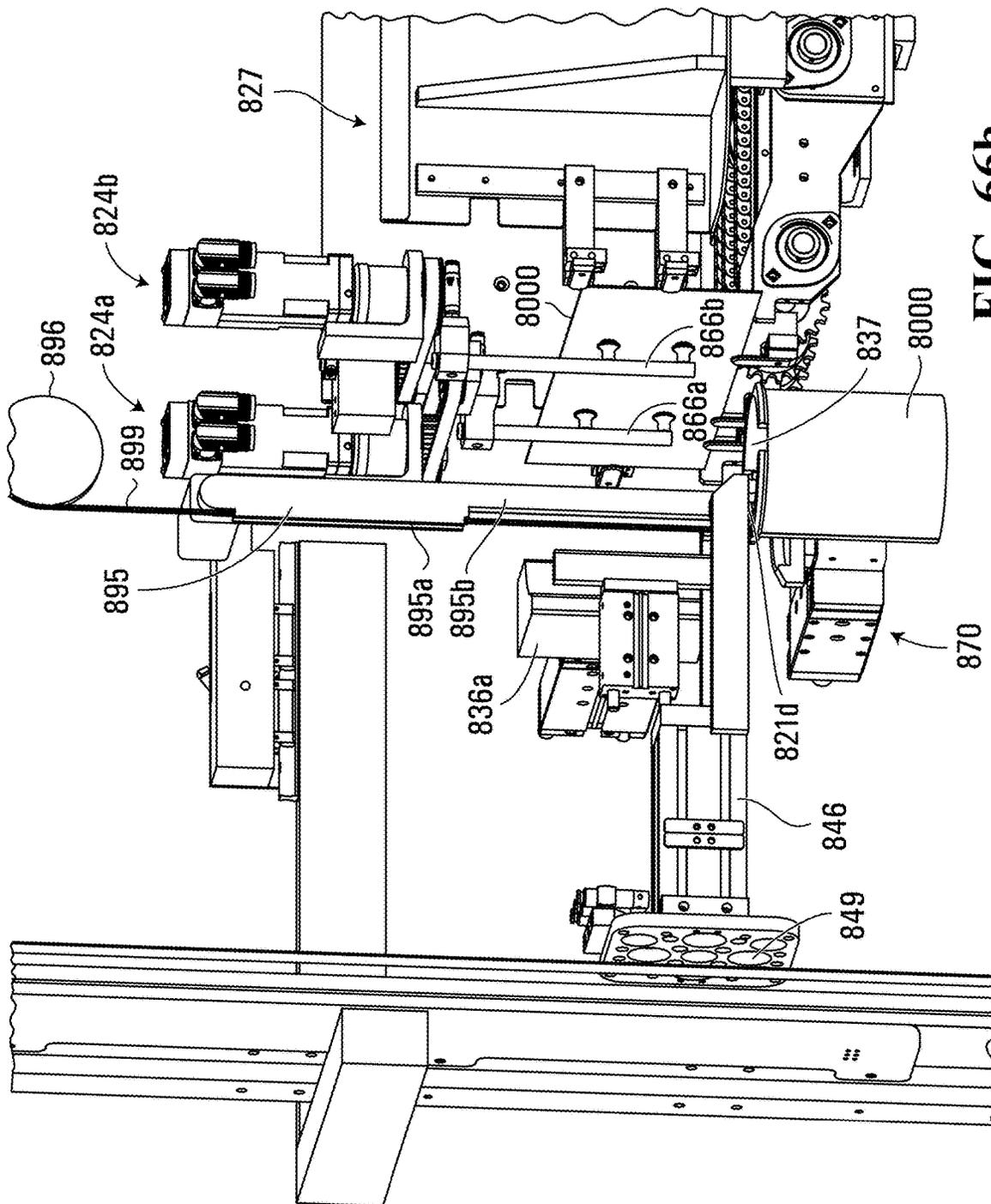


FIG. 66b

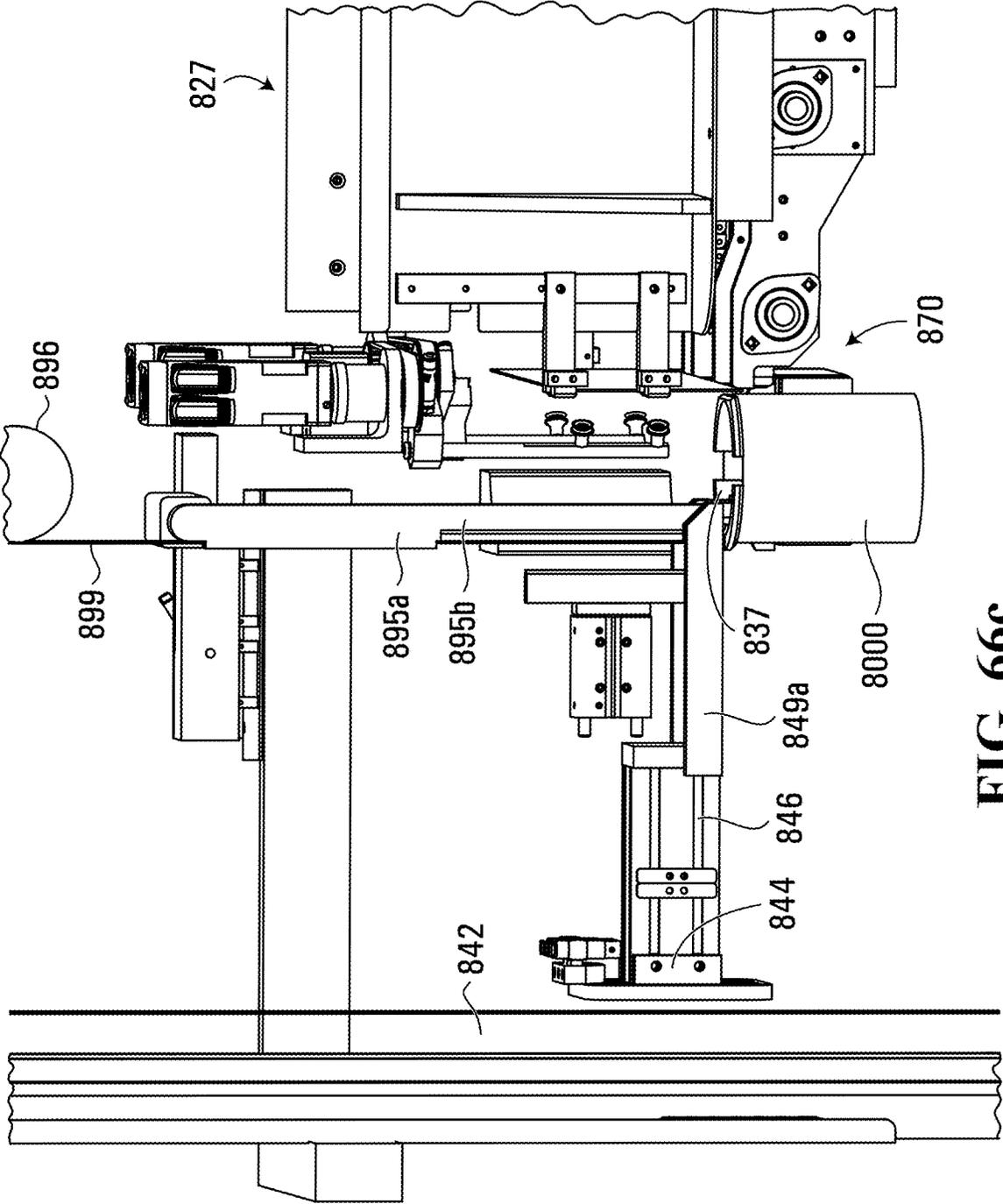


FIG. 66c

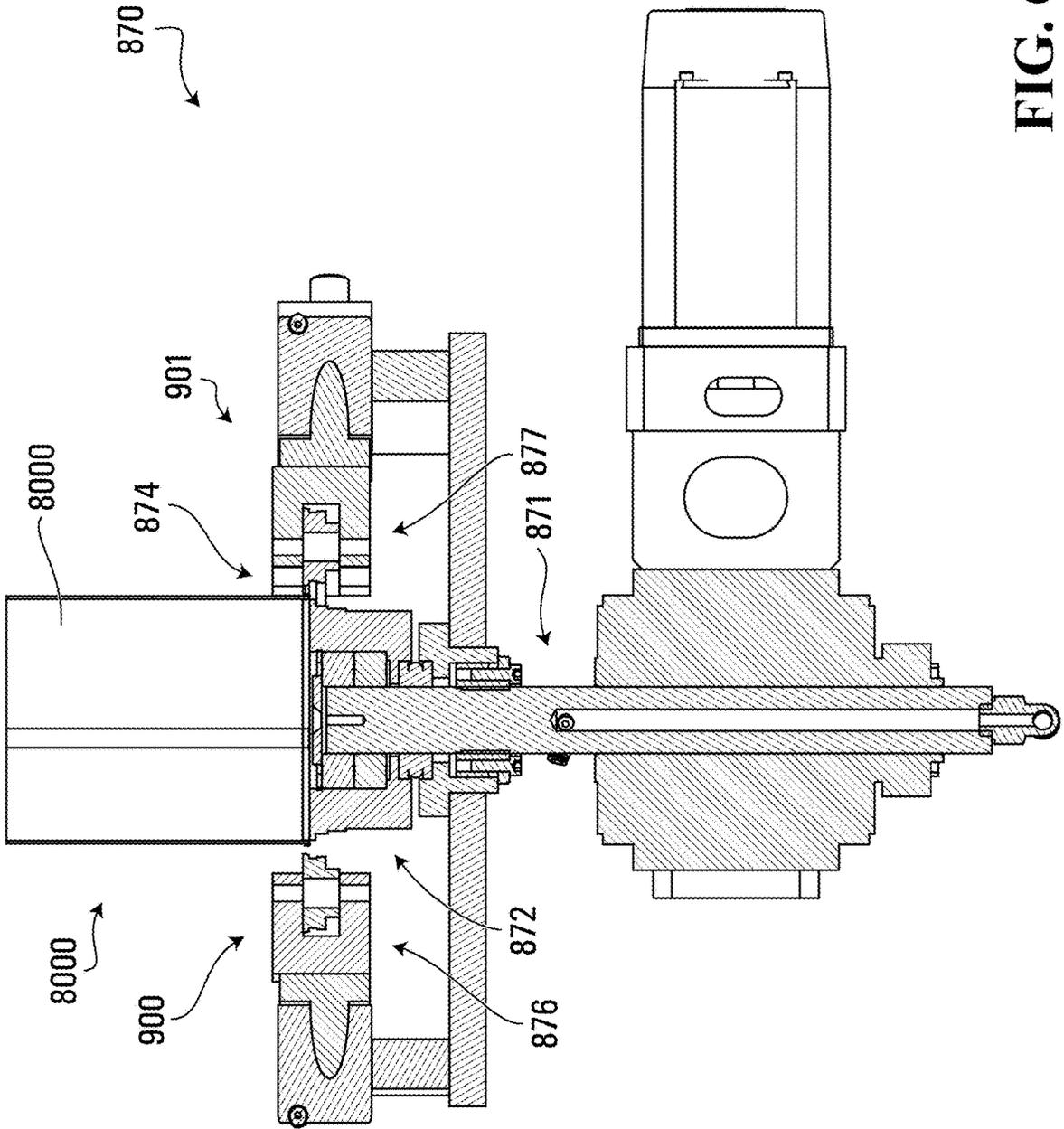


FIG. 68

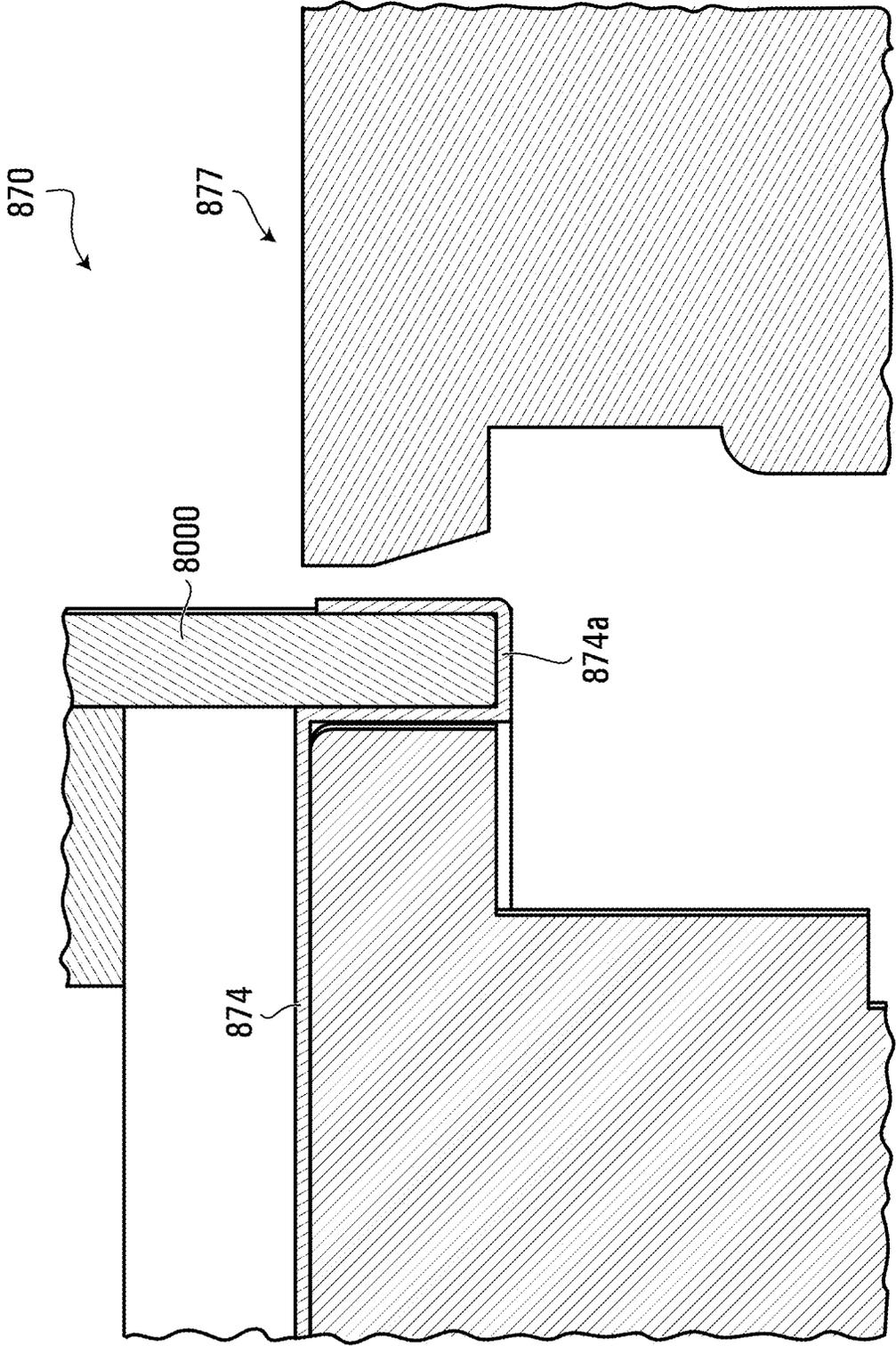


FIG. 69a

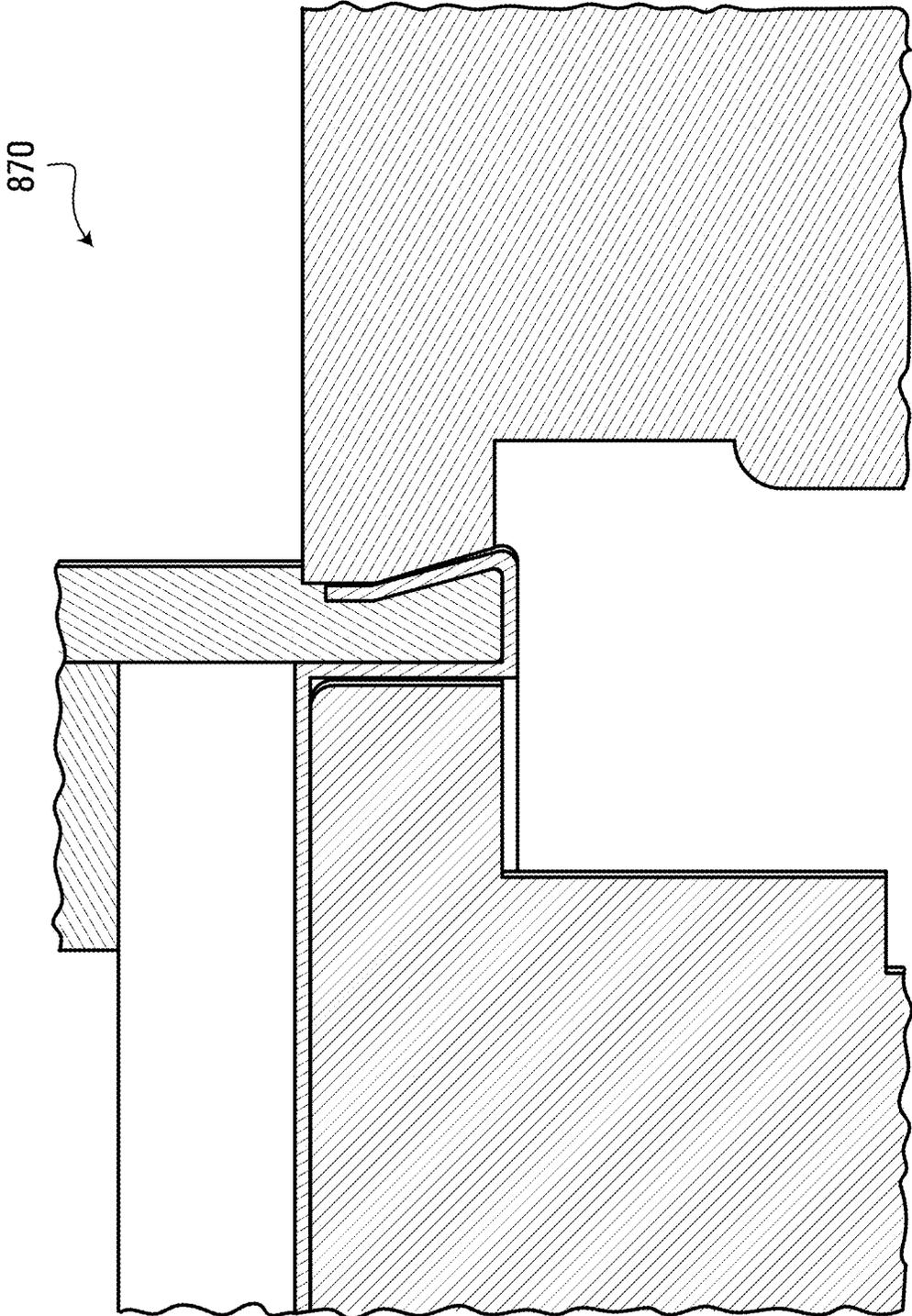
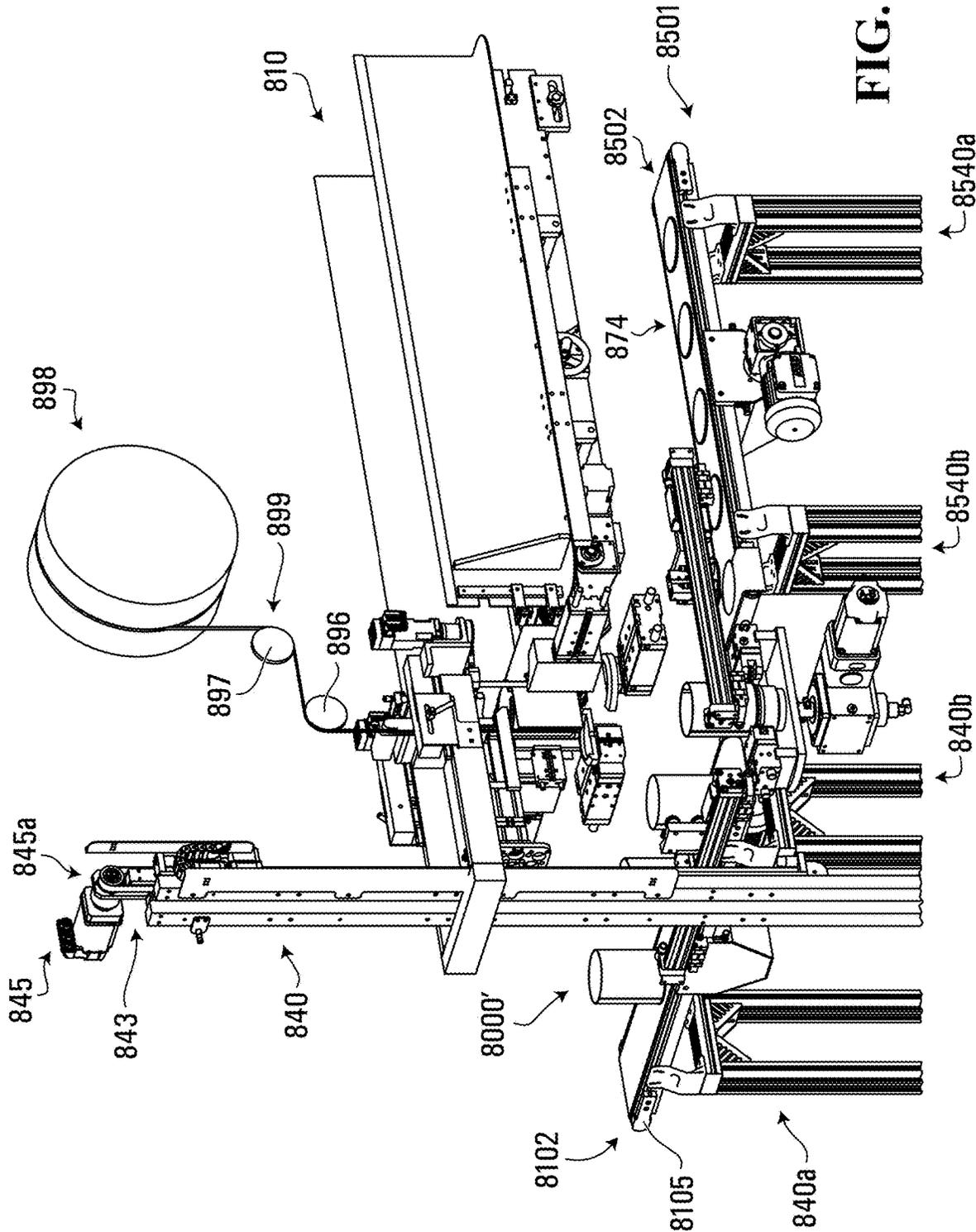


FIG. 69b



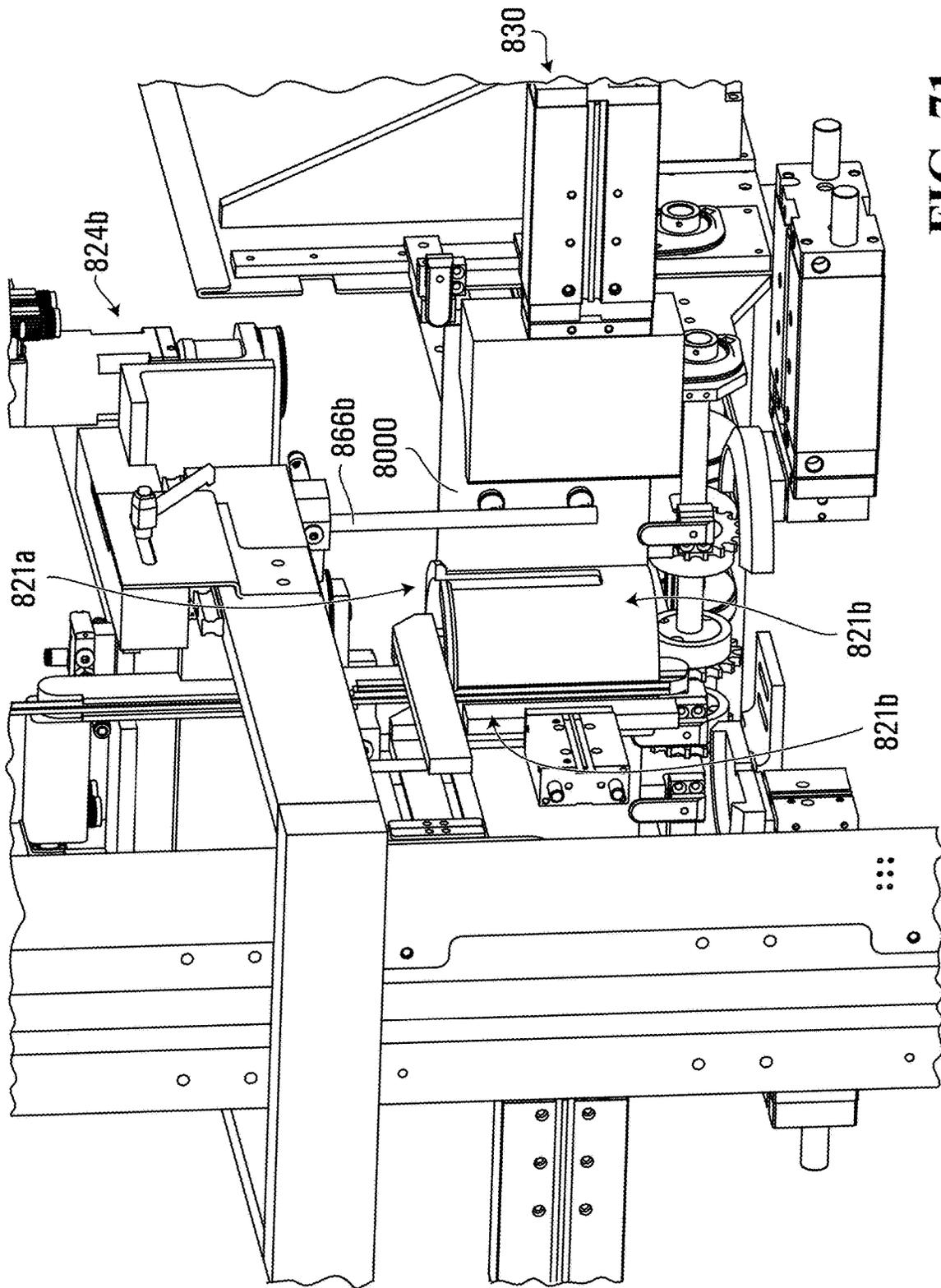


FIG. 71

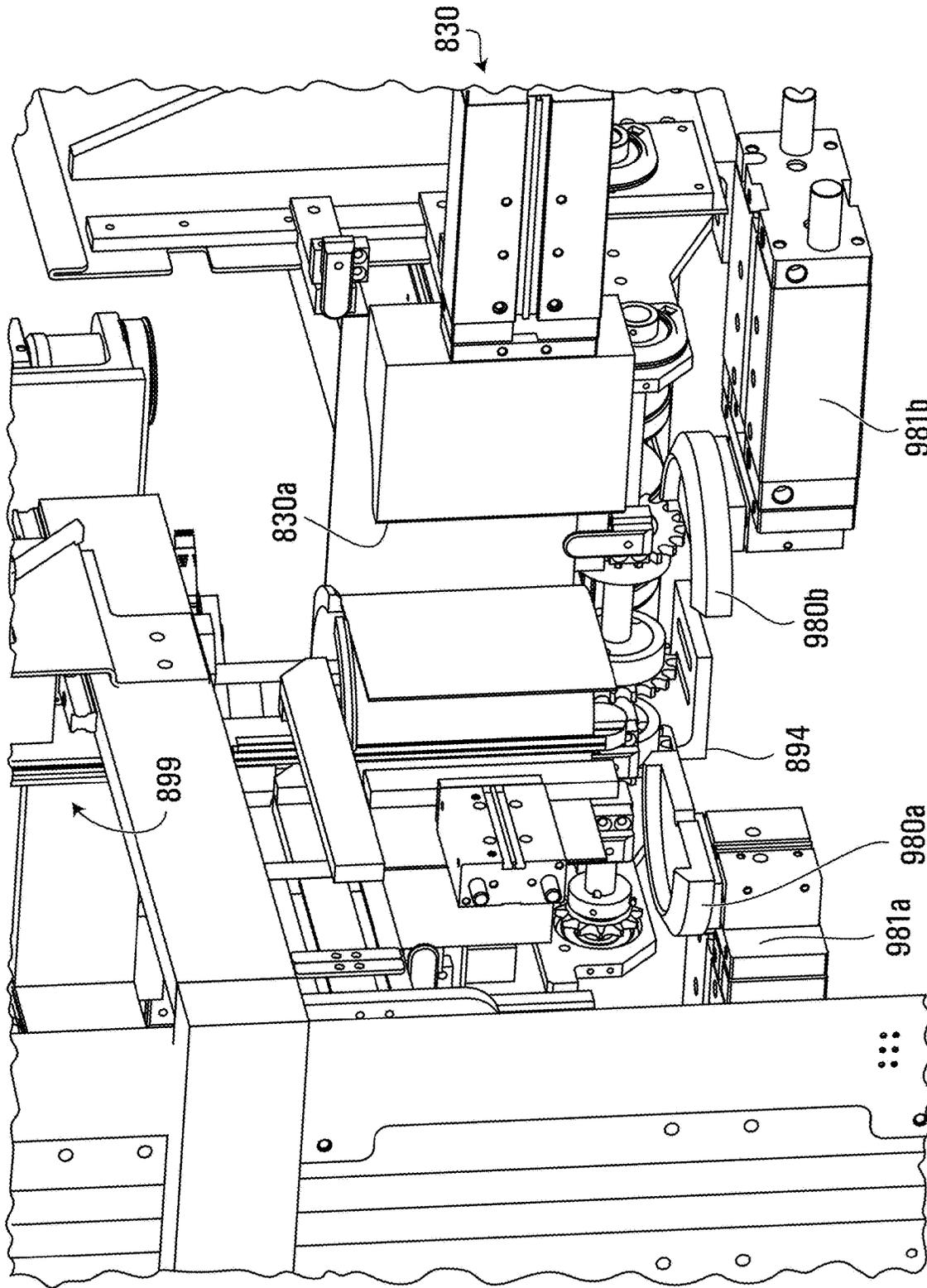


FIG. 72

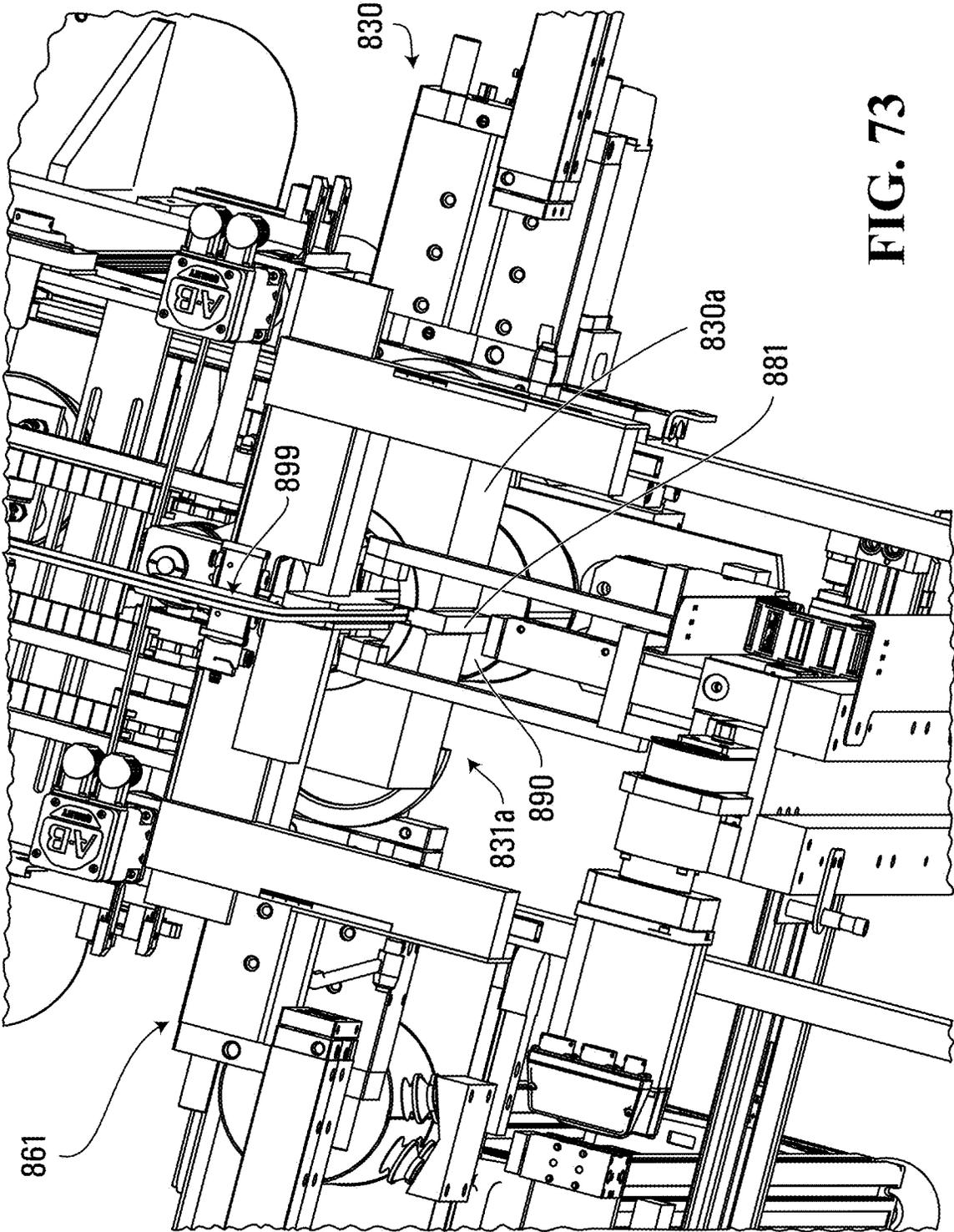


FIG. 73

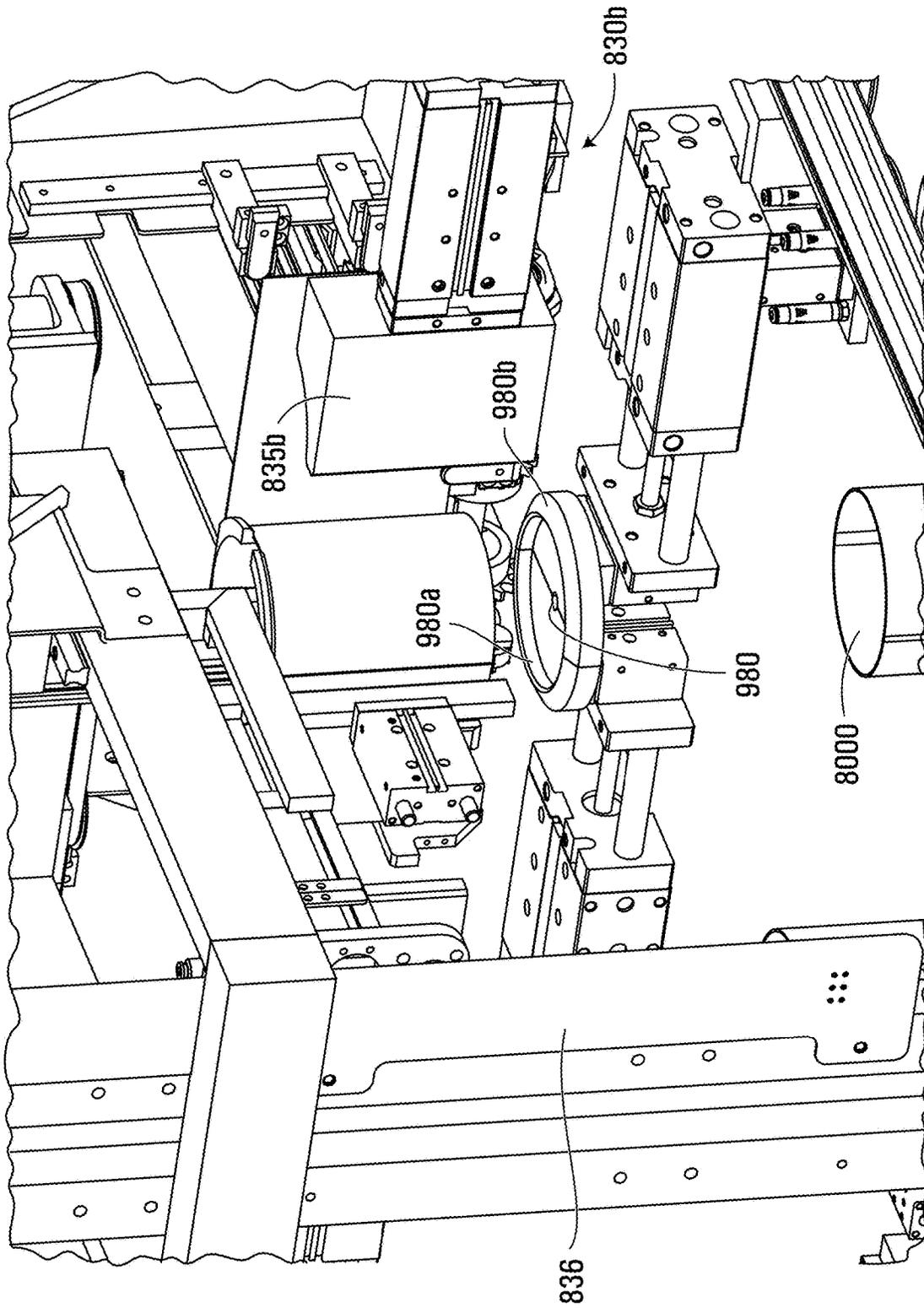


FIG. 74

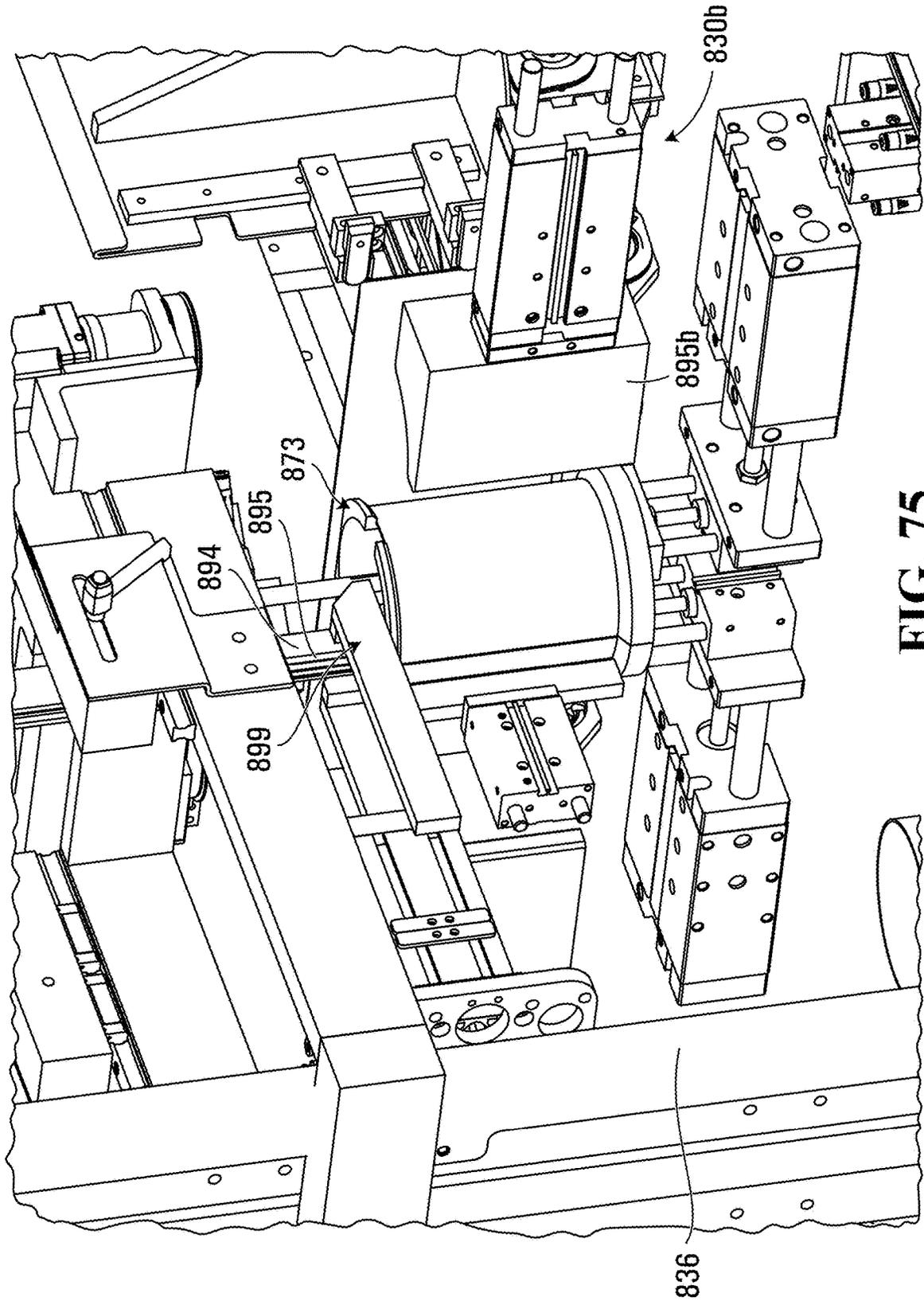


FIG. 75

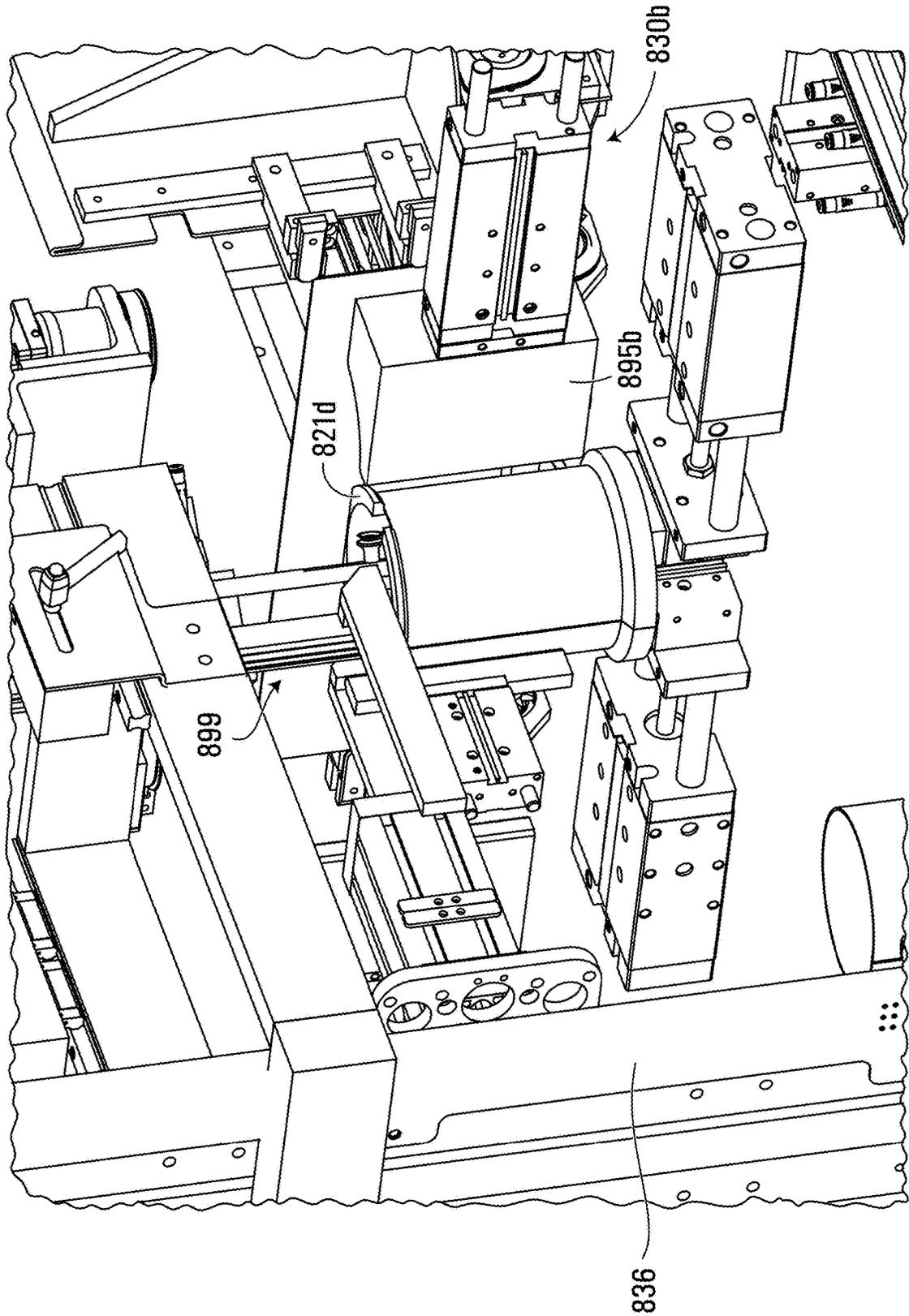


FIG. 76

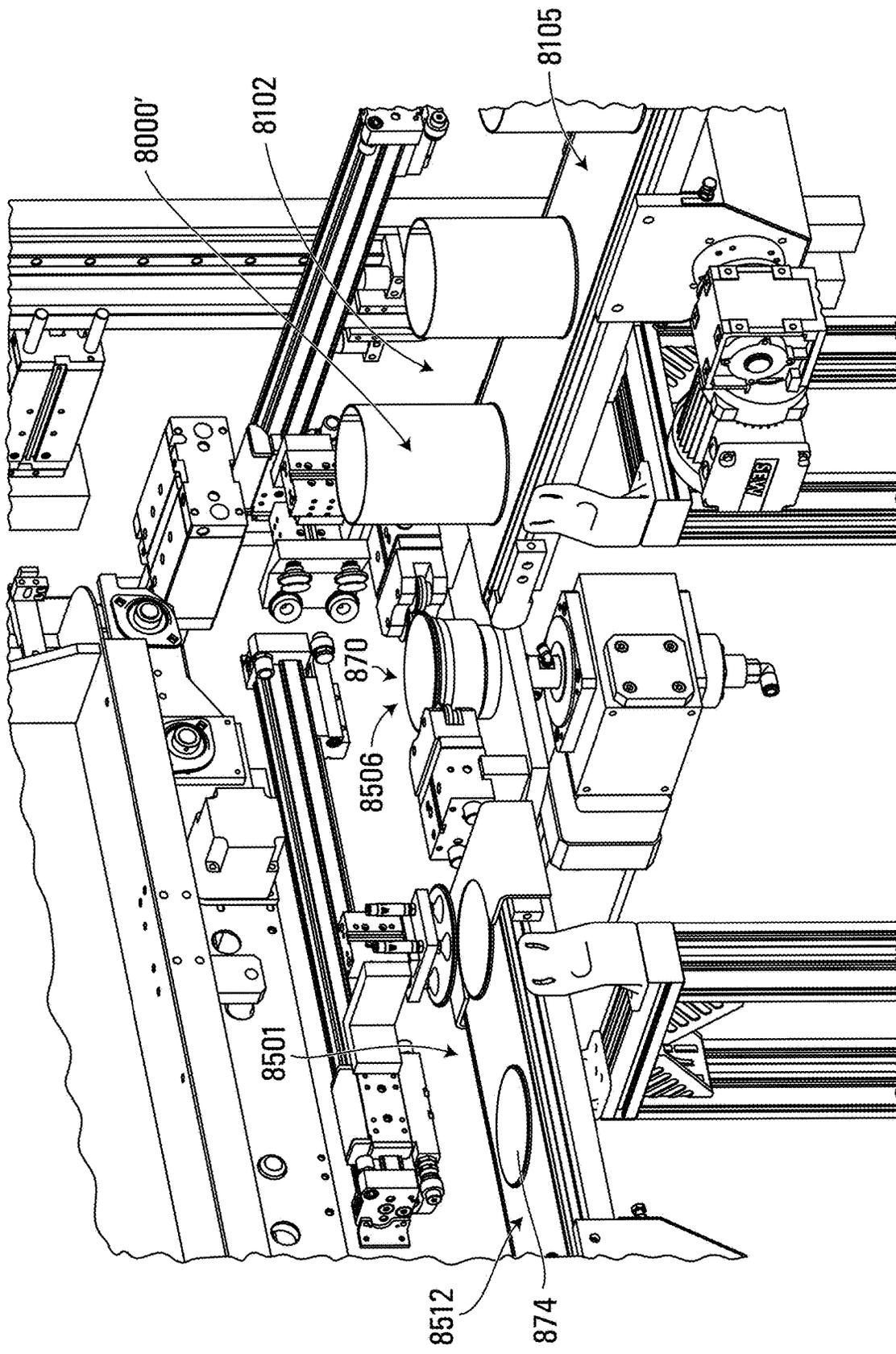


FIG. 77

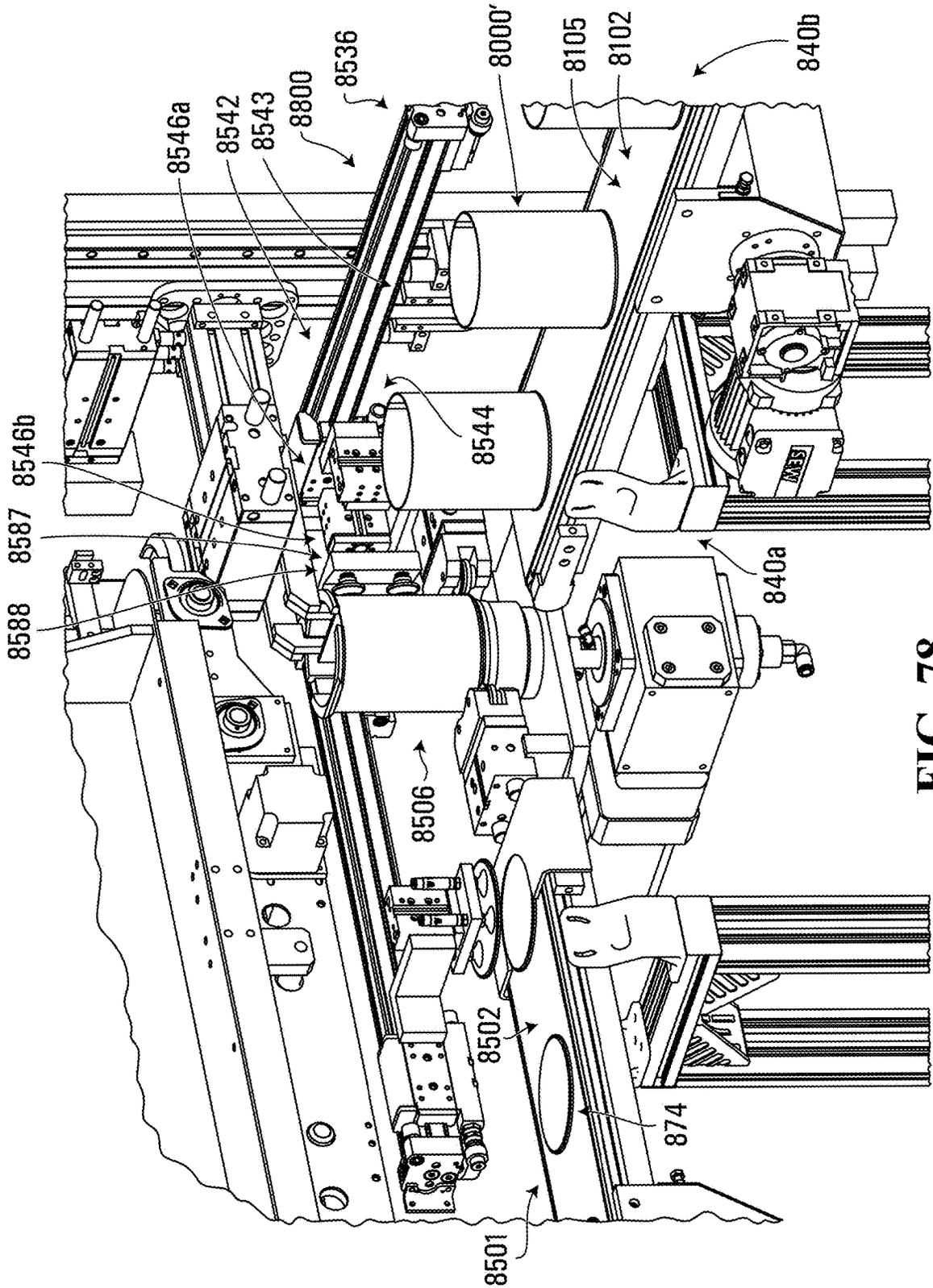


FIG. 78

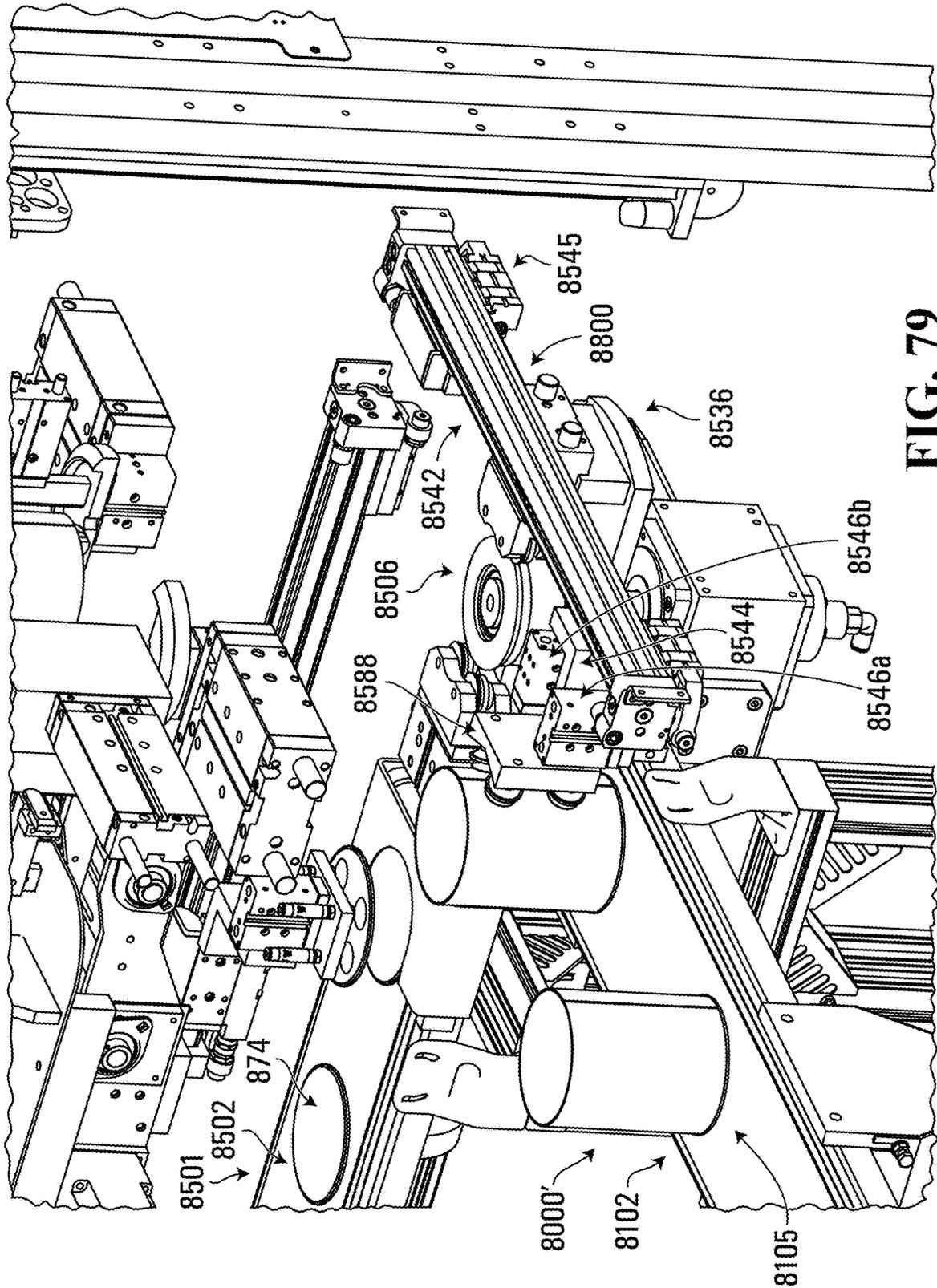


FIG. 79

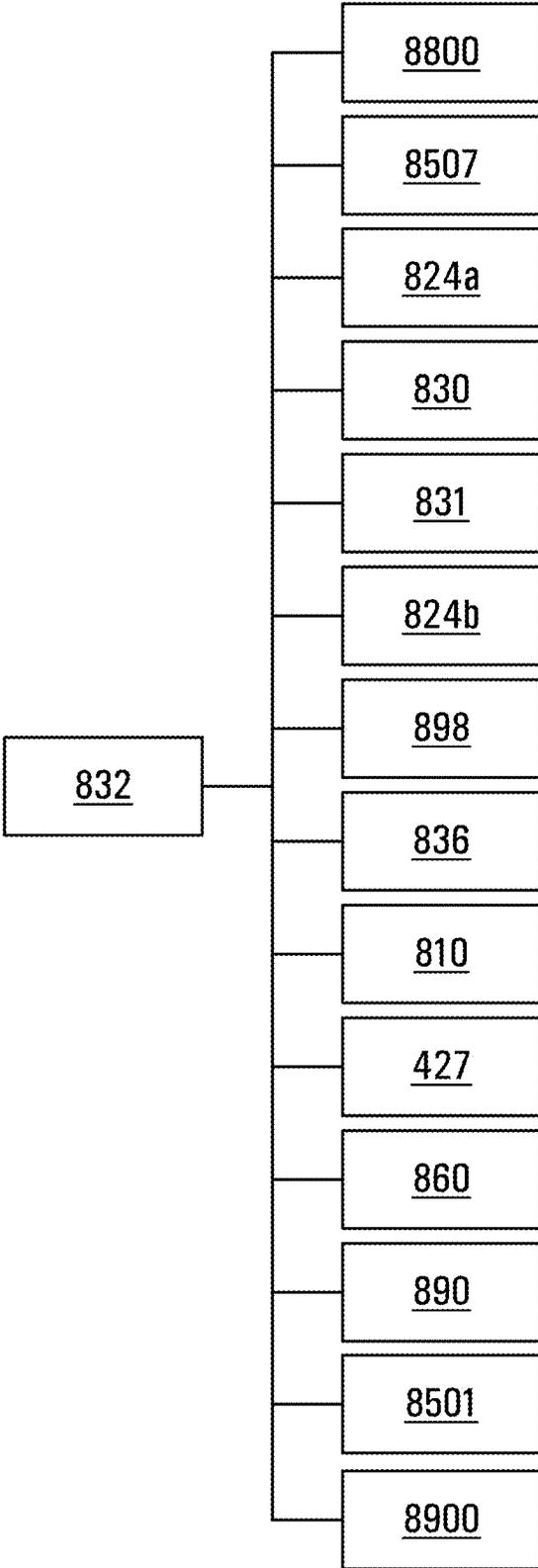


FIG. 80

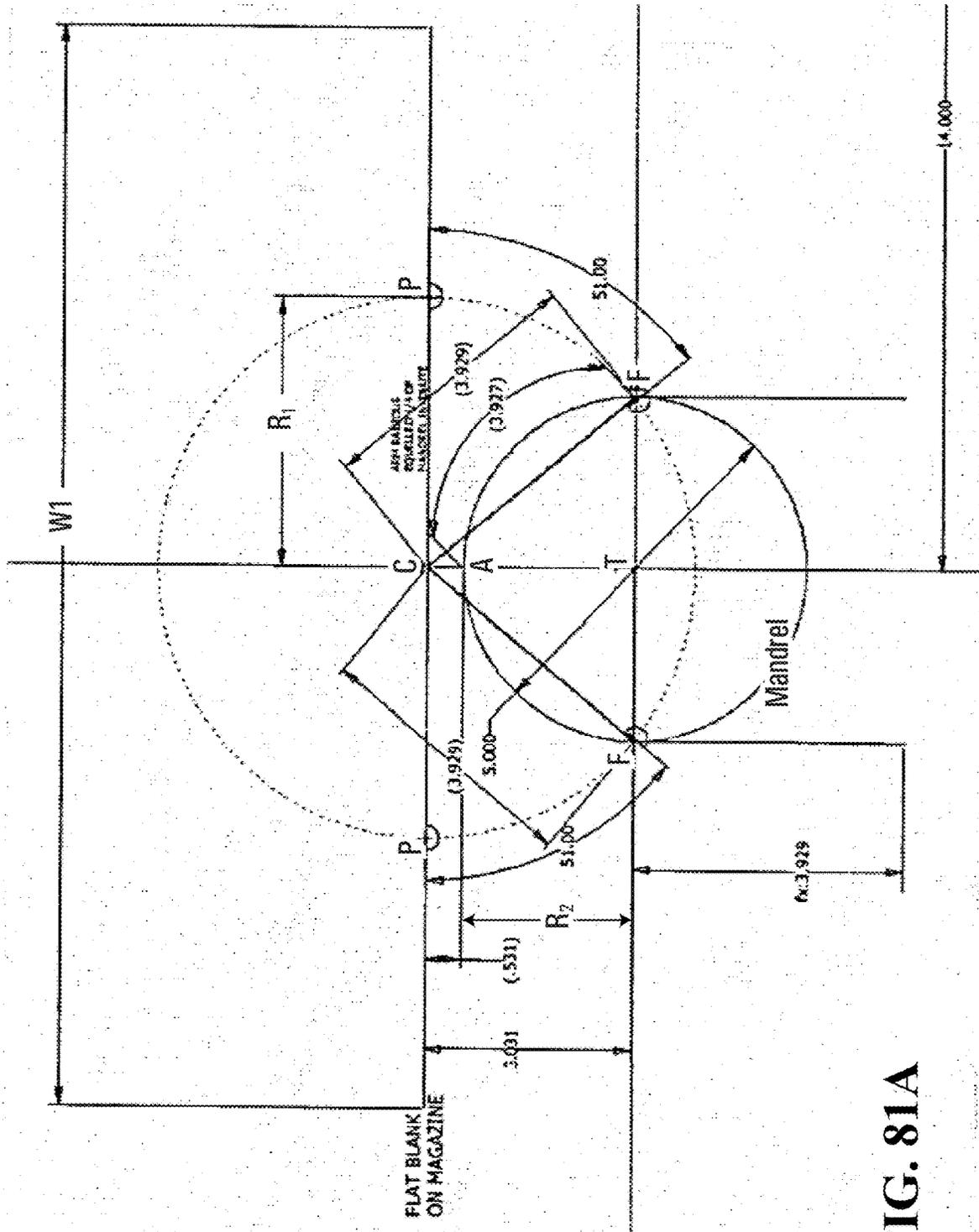


FIG. 81A

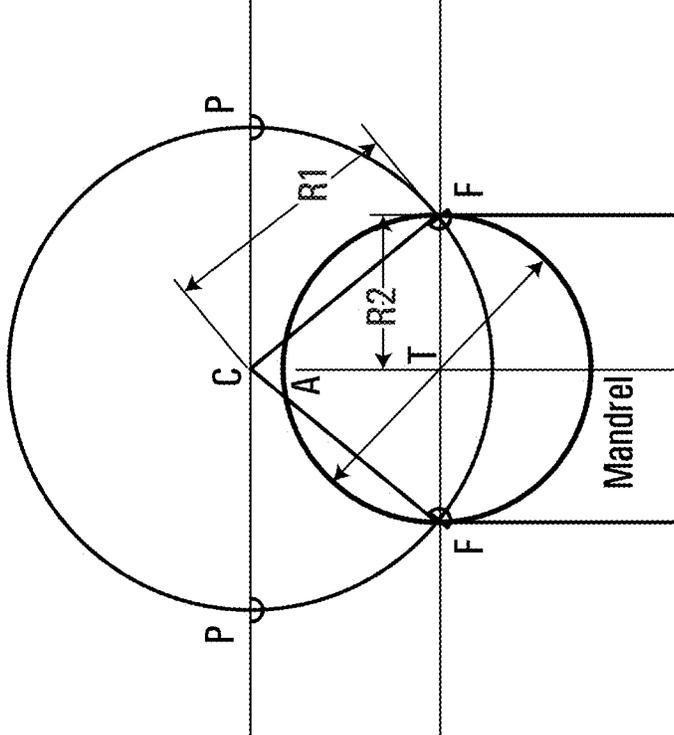


FIG. 81C

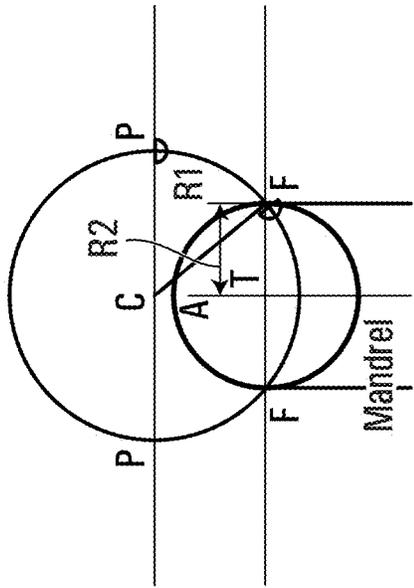


FIG. 81D

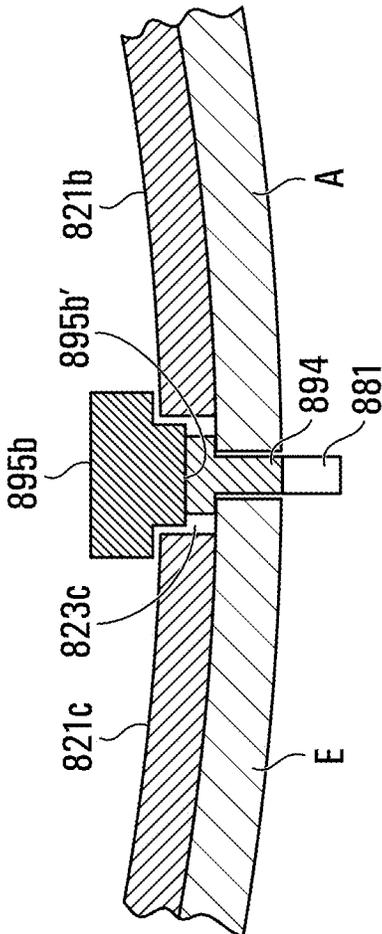


FIG. 82

METHOD AND APPARATUS FOR FORMING CONTAINERS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of U.S. patent application Ser. No. 16/853,471 filed on Apr. 20, 2020, (and published as US patent application publication no. US 2021/0323259 A1 on Oct. 21, 2021) the entire contents of which are hereby incorporated herein by reference.

FIELD

[0002] The present invention relates generally to methods and systems for forming containers, including cans, including composite cans.

BACKGROUND

[0003] Containers are used to package many different kinds of items. One form of container used in the packaging industry is a carton. Cartons come in many different configurations and are made from a wide variety of materials. A related type of container used in the packaging industry is referred to as a case and is typically used for shipping items/products or cartons containing items/products. In the present document, the term “case” is used to refer to cartons, boxes, cases and other similar types of containers.

[0004] Cases come in many different configurations and are made from a wide variety of materials. Many cases are foldable and are formed from a flattened piece of material of a specific configuration (commonly called a case blank). Cases may be made from an assortment of foldable materials, including cardboard, paperboard, plastic materials, composite materials, and the like and possibly even combinations thereof.

[0005] Other types of cases that may be employed to hold items are composite cans and paper material-based cans, such as cans formed from a single layer or multi-layer of cardboard/paperboard. Such cans may be used to hold food products or other sensitive products and may provide an inner holding cavity that is relatively impermeable to gases and/or liquids when being used to store such products.

[0006] Composite cans may be rigid or semi-rigid cans and may be formed using in a continuous form-and-seal type process combining multiple reels of materials which may be formed into a multi-layer composite web. The web of interconnected layers of materials may be shaped around a mandrel and the overlapping longitudinal edges sealed with an adhesive to form a tubular side wall. An insider liner material may be heat sealed at the inside of the side wall to provide a relatively high level moisture/liquid barrier. The inside liner materials may for example be made from an aluminium foil, a suitable plastic film, or both. The bottom component of a composite can may be made from a wide variety of materials such as a metal, a composite material or a suitable hard plastic material. A top lid may also be provided and may be made from a suitable material such as a strong injection molded plastic. Seals, such as heat seals, may be provided between the bottom and the side wall, and the top lid and the side wall.

[0007] Composite cans may be formed with sidewalls of a variety of materials and in a variety of shapes such as for example, generally round, square, rectangular or oval. It is known to form such sidewalls for composite cans by form-

and-seal processes that may utilize a plurality of reels of feed materials which are combined together. The bottom end of a composite can is generally formed of a metal material but could be another material or combination of materials, including the same materials from which the sidewall is formed. Known techniques can be used to seal such a bottom to the sidewall. The top may be another material such as a heavy injection-molded plastic that may be heat sealed to the upper edge of the sidewall.

[0008] Similarly, paper based cans, such as cardboard/paperboard cans, may also be used to hold items such as for example food and other sensitive items. Paper based cans may be rigid/semi-rigid containers that may also be formed from three separate parts/components. The first part may be a side wall that may be formed from a “flat blank”. The base substrate material for the side wall may be a suitably strong, paper based material such as paperboard/cardboard. A paperboard/cardboard substrate may have interconnected to it one or more additional layers of other materials.

[0009] An example of a paperboard can is the CEKACAN™ system which may provide an inner cavity with a relatively high level of impermeability to gases (eg. air) and liquids. In addition to a paperboard substrate, the CEKACAN system may use a polyolefin laminate inner layer (such as polyethylene), and an intermediate conducting metal layer (eg. an aluminium foil layer) interconnected to and positioned between the inner layer and the paperboard substrate. Methods of application of the polyolefin layer to the aluminium foil layer include: extrusion, co-extrusion, extrusion-lamination, or adhesion-lamination. In some embodiments the three separate layers may be laminated together.

[0010] Each multi-layer sidewall blank for a CEKACAN may be foldable and/or bendable from a flat configuration into a tubular side wall configuration that may be sealed at or proximate longitudinal edges. The portions of the polyolefin laminate inner layer at the longitudinal edges may be utilized to assist in creating the longitudinal seal.

[0011] To form a CEKACAN paperboard can, the blank may be wrapped around a mandrel and butt-sealed (i.e. not overlapped) through the application of a foil-laminated tape, which may be induction sealed to the two abutting longitudinal edges of the blank. Typically, high frequency electrical current can be induced within the a metal foil tape which then heats up and melts the polyolefin layer on the sidewall causing it to be able to bond to the aluminium foil tape and causes the polyolefin layer at the abutting edges melt to create a longitudinal seal. As such there are no discontinuous joints. However, there have been difficulties in effectively and efficiently forming the tubular shape of the side wall around a mandrel and in creating a suitable longitudinal seal on the side wall. Also the machinery used to form a CEKACAN is complex and expensive.

[0012] A paperboard may also include a separate base component and a separate lid/top component. The lid/top component may include more than one sub-components.

[0013] The material used for sealing the side wall to the base may also be used to seal the base component and top/lid component to the side wall. Similarly, high frequency electrical current can be induced to flow within the aluminium foil of the side wall which then heats up and melts the polyolefin inner layer causing it to be able to bond to another material or the same material. In this way, surface of the base and/or lid components which are brought into contact with

the inner polyolefin layer may become bonded to the base/lid component and provide a seal. However, there are challenges in efficiently and effectively forming gas and/or liquid seals between the inner side wall and the base and lid components.

[0014] It is therefore also desirable to provide improved composite and paperboard cans, and methods and apparatuses for forming the same.

SUMMARY

[0015] In accordance with one aspect of the present invention, there is provided a method for forming a cylindrical container from a re-configurable blank that is supported in a first generally flat configuration with a first wall surface and an opposite second wall surface; wherein said method comprises: positioning a blank support device proximate said first wall surface of said blank while said blank is in said first configuration, said blank support device having a generally cylindrical outward facing surface; engaging said first wall surface of said blank and rotating a first portion of said blank, around a first portion of the outward facing surface of said blank support device, such that said first portion of said blank wraps around a first quarter surface area of the generally cylindrical outward facing surface of the blank support device; engaging the first wall surface and rotating a second portion of said blank around a second portion of the outward facing surface of said blank support such that said section portion of said blank wraps around a second quarter surface area of the generally cylindrical outward facing surface of said blank support device, said first and second quarter surface areas of the generally cylindrical outward facing surface of said blank support device being adjacent to each other; rotating a part of said first portion of the blank around a third quarter surface area of the generally cylindrical outward facing surface of said blank support device, said second and third quarter surface areas of the generally cylindrical outward facing surface of said blank support device being adjacent to each other; rotating a part of said second portion of the blank around a fourth quarter surface area of the generally cylindrical outward facing surface of said blank support device, said third and fourth quarter surface areas of the generally cylindrical outward facing surface of said blank support device being adjacent to each other; to thereby form a blank that has a generally cylindrical tubular side wall configuration for said container around the generally cylindrical outward facing surface of said blank support device; wherein said first wall surface of said blank forms an inner surface of said blank when said blank is in said generally cylindrical tubular side wall configuration around said blank support device.

[0016] According to another aspect there is provided a method for forming a cylindrical container from a re-configurable blank comprising: forming a cylindrical tubular side wall around a mandrel with a single vertical sealed joint; installing a cup into an end opening of said cylindrical tubular side wall with a seaming apparatus to form a circumferential seamed sealed joint.

[0017] According to another aspect there is provided a method for forming a container from a re-configurable blank comprising: (a) forming a tubular side wall by wrapping first and second portions of a blank around a mandrel; (b) after (a), forming a vertical sealed joint between two free edges of said first and second portions of said blank by providing a sealing strip that is interconnected to both said first and

second portions; and wherein said sealing strip has a generally T-shape in cross section and comprises a first portion that bonds to inner surfaces of first and second portions of said blank and across a joint between the first and second portions of the blank, and said sealing strip comprises a base portion that is received between and bonds the opposing edge faces of said first and second portions of said blank.

[0018] According to another aspect there is provided a method for forming a container from a re-configurable blank comprising: (a) positioning part of an outward facing surface of a blank support device proximate a first surface of said blank while said blank is in a first orientation; (b) rotating a first portion of said blank with a rotating sub-system in a clockwise direction around a first semi-cylindrical portion of an outward facing surface of said blank support device; (c) rotating a second portion of said blank with said rotating sub-system in a counterclockwise direction around a second semi-cylindrical portion of said outward facing surface of said blank support device; wherein a generally cylindrical tubular side wall configuration is formed around said outward surface of said blank support device.

[0019] According to another aspect there is provided a system for forming a container from a re-configurable blank, said system comprising: a blank support device having a generally cylindrical outward facing surface, said blank support device being positioned such that in operation said blank support device is located proximate said blank while said blank is in a first generally flat configuration; a rotating sub-system operable to: engage a first wall surface of said blank and rotate a first portion of said blank around a first portion of a first facing surface of said blank support device, such that said first portion of said blank wraps around a first quarter surface area of the generally cylindrical outward facing surface of the blank support device; engage the first wall surface and rotate a second portion of said blank around a second portion of the first outward facing surface of said blank support such that said section portion of said blank wraps around a second quarter surface area of the generally cylindrical outward facing surface of said blank support device, said first and second quarter surface areas of the generally cylindrical outward facing surface of said blank support device being adjacent to each other; rotate a part of said first portion of the blank around a third quarter surface area of the generally cylindrical outward facing surface of said blank support device, said second and third quarter surface areas of the generally cylindrical outward facing surface of said blank support device being adjacent to each other; rotate a part of said second portion of the blank around a fourth quarter surface area of the generally cylindrical outward facing surface of said blank support device, said third and fourth quarter surface areas of the generally cylindrical outward facing surface of said blank support device being adjacent to each other; to thereby form a blank that has a generally cylindrical tubular side wall configuration around the generally cylindrical outward facing surface of said blank support device; wherein said first wall surface of said blank forms an inner surface of said blank when said blank is in said generally cylindrical tubular side wall configuration around said blank support device.

[0020] According to other aspects, there is provided a system for forming a container from a re-configurable blank, said system comprising: (a) a blank support device having a generally cylindrical outward facing surface, said blank

support device being positioned such that during operation, said outward facing surface of said blank support device is located proximate said blank while said blank is in a first configuration; (b) a rotating sub-system operable to rotate said blank around the outward facing surface of said blank support device to form a generally cylindrical tubular side wall configuration around said outward surface of said blank support device; (c) a bottom forming subsystem and a blank support movement subsystem; wherein in operation, after said blank is formed into said generally cylindrical tubular side wall configuration by said rotating sub-system, said blank support movement subsystem is operable to move said blank on said case blank support device to a bottom forming station, where said bottom forming subsystem is located, and said bottom forming sub-system is operable for forming a bottom portion of said container by installing a circular bottom cup in a circular bottom opening of said tubular side wall configuration of said blank.

[0021] According to other aspects, there is provided a system for forming a cylindrical container from a re-configurable blank comprising: An apparatus operable for forming a cylindrical tubular side wall around a mandrel with a single vertical sealed joint; An apparatus operable for locating a bottom cup into a bottom opening of said cylindrical tubular side wall; and a seaming apparatus operable to form a circumferential seamed sealed joint between a circumferential edge region of said bottom cup and a circumferential lower edge region of said cylindrical tubular side wall.

[0022] According to other aspects, there is provided a system for forming a container from a re-configurable blank comprising: an apparatus operable for forming a tubular side wall around a mandrel with a single vertical sealed joint at opposed vertical free edges of said blank; an apparatus operable to place a vertically extending sealing strip that extends across and between said joint to form a seal, wherein said sealing strip has a generally T-shape in cross section and comprises a first top portion that bonds to inner surfaces of the opposed free edges of said blank and across said joint and said sealing strip comprises a base portion that is received between and bonds opposing edge faces of said free edges of said blank.

[0023] According to other aspects, there is provided a blank for a can comprising a generally cylindrical tubular side wall having a single vertical joint at opposed vertical free edges of said blank; wherein said opposed vertical free edges of said blank are interconnected by a vertically extending sealing strip that extends across said joint; and wherein said sealing strip has a generally T-shape in cross section and comprises a first top portion that bonds to inner surfaces of the opposed free edges of said blank and across said joint and said sealing strip comprises a base portion that is received between and bonds opposing edge faces of said free edges of said blank.

[0024] Other aspects and features of the present invention 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

[0025] In the figures which illustrate by way of example only, embodiments of the present invention,

[0026] FIG. 1 is a top plan view of an example RSC blank;

[0027] FIG. 2A is schematic view of an example method of forming a case from a case blank, such as the blank of FIG. 1;

[0028] FIG. 2B is another schematic view of the method of FIG. 2A;

[0029] FIG. 3 is a top, left front perspective view of a case forming system in a first operational position;

[0030] FIG. 4 is a lower, left front perspective view of the case forming system of FIG. 2, in a second operational position;

[0031] FIG. 5 is an upper, right front perspective view of the system of FIG. 2 in the second operational position of FIG. 4, but with some components omitted for simplicity;

[0032] FIG. 5A is a schematic diagram of a control system for the system of FIG. 4;

[0033] FIG. 6 is a view of the system of FIG. 4 similar to FIG. 5;

[0034] FIG. 7 is an upper, right front perspective view of the system of FIG. 2 in a third operational position, but also with some components omitted for simplicity;

[0035] FIG. 8 is an upper, right rear perspective view of the system of FIG. 2 in the third operational position;

[0036] FIG. 9 is an upper, right front perspective view of the system of FIG. 2 in a fourth operational position;

[0037] FIG. 10 is an upper, left front perspective view of the system of FIG. 2 in the fourth operational position;

[0038] FIG. 11 is an upper, right front perspective view of the system of FIG. 2 in a fifth operational position;

[0039] FIG. 12 is an upper, left front perspective view of the system of FIG. 2 in the fifth operational position;

[0040] FIG. 13 is a lower, left front perspective view of the system of FIG. 2 in a sixth operational position;

[0041] FIG. 14 is a lower, right front perspective view of the system of FIG. 2 in the sixth operational position;

[0042] FIG. 15 is an upper, right front perspective view of an upper portion of the system of FIG. 2 in the sixth operational position;

[0043] FIG. 16 is a lower, left front perspective view of the system of FIG. 2 in a seventh operational position;

[0044] FIG. 17 is a lower, left side perspective view of the system of FIG. 2 in the seventh operational position;

[0045] FIG. 18 is a lower, left front perspective view of the system of FIG. 2 in an eighth operational position;

[0046] FIG. 19 is an enlarged view of portion of the system as shown in FIG. 18, in the eighth operational position;

[0047] FIG. 20 is a lower, left rear perspective view of the system of FIG. 2 in the eighth operational position;

[0048] FIG. 21 is an upper, left side perspective view of the system of FIG. 2 in a ninth operational position;

[0049] FIG. 22 is an upper, left front perspective view of the system of FIG. 2 in a ninth operational position;

[0050] FIG. 23 is a perspective view of some components of the system of FIG. 2 shown in isolation;

[0051] FIG. 24 is a perspective view of some other combination of components of the system of FIG. 2 shown in isolation;

[0052] FIG. 25 is another perspective view of some combination of components of the system of FIG. 2 shown in isolation;

[0053] FIG. 26 is a top plan view of an alternate blank;

[0054] FIG. 27 is schematic view of an alternate example method of forming a case from a case blank;

[0055] FIG. 28 is an upper, left front perspective schematic view of an alternate case forming system in a first operational position;

[0056] FIG. 29 is an upper, right front perspective view of the case forming system of FIG. 28, in a second operational position;

[0057] FIG. 30 is an upper, right front perspective view of the case forming system of FIG. 28, in a third operational position;

[0058] FIG. 31 is an upper, right front perspective view of the case forming system of FIG. 28, in a fourth operational position;

[0059] FIG. 32 is an upper, perspective view of some components of the case forming system of FIG. 28 shown in isolation;

[0060] FIG. 33 is a top plan view of an example blank for a can;

[0061] FIG. 33A is a top plan view of an alternate blank for a can;

[0062] FIG. 33B is a top plan view of another alternate blank for a can;

[0063] FIG. 33C is a top plan view of another alternate blank for a can;

[0064] FIG. 33D is a top plan view of another alternate blank for a can;

[0065] FIG. 34 is schematic view of an example method of forming a can from a can blank, such as the blank of FIG. 33;

[0066] FIG. 35 is schematic view of an example method of forming a can from a can blank, such as the blank of FIG. 33A;

[0067] FIG. 36 is an upper, left front side perspective view of part of a can forming system in an operational position;

[0068] FIG. 36A is an upper, right rear perspective view of the can forming system of FIG. 36 in an operational position;

[0069] FIG. 36B is an upper, right side perspective view of the can forming system of FIG. 36 in an operational position;

[0070] FIG. 36C is an upper, right side perspective view of part of the can forming system of FIG. 36 in another operational position;

[0071] FIG. 37 is an upper, rear perspective view of the can forming system of FIG. 36 in an operational position;

[0072] FIG. 38 is an upper left front side perspective view of part of the can forming system of FIG. 36 in another operational position;

[0073] FIG. 39 is an upper left rear perspective view of part of the can forming system of FIG. 36 in the same operational position as FIG. 38;

[0074] FIG. 40 is an upper left front perspective view of part of the can forming system of FIG. 36 in another operational position;

[0075] FIG. 41 is an upper left front perspective view of part of the can forming system of FIG. 36 in the same operational position as FIG. 40;

[0076] FIG. 42 is an upper, left front side perspective view of part of the can forming system of FIG. 36 in an operational position;

[0077] FIG. 43 is a left front side perspective view of part of the can forming system of FIG. 36 in an operational position;

[0078] FIG. 44 is a right rear side perspective view of a lower part of the can forming system of FIG. 36 in an operational position;

[0079] FIG. 45 is a lower right rear side perspective view of the lower part of the can forming system shown in FIG. 44 in an operational position;

[0080] FIG. 46 is a lower right rear perspective view of the lower part of the can forming system shown in FIG. 45 in an operational position;

[0081] FIG. 47 is an upper right front perspective view of the lower part of the can forming system shown in FIG. 46 in an operational position;

[0082] FIG. 48 is an upper left perspective view of the lower part of the can forming system shown in FIG. 47 in an operational position;

[0083] FIG. 49 is an upper right front perspective view of the lower part of the can forming system shown in FIG. 47 in another operational position;

[0084] FIG. 50 is an upper left front perspective view of the part of the can forming system of FIG. 36 in an operational position; and

[0085] FIG. 51 is a schematic diagram of a control system for the can forming system of FIGS. 36-50.

[0086] FIG. 52 is a top plan view of an example blank for a can, according to another embodiment;

[0087] FIG. 53 is schematic view of an example method of forming a can from a can blank, such as the blank of FIG. 52;

[0088] FIG. 54 is an upper, left front side perspective view of part of a can forming system;

[0089] FIG. 55 is a lower, right rear side perspective view of part of a can forming system in an operational position;

[0090] FIG. 56 is an upper, face front side perspective view of part of a can forming system in an operational position;

[0091] FIG. 57 is a side view of part of a can forming system in an operational position;

[0092] FIGS. 58a, 58b, and 58c are top, front, and rear views of a rotating subsystem used in part of a can forming system;

[0093] FIG. 59 is a mandrel and forming apparatus used in part of a can forming system in a second operational position;

[0094] FIG. 60 is a top view of the mandrel and forming apparatus as shown in FIG. 59;

[0095] FIG. 61 is a top view of the mandrel and forming apparatus as shown in FIG. 59 in the second operational position;

[0096] FIG. 62 is a top view of the mandrel and forming apparatus as shown in FIG. 59 in a third operational position;

[0097] FIG. 63 is a top view of the mandrel and forming apparatus as shown in FIG. 59 in a third operational position;

[0098] FIG. 64 is a top view of the mandrel and forming apparatus as shown in FIG. 59 in a fourth operational position;

[0099] FIG. 65 is a top left view of the mandrel and forming apparatus as shown in FIG. 59 in a fifth operational position;

[0100] FIG. 66a is a top left view of the flaring apparatus;

[0101] FIGS. 66b and 66c are top and side views of the flaring apparatus in a sixth operational position;

[0102] FIG. 67 is a top view of a seaming mandrel;

[0103] FIG. 68 is a sectional view of a seaming assembly mandrel in an operational position;

[0104] FIG. 69a is an enlarged cross-sectional view of part of the seaming assembly of FIGS. 67 and 68 in a first operational position;

[0105] FIG. 69b is an enlarged cross-sectional view of part of the seaming assembly of FIG. 69a in a second operational position;

[0106] FIG. 70 is a blank retention and delivery apparatus;

[0107] FIG. 71 is a rear view of the mandrel and forming apparatus as shown in FIG. 59 in the first operational position;

[0108] FIG. 72 is a rear view of the mandrel and forming apparatus as shown in FIG. 59 in the second operational position;

[0109] FIG. 73 is a top rear view of the mandrel and forming apparatus as shown in FIG. 59 in the third operational position;

[0110] FIG. 74 is a rear view of the mandrel and forming apparatus as shown in FIG. 59 in the fourth operational position;

[0111] FIG. 75 is a rear view of the mandrel and forming apparatus as shown in FIG. 59 in the fifth operational position;

[0112] FIG. 76 is a rear view of the mandrel and forming apparatus as shown in FIG. 59 in the sixth operational position;

[0113] FIG. 77 is a front view of blank retention and delivery apparatus in a first operational position;

[0114] FIG. 78 is a front view of blank retention and delivery apparatus in a second operational position;

[0115] FIG. 79 is a rear view of blank retention and delivery apparatus in the first operational position;

[0116] FIG. 80 is a schematic diagram of a control system for the can forming system of FIGS. 52-79;

[0117] FIG. 81a, 81b, 81c, and 81d are illustrated representations of relationships between the position of some components of the can forming system of FIGS. 52-79; and

[0118] FIG. 82 is a cross-sectional view of a blank on the mandrel and forming apparatus in the fifth operational position.

DETAILED DESCRIPTION

[0119] With reference to FIG. 1, a flat case blank 1000, such as a case blank that is suitable to form an RSC case is shown. A case blank as contemplated herein may be made from a material and/or be formed in a way that is flexible so that it may be oriented and configured from a generally flat shape to a generally tubular shape positioned around the outer surface of a blank support device referred to herein as a blank support device, as will be described hereinafter. The case blank may thereafter be reconfigured to form a case with an opening to receive one or more items. For example, a case blank 1000 may have minor side wall panels A and C and major side wall panels B and D. Minor side wall panel A may be located adjacent to and joined at a vertical side edge along a fold line (all fold lines shown in broken lines in FIG. 1) to a vertical side edge of major side wall panel B. Major side wall panel B may be located adjacent to and joined at an opposite vertical side edge along a fold line to a vertical side edge of minor side wall panel C. Minor side wall panel C may be located adjacent to and joined at an opposite vertical side edge along a fold line to a side edge of major side wall panel D. A side sealing panel E may also

be provided adjacent and joined along a fold line to an opposite vertical side edge to major side wall panel D.

[0120] Case blank 1000 may also have lower minor panels J and G and lower major panels H and F, joined at transverse side edges along fold lines, to respective minor side wall panels A and C and major side wall panels B and D. Case blank 1000 may also have upper minor panels K and M and upper major panels L and N, joined at opposite transverse side edges along fold lines, to respective minor side wall panels A and C and major side wall panels B and D. However, in other embodiments, case blanks having other panel configurations can be formed into cases ready to be loaded using the methods and apparatuses disclosed hereinafter.

[0121] As indicated, the panels may be fixedly connected to and/or integrally formed with, adjacent panels by/along predetermined fold lines. These fold lines may 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 line is such that when one panel such as for example panel C is bent relative to an adjacent panel D, the panels C and D will tend to be pivoted relative to each other along the common fold line.

[0122] As will be described hereinafter, the major and minor side wall panels A, B, C and D, and the lower major and minor panels F, G, H and J, may be folded and sealed to form a desired open top case configuration that can be delivered to a case discharge conveyor. The sealing of specific panels together can in various embodiments be made with any suitable connection mechanism (such as for example with application of an adhesive or in some alternate embodiments, a mechanical connection such as for example is provided in so-called "click-lock" case blanks) so as to interconnect panel surfaces, to join or otherwise interconnect, panels to adjacent panels, to hold the case in its desired configuration.

[0123] Case blanks 1000 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 yet also meet the particular structural requirements for holding one or more items. Examples of suitable materials are 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 per se easily foldable but which is divided into separate panels separated by creases or hinge type mechanisms so that the carton can be formed.

[0124] With reference now to FIGS. 2A and 2B, an example sequence of steps 1000(1) to 1000(10) are shown of folding and sealing a flat RSC blank 1000 to form an open top RSC case that is suitable for top loading of items/other cases.

[0125] A plurality of case blanks may be presented 1000 (1) in a stacked arrangement with the blanks each configured in a generally flat and planar configuration. A particular individual case blank 1000 may be identified at/selected from the front of the stack of blanks for processing 1000(2). In a first folding step 1000(3) side wall panel C along with its respective adjacent upper and lower minor panels M and G along with major side wall panel D and its respective adjacent upper and lower major panels N and F, along with sealing panel E, can all be rotated together from the orientation shown at 1000(2), 90 degrees in a counter clockwise direction about the vertically oriented fold line between side

wall panels B and C, to the configuration as shown at **1000(3)**. In the next folding step **1000(4)**, side wall panel D and its respective adjacent upper and lower major panels N and F, and sealing panel E, are all rotated together counter clockwise 90 degrees about the vertically oriented fold line between side wall panels D and C, to the configuration shown in FIGS. 2A and 2B at **1000(4)**.

[0126] In the next folding step **1000(5)**, sealing panel E is rotated counter clockwise 90 degrees about the vertically oriented fold line between sealing panel E and side wall panel D to the configuration shown at **1000(5)**. In the next folding step, minor side wall panel A and its respective adjacent upper and lower minor panels K and J, are all rotated together clockwise 90 degrees about the vertically oriented fold line between side wall panels A and B, to the configuration shown in FIGS. 2A and 2B at **1000(6)**, and wherein an upper surface of sealing panel E engages with part of the lower surface of side wall panel A. Adhesive or other connection mechanism may be provided, such as adhesive line **1005** (see FIG. 1), for example between opposing surfaces of sealing panel E and side wall panel A, such that sealing panel E may engage and become permanently connected to minor side wall panel A. The result at the end of this step, as depicted at **1000(6)**, case blank **1000** is formed into a generally rectangular shaped tube. While not shown in FIGS. 2A and 2B, folding steps from case blank orientations depicted at **1000(3)** to **1000(6)** may be carried out in such manner the panels are wrapped about a centrally positioned blank support device, as is described hereinafter.

[0127] The remaining steps to configurations shown from **1000(7)** to **1000(10)** as illustrated in FIGS. 2A and 2B represent a sequence of steps that may be utilized to close and seal the lower major and minor panels, F, H and G, J respectively to close and seal the bottom of the case blank **1000** to form an RSC case with an open top.

[0128] In the next step, as depicted at **1000(7)**, the tubular shaped case blank **1000** may be moved vertically downwards to a second vertical location, at which the lower major panels F and H may be rotated outwards, about their respective horizontally oriented fold lines with respective major side panels D and B. The amount of rotation is sufficient to ensure that there will be no interference with the subsequent inward rotation of lower minor panels G and J and no contact is made with adhesive that may be on an inward surfaces of lower major panels F and H, such as respective adhesive lines **1001**, **1002** and **1003**, **1004** (FIG. 1). By way of example only, the amount of outward rotation of lower minor panels G and J from vertical planar alignment with their respective adjacent lower major side wall panels D and B may be about 45 degrees.

[0129] In the next step, as depicted at **1000(8)**, lower minor panels G and J are rotated inwardly, preferably about 90 degrees, about their respective horizontally oriented fold lines with respective major side wall panels C and A.

[0130] In the next step, as depicted at **1000(9)**, lower major panels F and H may be rotated inwards, about their respective horizontally oriented fold lines with respective major side panels D and B. The amount of rotation is sufficient to ensure that there will be contact between inner surfaces of lower major panels of lower major panels F and H and the outer surfaces of lower minor panels G and J.

[0131] Adhesive or other connection mechanism may be provided on the inner surfaces of lower major panels F and

H so that these panels engage with, and become fixedly connected to the outward adjacent surfaces of lower minor panels G and J. For example, adhesive lines **1001**, **1002**, and **1003**, **1004** (FIG. 1) may be on the inward surfaces of lower major panels F and H and may make contact with the outward surfaces of lower minor panels G and J and provide for a fixed connection.

[0132] The result at the end of step, as depicted at **1000(9)**, case blank **1000** is formed into a generally cuboid shaped, open top case.

[0133] In the final step, as depicted at **1000(10)**, case blank **1000** may be moved away to another location, and may be subsequently filled with one or more items/other cases and thereafter the upper major panels N and L, may be folded about 90 degrees along with upper minor panels M and K, to close and seal the completed case.

[0134] With reference now to FIGS. 3-5, in overview, a case forming system **100** may include a magazine **110** adapted to hold a plurality of case blanks **1000** (only one or two case blanks **1000** are shown for clarity in FIGS. 3-5) in a substantially flat orientation such as is shown in FIGS. 2A and 2B. System **100** may also include a case blank support apparatus (also referred to herein as a mandrel apparatus) **120** and a panel rotating sub-system **134** (designated in FIG. 4). As will become evident from the description that follows, panel rotating sub-system **134** may be configured in some example embodiments of the system to engage a blank on an outward facing surface of the blank as the blank is held in the magazine **100** and rotate the blank **1000** around a case blank support device **137** of case blank support apparatus **120** in such a manner that the blank surface that is engaged becomes an inner surface of a tubular shaped and formed case blank.

[0135] Panel rotating sub-system **134** may utilize one or more panel rotating apparatuses in order to rotate one or more panels of a blank such as blank **1000** relative to each other. For example, panel rotating apparatus **134** may include a first panel rotating apparatus **124**. Panel rotating sub-system may also include a second panel folding apparatus **130**, and may also include a third panel rotating apparatus **131**. Panel rotating sub-system **134** may also include a fourth panel rotating apparatus **138**. Case forming system **100** may also include an adhesive applicator apparatus **135**, a support frame **140** and a vertical mandrel movement apparatus **136** (designated generally in FIG. 8).

[0136] The operation of the components of carton forming system **100** may be controlled by a controller such as a programmable logic controller ("PLC") **132** (such as for example as shown schematically in FIGS. 3 and 5A). PLC **132** may be in communication with and control all the components of system **100**, in a manner such as is depicted schematically in FIG. 5A and may also control other components associated therewith such as conveyor **102**. PLC **132** may for example be a model from the Compact Logix PLC family made by Allen-Bradley. Additionally PLC **132** may include a Human-Machine-Interface (HMI) such as the Allen Bradley Panelview **700** plus colour touch screen graphic workstation so that the operation of system **100** can be monitored, started, operated, controlled, stopped, modified for different mandrel/case blank configurations, by an operator using a touch screen panel.

[0137] A generally vertically oriented support frame **140** may support vertical blank support device apparatus (mandrel movement apparatus) **136** for vertical upward and

downwards movement. It should be noted however, that while system 100 is generally oriented for vertical movement of the mandrel movement apparatus 136, other orientations can be utilized in other embodiments.

[0138] Mandrel movement apparatus 136 may include a generally vertically oriented linear rail 142 (FIG. 8) which may support for sliding upward and downward sliding vertical movement a carriage block 144 (FIG. 5). It should be noted that in FIGS. 5, 6 and 7, for simplicity, support frame 140 and linear rail 142 have been omitted. The movement of carriage block 144 on linear rail 142 may be driven by a drive belt (not shown) interconnected to carriage block 144 and supported by vertical support frame 140. The drive belt (not shown) may be interconnected to, and driven by, a servo drive motor 145, mounted at an upper end portion of vertical support frame 140. An encoder (not shown) may be associated with servo drive motor 145 and the encoder and servo drive motor 145 may be in communication with PLC 132. In this way, PLC 132 on receiving signals from the encoder may be able to monitor and control the vertical position of carriage block 144 (and the components interconnected thereto) by appropriately controlling and operating servo motor 145.

[0139] Magazine 110 may be configured to hold a plurality of case blanks 1000 in a stacked, vertically and transversely oriented, flat configuration on their bottom edges (see FIG. 10). Many different types and/or constructions of a suitable magazine 110 might be employed in system 100. Magazine 100 may be configured to hold a plurality of case blanks 1000 that may be held in a longitudinally extending, stacked arrangement. Magazine 110 is adapted to present an outward facing surface of a plurality of case blanks 1000, individually in turn. Magazine 110 may comprise a large number of case blanks 1000 held in a generally vertically and transversely oriented, longitudinally extending, case blank stack by side walls 114a, 114b (FIG. 3). In this configuration where case blanks 1000 are individually and selectively retrieved in series from the front of a stack of generally flat blanks, the stack of case blanks 1000 in the magazine can be moved forward by longitudinally oriented conveyors 113a, 113b each having a first set of longitudinally oriented conveyor belts 112 driven by a motor which is also controlled by PLC 132. The purpose of moving the stack of blanks 1000 forward is so that the outward facing surface of major panel B, of the most forward case blank 1000 in the stack, is positioned and held close to or against an outer generally adjacent surface of the mandrel 137. This enables first panel rotating apparatus 124 (FIG. 3) and second panel rotating apparatus 130 (FIG. 5), to be able to engage the other exposed outward facing surfaces of panels of the forward most case blank 1000 in the stack held in magazine 110, as described further hereinafter. Additionally, a back pressure device 165 (only shown schematically in FIGS. 8 and 10) may be provided that can apply a back pressure against the case blank stack in a longitudinal direction toward the front of the magazine, of a magnitude and direction sufficient to keep the stack upright and prevent it from falling longitudinally backwards as the case blank stack on conveyors 113a, 113b is indexed longitudinally forward to maintain the next case blank 1100 at the front of the stack securely in a pick-up position.

[0140] Selected panels of the forward most blank may be pulled away from holding clips associated with magazine 110 by first panel rotating apparatus 124 and second panel

rotating apparatus 130 from retention by magazine 110 then rotated (wrapped) around mandrel 137 of mandrel apparatus 120. As case blanks 1000 are taken from magazine 110 and formed, PLC 132 may cause the conveyor 112 of magazine 110 to move the entire stack forward sequentially so that the most forward case blank 1000 has its the outward facing surface of major panel B positioned against or very close to adjacent outer rear vertically and transversely oriented surface of mandrel 137. A sensor (not shown) in communication with PLC 132 may be provided to monitor the level of case blanks 1000 in magazine 110 during operation of case forming system 110. Magazine 110 can be loaded with additional flat case blanks 1000 at the rear of the magazine.

[0141] Magazine 110 may have a magazine frame generally designated 127. Magazine 110 may include a conveyor system to move flat case blanks sequentially to a pick-up position. A wide variety of conveyor systems or other case blank movement systems may be employed. By way of example, conveyor system may include a pair of spaced conveyors 113a, 113b mounted to frame 127, each conveyor 113a, 113b having a generally horizontal floor plate 115. Conveyors 113a, 113b, may be longitudinally spaced from each other, and be oriented generally longitudinally, and generally parallel to each other. Each conveyor 113a, 113b, may be operated to move longitudinally together to move case blanks 1100 in a stack of blanks forward in the magazine, while being maintained in a generally transverse and vertical orientation.

[0142] Each conveyor 113a, 113b, may in some embodiments be divided into a rear conveyor portion 191 (FIG. 8) and a forward conveyor portion 193 (FIG. 8). Rear conveyor portion 191 may have a plurality of continuous conveyor belts 112. Continuous belts 112 may be oriented longitudinally parallel to each other and be supported for longitudinal movement at opposite ends by opposed sets of drive pulleys 117 and idler wheels 177. Belts 112 of the rear portions of each conveyor 113a, 113b may be driven by drive pulleys 117 (FIGS. 8 and 19). Drive pulleys 117 may be interconnected to a drive motor 178b (that may be a DC motor operated by PLC 132) through a drive mechanism comprising drive gears 172 (FIG. 19) and drive chains 176 (only partially shown in FIG. 19) connected to driven wheels 179 that are fixed to drive shaft 173. Thus drive shaft 173 may be driven by drive motor 178b that is in communication with, and controlled by PLC 132. An encoder may be provided to monitor and control the position of the drive belts 112.

[0143] Each forward conveyor portion 193 (FIG. 8) of conveyors 113a, 113b may utilize conveyor chains 174 which may also move/intermittently index blanks to the pick-up position of the magazine as described herein. A similar drive mechanism as the rear conveyor portions 191 may be provided for forward conveyor portion 193 on each conveyor. For example a motor 178a such as a DC motor in communication with PLC 132 may be inter connected to driven wheels 175 (FIG. 19) which may be fixedly attached to drive shaft 128. Driven wheels 175 may be interconnected with driven conveyor chains 174 (FIG. 8) which are supported also at opposite end by wheels. Thus by controlled operation of motor 178a, conveyor chains 174 may move blanks supported thereon and transferred from rear conveyor portion 191, to the pick-up position on front conveyor portion 193.

[0144] Blanks 1000 in the stack supported on belts 112 in conveyors 113a, 113b, may be moved forward by belts 112 and then be transferred to conveyor chains 174. Conveyor chains 174 may move together longitudinally to move a forward group of blanks into the pick-up position. A back pressure device 165 (shown only schematically in FIG. 8) may be provided to keep a low level of pressure acting in a forward direction on the rear of the stack of case blanks (see FIG. 10). This can prevent some or all of the blanks in the stack from falling backwards as they are indexed forward.

[0145] Electronic sensors (not shown) in communication with PLC 132 may be positioned to monitor the stack of blanks and ensure that a blank 1000 at the front of the stack of blanks is properly positioned at the pick-up position.

[0146] Conveyor belts 112 and conveyor chains 174 of both conveyors 113a, 113b may be oriented longitudinally and parallel to each other and the belts of each conveyor 113a, 113b may be synchronized to move intermittently together at the same speed driven by drive motors 178a, 178b. The top run portions of conveyor belts 112 of conveyors 113a, 113b may be supported on the upper surface of floor plates 115 of magazine 110 and the bottom edges of the case blanks 1000 in the stack of case blanks may rest on top of the upper runs of the drive belts 112. Similarly conveyor chains 174 may be oriented longitudinally and parallel to each other and may be synchronized to move intermittently together at the same speed driven by drive motor 178a. The top run portions of conveyor belts 112 of conveyors 113a, 113b may be supported on the upper surface of floor plates 115 of magazine 110 and the bottom edges of the case blanks 1000 in the stack of case blanks may rest on top of the upper runs of the drive belts 112.

[0147] Conveyors 113a, 113b may thus be operable to move a vertically and transversely oriented stack of flat case blanks 1000 sequentially longitudinally forward under the control of PLC 132, so that single case blanks 1000 may be sequentially placed in the pick-up position to be retrieved in series from the stack for processing by first panel rotating apparatus 124.

[0148] The stack of case blanks 1000 may be supported at vertically oriented side edges by longitudinally and vertically oriented side wall plates 114a, 114b that may be spaced apart from each other and oriented generally parallel to each other. One or both of side wall plates 114a, 114b may be mounted on transversely oriented and movable rods 126 that are supported on magazine frame 127. Actuation of rods 126 may be made by any suitable mechanism such as by way of example only, servo drive motors with appropriate drive shafts and gear mechanisms or a hand operated gear and crank shaft mechanism. Side wall plates 114a, 114b serve to guide the case blanks within magazine 110 and can be accurately adjusted to be in close proximity to or contact with the particular case blank size that is being handled at a particular time. This adjustability of the relative transverse spacing of side walls 114a, 114b allows for case blanks of different configurations to be easily held in magazine 110 for processing as described herein.

[0149] Clip mechanisms 111a-d (FIGS. 4 and 5) may be provided to releasably hold each case blank 1000 that is at the front of the stack within magazine 110, and thus hold the stack in place. When first panel rotating mechanism 124 and second panel rotating mechanism 130 selectively engage panels D/F and A respectively, as described hereinafter, clip mechanisms 111a (FIG. 4), and 111b (FIG. 5) and 111d

allow for the engaged panels E/D/F/N and A/K/J of the front case blanks 1000 in the stack to be pulled away from the same corresponding panels on the case blank immediately behind the front case blank in the stack held in the magazine. Also, clip mechanisms 111c (FIG. 5) will hold panels H, B and L, in magazine 110 while the other panels are being wrapped around the mandrel 137, but will then allow for the release of panels H, B and L to allow the remaining portion of case blank 1000 to be removed from being held by magazine and moved vertically downward once the case blank 1000 at the front of the stack is engaged by second panel rotating apparatus 130 and mandrel 137 moves vertically downwards, all as described further hereinafter.

[0150] First panel rotating apparatus 124 may be one of numerous types of robotic systems, but a particularly useful and efficient type of robotic system that may be employed is a Selective Compliance Assembly Robot Arm (referred to as a "SCARA") device. By way of example, first panel rotating apparatus 124 may be a SCARA robot made by Epson Robots, Motoman or Fanuc. First panel rotating apparatus 124 may be capable of intermittent motion, as will be evident from this description.

[0151] With particular reference to FIGS. 3-6, first panel rotating apparatus 124 may be secured to a fixed, longitudinally oriented robot support member 158 proximate a first end thereof. An opposite end of longitudinal robot support member 158 may be secured to an end portion of a fixed, transversely oriented robot support member 156. The opposite end portion of transverse robot support member 156 may be fixedly mounted to vertical support frame 140.

[0152] First panel rotating apparatus 124 may include a first rotational drive unit 160 having one upper end fixedly mounted to longitudinal robot support member 158. Extending from an opposite lower end of first rotation drive unit 160 is a first rotational drive that may comprise a drive shaft (not shown) that is operable for rotation clockwise and anti-clockwise about a first vertical axis of rotation Y1 (FIG. 3). The drive shaft of first rotational drive unit 160 is operably connected to a first end portion 162a (FIG. 4) of a first articulating arm 162. Thus, when rotational drive unit 160, under the control of PLC 132, causes the drive shaft of first rotation drive unit 160 to rotate, first articulating arm 162 is able to pivot clockwise or anti-clockwise relative to the drive shaft about vertical axis Y1, depending upon the direction of rotation of the drive shaft.

[0153] A second rotational drive unit 169 may be mounted at or proximate a second opposite end portion 162b (FIG. 5) of articulating arm 162. Rotational drive unit 169 may include a second rotational drive 164 (FIG. 5) that has a drive shaft (not shown) that is operable for rotation clockwise and anti-clockwise about a second vertical axis of rotation Y2 (FIG. 5) under the control of PLC 132. The drive shaft of rotational drive 164 may be located proximate a first end portion 169a of rotational drive unit 169. The drive shaft of rotational drive 164 is fixedly connected to opposite end portion 162b of first articulating arm 162.

[0154] When rotational drive unit 169, under the control of PLC 132, causes the drive shaft of rotational drive 164 to rotate relative to rotational drive unit 169 about axis Y2 (FIG. 5), and thus rotational drive 164 along with rotational drive unit 169 can rotate clockwise and anti-clockwise relative to first articulating arm 162 about the drive shaft of rotational drive 164 and thus about vertical axis Y2.

[0155] Rotational drive unit 169 may also have an opposite end portion 169b at which may be another vertical drive shaft 163 (FIG. 5) which is operable for clockwise and counter-clockwise rotation by a third rotational drive 167, under the control of PLC 132, about vertical axis Y3. Mounted to drive shaft 163 of second rotational drive 164 is an end effector rod 166 formed in a generally tubular cylinder and having suction cups 168.

[0156] Air suction cups 168 may be interconnected through hoses passing through cavities in end effector 166, second rotational drive 164, articulating arm 162, first rotational drive 160 and robot support members 158, 156 and vertical support frame 140 to a source of vacuum by providing for an air channel through the aforesaid components. The supply of vacuum to suction cups 168 may be provided by a pressurized air distribution unit generally designated 227 (FIG. 5A). Air distribution unit 227 may include a plurality of valves that may be operated by PLC 132 and may also include local vacuum generator apparatuses that may be in close proximity to, or integrated as part of, suction cups 168. In other embodiments, a vacuum pump mounted externally may generate vacuum externally and then vacuum can be supplied through the aforementioned air channels. If local vacuum generators are utilized, pressurized air may be delivered from an external source through air distribution unit 227 to the vacuum generators. The local vacuum generators may then convert the pressurized air to vacuum that can then be delivered to suction cups 168.

[0157] The air suction force that may be developed at the outer surfaces of suction cups 168 will be sufficient so that when activated they can engage and hold panel D, and rotate panels D (along with panels F, N, E and M, C and G) of a case blank 1000 from (i) the position shown in FIG. 3 to (ii) the position shown in FIGS. 5 and 6, and thereafter (iii) to the position shown in FIGS. 7 and 8 and then (iv) after releasing a first engaged blank 1000, eventually return to the position shown in FIG. 3 to engage a next case blank 1000 positioned at the pick-up position in magazine 110. The vacuum generated at suction cups 168 can be activated and de-activated by PLC 132 through operation of air distribution unit 227.

[0158] First rotating apparatus 124 may be readily adjustable for different types/configurations of mandrel apparatuses 120, including mandrels 137, for forming different types/configurations of case blanks 1000 into cases by suitable programming of PLC 132 appropriately to provide for appropriate movements of the suction cups 168 through movement of the first rotational drive 160 and second rotational drive 164 and third rotational drive 167. Thus by an interchange of mandrel 137 to provide for alternate configurations of the mandrel side wall and bottom walls, PLC 132 and its operation of first rotating apparatus 124 may be appropriately programmed and thus different sized and configurations of blanks may be processed.

[0159] Mandrel apparatus 120 may have several components including a mandrel 137 (FIG. 3) and a mandrel support apparatus generally designated 148 (FIGS. 5 and 7). Mandrel 137 may be easily removable from mandrel support apparatus 148, so that a mandrel of one configuration may be easily replaced with a mandrel of another configuration. With particular reference to FIGS. 5-6 and FIGS. 23-25, mandrel 137 may comprise a pair of opposed, spaced, vertically and transversely oriented, spaced, major side walls 121a, 121b interconnected with a pair of opposed, spaced,

vertically and longitudinally oriented, spaced, minor side walls 122a, 122b. A generally horizontally and transversely oriented bottom wall 118 is interconnected to major and minor side walls 121a, 121b, 122, 122b to form a generally cuboid, open top, box shape. Mandrel 12 may be generally configured in a variety of different sizes and shapes, each selected for the particular type of case blank 1000 that are to be formed into cases.

[0160] The dimensions of the outer surfaces of mandrel 137 may be selected so that the specific case blank 1000 that it is desired to fold has, during the forming process, fold lines that are located substantially at or along the four corner vertical side edges and the four corner horizontal bottom edges of mandrel 137. Such a selection may improve the performance of case forming system 100 in creating a formed case that is ready for loading with items. Mandrel 137, and surrounding components in system 100, may be configured to permit for the easy interchange of mandrels 137 so that case forming system 100 can be readily adapted to forming differently sized/shaped cases from differently configured case blanks 1000.

[0161] Front mandrel side wall 121a may be provided with a vertical slot 123 that may be configured to permit part of end effector 166 and suction cups 168 to move from the position shown in FIGS. 5 and 6, and pass through slot 123 to the position shown in FIGS. 7 and 8. By allowing the end effector 166 to pass through vertical slot 123, end effector 166 and suction cups 168 may engage the outer surface of the major side panel D of case blank 1000 when it is held in magazine 110 and then may wrap the case blank around the mandrel 137 such that the surface being held becomes an inner surface of the tubular formed case blank and major side panel D may be held substantially flat against the outside surface of major side wall 121a of mandrel 137, as shown.

[0162] With particular reference to FIGS. 23-25, rear mandrel side wall 121b may not extend transversely the full length of bottom wall 118 and may have a vertical end edge 171 that defines an opening 170. Mounted to an inward surface of rear side wall 121b may be a releasable mandrel mounting bracket unit 125. Mandrel mounting unit 125 may be configured to releasably connect a transversely extending mandrel mounting plate 155 to mandrel rear side wall 121b, such as having mounting plate 155 be received into slot 161 in mounting bracket unit 125, with the plate being releasably held in the slot by a screw of the mounting bracket unit being removably receivable in a threaded aperture 159 of the mounting plate 155. It will be noted that by simple transverse movement of mandrel 137 relative to mounting plate 155 one mandrel 137 may be replaced by another mandrel 137 of a different configuration.

[0163] Horizontally and vertically oriented mounting plate 155 can be fixedly connected to an end of vertical mandrel support member 154. A lower portion of mandrel support member 154 may also serve to complete the rear side wall of mandrel 137, when mandrel mounting plate 155 is received into mounting bracket unit 125.

[0164] Mounted to an inner surface of mandrel mounting plate 155 is second panel rotating apparatus 130. With particular reference to FIGS. 23 and 24, second panel rotating apparatus 130 may include a double acting pneumatic cylinder device 180 which may for example be one of several different types made by Festo.

[0165] Pneumatic cylinder 180 may be supplied with pressurized air controlled by valves (not shown) operated by PLC 132. Pneumatic cylinder 180 may have a piston arm 181 that has an end pivotally connected to a suction cup arm 182. Suction cup arm 182 may be provided with suction cups 183. Air suction cups 183 may be interconnected through hoses passing through cavities (not shown) in suction cup support arm 182, first vertical support member 154, longitudinally oriented mandrel support member 152, second vertical mandrel support member 150 and longitudinally oriented and carriage support arm 146 and carriage 144 to a source of vacuum by providing for one or more air channels carrying pressurized air through the aforesaid components. The supply vacuum to suction cups 183 may be controlled by pressurized air distribution unit generally designated 227 (FIG. 5A). Air distribution unit 227 may include a plurality of valves that may be operated by PLC 132 and may also include local vacuum generator apparatuses that may be in close proximity to, or integrate as part of, suction cups 168. In other embodiments, a vacuum pump may generate vacuum externally and then vacuum can be supplied through the aforementioned air channels. If local vacuum generators are utilized in close proximity to vacuum cups 183, pressurized air may be delivered from an external source through air distribution unit 227 to the vacuum generators. The local vacuum generators will then convert the pressurized air to vacuum that can then be delivered to suction cups 183.

[0166] The air suction force that may be developed at the outer surfaces of suction cups 183 will be sufficient so that when activated they can engage and hold panel A, and rotate panels K, A and J of a case blank 1000 past clip mechanisms 111b and 111d, from the position shown in FIGS. 5-9 to initially the position shown in FIG. 11, and then, once the case blank 1000 is released, eventually return to the position shown in FIG. 5. The vacuum generated at suction cups 183 can be activated and de-activated by PLC 132 through operation of unit 227.

[0167] When PLC 132 causes pneumatic cylinder 180 to extend piston arm 181, such cup arm 182 with suction cups 183 can rotate about a pivot device 184 through a longitudinally and vertically extending opening 119 in mandrel side wall 122a (see for example FIG. 9) and can then suction cups 183 can engage an outward facing surface of a panel A of case blank 1000.

[0168] It may be appreciated that the end effector 166 engages an outward facing surface of a case blank 1000 held in a pick-up position in the magazine 110. However, by allowing end effector 166 with suction cups 168 to pass into a recess in the wall, and in this embodiment shown, through vertical slot 123 in mandrel 137, and allowing suction cup arm 182 to pass through opening 119 in mandrel 137, and then move their respective suction cups to appropriate positions at least partially within the respective slot 123 and opening 119, enables the first panel rotating apparatus 124 and second panel rotating apparatus 130 to in effect wrap the case blank around the outer surfaces of 122a-122d of mandrel 127 by engaging only what become the inward facing vertical surfaces of the tubular case blank formed from case blank 1000 (ie. the case blank 1000 is wrapped around the mandrel by engaging what become inward facing surfaces of the tubular shaped case blank 1000).

[0169] Horizontally and vertically oriented mounting plate 155 may be fixedly connected at an outer end to a lower end

portion of vertical mandrel support member 154. An opposite, upper end of vertical mandrel support member 154 may be fixedly connected to a first end of a longitudinally oriented mandrel support member 152. An opposite second end of longitudinally oriented mandrel support member 152 may be fixedly connected to a first end of a second vertical mandrel support member 150. A second opposite end of second vertical mandrel support member 150 is fixedly attached to a first end of longitudinally oriented and extending carriage arm 146. Proximate the connection location of mandrel support member 150 and carriage arm 146 may be mounted to opposite outer surfaces of vertical mandrel support member 150, a pair of spaced and opposed, longitudinally oriented support blocks 147a, 147b (see FIG. 25).

[0170] Mandrel side wall 121b, with its mounting plate 125 can facilitate the support of mandrel 137 on mandrel support frame 148 that includes mounting block plate 155, first vertical support member 154, longitudinally oriented mandrel support member 152, second vertical mandrel support member 150 with longitudinally oriented support blocks 147a, 147b, and carriage arm 146.

[0171] With reference to FIGS. 5 and 24, as noted above, vertical mandrel support member 150 is fixedly attached at its upper end portion to a first end portion of longitudinally oriented and extending carriage arm 146. The opposite end portion of longitudinally oriented and extending carriage arm 146 is fixedly connected to carriage block 144. Carriage block 144 is attached for sliding vertical upward and downward movement on a vertically oriented linear rail 142. Linear rail 142 may for example be a linear rail device of many types made by Bosch Rexroth AG, and provides a vertical movement apparatus 136 for mandrel apparatus 120 and the mandrel supporting members.

[0172] Linear rail 142 may be mounted to vertical support frame 140. Linear rail 142 may have a carriage drive mechanism 198 (FIGS. 8 and 2) which is operable under the control of PLC 132 to move the carriage 144 and thus also mandrel 137 vertically upwards and downwards within a range of movement as required for completing the case forming operations described herein.

[0173] First vertical support member 154, longitudinally oriented mandrel support member 152, second vertical mandrel support member 150 and longitudinally oriented and carriage support arm 146 and carriage 144 may be appropriately configured to permit electrical and communication cables and pressurized air/vacuum air hoses to pass through from an upper end to a lower end where operational components of mandrel apparatus 120 are located. In this way, electrical power/communication cable and air hoses can deliver power, electrical signals and pressurized air/vacuum to the mandrel 137 and second panel rotating apparatus 130 which is mounted on mandrel 137.

[0174] It will also be appreciated that in first panel rotation apparatus 124 and second panel rotating apparatus 130, suction cups are used to apply a force to hold and move panels of a case blank 1000. However alternative engagement mechanisms to suction cups could be employed in other embodiments to engage, hold and rotate panels of case blanks 1000.

[0175] With particular reference now to FIGS. 8 and 20, linear rail 142 may include carriage drive mechanism 198 that is operable to drive carriage 144 vertically upwards and downwards on linear rail 142. Carriage drive mechanism 198 may include a continuous vertically oriented drive belt 143

that extends between an idler wheel **141** and a drive wheel **139**. Drive wheel **139** may be driven in both rotational directions and at varying speeds by the drive shaft of a servo drive motor **145**. The operation of drive motor **145** may be controlled by PLC **132** in combination with a position sensing apparatus such as an encoder (not shown) associated with drive motor **145** so that PLC **132** can determine when and how to operate drive motor **145** to appropriately position the drive belts **143a**, **143b** and thus move carriage **144** upwards and downwards, consequently also moving mandrel **137** and adhesive applicators **133a-e** upwards and downwards. Drive motor **145** may be mounted at an upper end portion of support frame **140**. Carriage **144** may be interconnected to drive belt **143** with a connection mechanism that may include opposed side connector plates **205** (FIGS. **20** and **21**).

[0176] Also associated with vertical moving apparatus **136** may be a caterpillar device **189** (FIG. **9**). Caterpillar **189** has a hollow cavity extending along its length. Within the cavity of caterpillar **189** hoses carrying pressurized air/vacuum and electrical/communication wires can be housed. Caterpillar **189** allows such hoses and wires to move vertically as the mandrel support components and thus mandrel **137** are moved vertically by vertical moving apparatus **136**. The hoses and wires may extend from external sources to enter at an inlet of caterpillar **189** mounted to vertical support frame **140** and emerging at an outlet on carriage arm **146**. Upon leaving the outlet of caterpillar **189**, the hoses and wires may pass into the internal cavity of carriage arm **146** (see FIG. **9**). An example of a suitable caterpillar device that could be employed is the E-Chain Cable Carrier System made by Igus Inc.

[0177] Also mounted for vertical upwards and downwards movement with mandrel apparatus **120** is an adhesive applicator apparatus **135**. Adhesive applicator apparatus **135** may include a transversely oriented support beam **149** to which may be mounted a plurality of adhesive applicators **133a** to **133e** (FIG. **3**). Adhesive applicators **133a-e** may be provided with nozzles **153** (FIG. **8**). Individual adhesive applicators **133a** to **133e** can be appropriately positioned transversely along support beam **149** such that adhesive applicators **133a-e** can provide a suitable adhesive pattern to the outward facing surface of a case blank **1000** and certain panels thereof, held at the front of magazine **110** in the pick-up position. The operation of each adhesive applicator **133a-e** may be controlled by PLC **132** by for example suitable wire connections that pass through caterpillar **189** and other components of mandrel apparatus **120**. Applicators **133a-e** can apply a suitable adhesive to various panel surfaces of a bank **1000** held in magazine **110** so that when the panels are folded as described herein, the panels and flaps can be held in the desired carton configuration.

[0178] An example of a suitable adhesive applicator apparatus **135** that can be employed is the model ProBlue 4 hot melt application system made by Nordson Inc. which includes adhesive tank, nozzles/guns and hoses as well as solid state temperature control for the tank, guns and hoses. The operation of adhesive applicator apparatus **134** may be monitored and controlled by PLC **132**.

[0179] Various types of adhesives may be employed in case forming system **100**. A particular class of adhesives that may be suitable are adhesives in the class of "Hot Melt Adhesives" (referred to as a "HMA"). HMAs may be a thermoplastic adhesive/glue which may be heated in an

applicator such as applicators **133a-e** by respective heating elements and then expelled from the applicators while hot and tacky onto surfaces which are to be adhered to other surfaces. Depending upon the particular formulation of the HMA selected, the adhesive may for example remain tacky and capable of bonding two surfaces together for, from perhaps a second or a few seconds, to up to a minute or more. In case forming system **110**, an HMA may be applied to the outward facing surfaces of panels of a blank **100** (such as shown in FIG. **1**) while held in magazine **100** by applicators **133a-e**, to form adhesive lines such as adhesive lines **1001**, **1002**, **1003**, **1004** and **1005**.

[0180] One particular type of HMAs are pressure sensitive HMAs which may remain tacky and capable to bonding two surfaces together until pressure is applied to the HMA, such as when the HMA is compressed between two surfaces of two panels of a blank **1000** as the two panels are brought together. Such pressure sensitive HMAs may remain tacky and capable of bonding two surfaces together for a long period of time, and potentially for an infinite amount of time, until pressure is applied to the HMA.

[0181] An example of a suitable adhesive that could be employed on a case blank **1000** made of cardboard is Cool-Lok adhesive made by Nacan Products Limited or a suitable pressure sensitive HMA made by Henkel Corporation.

[0182] Adhesive applicators **133a-e** can for example be positioned transversely along support beam **149**, and their operation controlled by PLC **132** to provide apply a suitable adhesive to various panel surfaces, such as vertical adhesive lines **1001**, **1002** on lower major panel F, vertical adhesive lines **1003**, **1004** on lower major panel H and adhesive line **1005** on minor side wall panel A (FIG. **1**). This can be done as the adhesive applicators **133a-e** are moving upwardly on support beam **149** during an upward stroke of the mandrel apparatus **120** including mandrel **137**.

[0183] The transverse positions of adhesive applicators **133a-e** may be individually selected and adjusted by use of a releasable adjustment mechanisms **199a-e** which releasably secures the applicators **133a-e** to support beam **149**, at positions suitable dependent upon which particular type/configuration of case blank **1000** that is being processed (see for example FIG. **25**). This adjustable positioning of adhesive applicators **133a-e** is another part of the features of case forming system **100** that enables case forming system **100** to be easily modified when changing over from handling one type/configuration of case blank to another type/configuration of case blank.

[0184] Applicator support beam **149** may be fixedly mounted to support blocks **147a**, **147b** (FIG. **5**) and thus applicator support beam **149** and adhesive applicators **133a-e** may move and stroke vertically upwards and downwards along with carriage **144** and mandrel movement apparatus **136** within a range of intermittent movement as required for completing the case forming operations and process described herein. It will be appreciated that by interconnecting adhesive applicator apparatus **135**, including applicator support beam **149** carrying adhesive applicators **133a-e**, to the carriage **144**, the adhesive applicator apparatus **135** may be moved in reciprocating motion vertically upwards and downwards in space with the mandrel apparatus **120** and mandrel **137**. Both portions of adhesive applicator apparatus **135** and at least portions of mandrel apparatus **120** will occupy some of the same spatial region

in the vicinity of the front of the magazine **110** and the pick-up location of case blanks **1000** located in the magazine **110** at the front of the stack. This enables the adhesive applicator apparatus **135** to apply adhesive to the outward facing surface of the blank at the pick-up position during upward vertical movement, while the case blank **1000** at the front of the stack is being held in the magazine, and prior to the mandrel apparatus **120** being brought into an engagement position with the case blank being located at the pick-up location.

[0185] The next component of system **100** to be described in detail is third panel rotating apparatus **131** which is configured to cause the appropriate lower panels F, G, H, J (FIG. 1) to be folded and sealed to provide a closed bottom and thus form an open top case configuration that is suitable for delivery to a case conveyor **102** (FIG. 3). Third panel rotating apparatus **131** is operable (a) to rotate outwards lower major panels F and H about their respective fold lines with respective major side panels D and B. The amount of rotation is sufficient to ensure that there will be no interference with the subsequent inward rotation of lower minor panels G and J and no contact is made with adhesive that may be on an inward surfaces of lower major panels F and H, such as respective adhesive lines **1001**, **1002** and **1003**, **1004** (FIG. 1). In an example embodiment the amount of outward rotation of lower minor panels G and J from vertical planar alignment with their respective adjacent lower major side wall panels D and B, may be about 45 degrees from the vertical.

[0186] Third panel rotating apparatus **131** may also be operable to (b) rotate lower minor panels G and J inwardly, preferably about 90 degrees to a generally horizontal orientation, about their respective fold lines with respective major side wall panels C and A; and (c) rotate lower major panels F and H inwards, about their respective fold lines with respective major side panels D and B, an amount of rotation is sufficient to ensure that there will be contact between inner surfaces of lower major panels of lower major panels F and H and the outer surfaces of lower minor panels G and J. Third panel rotating apparatus **131** may also be operable to apply compression to lower major panels F and H against the bottom wall **188** of mandrel **137** to ensure that a fixed adhesive connection is formed between inner surfaces of lower major panels of lower major panels F and H and the outer surfaces of lower minor panels G and J.

[0187] With particular reference to FIGS. **13** and **14**, third panel rotating apparatus **131** may include opposed longitudinally oriented pivoting fingers **200a**, **200b**, that may pivot within a desired range outwards and inwards about respective pivots **201a**, **201b** about transversely oriented pivot axes. The pivoting movement of fingers **200a**, **200b** may be caused by actuator motors **202a**, **202b** controlled in operation by PLC **132**.

[0188] Operation of fingers **200a**, **200b** can rotate outwards lower major panels F and H about their respective fold lines with respective major side panels D and B.

[0189] Third panel rotating apparatus **131** may also include opposed transversely oriented plough devices **210a**, **210b**, that have plough plates **211a**, **211b** that may be moved transversely in intermittent, reciprocating movement by actuating double acting pneumatic cylinders **212a**, **212a**, with movable piston arms, within a desired range outwards and inwards. The transverse movement of plough devices **210a**, **210b** may be controlled by valves in air distribution

unit **227** (not shown) that selectively deliver pressurized air through hoses (not shown) to double acting pneumatic cylinders **212a**, **212b**, under the control of PLC **132**.

[0190] Third panel rotating apparatus **131** may also include opposed longitudinally oriented plough devices **220a**, **220b**, that have plough plates **221a**, **221b** that may be moved transversely in intermittent, reciprocating movement by double acting pneumatic cylinders **222a**, **222a**, with movable piston arms, within a desired range outwards and inwards. The transverse reciprocating intermittent movement of plough devices **220a**, **220b** may be controlled by valves (not shown) that selectively deliver pressurized air through hoses (not shown) to pneumatic cylinders **222a**, **222b**, that may be supplied by pressurized air controlled by valves in air distribution unit **227**, under the control of PLC **132**.

[0191] The aforementioned components of third panel rotating apparatus **131** may be mounted to a frame (not shown for simplicity). In some embodiments, the horizontal longitudinal/transverse positions and possibly also their vertical positions may be adjustable on the frame to enable the components of third panel rotating apparatus **131** to accommodate different sized/configured mandrel apparatuses **120** and corresponding different size and configuration of case blanks and their lower panels F, G, H, J. The adjustment may be made by hand or by servo motors operating moving support components under control of PLC **132**. However, it is preferred if third panel rotating apparatus is configured so that it can accommodate the processing of several different size/configurations of mandrels and case blanks without having to adjust the positions of their components, to be more easily able to facilitate change-over from one mandrel/case blank size and configuration to another.

[0192] The next component of system **100** to be described in detail is fourth panel rotating apparatus **138**. Fourth panel rotating apparatus **138** can co-operate with first panel operating apparatus **134** and second panel operating apparatus **130** to form a tubular shaped blank. Fourth panel rotating apparatus **138** is operable to rotate inwards 90 degrees, sealing panel E of case blank **1000** relative to major side wall panel D, from the position shown in FIG. **7** to the position shown in FIG. **9**. Fourth panel rotating apparatus **138** may be mounted to a supporting frame component (not shown) and include a plough device **230** having plough plate **231** that may be moved longitudinally in intermittent, reciprocating movement by a double acting pneumatic cylinder **232**, with a movable piston arm, within a desired range outwards and inwards. The longitudinal reciprocating intermittent movement of plough device **220** may be controlled by valves (not shown) in air distribution unit **227** that deliver pressurized air through hoses (not shown) to pneumatic cylinder **232** under the control of PLC **132**.

[0193] Pneumatic cylinders **211a**, **212b**, **222a**, **222b**, and **232** may each be a conventional pneumatic reciprocating cylinder with piston arms that are operable to move in a reciprocal movement between fully extended positions and fully retracted position. This reciprocating motion can be achieved in known ways such as for example, by using a double acting cylinder, which can for example, channel compressed air to two different chambers which in turn provides interchanging forward and backward acting forces on the piston arms of the cylinders. Pneumatic cylinders **211a**, **212b**, **222a**, **222b**, and **232** may for example be one of many different types made by Festo.

[0194] Compressed air may be delivered to pneumatic cylinders 211a, 212b, 222a, 222b, and 232 by hoses (not shown) in communication with a source of pressurized air through air distribution unit 227. To channel the compressed air appropriately, valves (not shown) in distribution unit 227 (FIG. 5) can be driven between open and closed positions by solenoids responsive to signals from PLC 132. The valves could be located proximate the pneumatic cylinders 211a, 212b, 222a, 222b, and 232 or be disposed elsewhere. Electrical communication lines carrying signals to and from PLC 132 could also be provided to operate the valves.

[0195] It should also be noted that during the downward vertical movement of a case blank 1000 secured to mandrel 137, a compression rail 195 supported on part 140a of vertical support frame 140 (FIG. 3) is configured and positioned to apply pressure to the panels A and E pushing against the outward surface of side wall 122a of mandrel 137, to ensure appropriate sealing of panels A and E with the adhesive.

[0196] In some embodiments, the longitudinal/transverse position and possibly also the vertical position of compression rail 195 may be adjustable on the frame 140 to enable the components of third panel rotating apparatus 131 to accommodate different sized/configured mandrel apparatuses 120 and corresponding different size and configuration of case blanks and their lower panels F, G, H, J. The adjustment may be made by hand or by servo motors operating moving support components under control of PLC 132.

[0197] With reference to FIGS. 3, 21 and 22, case discharge conveyor 102 (for simplicity not shown in the other Figures) may be provided with spaced continuous conveyor belts 105 driven in a conventional manner by a drive motor under control of PLC 132 and configured to support and move open topped cases formed from case blanks 1000 by case forming system 100. A lift platform 104 may have upward facing suction cups 103. Lift platform 104 may be employed to assist in “handing off” a formed case from mandrel 137 to case conveyor 102. The lift platform 104 may be vertically movable upwards and downwards and along with suction cups 103 and corresponding suction cup valves (not shown) be controlled by valves and PLC 132. Lift platform 104 may move suction cups 103 to engage and hold the blank (which has become a formed case) in position during disengagement of the mandrel 137 from the formed case. Then lift platform 104 may be lowered to position the formed case onto the case conveyor for discharge for filling, packing and top sealing. Suction cups 103 may be deactivated allowing case conveyor 102 to move the formed case from case forming system 100.

[0198] Various components of system 100 such as mandrel apparatus 120 including mandrel 137 and the various support members 155, 154, 152 and 150; first, second, third and fourth panel rotating apparatuses; robot support members 156 and 158; and support frame 140, may all be made of any suitable materials such as for example aluminium or steel.

[0199] Also a least some of the various components of system 100 mandrel support members 155, 154, 152 and 150 may be integrally formed or interconnected to each other by known techniques. For example if the components are made of a suitable metal or plastic, welding techniques can be employed. Also, the use of screws and/or nut and bolts may be employed.

[0200] The operation of system 100 will now be described in detail. A plurality of case blanks 1000 may be presented in a vertically and transversely oriented stacked arrangement and held in magazine 110. Magazine 110 may be operated such that the front generally vertically and transversely oriented surface of panel B of the forward-most blank 1000 will be at a pick-up location that will be just in contact with, or be a very short distance spaced from (e.g. within ¼ inch), the inward surface of rear wall 121b of mandrel 137 when the mandrel is appropriately vertically positioned.

[0201] The start position of mandrel 137 will typically be a vertically downward position, where the adhesive ejection nozzles 153 (FIG. 8) of adhesive applicators 133a-e are also below the level of the bottom edge of case blank 1000 held in magazine 110). Then, under control of PLC 132, vertical movement apparatus 136 can cause mandrel apparatus 120 with adhesive applicator apparatus 135 connected thereto, to move vertically upwards an appropriate amount at an appropriate velocity. In doing so, ejection nozzles 153 of adhesive applicators 133a-e can be operated by PLC 132 over a suitable range of upward movement, to apply adhesive to respective panels A, H and F. PLC 132 is able to activate adhesive applicators 133a-e at a suitable vertical location because of signals received from the encoder associated with servo drive motor 145. Adhesive applicators 133a-e will then apply adhesive lines 1001, 1002, 1003, 1004 and 1005 as shown in FIG. 1, to the outward facing surface of the front case blank 1000 in magazine 110, while the front case blank is in the pick-up position.

[0202] Next, under control of PLC 132, magazine 110 and first panel rotating apparatus 124 may co-operate so that suction cups 168 engage and hold the outward facing surface of major side wall panel D, and pull panels N, D and F from clip mechanism 111a, while clip mechanisms 111c holding panels G/C/M and J, B/L in the pick-up position in the magazine, and clip mechanisms 111b, 111d hold panels J/A/K also in the pick-up position in the magazine.

[0203] First panel rotating apparatus 124 can then start to rotate major side wall panel D along with panels E, N, F and also pull panels M, C and G from retaining clips 111c to also rotate them, 90 degrees in a counter clockwise direction about the vertical fold line between side wall panels B and C, to the configuration shown in FIG. 5, where minor side wall panel C is held against the outer surface of mandrel side wall 122b (see also step 1000(3) in FIGS. 2A and 2B).

[0204] In the next folding step, PLC 132 causes first panel rotating apparatus 124 to rotate side wall panel D and its respective adjacent upper and lower major panels N and F, and connected sealing panel E, together counter clockwise 90 degrees about the vertical fold line between side wall panels D and C, to the configuration shown in FIG. 7, where major side wall panel D is held against the outer surface of mandrel side wall 121a, as end effector 166 with suction cups 168 pass through slot 123 (see also step 1000(4) in FIGS. 2A and 2B).

[0205] In the next folding step, PLC 132 causes plough plate 231 of fourth panel rotating apparatus 138 to extend causing sealing panel E to be rotated counter clockwise 90 degrees about the vertical fold line between sealing panel E and side wall panel D to the configuration shown in FIG. 9 (see also step 1000(5) in FIGS. 2A and 2B).

[0206] In the next folding step, PLC 132 causes second panel rotating apparatus 130 to be activated by activating pneumatic cylinder 180 to extend piston arm 181 so that

suction cups **183** can engage and hold the outward facing surface of side wall panel A. PLC **132** can then cause pneumatic cylinder **180** to retract piston arm **181**, causing suction cup arm **182** to rotate about its pivot **184**, thus causing side wall panel A, along with and its respective adjacent upper and lower minor panels K and J, to be all rotated together clockwise 90 degrees about the fold line between side wall panels A and B, to the configuration shown in FIG. **11**. But as panel A is approaching the position shown in FIG. **11**, where a large portion of minor side wall panel A is held against the outer surface of mandrel side wall **122a**, PLC **132** causes plough plate **231** of fourth panel rotating apparatus **138** to retract allowing an outward facing surface of sealing panel E to engage with an edge portion of the inward facing surface of minor side wall panel A, and wherein the surface of sealing panel E becomes connected to side wall panel A as a result of adhesive line **1005** bonding the two panels together. Thus sealing panel E in combination with adhesive line **1005** provides a connection mechanism for connecting the free vertical side edge portions of blank **1000**. However, in other example embodiments, other connection mechanisms may be provided to connect the free vertical side edge portions to secure the blank in a generally tubular configuration.

[0207] The result at the end of this step is that blank **1000** is formed into a generally rectangular tubular shape, such that panels A-E have been wrapped about a centrally positioned mandrel **137** as shown in FIG. **12** (see also step **1000(6)** in FIGS. **2A** and **2B**). The case blank **1000** is being held on the mandrel by suction cups **183** of second rotating apparatus **130** and suction cups **168** on end effector **168** which are engaged on what have become the inner surfaces of the tubular shaped case blank. The result is a very efficient sequence of movements to extract a flatly configured blank held in magazine **110** and form it into a tubular shaped blank.

[0208] The remaining steps carried out by case forming system **100** as illustrated in FIGS. **13** to **23** show a sequence of steps that may be utilized to close and seal the lower major and minor panels F, H, and G, J to close and seal the bottom of the case blank **1000** to form an RSC case with an open top and deposit the formed case onto case discharge conveyor **102**. However, alternate bottom panel closing systems may be employed in other embodiments.

[0209] In the next step of carton forming system **100** as disclosed, PLC **132** de-activates suction cups **168** so that only suction cups **183** hold case blank **1000** on mandrel **137**. Thereafter, PLC **132** will activate vertical mandrel movement apparatus **136** and in particular servo motor **145** to move carriage **144** and thus mandrel **137** vertically downward with case blank **1000** secured thereto, to a lower panel folding and sealing position shown in FIG. **13** (see also step **1000(7)** in FIGS. **2A** and **2B**). Clip mechanisms **111c** (FIG. **5**) holding panels H, B and L, in magazine **110** will allow for the release of panels H, B and L to allow the remaining portion of case blank **1000** to be removed from being held by magazine **110** and moved vertically downward once the case blank **1000** at the front of the stack is engaged by second panel rotating apparatus **130** and mandrel **137** moves vertically downwards. Additionally, PLC **132** will cause the suction force at suction cups **168** on effector **166** of first rotating panel apparatus **124** to be curtailed, thus allowing the case blank **1000** formed around mandrel **137** to move vertically away from suction cups **168**. The tubular formed case blank **1000** may be held in contact for movement with

mandrel **137** by surface friction forces between the blank and the exterior surface of mandrel **137** and by the operation of suction force exerted by suction cups **183** of second panel folding apparatus **130**.

[0210] At the vertical position of mandrel **137** shown in FIG. **13**, PLC **132** activates motors **202a**, **202b** to rotate fingers **200a**, **200b** outwards, so that they engage respective lower major panels F and H may be rotated outwards, about their respective fold lines with respective major side panels D and B. The amount of rotation is sufficient to ensure that there will be no interference with the subsequent inward rotation of lower minor panels G and J and no contact is made with adhesive that is on inward surfaces of lower major panels F and H, such as respective adhesive lines **1001**, **1002** and **1003**, **1004** (FIG. **1**).

[0211] Next, with reference to FIGS. **16** and **17**, PLC **132** activates pneumatic cylinders **212a**, **212b** to cause plough plates **211a**, **211b** to be extended transversely inwards to rotate lower minor panels G and J respectively inwards, preferably about 90 degrees, about their respective fold lines with respective major side wall panels C and A.

[0212] Next with reference to FIG. **18**, PLC **132** activates motors **202a**, **202b** to rotate fingers **200a**, **200b** inwards it a vertically downward position, so that they no longer engage with lower major panels F and H, so that lower major panels F and H may be rotated inwards, about their respective fold lines with respective major side panels D and B. The amount of rotation of fingers **200a**, **200b** is sufficient to ensure that there will be no interference with the subsequent inward rotation of lower major panels F and H.

[0213] Also as shown in FIG. **18** and in FIG. **19**, next PLC **132** will cause pneumatic cylinders **222a**, **222b** to be operated to cause plough plates **221a**, **221b** to be extended transversely inwards to rotate lower major panels F and H respectively inwards, preferably about 90 degrees, about their respective fold lines with respective major side wall panels D and B. The amount of rotation is sufficient to ensure that there will be contact between inner surfaces of lower major panels of lower major panels F and H and the outer surfaces of lower minor panels G and J such that the lines of adhesive **1001**, **1002** on the inward surface of panel F, and lines of adhesive **1003**, **1004** on inward surface of panel H will cause panels F to fixedly connect with both panels G and J, and cause panel H to fixedly connect with both panels G and J such that blank **1000** is formed into a generally rectangular shaped, open top case (see also step **1000(9)** in FIGS. **2A** and **2B**). There is a sufficient gap present between lower major panels F and H when they are rotated to permit the plough plates **211a**, **211b** to remain in position to hold panels J and G in a suitable orientation for engagement with panels F and H.

[0214] Next with reference to FIG. **20**, PLC **132** activates pneumatic cylinders **212a**, **212b** to cause plough plates **211a**, **211b** to retract transversely outwards. Next PLC **132** activates activating cylinder **222a**, **222b** to cause plough plates **221a**, **221b** to be retracted transversely outwards as shown in FIG. **21**.

[0215] Lift platform **104** may be operated along with upward facing suction cups **103** to assist in "handing off" a formed case from mandrel **137** to case conveyor **102**. The lift platform **104** may be vertically movable upwards and along with suction cups **103** and corresponding suction cup valves (not shown) be controlled by valves and PLC **132** may be operated to engage the bottom of the case. PLC **132** may also

cause suction cups **183** to be deactivated, thus releasing the case from engagement with mandrel **137**. Mandrel **137** may then be moved upwards back to the start position. Lift platform **104** may move suction cups **103** to engage and hold the blank (which has become a formed case) in position during disengagement of the mandrel **137** from the formed case. Then lift platform **104** may be lowered to position the formed case onto the case conveyor for discharge for filling, packing and top sealing. Suction cups **103** may then be deactivated allowing case conveyor **102** to move the formed case from case forming system **100**.

[0216] The formed, open top case, may be moved away to another location, and may subsequently be filled with one or more items/other cases and thereafter the upper major panels N and L, may be folded along with upper minor panels M and K, to close and seal the completed case.

[0217] The foregoing cycle can be repeated multiple times to form multiple cases. It is anticipated that cartons may be formed at a rate of in the range of about 10 to about 50 cases per minute depending on the overall dimensions of the case and the size of the machine but other rates of operation are also possible and contemplated. In general, the smaller the case blank that is being processed, the faster will be the case forming rates.

[0218] As discussed above, when it is desired to change the type/configuration of case to be formed, using a different type/configuration of case blank **1000**, case forming system **100** can be quite easily modified. For example, one mandrel **137** can be replaced by a differently configured mandrel. PLC **132** may be pre-programmed to make adjustments to the operation of other components in particular to the operation of the first, third and fourth panel rotating apparatuses and the position of compression rail **195**. Additionally, it may in some circumstances be necessary to adjust the positioning and movements of some components of third panel rotating apparatus **131** such as fingers **200a**, **200b**; plough devices **210a**, **210b**, and their plough plates **211a**, **211b**; and plough devices **220a**, **220b**, and their plough plates **221a**, **221b**.

[0219] Many variations of the embodiments described above are possible. For example, now with reference to FIG. **26** another alternate form of case blank **2000** that may be configured and formed in any similar way to case blank **1000**, except that case blank **2000** has panel E adjoined to the outer edge of minor side wall panel A, instead of to major side wall panel D. Also, a line adhesive **2005** is formed on a surface of panel D instead of on sealing panel E.

[0220] With reference now to FIG. **27**, an example sequence of steps **2000(1)** to **2000(10)** are shown of folding and sealing a flat blank **2000** to form an open top case that is suitable for top loading of items/other cases.

[0221] A plurality of case blanks **2000** may be presented in a stacked arrangement with the blanks each configured in a generally flat and planar configuration [step **2000(1)**]. A particular individual case blank **2000** may be identified at/selected from the front of the stack of blanks for processing [step **2000(2)**]. In a first folding step **2000(3)** side wall panel B along with its respective adjacent upper and lower minor panels L and H, along with minor side wall panel C and its respective adjacent upper and lower minor panels M and G, along with major side wall panel D and its respective adjacent upper and lower major panels N and F, can all be rotated from the orientation shown at **2000(2)**, so that panel B is rotated 90 degrees in a counter clockwise direction

about the vertically oriented fold line between side wall panels A and B, to the configuration as shown at step **2000(3)**. In the next folding step **2000(4)**, minor side wall panel C and its respective adjacent upper and lower minor panels M and G, along with major side wall panel D and its respective adjacent upper and lower major panels N and F, are all rotated counter clockwise so that panel C is rotated 90 degrees about the vertically oriented fold line between side wall panels B and C, to the configuration shown in FIG. **27** at step **2000(4)**.

[0222] In folding step **2000(5)**, sealing panel E is rotated clockwise 90 degrees about the vertically oriented fold line between panel E and panel A. This step can be done in any time prior to the next step **2000(6)**. In the next step **2000(6)** major side wall panel D and its respective adjacent upper and lower major panels N and F are rotated counter clockwise 90 degrees about the vertically oriented fold line between side wall panel C and side wall panel D to the configuration shown at **2000(5)**. In this folding step the adhesive line **2005** on the inner surface of panel D will engage with the outward facing surface of sealing panel E such that sealing panel E may engage and become permanently connected to major side wall panel D. The result at the end of this step, as depicted at **2000(6)**, case blank **2000** is formed into a generally rectangular shaped tube. While not shown in FIG. **27**, folding steps from case blank orientations depicted at **2000(3)** to **2000(6)** may be carried out in such manner the panels are wrapped about a centrally positioned mandrel, as is described hereinafter.

[0223] The remaining steps to configurations shown from **2000(7)** to **2000(10)** may be substantially the same as the steps **1000(7)** to **1000(10)** as illustrated in FIGS. **2A** and **2B** and represent a sequence of steps that may be utilized to close and seal the lower major and minor panels, F, H and G, J respectively to close and seal the bottom of the case blank **2000** to form an RSC case with an open top.

[0224] Now with reference to FIGS. **28-32**, a case system **2100** is disclosed which may be substantially the same as case forming system **100** except as varied as shown in schematic illustrations in FIGS. **28-32** with reference to the following description. In overview, a first panel rotating apparatus **2134** is positioned relative to a stack of blanks (stack not shown) like blanks **2000** held in a magazine **2110** (like magazine **110**), with the mandrel **2137** when positioned at a pick-up position to pick-up the front blank in the stack, being located transversely and vertically in front of panel A of case blank **2000**. In this way, first panel rotating apparatus **2134** is able to wrap each of panels B, C and D around corresponding side walls of mandrel **2137**, and engage with sealing panel E, which may be rotated clockwise 90 degrees about the vertical fold line with panel E. Thus by use of just a first panel rotating system **2134** and a second panel rotating apparatus **2138**, a generally flat case blank **2000** held in magazine **2100** can be formed into a tubular shaped blank around mandrel **2137**. Thereafter bottom panels can be closed with another panel rotating apparatus which may be like third panel rotating apparatus **131**, as described above in relation to system **100**, to form an open top, case from case blank **2000**. In some other embodiments only a single panel rotating apparatus may be required to wrap the blank around a mandrel.

[0225] System **2100** may include a magazine **2110** like magazine **110** adapted to hold a plurality of case blanks **2000** in a substantially flat orientation such as is shown in FIG. **28**

(only one case blank **2000** is shown for clarity). Case blanks **2000** may generally be like blanks **1000**, except with respect to an alternative positioning of sealing panel E, as shown in FIG. 26. System **2000** may also include a mandrel apparatus **2120** (including a mandrel **2137**) and a panel rotating sub-system **2134** (designated in FIG. 4).

[0226] Panel rotating sub-system **2134** may include a first panel rotating apparatus **2124** which may be generally like panel rotating apparatus **124**. A controller (not shown) like PLC **132** may be programmed to provide a different sequence of movement for first panel rotating apparatus **2124** compared to the sequence of movement of first panel rotating apparatus **124** described above in system **100**. Panel rotating sub-system **2134** may also include a second panel folding apparatus **2138** that is like panel folding apparatus **138**, but arranged and oriented to move in a longitudinally opposite direction to panel folding apparatus **138**, so it can fold panel E in a clockwise direction 90 degrees relative to panel A of blank **2000**, as described further hereinafter. System **2100** may also include a third panel rotating apparatus (not shown) that may function like third panel rotating apparatus **131**, to close the lower panels F, G, H and J, in a manner similar to that described above.

[0227] Case forming system **2100** may also include a mandrel apparatus **2120** similar to mandrel apparatus **120** with a mandrel **2137**, and an adhesive applicator apparatus **2135** (only shown in FIG. 32 for simplicity) that may be substantially the same as adhesive applicator apparatus **135** and include adhesive applicators **2133a-e** with nozzles that are mounted on transversely oriented support beam **2149**. Mandrel apparatus **2120** may be interconnected to adhesive applicator apparatus **2135** and operable for vertical up and down movement together, like that described above in case forming system **100**. Case forming system **2100** may also include a vertical support frame and a vertical mandrel movement apparatus also like those described above in relation to case forming system **100**. The operation of the components of carton forming system **2100** may be controlled by a controller like PLC **132**.

[0228] A generally vertically oriented support frame (not shown) that may be like support frame **140**, may support a vertical mandrel movement apparatus (also not shown) like mandrel movement apparatus **136**. Mandrel movement apparatus may include a generally vertically oriented linear rail (not shown) like linear rail **142** but which may support for sliding upward and downward sliding vertical movement a carriage block **2144** (FIG. 29) which may be like carriage block **144**. The movement of carriage block **2144** on linear rail may vertically aligned with panel A of a case blank **2000** held in magazine **2110** and may be driven by a drive belt (not shown) interconnected to carriage block **144** and supported by vertical support frame, like with case forming system **100**.

[0229] With reference to FIG. 32, mandrel apparatus **2120** may have several components including a mandrel **2137** and a mandrel support apparatus generally designated **148**. Mandrel **2137** may be easily removable from mandrel support apparatus **2148**, so that a mandrel of one configuration may be easily replaced with a mandrel of another configuration. Mandrel **2137** may comprise a pair of opposed, spaced, vertically and transversely oriented, spaced, major side walls **2121a**, **2121b** interconnected with a pair of opposed, spaced, vertically and longitudinally oriented, spaced minor side walls **122a**, **122b**. A generally horizontally and transversely

oriented bottom wall **2118** is interconnected to major and minor side walls **2121a**, **2121b**, **2122**, **2122b** to form a generally cuboid, open top, box shape. Mandrel **12** may be generally configured in a variety of different sizes and shapes, each selected for the particular type of case blank **2000** that are to be formed into cases.

[0230] The dimensions of the outer surfaces of mandrel **2137** may be selected so that the specific case blank **2000** that it is desired to fold has, during the forming process, fold lines that are located substantially at or along the four corner vertical side edges and the four corner horizontal bottom edges of mandrel **2137**. Mandrel **2137**, and surrounding components in system **2100**, may be configured to permit for the easy interchange of mandrels **2137** so that case forming system **2100** can be readily adapted to forming differently sized/shaped cases from differently configured case blanks **2000**.

[0231] Mandrel side wall **2121b** may be provided with a vertical slot **2123** that may be configured to permit part of end effector **2166** and suction cups **2168** to move from the position shown in FIG. 28, and pass through slot **2123** to the position shown in FIG. 31. By allowing the end effector **2166** to pass through vertical slot **2123**, major side panel D of case blank **1000** may be held substantially flat against the outside surface of major side wall **2121b** of mandrel **2137**.

[0232] Mandrel side wall **2122b** may not extend transversely the full length of bottom wall **2118** and may have a vertical end edge that defines a slot **2170**. Mounted to an inward surface of rear side wall **2122b** may be a releasable mandrel mounting bracket unit **2125**. Mandrel mounting unit **2125** may be configured to releasably connect a transversely extending mandrel mounting plate **2155** to mandrel rear side wall **2122b**, such as having mounting plate **2155** be received into a slot in mounting bracket unit **125**, with the plate being releasably held in the slot by a screw of the mounting bracket unit being removably receivable in a threaded aperture of the mounting plate **2155**.

[0233] Horizontally and vertically oriented mounting plate **2155** can be fixedly connected to an end of vertical mandrel support member **2154**. A lower portion of mandrel support member **2154** may also serve to complete the rear side wall of mandrel **2137**, when mandrel mounting plate **2155** is received into mounting bracket unit **2125**.

[0234] Mounted in an opening **2199** in side wall **2121b** may be one or more suction cups **2198**. In some embodiments, to establish a firm connection between the outer surface mandrel wall **2122b** and the adjacent surface of panel A of a blank **2000** held in magazine **2110**, mounted in an opening **2196** in side wall **2122b** may also be one or more suction cups **2195** (FIG. 32). In other embodiments there may be only suction cups on side wall **2122b** and in some embodiments suction cups may not be required on either wall **2121b** or **2122b** or on any other wall. Friction or other forces may be sufficient to hold the tubular shaped blank once formed on the mandrel, during subsequent folding of the lower panels.

[0235] Suction cups **2195** and **2198**, if present, may be supplied with pressurized air controlled by valves (not shown) operated by the PLC. Air suction cups **2195** and **2198** may be interconnected through hoses **2194** and **2197** respectively passing through cavities (not shown) in vertical support member **2154**, longitudinally oriented mandrel support member **2152**, second vertical mandrel support member **2150** and longitudinally oriented and carriage support arm

2146 and carriage **2144** to a source of vacuum by providing for one or more air channels carrying pressurized air through the aforesaid components. The supply vacuum to suction cups **2195** and **2198** may be controlled by pressurized air distribution unit which may include a plurality of valves that may be operated by the PLC and may also include local vacuum generator apparatuses that may be in close proximity to, or integrate as part of, suction cups **2195** and **2198**. With local vacuum generators utilized in close proximity to suction cups **2198**, pressurized air may be delivered from an external source through air distribution unit to the vacuum generators. The local vacuum generators will then convert the pressurized air to vacuum that can then be delivered to suction cups **2195** and **2198**.

[0236] An air suction force that may be developed at the outer surfaces of suction cups **2195** that is may be sufficient so that when activated they can engage with and hold panel A to mandrel side wall **2122b**, as the rest of case blank **2000** is wrapped around mandrel **2137**. The vacuum generated at suction cups **2195** can be activated and de-activated by the PLC through operation of distribution unit.

[0237] The air suction force that may be developed at the outer surfaces of suction cups **2198** will be sufficient so that when activated they can engage and hold panel D and the rest of case blank **2000** wrapped around mandrel **2137** on the mandrel including during vertical downward movement to close the bottom panels. The vacuum generated at suction cups **2198** can be activated and de-activated by PLC through operation of distribution unit.

[0238] Horizontally and vertically oriented mounting plate **2155** may be fixedly connected at an outer end to a lower end portion of vertical mandrel support member **2154**. An opposite, upper end of vertical mandrel support member **2154** may be fixedly connected to a first end of a longitudinally oriented mandrel support member **2152**. An opposite second end of longitudinally oriented mandrel support member **2152** may be fixedly connected to a first end of a second vertical mandrel support member **2150**. A second opposite end of second vertical mandrel support member **2150** is fixedly attached to a first end of longitudinally oriented and extending carriage arm **2146**. Proximate the connection location of mandrel support member **2150** and carriage arm **2146** may be mounted to opposite outer surfaces of vertical mandrel support member **2150**, a pair of spaced and opposed, longitudinally oriented support blocks **2147a**, **2147b** which can be used to secure adhesive applicator apparatus **2135**. Mandrel side wall **2122b**, with its mounting plate **2125** can facilitate the support of mandrel **2137** on mandrel support frame **2148**.

[0239] Vertical mandrel support member **2150** can be fixedly attached at its upper end portion to a first end portion of longitudinally oriented and extending carriage arm **2146**. The opposite end portion of longitudinally oriented and extending carriage arm **146** is fixedly connected to carriage block **2144**. Carriage block **2144** can be attached for sliding vertical upward and downward movement on a vertically oriented linear rail.

[0240] First vertical support member **2154**, longitudinally oriented mandrel support member **2152**, second vertical mandrel support member **2150** and longitudinally oriented and carriage support arm **2146** and carriage **2144** may be appropriately configured to permit electrical and communication cables and pressurized air/vacuum air hoses to pass through from an upper end to a lower end where operational

components of mandrel apparatus **2120** are located. In this way, electrical power/communication cable and air hoses can deliver power, electrical signals and pressurized air/vacuum to the mandrel **2137** and second panel rotating apparatus **2130** which is mounted on mandrel **2137**.

[0241] It will also be appreciated that in first panel rotation apparatus **2124** with suction cups **2198** and **2195**, suction cups are used to apply a force to move and hold to mandrel **2137** panels of a case blank **2000**.

[0242] Just like with mandrel **137** in system **100**, the start position of mandrel **2137** in system **2100** will typically be a vertically downward position, where the adhesive ejection nozzles of the adhesive applicators are below the level of the bottom edge of case blank **2000** held in magazine **2110**. Then, under control of PLC, the vertical movement apparatus can cause mandrel apparatus **2120** including mandrel **2137** to move vertically upwards. In doing so, ejection nozzles of adhesive applicators can be operated by PLC over a suitable range of upward movement, to apply adhesive to respective panels D, F and H. PLC **132** is able to activate adhesive applicators at a suitable vertical location because signals received from the encoder associated with the servo drive motor. Adhesive applicators will then apply adhesive lines **2001**, **2002**, **2003**, **2004** and **2005** as shown in FIG. **26**, to the outward facing surface of the front case blank **2000** in magazine **2110**, while the front case blank is in the pick-up position.

[0243] Next, under control of the PLC, magazine **2110** and first panel rotating apparatus **2124** may co-operate so that suction cups (not shown) on end effector **2166**, engage and hold the outward facing surface of major side wall panel D, and pull panels N/D/F; M/C/G and L/B/H from a clip mechanisms (not shown), while another clip mechanism (not shown) holding panels K/A/J in the pick-up position in the magazine.

[0244] First panel rotating apparatus **2124** can then rotate all of major side wall panel D along with panels N/F; M/C/G; and L/B/H, 90 degrees in a counter clockwise direction about the vertical fold line between side wall panels B and A, to the configuration shown in FIG. **29**, where major side wall panel B has an inward surface held against the outer surface of mandrel side **2121a** (see also step **2000(3)** in FIG. **27**).

[0245] In the next folding step, PLC causes first panel rotating apparatus **2124** to rotate side wall panel D and its respective adjacent upper and lower major panels N and F, along with panels M/C/G, together, counter clockwise 90 degrees about the vertical fold line between side wall panels C and B, to the configuration shown in FIG. **30**, where major side wall panel C has an inward surface held against the outer surface of mandrel side wall **2122a**, (see also step **2000(4)** in FIG. **27**).

[0246] In the next folding step, PLC causes plough plate of panel rotating apparatus **2138** to extend longitudinally causing sealing panel E to be rotated clockwise 90 degrees about the vertical fold line between sealing panel E and side wall pane A to the configuration (see step **2000(5)** in FIG. **27**).

[0247] In the next folding step, the PLC can cause panel rotating apparatus **2124** to rotate side wall panel D and its respective adjacent upper and lower major panels N and F, counter clockwise 90 degrees about the vertical fold line between side wall panels D and C, to the configuration shown in FIG. **31**, where major side wall panel D has an

inward surface held against the outer surface of mandrel side wall **2121b**, (see also step **2000(6)** in FIG. **27**). In moving to this position, part of end effector **2166** and suction cups **2168** can slide thorough slot **2123** to a position where suction cups are still able to engage with the inward directed surface of panel D of case blank **2000**. Also, as panel D is approaching the position shown in FIG. **31**, where a large portion of side wall panel D is held against the outer surface of mandrel side wall **2121b**, PLC can cause the plough plate of panel rotating apparatus **2138** to retract allowing an outward facing surface of sealing panel E to engage with an edge portion of the inward facing surface of side wall panel D, and wherein the surface of sealing panel E becomes connected to side wall panel D as a result of adhesive line **D005** bonding the two panels together.

[0248] The result at the end of this step is that blank **2000** is formed into a generally rectangular shaped tube, such that panels A-E have been wrapped about a centrally positioned mandrel **2137** as shown in FIG. **31** (see also step **2000(6)** in FIG. **26**) while being held by panel rotating apparatus **2134** on a surface that will become an interior surface of the tubular shaped blank.

[0249] The remaining steps to close and seal the bottom panels F, G, H and J can be carried out by case forming system **2100** in the same manner as case forming system **100** closes and seals the bottom panels of case blank **1000**. In carton forming system **2100** the PLC will de-activate suction cups **2168** so that only suction cups **2198** hold case blank **2000** on mandrel **2137** allowing mandrel **2137** with tubular case blank **2000** secured thereto, to be move vertically downwards.

[0250] Many other variations of the embodiments described above are possible. By way of example, in some other embodiments, a first panel rotating apparatus like panel rotating apparatuses **124** or **2124** may be employed and configured to on its own engage a suitable case blank and wrap the case blank around a mandrel while holding the case blank on one or more surfaces that will form an interior surface of a tubular shaped case blank. Similarly, there are other embodiments where while a case blank is being held in a magazine with a surface exposed, adhesive is applied to the exposed surface of the blank prior to it being removed from the magazine for folding into a case that is suitable to be loaded.

[0251] By way only of another example, in some other embodiments, case blanks that are not used to form substantially cuboid shaped boxes, may be formed with a modified system. For example, the initial rotation of one portion of the blank from a generally flat configuration of the entire blank, may for example be only in the range of from forty-five degrees to ninety degrees onto a correspondingly shaped mandrel. Once the first portion has been rotated from the flat configuration to the angled position, the blank is then more readily capable of being engaged by other mechanisms such that a further rotation of other portions of the blank can be carried out wrap the case around the mandrel to form a generally tubular shape. In some applications a mandrel might be employed which has outer surfaces that are not completely at rights angles to each other.

[0252] While it is contemplated that system **100** is oriented in a particular mutually orthogonal vertical, transverse and longitudinal frame of reference, systems could, with some other modifications, be provided in other spatial orientations. In such an inverted configuration, a blank could

by way of example only, be retrieved from the stack and after being wrapped around a mandrel be moved vertically upwards to close the bottom panels.

[0253] Case blanks **1000/2000** 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 yet also meet the particular structural requirements for holding one or more items. Examples of suitable materials are 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 per se easily foldable but which is divided into separate panels separated by creases or hinge type mechanisms so that the carton can be formed.

[0254] With reference now to FIG. **33**, a top view of a flat case blank **3000** is illustrated which is suitable to form a sidewall for a paperboard can. Blank **3000** may have a paperboard substrate made from a suitably rigid or semi-rigid paper based material such as paperboard or cardboard. Blank **3000** may also have a polyolefin laminate layer (eg. polyethylene, low-density polyethylene, linear low-density polyethylene, very low-density polyethylene, ultra low-density polyethylene, medium-density polyethylene, high-density polyethylene, ultra high-density polyethylene, ethylene/propylene copolymers, polypropylene, polyisoprene, polybutylene, polybutene, poly-3-methylbutene-1, poly-4-methylpentene-1 and polyethylenes comprising ethylene/ α -olefin which are copolymers of ethylene with one or more α -olefins such as butene-1, hexene-1, octene-1, or the like) or non-polyolefin laminate inner layer (eg. a polyester resin, a polyamide resin, a polyvinylidene chloride resin, an ethylene-vinyl alcohol copolymer, a polyvinyl chloride resin, an epoxy resin, a polyurethane resin, a polyacrylate resin, a polyacrylonitrile resin and a polycarbonate resin), and an intermediate conducting metal (eg. aluminium) foil layer. The foil layer may be interconnected to, and positioned between the inner layer and the paperboard substrate. Thus, blank **3000** may be a multiple layer blank.

[0255] The use of layers of laminated materials comprised of a thermoplastic layer (e.g. polyethylene), a metal foil layer (e.g. aluminium foil), and a paperboard layer in the packaging of food products is well-known. These materials are flexible, and may be gas and moisture resistant, such as for example as disclosed in U.S. Pat. No. 4,637,199 issued Jan. 20, 1987 the entire contents of which is hereby incorporated by reference. Known example methods of producing these laminates include: extrusion coating, roller coating, adhesive bonding, or by pressing the layers together and heating them by an induced radio frequency which causes the thermoplastic to soften and adhere to the other layers (See for example U.S. Pat. No. 3,556,887 issued Jan. 19, 1971 the entire contents of which is hereby incorporated by reference and U.S. Pat. No. 4,060,443 issued Nov. 29, 1977, the entire contents of which is also hereby incorporated by reference).

[0256] Blank **3000** may be bendable and/or may be foldable along fold lines from a flat configuration into a tubular side wall configuration that may be sealed at or proximate longitudinal edges, as described below. In top view, blank **3000** when formed into a tubular side wall configuration may, by way of example only, be generally square or rectangular in shape. In other embodiments, blank **3000** may, by way of example, be formed into a tubular shape that is arcuate (eg. circular or oval shaped) in top view.

[0257] The portions of the polyolefin laminate inner layer or non-polyolefin laminate inner layer of blank **3000** at the vertical longitudinal edges may be utilized to assist in creating the longitudinal seal.

[0258] A case blank **3000** as contemplated herein may be made from a material and/or be formed in a way that is flexible so that it may be re-configured from a generally flat configuration to a generally tubular configuration positioned around the outer surface of a blank support device such as a mandrel, as will be described hereinafter. The case blank **3000** may thereafter be supplemented with a base/bottom component to form a paperboard can with an upper opening to receive one or more items. For example, to form a tubular shaped side wall that is rectangular or square in shape in top view, a blank **3000** may have side wall panels B, C, D and minor side wall panels A and E. Minor side wall panels A and E may have a width that is half the width of sidewall panel C. Panels D and B may have the same width as panel C or a width that is different than the width of panel C.

[0259] Fold lines (shown in broken lines) may be provided between adjacent panels A-E. Thus, side wall panel B may be located adjacent to and joined at a vertical side edge along a fold line (all fold lines shown in broken lines in FIG. 33) to a vertical side edge of side wall panel C. Side wall panel C may be located adjacent to and joined at an opposite vertical side edge along a fold line to a vertical side edge of side wall panel D. Side wall panel D may be located adjacent to and joined at an opposite vertical side edge along a fold line to a side edge of minor side wall panel E. Another, opposite side, minor side wall panel A may be located adjacent to and joined at an opposite vertical side edge along a fold line to a side edge of side wall panel B. Minor side wall panels A and E may have vertical outer side edge surfaces which as described below, may be brought into abutment with each other and sealed together to provide a continuous longitudinal seal along the abutting panels A and E. The seal may be impermeable to gases and/or liquids.

[0260] As indicated, panels A-E may be fixedly connected to and/or integrally formed with, adjacent panels by/along predetermined fold lines. These fold lines may 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 line is such that when one panel such as for example panel A is bent relative to an adjacent panel B, the panels A and B will tend to be pivoted relative to each other along the common fold line.

[0261] As will be described hereinafter, the side wall panels A, B, C, D and E, may be folded and sealed to form a tubular configuration that can be then provided with one or more bottom components to provide a sealed and suitably strong bottom. The open top formed paperboard can thereafter be filled with one or more items, and then top sealed with one or more top components such as a top/lid.

[0262] With reference to FIG. 33A, an alternate flat case blank **4000** to flat case blank **3000**, that is also suitable to form a paperboard can, is illustrated. Case blank **4000** may be constructed substantially identically to case blank **3000**, but may also include an integrally formed bottom panel G (which provides an opening closure portion) made from the same materials and in the same manner as side wall panels A-E. Panels A-E and G may be formed together and as one continuous, integrally connected unit. Thus, blank Panel G may be integrally connected to side wall panel C along a transverse fold line **4003** at a lower horizontal/transverse

edge of panel C. Panel G may also be made of the same multi-layer materials as the remainder of blank **4000** and may be integrally formed therewith. Once the tubular side wall has been formed from panels A-E, panel G may be folded upwards along the lower generally horizontally/transversely oriented fold line **4003** with panel C, to engage with the inward facing surface of the tubular side wall to provide a bottom sealing panel for the paperboard can formed.

[0263] Panel G may have an outer perimeter **4005** which is slightly larger than the opening at the bottom of the tubular side wall formed by panels A-E. Panel G may also have a continuous fold line **4007** that generally follows but is spaced inwardly from perimeter **4005**. Fold line **4007** and perimeter **4005** define there between, an edge portion **4006** that may be folded at a fold line **4007** downwards and may have an inwardly directed surface portion that provides contact with a lower edge portion of the inner wall surface of the tubular side wall formed by panels A-E. When folded upwards, edge portion **4006** of panel G may engage with lower edge portions of panels A-E to provide a continuous sealed connection between the tubular side wall provided by panels A-E and bottom panel G. This may be accomplished for example by induction heating of the metal foil layer in both the area of edge portion **4006** of panel G and the area of the metal foil layer in lower edge portion of the inner wall of the tubular side wall formed by panels A-E. When those portions are heated and brought into contact with each other, the interfacing surfaces will melt and bond together to form a continuous seal at the bottom of the side wall with panel G.

[0264] With reference to FIG. 33B, another alternate flat case blank **5000** to flat case blanks **3000** and **4000**, that is also suitable to form a paperboard can, is illustrated. Case blank **5000** may be constructed substantially identically to case blank **4000**, with blank **5000** having an integrally formed bottom panel G integrally connected to and extending away from panel C along a fold line **5003**. Blank **5000** may additionally include an integrally formed top panel F (that may be another opening closure portion) that has is connected to and extends away from side wall panel C along a fold line **5004** at an upper horizontal/transverse edge of panel C. Panel F may also be made of the same multi-layer materials and in the same manner as the rest of blank **5000**. Panels A-E, G and F may be formed together and as one continuous, integrally connected unit. Panel F may during formation of a paperboard can, be folded downwards along the generally upper horizontally/transversely oriented fold line **5004**. Panel F may have an outer perimeter **4025** which is slightly larger than the opening at the bottom of the tubular side wall formed by panels A-E. Panel F may also have a fold line **5027** that generally follows but is spaced inwardly from perimeter **5025**. Fold line **5027** and perimeter **5025** define an edge portion **5026** that may be folded at a fold line **5027** upwards and may have inwardly directed surface portion that provides contact with the inner wall edge portions of the upper end of tubular side wall formed by panels A-E.

[0265] Once the tubular side wall from panels A-E has been formed, panel G may be folded upwards and sealed as described above. Similarly, once items have been loaded into the open top paperboard can, panel F can be folded downwards, causing the edge portion **4026** of panel F to bend upwards. Edge portion **4026** of panel F may then

engage with upper edge portions of panels A-E and be sealed in the same manner as panel G, to provide a continuous upper sealed connection between the side wall provided panels A-E and top panel F. This may also be accomplished for example by induction heating of the metal foil layer in both the area of edge portion 5026 of panel F and the area of the metal foil layer in upper edge portion of the inner wall of the tubular side wall formed by panels A-E. When those portions are heated and brought into contact with each other, the interfacing surfaces will melt and bond together to form a continuous seal at the bottom of the side wall with panel F.

[0266] When fully closed and sealed, side wall panels A-E, and panels F and G, may provide an inner cavity of the paperboard can which provides a gas and/or liquid seal between the inner cavity and the external environment.

[0267] With reference now to FIG. 33C, a blank 6000 is illustrated which may be substantially identical to blank 4000 as discussed above. Blank 6000 may be formed in substantially the same shape as blank 4000 and may be constructed in substantially the same manner using substantially the same materials as blank 4000. Blank 6000 may, like blank 4000, include a polyolefin laminate inner layer or non-polyolefin laminate inner layer across all of panels A-G. Additionally, pre-applied to specific regions of the polyolefin or non-polyolefin laminate inner polyolefin may be a pressure sensitive adhesive or cold seal adhesive material. Such materials are known and may comprise a quick-drying, adhesive (for e.g. latex rubber, an acrylic resin, a polyurethane resin, a silicone resin, an acrylonitrile-butadiene or isoprene copolymer resin) that once dried, will create a surface with essentially no tackiness and will only adhere to other surfaces coated with the same adhesive and when placed under pressure. Such a pressure or cold seal adhesive may be capable of being applied to a substrate material at a relatively high rate of production (eg. such as during a paperboard converting process when multiple blanks are being formed) and of drying relatively quickly. As a result, such a cold seal adhesive applied to blanks 6000 enables blanks 6000 to be manufactured at relatively high production rates. Examples of such pressure sensitive adhesives and cold seal adhesives are discussed in *Treatise on Adhesion and Adhesives* Vol. 2, "Materials", R. I. Patrick, Ed., Marcel Dekker, Inc., N.Y. (1969); *Adhesion and Adhesives*, Elsevier Publ. Co., Amsterdam, Netherlands (1967); *Handbook of Pressure-Sensitive Adhesive Technology*, Donates Satas, Ed., VanNostrand Reinhold Co., N.Y. (1982); EP 0372756 B1; and U.S. Pat. No. 8,895,656 the entire contents of which are hereby incorporated herein by reference. Suitable cold seal adhesives that may be employed are available from Henkel Corporation.

[0268] Like panel G of blanks 4000 and 5000, a lower panel G of blank 6000 may have an outer perimeter 6005 which is slightly larger than the opening at the bottom of the tubular side wall formed by panels A-E. Panel G may also have a fold line 6007 that generally follows but is spaced inwardly from perimeter 6005. Fold line 6007 and perimeter 6005 define an edge portion 6006 there between that may be folded at a fold line 6007 downwards and may have inwardly directed surface portion that provides contact with the inner wall portion of the tubular side wall formed by panels A-E.

[0269] A lower transversely extending edge region of the inner polyolefin layer, traversing panels A-E, may be pro-

vided with a cold seal adhesive band 6010, the cold seal adhesive band 6010 being applied to the inner polyolefin layer in the blank converting process as referenced above. Panel G may also include a band 6011 of the same cold seal adhesive that which may also be applied during the converting process such that it generally extends co-extensively with edge portion 6006 of panel G, and which may also extend inwardly a short distance beyond fold line 6007.

[0270] When panel G is folded upwards, the adhesive band 6011 made be brought into contact with the adhesive band 6010 at the lower edge region of the side wall formed from panels A-E. The corresponding edge regions carrying adhesive bands 6010 and 6011 may be compressed together by suitable mechanical devices thus triggering the bonding effect of the cold seal adhesive. Thus, panel G of blank 6000 may be engaged with lower edge portions of panels A-E to provide a continuous sealed connection between the side wall provided by panels A-E and bottom panel G. By using a cold seal adhesive to create the seal, the complexity associated with providing induction heating or other comparable heating to heat a material to a melting temperature in the specific desired areas, can be avoided.

[0271] A cold seal adhesive band 6015 along the free vertical edge of panel A and a cold seal adhesive band 6016 along the opposite free vertical edge of panel E may also be provided. Such cold seal adhesive bands 6015 and 6016 may be employed in conjunction with and attach to a vertical strip of sealing tape covering abutting vertical edges of panels A and E to provide a vertical butt seal.

[0272] With reference now to FIG. 33D, another paperboard can blank 7000 is illustrated which may be substantially identical to blanks 4000 and 6000 as discussed above. Blank 7000 may be formed in substantially the same shape as blanks 4000 and 6000 and may be constructed in substantially the same manner using substantially the same materials as blank 4000. Blank 7000 may also include a polyolefin inner layer. However, applied to the inner polyolefin inner layer during the forming of the paperboard may be a hot melt type adhesive material. Alternatively the hot melt type adhesive may be applied to a lower area/thin band of the blank 7000 which does not include a polyolefin layer or the metallic foil layer such that the hot melt adhesive is applied to the paperboard material.

[0273] The hot melt adhesive may be applied to the flat blank 7000 while the blank is in a flattened state, such as while it is being held in a magazine. Such hot melt adhesive materials are known and may be capable to adhering to other surfaces such as the edge perimeter region 7006 of panel G.

[0274] Like panel G in blanks 4000, 5000 and 6000, panel G of blank 7000 may have an outer perimeter 7005 which is slightly larger than the opening at the bottom of the tubular side wall formed by panels A-E. Panel G may also have a fold line 7007 that generally follows but is spaced inwardly from perimeter 7005. Fold line 7007 and perimeter 7005 define an edge portion 7006 that may be folded at a fold line 7007 downwards and may have inwardly directed surface portion that provides contact with the inner wall portion of the tubular side wall formed by panels A-E. A lower transverse edge region traversing panels A-E may be provided with a hot melt adhesive band 7010, the hot melt adhesive being as referenced above. Hot melt adhesive band 7010 may be applied to the lower edge portion of panel A-E while the blank is held in a blank magazine as discussed below.

[0275] When panel G is folded upwards, adhesive band 6010 at the lower edge region of the side wall formed from panels A-E may engage with the facing surface of edge portion 7006 which is bent downward at fold line 7007. Compression may be applied to push together the portion of the tubular side wall carrying the adhesive band 6010 with the interfacing surface of edge portion 7006 of panel G. Thus, panel G may be engaged with lower edge portions of panels A-E to provide a continuous sealed connection between the side wall provided by panels A-E and bottom panel G.

[0276] With reference now to FIG. 34, an example sequence of steps 3000(1) to 3000(7) are shown of folding and sealing a blank 3000 to form an open top paperboard can that is suitable for top loading of items and thereafter closing with a top component (not shown).

[0277] A plurality of case blanks 3000 may be presented 3000(1) in a vertically stacked arrangement with the blanks each configured in a generally flat and planar configuration. A particular individual case blank 3000 may be identified at/selected from the front of the stack of blanks for processing 3000(2). In a first folding step 3000(3), while first portion of blank 3000 (panel C) remains in the initial orientation, side wall panel B along with its connected minor panel A (a second portion of blank 3000) can be rotated together from the orientation shown at 3000(2), 90 degrees in a clockwise direction about the vertically oriented fold line between side wall panels B and C, to the configuration as shown at 3000(3). Also, optionally at substantially the same time as panels A and B are rotated 90 degrees, side wall panel D along with its connected minor panel E (a third portion) can be rotated together from the orientation shown at 3000(2), 90 degrees in a counter-clockwise direction about the vertically oriented fold line between side wall panels D and C, to the configuration as shown at 3000(3).

[0278] In the next folding step 3000(4), minor side wall panel A (a part of the second portion) is rotated clockwise 90 degrees about the vertically oriented fold line between side wall panels A and B, to the configuration shown at 3000(4). Also, optionally at substantially the same time as panel A is being rotated 90 degrees relative to panel B, side wall panel E (a part of the third portion) is rotated from the orientation shown at 3000(3), 90 degrees in a counter-clockwise direction about the vertically oriented fold line between side wall panels D and E, to the configuration as shown at 3000(3). At the configuration shown at 3000(4) panels A and E have their vertical longitudinal edges in abutment with each other such that a substantially flat continuous outer surface 3000a is formed across panels A and E.

[0279] In the next step 3000(5), the abutting edges of panels A and E are sealed together such as by a strip of sealing tape 3001 that may be activated by an induction sealing device (not shown) which may heat the inner polyolefin layer material of the blank 3000 causing the polyolefin layer at the abutting vertical longitudinal edge regions of panels A and E to heat up and be bonded to the longitudinal strip of sealing tape 3001.

[0280] In the next step 3000(6), blank 3000 having been formed into a generally tubular side wall shape, that may now be generally square in top view, may be moved/translated (eg. vertically downwards or upwards) to a bottom forming station.

[0281] At step 3000(6) a bottom cup 3003 which may have been delivered to the bottom forming station, may be

moved upwards into the bottom opening formed by tubular side wall of panels A-E. Bottom cup 3003 may be made from any suitable material or combination of materials. It may have a top layer surface material that is compatible for bonding with the inner layer of tubular side wall of panels A-E. The outer perimeter of cup 3003 may be slightly larger than the opening at the bottom of the tubular side wall formed by panels A-E. Thus, when cup 3003 is pushed into the opening, an edge perimeter portion of cup 3003 may be folded downwards and may have inwardly directed surface that provide contact with a lower inner wall surface portion of tubular side wall formed from panels A-E. There will thus be surface to surface contact between lower edge surface portion of the inner polyolefin layer of the side wall and the surface of the cup 3003, at the edges thereof. These interfacing surfaces can then be heat activated by for example induction heating to heat the metal foil layer in the bottom region of the side wall, to melt the corresponding inner polyolefin layer and thereby form a seal which may have a high degree of integrity and seal against gases and liquids.

[0282] After the bottom portion of blank 3000 has been formed at step 3000(6), blank 3000 may be moved away to another location, and may be subsequently filled with one or more items/other cases and thereafter a top component may be inserted into the top opening of tubular side wall of panels A-E, to close and seal the completed paperboard can.

[0283] With reference now to FIG. 35, an example sequence of steps 4000(1) to 1000(10) are shown of folding and sealing a flat blank 4000 to form an alternate open top paperboard can that is suitable for top loading of items.

[0284] A plurality of case blanks 4000 (as described above) may be presented 4000(1) in a vertically stacked arrangement with the blanks each configured in a generally flat and planar configuration. A particular individual case blank 4000 may be identified at/selected from the front of the stack of blanks for processing 4000(2). In a first folding step 4000(3) side wall panel B along with its connected minor panel A can be rotated together from the orientation shown at 4000(2), 90 degrees in a clockwise direction about the vertically oriented fold line between side wall panels B and C, to the configuration as shown at 4000(3). Also, optionally at substantially the same time as panels A and B are rotated 90 degrees, side wall panel D along with its connected minor panel E can be rotated together from the orientation shown at 4000(2), 90 degrees in a counter-clockwise direction about the vertically oriented fold line between side wall panels D and C, to the configuration as shown at 4000(3).

[0285] In the next folding step 4000(4), minor side wall panel A is rotated clockwise 90 degrees about the vertically oriented fold line between side wall panels A and B, to the configuration shown at 4000(4). Also, optionally at substantially the same time as panel A is rotated 90 degrees relative to panel B, side wall panel E is rotated together from the orientation shown at 4000(3), 90 degrees in a counter-clockwise direction about the vertically oriented fold line between side wall panels D and E, to the configuration as shown at 4000(3). At the configuration shown at 4000(4) panels A and E have their vertical longitudinal edges in abutment with each other such that a substantially flat outer surface 4000a is formed across panels A and E.

[0286] In the next step 4000(5), the abutting edges of panels A and E are sealed together such as by a strip of sealing tape 4001 that may be activated by an induction

sealing apparatus (not shown) which may heat the inner polyolefin layer material of the blank **4000** in the vicinity of the vertical longitudinal edges of panels A and E, causing the polyolefin layer at the abutting longitudinal edge regions of panels A and E to heat up and bond to the longitudinal strip of sealing tape **4001**.

[**0287**] In the next step **4000(6)**, blank **4000** having been formed into a generally tubular shape, that may now be generally square or rectangular in top view, may be moved/translated (eg. vertically downwards or upwards) to a bottom forming station.

[**0288**] From steps **4000(7)** to step **4000(8)** to step **4000(9)**, tubular shaped blank **4000** may start to undergo folding upwards of bottom panel G about the fold line with panel C, as it is folded upwards (eg. by a suitable folding apparatus) to an orientation perpendicular to the tubular side wall, and into the opening at the bottom the tubular side wall, formed by panels A to E. As referenced above, the outer perimeter **4005** of panel G may be slightly larger than the opening at the bottom of the tubular side wall formed by panels A-E. Thus, when panel G is pushed into the opening, the edge portion **4006** may be folded at fold line **4007** downwards and may have inwardly directed surface portion that provides contact with the lower inner wall portion of the tubular side wall formed by panels A-E. There will thus be surface to surface contact between lower edge region of the inner polyolefin layer of the side wall and the bottom panel G at the inner polyolefin layer of the edge portion **4006** thereof. These interfacing polyolefin surfaces can then be heat activated by for example induction heating in the vicinity of the interfacing surfaces to heat the metal foil layer therein, to melt the inner layer, to thereby form a continuous seal between the tubular side wall and bottom panel G, which may have a high degree of integrity and seal against both gases and liquids.

[**0289**] Optionally, (and not shown in FIG. **34**) a further protective bottom cup or plug portion made from a strong hard plastic material may be vertically inserted into the shallow opening remaining below panel G in side wall formed by panels A-E or may be secured around the bottom edge of the tubular side wall and may be secured by for example adhesive.

[**0290**] After the bottom portion of blank **4000** has been formed at step **4000(9)**, blank **4000** may be moved away to another location, and may be subsequently filled with one or more items/other cases and thereafter a top component may be inserted into the top opening of tubular side wall of panels A-E, to close and seal the completed paperboard can.

[**0291**] The example sequence of steps **4000(1)** to **4000(9)** described above of folding and sealing a flat blank **4000** to form an open top paperboard can also be used on blank **5000** to form open top paperboard can. However, after the bottom portion of blank **5000** has been formed at step **4000(9)**, blank **5000** may be moved away to another location, and may be subsequently filled with one or more items/other cases. Thereafter top panel F may be folded 90 degrees at the fold line with panel C (by a suitable folding apparatus) and inserted into the top opening of tubular side wall of panels A-E. As referenced above, the outer perimeter of panel F may be slightly larger than the opening at the top of the tubular side wall formed by panels A-E.

[**0292**] Thus, when panel F is pushed into the top opening, the edge portion **5026** may be folded upwards and may have inwardly directed polyolefin surface that provides contact

with the upper edge portion of the inner surface of tubular side wall. There will thus be surface to surface contact between the inner polyolefin layer of the tubular side wall and polyolefin layer of the edge portion of the top panel F, along the interfacing edges thereof. These interfacing surfaces can then be heat activated by for example induction heating to form a seal which may have a high degree of integrity and seal against both gases and liquids.

[**0293**] Blanks **6000** and **7000** may also be formed by a similar process to that depicted in FIG. **35**, to form a tubular side wall structure with a closed and sealed blank.

[**0294**] The initial steps **4000(1)** to **4000(9)** may be the same, however, the steps to seal the bottom panel G to the tubular side wall may be varied to the extent that a cold seal adhesive is used to provide the bottom seal for blank **6000** and a hot melt adhesive is used to provide the bottom seal for blank **7000**, as referenced above.

[**0295**] With reference now to FIGS. **36-50**, in overview, a can forming system **300** may include a magazine **310** that may be adapted to hold a plurality of can blanks such as paperboard can blanks **3000** in a substantially flat vertical orientation such as is shown in FIGS. **36** and **37**. Magazine **310** may be configured to selectively release in series single blanks **3000** from the front of the stack of plurality of blanks. In alternate embodiments, magazine **310** may be configured to hold in such an orientation and selectively release differently configured blanks such as blanks **4000**, **5000**, **6000** and/or **7000**.

[**0296**] With particular reference to FIGS. **36** and **37**, system **300** may also include a blank support apparatus (also referred to herein as a mandrel apparatus) **320** and a panel rotating sub-system **334**. Panel rotating sub-system **334** may be configured to engage a blank **3000** on at least two transversely spaced apart outward facing panel surfaces of the blank as the blank is held in the magazine **310** and rotate panels of the blank **3000** around a blank support device (referred to herein as a mandrel) **337** of blank support apparatus **320** in such a manner that the blank panel surfaces that are engaged by panel rotating sub-system **334** become inner surfaces of the side wall for a tubular shaped paperboard can **3000'** (see FIG. **50**).

[**0297**] Panel rotating sub-system **334** may utilize at least two panel rotating apparatuses in order to engage with surfaces of a plurality of panels of a blank **3000** as the blank is held in a generally flat configuration the magazine **310** and rotate those panels (and possibly certain other panels of the same blank **3000** interconnected thereto), relative to each other and relative to one or more other panels which may be initially retained in magazine **310** in the initial position and orientation. For example, panel rotating apparatus **334** may include a first panel rotating apparatus **324a** and a second panel rotating apparatus **324b**. Panel rotating apparatus **324a** may be configured and operable to engage with a facing surface of panel D of a blank **3000** held in magazine **310**. Panel rotating apparatus **324b** may be configured and operable to engage with a facing surface of a panel B of a blank held in magazine **310**.

[**0298**] Panel rotating sub-system **334** may also include a third panel rotating apparatus **330**, and a fourth panel rotating apparatus **331** (see FIGS. **36**, **36A-C** and **37**) as described further below. Third panel rotating apparatus **330** may be operable to rotate panel E, 90 degrees in a counter-clockwise direction relative to panel D about the fold line between panels D and E. Similarly, fourth panel rotating

apparatus **331** may be operable to rotate panel A, 90 degrees in a clockwise direction relative to panel B about the fold line between panels A and B.

[0299] Can forming system **300** may also include a support frame **340** and a vertical mandrel movement apparatus **336** (designated generally in FIGS. **36A** and **36B**).

[0300] The operation of the components of carton forming system **300** may be controlled by a controller such as a programmable logic controller (“PLC”) **332** which may be configured generally like PLC **132** described above. PLC **332** may be in communication with and control all the components/sub-systems of system **300**, in a manner such as is generally depicted schematically in FIG. **51** and may also control other components/sub-systems associated therewith. PLC **332** may also include a Human-Machine-Interface (HMI) such as the Allen Bradley Panelview **700** plus colour touch screen graphic workstation so that the operation of system **300** can be monitored, started, operated, controlled, stopped, modified for different blank configurations, by an operator using a touch screen panel.

[0301] Generally vertically oriented support frame **340** may support mandrel movement apparatus **336** to provide for vertical reciprocating upwards and downwards movement of mandrel **337**. It should be noted that although system **300** is shown in the Figures as being generally oriented for vertical movement of the mandrel movement apparatus **336**, alternative orientations can be utilized in other embodiments.

[0302] Mandrel movement apparatus **336** may include a generally vertically oriented linear rail **342** (FIGS. **36A**, **36B**). Linear rail **342** may support a carriage block **344** for sliding upward and downward sliding vertical movement relative to support frame **340** (FIGS. **36**, **36A**, **36B** and **39**). It should be noted that in some of the Figures depicting system **300**, for simplicity or clarity, support frame **340** and linear rail **342**, and/or some other components, have been omitted.

[0303] In a manner similar to system **100** as described above, the movement of carriage block **344** on linear rail **342** may be driven by a continuous drive belt **343** interconnected to carriage block **344**, supported on vertical support frame **340**. Drive belt **343** may be interconnected to, and driven by, a drive wheel **345a** of servo drive motor **345**, which may be mounted at an upper end portion of vertical support frame **340**. An encoder (not shown) may be associated with servo drive motor **345** and the encoder and servo drive motor may be in communication with PLC **332**. In this way, PLC **332** on receiving signals from the encoder may be able to monitor and control the vertical position of carriage block **344** (and the components interconnected thereto) by appropriately controlling and operating servo drive motor **345**.

[0304] Carriage block **344** may support and be rigidly connected to a carriage support arm **346** (FIGS. **36A-C**, **38** and **39**) that may be generally oriented horizontally and longitudinally. The outer end of carriage support arm **346** may be rigidly connected to a mandrel support apparatus generally designated **348** (FIG. **37**). Mandrel support apparatus **348** may generally support a mandrel **337** (FIGS. **36** and **44**).

[0305] Magazine **310** may be configured to hold a plurality of case blanks **3000** in a stacked, vertically and transversely oriented, flat configuration on their bottom edges. Many different types and/or constructions of a suitable magazine **310** might be employed in system **300**. Magazine

310 may be configured to hold a plurality of case blanks **3000** that may be held in a longitudinally extending, stacked arrangement. Magazine **310** may be adapted to present an outward facing surface of a plurality of case blanks **3000**, individually in turn. Magazine **310** may comprise a large number of case blanks **3000** held in a generally vertically and transversely oriented, longitudinally extending, case blank stack by side walls. In this configuration where case blanks **3000** are individually and selectively retrieved in series from the front of a stack of generally flat blanks, the stack of case blanks **3000** in the magazine can be moved forward by a longitudinally oriented conveyor which may be constructed like the conveyor system in the magazine of system **100**, as described above.

[0306] The purpose of moving the stack of blanks **3000** forward is so that the facing surface of panel C of the most forward case blank **3000** in the stack is positioned and held close to or against an outer generally adjacent surface of a transverse and vertical side wall **321a** of mandrel **337** (FIG. **36**). This enables first panel rotating apparatus **324a** and second panel rotating apparatus **324b** to be able to engage other exposed facing surfaces of panels D and B respectively (FIGS. **36** and **37**) of the forward most case blank **3000** in the stack held in magazine **110**, as described further hereinafter. Additionally, a back pressure device (not shown) may be provided that can apply a back pressure against the case blank stack in a longitudinal direction toward the front of the magazine, of a magnitude and direction sufficient to keep the stack upright and prevent it from falling longitudinally backwards as the case blank stack on conveyors is indexed longitudinally forward to maintain the next case blank **3000** at the front of the stack securely in a pick-up position.

[0307] Magazine **310** may be constructed and operate in manner similar to magazine **110** as described above. In overview, magazine **310** may have a magazine frame generally designated **327** (FIGS. **36**, **36A** and **36B**). Magazine **310** may include a conveyor system to move flat case blanks **3000** sequentially to a pick-up position. A wide variety of conveyor systems or other case blank movement systems may be employed. By way of example, conveyor system may include a conveyor **313** (FIG. **36A**) mounted to frame **327**, and having a generally horizontal floor plate **315**. Conveyor **313** may be operated to move longitudinally together to move case blanks **3000** in a stack of blanks forward in the magazine, while being maintained in a generally transverse and vertical orientation.

[0308] A motor such as a DC motor in communication with PLC may be inter connected to conveyor belts **312** of conveyor **313** to intermittently move a stack of blanks **3000** forward such that a front positioned blank in the stack is continuously available in a pick-up position.

[0309] The stack of case blanks **3000** may be supported at vertically oriented side edges by longitudinally and vertically oriented side wall plates **314a**, **314b** that may be spaced apart from each other and oriented generally parallel to each other. One or both of side wall plates **314a**, **314b** may be mounted on transversely oriented and movable rods that are supported on magazine frame **327**. Actuation of rods may be made by any suitable mechanism such as by way of example only, servo drive motors with appropriate drive shafts and gear mechanisms or a hand operated gear and crank shaft mechanism. Side wall plates **314a**, **314b** serve to guide the case blanks **3000** within magazine **310** and can be

accurately adjusted to be in close proximity to or contact with the particular case blank size that is being handled at a particular time. This adjustability of the relative transverse spacing of side walls **314a**, **314b** allows for case blanks of different widths to be held in magazine **310** for processing as described herein. Other modifications to magazine **310** may be provided to accommodate blanks of different configurations such as the configurations of blanks **4000**, **5000**, **6000** or **7000**. For example, panels E/D may be supported on one side of the blank by one conveyor belt and panels A/B may be supported on an opposite transverse side by another second conveyor belt running in parallel to the first conveyor belt. The first and second conveyor belts may be transversely spaced apart to provide a longitudinal opening to permit the lower panels G to move with the remainder of the blanks.

[0310] Selected panels of the forward most blank **3000** may be pulled away from holding clips (not shown) associated with magazine **310** by first panel rotating apparatus **324a** and second panel rotating apparatus **324b**, from retention by magazine **310**, then rotated (wrapped) at least partially around mandrel **337**. As case blanks **3000** are taken from magazine **310** and formed, PLC may cause the conveyor of magazine **310** to move the entire stack forward sequentially so that the most forward case blank **3000** has its the outward facing surface of major panel C positioned against or very close to adjacent outer rear vertically and transversely oriented surface of mandrel **337**. A sensor (not shown) in communication PLC **332** may be provided to monitor the level of case blanks **3000** in magazine **310** during operation of can forming system **310**. Magazine **310** can be loaded with additional flat case blanks **3000** at the rear of the magazine.

[0311] Electronic sensors (not shown) in communication with PLC **332** may be positioned to monitor the stack of blanks and ensure that a blank **3000** at the front of the stack of blanks is properly positioned at the pick-up position.

[0312] Clip mechanisms similar to those clip mechanisms **111a-111** described above in system **100**, including clip mechanisms **311a** (FIG. **36**) and **311d** (FIGS. **36A** and **36B**) may be provided to releasably hold each case blank **3000** that is at the front of the stack within magazine **310**, and thus hold the stack in place. When first panel rotating mechanism **324a** and second panel rotating mechanism **324b** selectively engage panels D and B respectively, as described hereinafter, clip mechanisms allow for the engaged and interconnected panels D/E and A/B of the front blank **3000** in the stack to be pulled away from the same corresponding panels on the blank immediately behind the front blank in the stack held in the magazine. Also, clip mechanisms will hold panel C in magazine **310** while the panels D/E and A/B are being wrapped around the mandrel **337**, but will then allow for the release of panel C to allow the remaining portion of case blank **3000** to be removed from being held by magazine **310** and move vertically downward once the case blank **3000** and mandrel **337** to which it is secured moves vertically downwards, as described further hereinafter.

[0313] First and second panel rotating apparatuses **324a**, **324b** may be one of numerous types of robotic systems but may alternatively be a simple servo driven motors controlled by PLC **332** which includes a generally vertically oriented drive shaft with rotatable members attached thereto. First and second panel rotating apparatuses **324a**, **324b** may be

capable of intermittent motion to rotate the rotatable members. The rotatable members may carry panel engagement devices.

[0314] With particular reference to FIGS. **36**, **36A-C**, **37** and **39**, first panel rotating apparatus **324a** may be laterally spaced apart from second panel rotating apparatus **324b** and both may be mounted to a fixed, transversely oriented support member **356**. Robot support member **356** may be fixedly supported at opposed ends by, and at first ends of, a pair of transversely spaced, longitudinally oriented robot support member **358a**, **358b**. The opposite ends of transversely spaced, longitudinally oriented robot support members **358a**, **358b** may be fixedly mounted to vertical support frame **340**.

[0315] With particular reference to FIG. **36C**, a transversely oriented linear rail **397** may be mounted to transverse support member **356** that is connected to longitudinal space support members **358a**, **358b** and which forms part of support frame **340**. Linear rail **397** may engage with rotary bearings provided on complimentary surfaces of first panel rotating apparatuses **324a**, **324b**. Thus panel rotating apparatuses **324a**, **324b** may be operable for sliding movement along linear rail **397** so that a desired transverse position in relation to blanks **3000** held in magazine **327** can be selected. A transversely extending scale **371** on the top of support member **356** can be useful in moving the rotating apparatuses to the appropriate transverse positions on linear rail **397** that allows for the sequence of operations described hereinafter.

[0316] First panel rotating apparatus **324a** may include a support frame **376a** which may carry the linear bearings which provide for attachment to and sliding movement relative to linear rail **397**. Similarly, second panel rotating apparatus **324b** may include a support frame **376b** which may carry the linear bearings which provide for sliding attachment to linear rail **397**.

[0317] First panel rotating apparatus **324a** may include a rotational drive unit **360a** (FIG. **39**) that may be supported on support frame **376a**. Extending from a lower end of rotational drive unit **360a** is a rotational drive that may comprise a drive shaft that is operable for rotation clockwise and anti-clockwise about a first vertical axis of rotation. The drive shaft and its axis of rotation, may be aligned transversely and longitudinally with, and may be positioned above, an inward corner of mandrel **337**. The drive shaft of rotational drive unit **360a** may be operably connected to a first end portion (FIGS. **38** and **41**) of a first articulating arm **362a**. Thus, when rotational drive unit **360a**, under the control of PLC, causes the drive shaft of rotational drive unit **360a** to rotate, first articulating arm **362a** is able to pivot clockwise or anti-clockwise relative to the drive shaft about a vertical axis, depending upon the direction of rotation of the drive shaft.

[0318] Mounted to the opposite end of articulating arm **362a** of first rotational drive **364a** is a vertically oriented end effector rod **366a** (FIG. **41**) formed in a generally tubular cylinder and having one or more suction cups **368a**.

[0319] Air suction cups **368a** may be interconnected through hoses passing through cavities in end effector **366a**, articulating arm **362a** and rotational drive **360a** to a source of vacuum by providing for an air channel through the aforesaid components. The supply of vacuum to suction cups **368a** may be provided by a pressurized air distribution unit generally designated **427** (see FIG. **51**). Air distribution

unit **427** may include a plurality of valves that may be operated by PLC **332** and may also include local vacuum generator apparatuses that may be in close proximity to, or integrated as part of, suction cups **368a**. In other embodiments, a vacuum pump mounted externally may generate vacuum externally and then vacuum can be supplied through the aforementioned air channels. If local vacuum generators are utilized, pressurized air may be delivered from an external source through air distribution unit **427** to the vacuum generators. The local vacuum generators may then convert the pressurized air to vacuum that can then be delivered to suction cups **368a**.

[0320] The air suction force that may be developed at the outer surfaces of suction cups **368a** will be sufficient so that when activated by PLC they can engage and hold panel D, and rotate panel D (along with panel E) of a case blank **3000** from (i) the position shown in FIG. **36** to (ii) the position shown in FIG. **38**, and then (iii) after releasing a first engaged blank **3000**, eventually return to the position shown in FIG. **36** to engage a panel D of the next case blank **3000** positioned at the pick-up position in magazine **310**. The vacuum generated at suction cups **368a** can be activated and de-activated by PLC through operation of air distribution unit **427**.

[0321] Second panel rotating apparatus **324b** may be constructed and configured in generally the same manner as first panel rotating apparatus **324a**. Second panel rotating apparatus **324b** may operate in opposite rotational directions to first panel rotating apparatus **324a**, when engaging and rotating other panels of blank **3000** than the panels engaged and rotated by first panel rotating apparatus **324a**.

[0322] Second panel rotating apparatus **324b** may include a rotational drive unit **360b** (FIG. **39**) that may be supported on support frame **376b**. Extending from a lower end of rotational drive unit **360b** is a rotational drive that may comprise a drive shaft that is operable for rotation clockwise and anti-clockwise about a vertical axis of rotation. The drive shaft and its axis of rotation, may be aligned transversely and longitudinally with, and may be positioned above, an inward corner of mandrel **337**, that inward corner being transversely opposite to the corner which the drive shaft of first panel rotating apparatus **324a** is positioned.

[0323] Extending from an opposite lower end of first rotation drive unit **360b** is a second rotational drive (that may comprise a drive shaft that is not visible) that is operable for rotation clockwise and anti-clockwise about a second vertical axis of rotation. The drive shaft of second rotational drive unit **360b** is operably connected to a first end portion (FIGS. **38** and **41**) of a corresponding articulating arm **362b** (FIG. **40**). Thus, when rotational drive unit **360b**, under the control of PLC **332**, causes the drive shaft of second rotational drive unit **360b** to rotate, articulating arm **362b** is able to pivot clockwise or anti-clockwise relative to the drive shaft about a vertical axis, depending upon the direction of rotation of the drive shaft.

[0324] Mounted to the opposite end of articulating arm **362b** of rotational drive **364b** is a vertically oriented end effector rod **366b** (FIG. **41**) formed in a generally tubular cylinder and having one or more suction cups **368b**.

[0325] Air suction cups **368b** may, like air suction cups **368a**, be interconnected through hoses passing through cavities in end effector **366b**, articulating arm **362b** and rotational drive **360b** to a source of vacuum by providing for an air channel through the aforesaid components. The supply

of vacuum to suction cups **368b** may also be provided by pressurized air distribution unit **427**. Air distribution unit **427** may include a plurality of valves that may be operated by PLC **332** and may also include local vacuum generator apparatuses that may be in close proximity to, or integrated as part of, suction cups **368b**. In other embodiments, a vacuum pump mounted externally may generate vacuum externally and then vacuum can be supplied through the aforementioned air channels. If local vacuum generators are utilized, pressurized air may be delivered from an external source through air distribution unit **427** to the vacuum generators. The local vacuum generators may then convert the pressurized air to vacuum that can then be delivered to suction cups **368b**.

[0326] The air suction force that may be developed at the outer surfaces of suction cups **368b** will be sufficient so that when activated they can engage and hold panel B, and rotate panel B (along with panel A) of a case blank **3000** from (i) the position shown in FIG. **36** to (ii) the position shown in FIG. **38**, and then (iii) after releasing a first engaged blank **3000**, eventually return to the position shown in FIG. **36** to engage the next case blank **3000** positioned at the pick-up position in magazine **310**. The vacuum generated at suction cups **368b**, like suction cups **368a**, can be activated and de-activated by PLC through operation of air distribution unit **427**.

[0327] First rotating apparatus **324a** and second rotating apparatus **324b**, may be configured to be readily adjustable for different types/configurations of mandrel apparatuses **320**, including mandrels **337**, for forming different types/configurations of blanks such as blanks **3000** into tubular side wall of paperboard cans, by suitable programming of PLC appropriately to provide for appropriate movements of the suction cups **368a**, **368b**, through movement of the first and second rotational drives **360a**, **360b** respectively and by adjustment of first and second rotating apparatuses **324a**, **324b** on linear rail **397**. For example the articulating arms **362a**, **362b** may be interchanged to provide for arms of different lengths. Thus by an interchange of mandrel **337** to provide for alternate configurations of the mandrel side wall, PLC **332** and its operation of first rotating apparatus **324a** and second rotating apparatus **324b**, may be appropriately modified and programmed and thus different sized and configurations of blanks may be processed.

[0328] Mandrel apparatus **320** may have several components including mandrel **337** (FIG. **36**) and mandrel support apparatus generally designated **348** (FIG. **39**). Mandrel **337** may be easily removable from fixed connection to mandrel support apparatus **348**, so that a mandrel of one configuration may be easily replaced with a mandrel of another configuration.

[0329] With particular reference to FIGS. **36** and **37**, mandrel **337** may comprise a pair of opposed, generally rectangular or square, spaced, vertically and transversely oriented, spaced, side walls **321a**, **321b** fixedly interconnected or integrally formed, with a pair of opposed, generally rectangular or square, spaced, vertically and longitudinally oriented, spaced, side walls **322a**, **322b**. Side walls **121a**, **121b**, **122**, **122b** may be connected/integrally formed to provide a generally cuboid, open top and bottom, square box shape. Alternate, substitutable mandrels **337** may be generally configured in a variety of different sizes and shapes, each selected for the particular type of case blank **3000** to be formed into a paperboard can.

[0330] The dimensions of the outer surfaces of mandrel 337 may be selected so that the specific can blank 3000 that it is desired to fold has, during the forming process, vertical fold lines that are located substantially at or along the four corner vertical side edges of mandrel 337. Such a selection may improve the performance of can forming system 300 in creating a formed can that is ready for loading with items. Mandrel 337, and surrounding components in system 300, may be configured to permit for the easy interchange of mandrels 337 so that can forming system 300 can be readily adapted to forming differently sized/shaped cases from differently configured case blanks 3000.

[0331] With reference to FIG. 36, left side mandrel side wall 322a may be provided with a vertical slot 323a that may be configured to permit a lower portion of end effector 366a and suction cups 368a thereon to move from the position shown in FIG. 36 to pass through slot 323a to the position shown in FIGS. 38 and 39. By allowing the end effector 366a to pass through vertical slot 323a, end effector 366a, and in particular suction cups 368a, may engage the outer surface of the panel D of blank 3000 when it is held in magazine 310 and bring panel D into face to face relation with the outward facing surface of mandrel side wall 322a. The surface of panel D being held by suction cups 368a becomes an inner surface of the tubular shaped blank and side panel D may be held substantially flat against the outside surface of side wall 322a of mandrel 337, as shown.

[0332] Similarly, with reference to FIG. 36C, the transversely opposite, right side mandrel side wall 322b may be provided with a similar vertical slot 323b that may be configured to permit a lower portion of end effector 366b, and suction cups 368b thereon, to move from the position shown in FIG. 37 to pass through slot 323b to the position shown in FIG. 38. By allowing the end effector 366b to pass through vertical slot 323b, end effector 366b, and in particular suction cups 368b, may engage the outer surface of the side panel B of blank 3000 when it is held in magazine 310 and bring panel B into face to face relation with the outward facing surface of side wall 322b. The surface of panel B being held by suction cups 368b becomes an inner surface of the tubular shaped blank and side panel B may be held substantially flat against the outside surface of major side wall 322b of mandrel 337, as shown.

[0333] Mandrel 337 may have one or more laterally extending tabs 370 (FIGS. 36 and 36C) at the upper perimeter edge. This ensures that when the mandrel 337 moves vertically downward with a blank 3000 wrapped around it and formed into a tube, the upper edge of the tubular shaped blank with its side wall formed from panels A-E will move vertically downwards with mandrel 337 as the edge of the side wall engages the downward facing surfaces of the tabs 370 such that the tabs 370 exert a downward force on the upper edge of the tubular side wall.

[0334] Mandrel side walls 321a, 321b, may be configured to facilitate the support of mandrel 337 on mandrel support apparatus 348. In particular vertical side support members 350a, 350b (FIGS. 39, 40 and 48) may be connected to a generally U-shaped support frame with side members 349a, 349b which may be supported at, and fixedly connected to, an outer end of carriage support arm 346. Support arm 349a may have secured to a distal end thereof vertical attachment member 350a. Similarly, support arm 349b may have secured to a distal end thereof vertical attachment member 350b (FIGS. 39, 47 and 48). Mandrel 337 may be connected

to lower portions of vertical side support members 350a, 350b with releasable nuts/bolts to permit relatively easy interchange of differently sized/configured mandrels that are suitable for processing differently sized/configured blanks.

[0335] With reference to FIGS. 39 and 48, as noted above, mandrel support apparatus 368 is fixedly attached of a first end portion of longitudinally oriented and extending carriage arm 346. The opposite end portion of longitudinally oriented and extending carriage arm 346 is fixedly connected to carriage block 344. Carriage block 344 is attached for sliding vertical upward and downward movement on vertically oriented linear rail 342. Linear rail 342 may for example be a linear rail device of many types made for example by Bosch Rexroth AG and provides a vertical movement apparatus 336 for mandrel 337 and the mandrel supporting apparatus 368.

[0336] Linear rail 342 may be mounted to vertical support frame 340. As indicated above, linear rail 342 may have a carriage drive mechanism which is operable under the control of PLC to move the carriage 344 and thus also mandrel 337 vertically upwards and downwards within a range of movement as required for completing the can forming operations described herein.

[0337] It will also be appreciated that in first panel rotation apparatus 324a and second panel rotating apparatus 324b, suction cups 368a, 368b respectively are used to apply a force to engage and move panels of a blank 3000. However alternative engagement mechanisms to suction cups could be employed in other embodiments to engage and rotate panels of blanks 3000.

[0338] The next components of system 300 to be described in detail are third panel rotating apparatus 330 and fourth panel rotating apparatus 331 (see FIGS. 36 and 37) which are respectively configured to cause panels E and A to be folded 90 degrees relative to panels D and B respectively about their corresponding panel fold lines to complete the wrapping of the panels A-E around the outward facing surfaces of mandrel 337 to form a generally square tubular shape as shown in FIGS. 40 and 41.

[0339] Third panel rotating apparatus 330 is operable to rotate panel E counter clockwise 90 degrees about the fold line with panel D. Fourth panel rotating apparatus 331 is operable to rotate panel A clockwise 90 degrees about the fold line with panel B. When panels A and E are so rotated, the vertical longitudinal side edges of the panels come into abutment with each other. Between the inner surface of the panels A and E (when they are rotated relative to panels B and D respectively, and have their vertical edges in abutment with each other) and the outward facing surface of side wall 321a of mandrel 337, is provided a strip portion 494 of sealing tape 499 (see FIGS. 36, 36C and 37). In some embodiments, sealing tape 499 may for example be a metalized foil ribbon material such as the same material that is used in the intermediate metallic foil layer in the blank. Sealing tape may be in some embodiments be the same or a similar material to that used in the inner layer of the blank such as a polyolefin layer which will bond to the polyolefin layer on the inner surface of the blank when appropriately heated, or it may be a material comprising a combination of these two materials from the blank, with the polyolefin layer of the sealing tape being in face to face relation with the polyolefin layer of the tubular blank at the abutting edges of

the panels A/E of the blank. In other embodiments, a plastic type material bearing a cold seal adhesive may be employed for the sealing tape.

[0340] Sealing tape 499 may be wound around and delivered from a reel/spool 498 which feeds sealing tape 499 over wheels 497 and 496 to a sealing tape support bracket device 495. Bracket device 495 may be mounted to transverse support member 356 and may include a vertically oriented guide channel which allows for sealing tape 499 to be delivered to provide a strip portion 494 to be positioned and held in vertical orientation on the outward facing surface of side wall 321a of mandrel 337 opposite and spanning the abutting vertical edges of panels A and E.

[0341] Third panel rotating apparatus 330 and fourth panel rotating apparatus 331 may each include a respective transversely oriented plough device, 410a, 410b, each having a plough plate that may be moved transversely in intermittent, reciprocating transverse movement outwards and inwards a desired amount by corresponding actuating double acting pneumatic cylinders 412a, 412b with movable piston arms that are connected to plough devices 410a, 410b. The transverse movement of plough devices 410a, 410b may be controlled by valves in air distribution unit 427 (not shown) that selectively deliver pressurized air through hoses (not shown) to respective double acting pneumatic cylinders 412a, 412b, under the control of PLC. The plough devices 410a, 410b may be configured such that the movement of plough plates of plough devices 410a, 410b may engage and push on panels E and A respectively causing rotating of panels E and A 90 degrees relative to panels D and B respectively about the corresponding panel fold lines.

[0342] System 300 may also include a sealing device 490 (FIGS. 36, 36C, 37, 38 and 41) which may also include a vertically oriented sealing jaw (aka sealing bar) 421 that may be moved longitudinally in intermittent, reciprocating movement by double acting pneumatic cylinder 422 with movable piston arm 423 (FIG. 40), within a desired range outwards and inwards. The transverse reciprocating intermittent movement of sealing jaw 421 may be controlled by valves (not shown) that selectively deliver pressurized air through hoses (not shown) to pneumatic cylinder 422 that may be supplied by pressurized air controlled by valves in air distribution unit 427, under the control of PLC 332. With reference to FIG. 40, when piston arm 423 is extended, sealing jaw 421 will be received into a vertical longitudinal gap between the extended vertical edges of plough devices 410a, 410b and be able to engage the abutting outward faces of the edges of panels A and E.

[0343] Heat can be applied to the polyolefin layer in the vertical edge portions of the abutting panels A and E and to the strip portion 494 which includes a metalized foil material, to thereby melt the polyolefin layer in the abutting edge regions. The melted polyolefin material will then bond to sealing strip 494 that is adjacent to and overlaps the vertical edges of abutting panels A and E. For example, heating may be provided sealing jaw 421 which may contain therein electrical heating elements (such as induction heating components that may be powered by electrical current supplied to sealing device 490.

[0344] Once strip portion 494 of sealing tape 499, that extends down the entire abutting joint, has bonded to panels A and E, the tubular sidewall shaped for a paperboard can has been formed. As the mandrel 337 is moved vertically downwards by mandrel movement apparatus 336, strip

portion 494 of the sealing strip 499 that has been bonded to the abutting vertical edge region of panels A/E will also be moved downwards with the mandrel 337 and the tubular shaped blank 3000. This downward movement will pull down an additional strip portion 494 of sealing tape 499 from reel 498 that will be retained in the guide in bracket device 495, and will be available to be used to seal the vertical abutting edges of panels A/E on the next blank 3000 that will be processed by can forming system 300.

[0345] When one sealing strip portion 494 attached to the vertical edge region of abutting panels A and E of a blank 3000 that has been already formed into a tubular shape on mandrel 337, has been moved down sufficiently to provide for the next sealing strip portion 494 to be appropriately positioned in guide device 495, a cutting device (not shown) will be employed to cut the sealing strip portion 494 that is attached to panels A/E of the tubular blank 3000 that has moved downward vertically, at the top vertical edges of abutting panels A and E, so that the sealing strip portion 494 that is attached to that tubular blank 3000 that has moved downward, is detached from the reel of sealing tape 499 being fed from reel 498.

[0346] The cutting device may be a scissor style cutting device and its operation may be controlled by PLC 332. The aforementioned components of third panel rotating apparatus 330, fourth panel rotating apparatus 331, and sealing device 490 may be mounted to frame members (not shown for simplicity) of support frame 340. In some embodiments, the horizontal longitudinal/transverse positions and possibly also their vertical positions may be adjustable on the frame to enable the components thereof to accommodate/substitute different sized/configured mandrel apparatuses 320 and corresponding different size and configuration of blanks. The adjustment may be made by hand and/or by servo motors operating moving support components under control of PLC 332.

[0347] Pneumatic cylinders 412a, 412b and 422 may each be a conventional double/two way acting pneumatic reciprocating cylinder with piston arms that are operable to move in a reciprocal movement between fully extended positions and fully retracted positions. Compressed air may be delivered to pneumatic cylinders 412a, 412b, 422, by hoses (not shown) in communication with a source of pressurized air through air distribution unit 427. To channel the compressed air appropriately, valves (not shown) in distribution unit 427 can be driven between open and closed positions by solenoids responsive to signals from PLC 332. The valves could be located proximate the pneumatic cylinders or be disposed elsewhere. Electrical communication lines carrying signals to and from PLC 332 could also be provided to operate the valves.

[0348] It should also be noted that during the downward vertical movement of a case blank 3000 secured to mandrel 337, one or more compression rails (not shown) supported on part of vertical support frame 140 may be configured and positioned to apply pressure to the panels A and E pushing against the outward surface of side wall 121a of mandrel 337, to ensure appropriate sealing of panels A and E to the sealing strip portion 494.

[0349] With particular reference now to FIGS. 36A and 43, a can discharge conveyor 3102 (for simplicity not shown in the other Figures) may be provided with a continuous conveyor belt 3105 driven in a conventional manner by a drive motor under control of PLC. Conveyor belt 3105 may

be configured with a top run to support and move open topped cans **3000'** formed from blanks **3000** by case forming system **300**. Can discharge conveyor **3102** may be supported on frame support leg components **340a**, **340b** (FIG. **36A**) which may be part of frame **340**.

[**0350**] With particular reference to FIG. **44**, a bottom cup delivery conveyor **3501** which may be under control of PLC **332** may be provided with a pair of spaced apart continuous conveyor belts **3502a**, **3502b** driven in a conventional manner by a drive motor **3504** with drive wheels **3505a**, **3505b**, under control of PLC and configured to support and deliver a plurality of bottom cups **3510** in series to a bottom forming station generally designated **3506**.

[**0351**] With reference to FIGS. **42-46**, at bottom forming station **3506** may also be horizontal support and forming plate **3509** having an opening **3509a** through which a bottom cup **3510** may be moved vertically upwards by a vertical lift mechanism **3507** under control of PLC **332** from cup delivery conveyor **3501** through opening **3509a**. Vertical lift mechanism **3507** may include a two way acting pneumatic cylinder **3509** with piston arm connected to a lift platform **3510**. Pneumatic cylinder **3569** may move lift platform **3510** vertically movable upwards and downwards as pneumatic cylinder **3569** is activated by valves controlled by PLC **332**.

[**0352**] When a bottom cup **3510** is transversely and horizontally aligned with opening **3509a** of plate **3509**, vertical lift mechanism **3507** may lift an aligned bottom cup upwards through opening **3509a**. Depending upon the nature of the construction of bottom cup **3510**, the size and configuration of opening **3509a** may be configured such that plate **3509** functions as a former, in that a perimeter edge portion of the bottom cup **3510** may be bent downwards relative to the remaining body portion of bottom cup **3510** as bottom cup **3510** is pushed through opening **3509a**. This may provide an edge surface portion of the bottom cup to more easily facilitate bonding with and sealing to the inner wall surface of tubular shaped side wall of blank **3000**.

[**0353**] Vertical lift mechanism **3507** may continue lifting bottom cup **3510** and/or vertical movement apparatus **348** of mandrel **337** such that bottom cup **3510** is moved into the lower opening of tubular shaped blank **3000**. The bottom edge of mandrel **337** may be located above the lower edge of the tubular shaped side wall of blank **3000** to provide adequate space for bottom cup **3510** to be received into the lower opening of the tubular shaped blank.

[**0354**] With reference to FIGS. **42** to **48**, a heating apparatus **3600** under control of PLC **332** is provided which is operable to engage the outer perimeter of tubular shaped blank **3300** that is wrapped around mandrel **337** when the mandrel **337** has positioned the blank **3000** at a bottom forming position at bottom forming station **3506** (as shown in FIGS. **47** and **48**). Heating apparatus **3660** may include a first heating fork **3610a** that is mounted to the piston arm of a double acting pneumatic cylinder **3611a**. Pneumatic cylinder **3611a** may move heating fork **3610a** in reciprocating longitudinal and horizontal movement activated by valves controlled by PLC **332** between an engaged heating position (FIGS. **47** and **48**), and a disengaged position.

[**0355**] Heating apparatus **3660** may also include a second heating fork **3610b** that is mounted to the piston arm of a double acting pneumatic cylinder **3611b** and is positioned opposite to first heating fork and pneumatic cylinder **3611a**. Pneumatic cylinder **3611b** may move heating fork **3610b** in reciprocating longitudinal and horizontal movement, oppo-

site to the movement of heating fork **3610a**, and may also be activated by valves controlled by PLC **332** between an engaged heating position (FIGS. **47** and **48**), and a disengaged position.

[**0356**] Heating forks **3610a**, **3610b** may incorporate electrical heating elements that are operable to provide sufficient heating of the polyolefin inner layer at the lower perimeter edge of tubular shaped blank **3000** to melt the polyolefin material at the lower edge region and thus create a bond between the edge region of the bottom cup **3510** that is positioned within the tubular opening at the lower edge region of blank **3000**. Heating forks **3610a**, **3610b** may also apply pressure to the outer surface of the blank **3000** at the lower edge region to press the inner polyolefin layer in that region against a side edge surface of the bottom cap **3510** and thereby create a bottom perimeter seal between the bottom cap **3510** and the tubular side wall blank **3000**.

[**0357**] A blank retention and delivery apparatus **3800** under control of PLC **332** may also be provided at bottom forming station **3506**. Blank retention and delivery apparatus **3800** may include a double acting pneumatic cylinder **3811** with one or more movable piston arms **3899** (FIG. **49**). Mounted to piston arms **3899** may be a suction cup block **3888** which may have mounted thereto a plurality of suction cups **3887** (FIG. **42**). Pneumatic cylinder **3811** may move suction cup block **3888** in reciprocating transverse horizontal movement, and may also be activated by valves controlled by PLC **332** between a blank engagement position (FIG. **46**), a blank delivery transfer position (FIG. **49**) and a disengaged position (FIG. **42**). In the engagement position, suction cups **3887** have a suction force that engages a facing surface of blank **3000**. This may assist in holding the blank **3000** in a fixed position while a bottom cup **3510** is being installed in the blank **3000**. In the engaged position, suction cups **3887** may also hold the blank in a fixed position when mandrel **337** is moved to a vertical position as it is being disengaged from blank **3000**, after bottom cup **3510** has been inserted into the blank **3000** (ie. when mandrel **337** is moving from the position in FIG. **47** to the position in FIG. **48**).

[**0358**] In the delivery positions, the suction cups **3887** are being moved by piston arms **3899** and block **3888** in a transverse direction toward discharge conveyor **3102** so that the blank **3000** which is now formed into an open top can **3000'** with bottom cup **3510** installed, is moved to a delivery transfer position. At the delivery transfer position suction cups **3887** can be deactivated allowing the can **3000'** to be deposited onto conveyor belt **3105** such that the can **3000'** can be moved for further processing. That further processing will typically include filling the interior space of the can **3000'** with one or more items/products and then closing the top, including creating a top seal.

[**0359**] In operation, can forming system **300** is operable to perform the sequence of steps **3000(1)** to **3000(7)** illustrated in FIG. **34** of folding and sealing a blank **3000** to form an open top paperboard can **3000'**. At the beginning of a cycle of operation, magazine **310** which has a plurality of blanks **3000** held therein has a blank **3000** at the front of the magazine in a pick-up position (see FIGS. **36** and **37**).

[**0360**] Panel rotating apparatus **324a** may then be operated by PLC **332** to engage with the facing surface of panel D of the front blank **3000** held in magazine **310** and rotate panels D and E 90 degrees in a counter clockwise direction such that they are in engagement with a surface of side wall

322a of mandrel **337** (see FIGS. **38** and **39**). Panel rotating apparatus **324b** may also be operated to engage with a facing surface of a panel B of a blank held in magazine **310** and rotate panels A and B 90 degrees such that they are in engagement with a surface of opposite side wall **322b** of mandrel **337**. Vertical slot **323a** of left side mandrel side wall **322a** permits a lower portion of end effector **366a** and suction cups **368a** thereon to move from the position shown in FIG. **36** to pass through slot **323a** to the position shown in FIGS. **38** and **39**. By allowing the end effector **366a** to pass through vertical slot **323a**, end effector **366a**, and in particular suction cups **368a**, may engage the outer surface of the panel D of blank **3000** when it is held in magazine **310** and bring panel D into face to face relation with the outward facing surface of mandrel side wall **322a**. The surface of panel D being held by suction cups **368a** becomes an inner surface of the tubular formed blank and side panel D may be held substantially flat against the outside surface of side wall **322a** of mandrel **337**, as shown.

[**0361**] Similarly, vertical slot **323b** of transversely opposite, right side mandrel side wall **322b** permits a lower portion of end effector **366b**, and suction cups **368b** thereon, to move from the position shown in FIG. **36** to pass through slot **323b** to the position shown in FIG. **38**. By allowing the end effector **366b** to pass through vertical slot **323b**, end effector **366b**, and in particular suction cups **368b**, may engage the outer surface of the major side panel B of blank **3000** when it is held in magazine **310** and bring panel B into face to face relation with the outward facing surface of side wall **322b**. The surface of panel B being held by suction cups **368b** becomes an inner surface of the tubular formed blank and side panel B may be held substantially flat against the outside surface of major side wall **322b** of mandrel **337**, as shown (see FIGS. **38** and **39**).

[**0362**] Next, with reference to FIGS. **40** and **41**, third panel rotating apparatus **330** may be operated to rotate panel E 90 degrees in a counter-clockwise direction relative to panel D about the fold line between panels D and E. Similarly, fourth panel rotating apparatus **331** may be operated to rotate panel A 90 degrees in a clockwise direction relative to panel B about the fold line between panels A and B. The result is a generally square shaped tubular blank formed generally around the outer surfaces of mandrel **337**. Panels A and E are positioned in transverse orientation in parallel to panel C about opposed vertical and transverse oriented surfaces of mandrel **337**. When panels A and E are so rotated, the vertical longitudinal edges of the panels come into abutment with each other. Between the inner surface of the panels A and E (when they are rotated relative to panels B and D respectively, and have their vertical edges in abutment with each other) and the outward facing surface of side wall **321a** of mandrel **337**, is strip portion **494** of sealing tape **499** (see FIG. **41**).

[**0363**] Next, sealing device **490** (FIG. **41**) may be operated such that vertically and longitudinally oriented sealing jaw **421** that may be moved under control of PLC **332** in longitudinally inward direction by double acting pneumatic cylinder **422**. With the piston arm **423** extended, sealing jaw **421** is received into a vertical longitudinal gap between the extended vertical edges of plough devices **410a**, **410b** and may engage the abutting outward faces of the edges of panels A and E.

[**0364**] Heat can be applied to the polyolefin layer in the vertical edge portions of the abutting panels A and E and the

metal foil layer in strip portion **494** to thereby melt the polyolefin layer in the abutting edge regions. The melted polyolefin material will then bond to sealing strip **494** that is adjacent to and overlaps the vertical edges of abutting panels A and E. Once a portion of sealing tape **499** that extends down the entire joint has bonded to panels A and E, the tubular sidewall for the can has been formed.

[**0365**] With reference now to FIGS. **42** and **43**, next PLC **332** may operate vertical movement apparatus **336** to move mandrel **337** vertically downwards, with the result that the sealing strip portion **494** of sealing tape **499** which is bonded to panels A/E will also be pulled down with the mandrel **337** and the tubular formed blank **3000**. This downward movement will pull down an additional, next strip portion **494** of sealing tape **499** that will be retained in the guide in bracket device **495**, and will be available to seal panels A/E on the next blank **3000** that will be processed by can forming system **300**.

[**0366**] When a sealing strip portion **494** attached to a blank **3000** formed into a tubular shape on mandrel **337** has been pulled down sufficiently to provide for the next sealing strip **494**, the cutting device (not shown) is employed to cut the sealing strip **494** that is attached to panels A/E of the tubular blank **3000** that has moved downward vertically, so that the sealing strip portion **494** attached to that tubular blank **3000** that has moved downward, is detached the rest of the sealing tape **499** being fed from spool **498**.

[**0367**] Now with reference to FIGS. **44** and **45**, PLC **332** continues to operate vertical movement apparatus **336** to move mandrel **337** and the tubular shaped blank **3000** wrapped around it, to the bottom forming station **3506** where a bottom cup **3510** may be installed. With the mandrel **337** moved to the bottom forming position, a bottom cup **3510** may be moved up through opening **3509a** in forming plate **3509** by vertical lift mechanism **3507**. A bottom cup **3510** may be positioned in a lift position having been delivered there by a cup delivery conveyor **3501**. Vertical lift mechanism **3507** may continue lifting bottom cup **3510** and/or vertical movement apparatus **348** of mandrel **337** such that bottom cup **3510** is moved into the lower opening of tubular shaped blank **3000** that is held on mandrel **337**.

[**0368**] With reference now to FIGS. **46** to **48**, next heating apparatus **3600** is operated by PLC to engage the outer perimeter of tubular shaped blank **3300** that is wrapped around mandrel **337** when the mandrel **337** has positioned the blank at a bottom forming position at bottom forming station **3506**, first heating fork **3610a** and second heating fork **3610b** are moved to the engaged heating position (FIGS. **46**, **47** and **48**).

[**0369**] Electrical heating elements of heating forks **3610a**, **3610b** may be operated to provide sufficient heating of the polyolefin inner layer and metal foil layer at the lower perimeter edge of tubular shaped blank **3000** to melt the polyolefin material at the lower edge region and thus create a bond between the bottom cap **3510** that is positioned within opening at the lower edge region of blank **3000**. Heating forks **3610a**, **3610b** may also apply pressure to the outer surface of the blank at the lower edge region to press the inner polyolefin layer in that region against a side edge surface of the bottom cap **3510** and thereby create a bottom perimeter seal around and between the bottom cap **3510** and the tubular side wall of blank **3000**.

[**0370**] Blank retention and delivery apparatus **3800** may also be operated such that suction cups **3887** have a suction

force that engages a facing surface of blank **3000**. This may assist in holding the blank **3000** in a fixed position while a bottom cup **3510** is being installed in the blank **3000**.

[0371] Next, with suction cups still in the engaged position, suction cups **3887** may also hold the blank in a fixed position while mandrel **337** is moved upwards to disengage from blank **3000** (that has now been formed into an open top can **3000'**), after bottom cup **3510** has been inserted into the blank **3000** (ie. when mandrel **337** is moving from the position in FIG. **47** to the position in FIG. **48**).

[0372] With reference next to FIG. **49**, heating apparatus **3600** is operated by PLC to disengage from the outer perimeter of tubular shaped blank **3300** such that first heating fork **3610a** and second heating fork **3610b** are moved to the disengaged heating position.

[0373] Next and with reference to FIG. **50**, under control of PLC **332**, suction cups **3887** are moved in a transverse direction toward discharge conveyor **3102** and the can **3000'** is moved to a delivery transfer position where the suction cups **3887** can be deactivated by PLC **332** thus allowing the blank to be deposited onto conveyor belt **3105** such that the can **3000'** can be moved for further processing.

[0374] Mandrel **337** will in the meantime be moved upwards by mandrel movement apparatus **336** under the control of PLC to the blank pick-up engagement position where the next blank **3000** held magazine **327** can be engaged and processed. Thus the foregoing process can be performed on multiple blanks **3000** in series. It is expected that in the range of approximately 20-40 blanks **3000** may be processed per minute with such a can forming system **3000**, depending upon the configuration and construction of the blank to be processed.

[0375] Can forming system **300** may be modified to process blanks **4000**, **5000**, **6000** and **7000**.

[0376] With respect to processing a blank **4000** as shown in FIGS. **33A** and **35**, to form a bottom closed can **4000'**, modifications are required to can forming system **3000**. Instead of, or possibly in addition to, bottom forming station **3506**, another bottom forming station is required that can as shown in step **4000(7)** to step **4000(9)**, rotate panel **G** 90 degrees upwards into the lower opening of a tubular shaped side wall of blank **4000** and then form a seal between panel **G** and the interior surface in the lower edge region of blank **4000**.

[0377] With respect to processing a blank **5000** as shown in FIGS. **33B**, in addition to forming a bottom closed can from blank **5000** like can **4000'**, modifications are required to can forming system **3000** also close the top of the can with panel **F**. Therefore a top forming station **3506** is required that can rotate panel **F** 90 degrees downwards into the upper opening of a tubular shaped side wall of blank **5000** and then form a seal between panel **F** and the interior surface in the upper edge region of blank **4000**.

[0378] With respect to processing a blank **6000**, modifications are also required to can forming system **300**. Instead of, or possibly in addition to, bottom forming station **3506**, another bottom forming station is required that can rotate panel **G** 90 degrees upwards into the lower opening of a tubular shaped side wall of blank **4000** and then activate the cold seal adhesive to form a seal between panel **G** and the interior surface in the lower edge region of blank **6000**.

[0379] Finally, with respect to processing a blank **7000**, modifications are also required to can forming system **300**. Instead of, or possibly in addition to, bottom forming station

3506, another bottom forming station is required that can (a) apply the hot melt adhesive to the regions of blank **7000** in the pattern shown in FIG. **33D**, and (b) rotate panel **G** 90 degrees upwards into the lower opening of a tubular shaped side wall of blank **7000** and then cause the hot melt adhesive to form a seal between panel **G** and the interior surface in the lower edge region of blank **7000**.

[0380] The step of applying the hot melt adhesive to the blank **7000** in the pattern shown in FIG. **33D** may be done while the blank **3000** is being held in an appropriately configured magazine similar to magazine **327**. By way of example a hot melt adhesive system **998** (FIG. **51**) that may comprise two hot met adhesive guns may be deployed on reciprocating piston arms of pneumatic cylinders (not shown) under control of PLC **332**. While the mandrel **337** is in a lowered position away from magazine **327**, the opposed adhesive guns may be moved transversely across the face of the next blank **7000** held in the magazine and apply the adhesive to the surface of the panels **A-E**.

[0381] Various components of system **300** such as mandrel apparatus **320** including mandrel **337** and the various support members; first, second, third and fourth panel rotating apparatuses; robot support members and support frame **340**, may all be made of any suitable materials such as for example aluminium or steel.

[0382] Also a least some of the various components of system **300** may be integrally formed or interconnected to each other by known techniques. For example, if the components are made of a suitable metal or plastic, welding techniques can be employed. Also, the use of screws and/or nut and bolts may be employed.

[0383] With reference now to FIG. **52**, a top view of a flat blank **8000** is illustrated which may be suitable to form a sidewall for a composite can. Similar to blank **3000**, blank **8000** may comprise a substrate made from a rigid or semi-rigid paper-based material, such as paperboard or cardboard. Blank **8000** may also comprise an inner polyolefin laminate layer (for e.g. polyethylene, low-density polyethylene, linear low-density polyethylene, very low-density polyethylene, ultra low-density polyethylene, medium-density polyethylene, high-density polyethylene, ultra high-density polyethylene, ethylene/propylene copolymers, polypropylene, polyisoprene, polybutylene, polybutene, poly-3-methylbutene-1, poly4-methylpentene-1 and polyethylenes comprising ethylene/ α -olefin which are copolymers of ethylene with one or more α -olefins, such as butene-1, hexene-1, octene-1 or the like) or non-polyolefin laminate inner layer (for e.g. a polyester resin, a polyamide resin, a polyvinylidene chloride resin, an ethylene-vinyl alcohol copolymer, a polyvinyl chloride resin, an epoxy resin, a polyurethane resin, a polyacrylate resin, a polyacrylonitrile resin and a polycarbonate resin), and an intermediate conducting metal (for e.g. aluminium) foil layer. The foil layer may be interconnected to, and positioned between the inner layer and the paperboard substrate. Thus, blank **8000** may be a multiple layer blank. In other embodiments, the blank **8000** may be made of a wide variety of other types of materials including by way of example only, paperboard or cardboard laminated with a plant-based polymer film to act as a moisture and oxygen barrier with compostable capabilities.

[0384] In some embodiments, blank **8000** for the sidewall may comprise a substrate including a metal and in some embodiments the sidewall may be made solely from a metal

which can be relatively easily bent around another surface such as the surface of a mandrel. Various kinds of metal may be used in making the metal-based substrate can, depending on the properties desired as well as the economics involved. For most practical purposes, aluminum, magnesium, tin, steel, copper, bronze, brass, low carbon steel sheets, low carbon steel sheets whose surfaces have been plated with a metal such as tin, aluminum, zinc or chromium and low carbon steel sheets whose surfaces have been treated with phosphoric acid or chromic acid electrolytically or non-electrolytically may be used. In some embodiments, the metal may be coated with a known primer.

[0385] In some embodiments blank **8000**, like blank **3000**, may be bendable and/or may be foldable along fold lines from a flat configuration into a tubular side wall configuration which can be sealed at or proximate vertical longitudinal edges and inner facing surfaces as described below. In top view, blank **8000**, when formed into a tubular side wall configuration, by way of example only, may be in a shape that is arcuate (for e.g. circular/cylindrical or oval shaped). In other embodiments, blank **8000**, by way of example, may be formed into a tubular shape that is generally square or rectangular in top view.

[0386] In embodiments, the material when formed into a blank **8000**, will only have one vertical seam/joint between two vertical sides. This is an important benefit, including when attaching a lid and bottom cup, such as by a seaming operation, as described below.

[0387] Accordingly, blank **8000** as contemplated herein may be made from a material and/or be formed in a way so that it is flexible and may be re-configured from a generally flat configuration to a generally tubular configuration positioned around an outer surface of a blank support device, such as a mandrel, as will be described hereinafter. Blank **8000** may thereafter be supplemented with a bottom end component or cup to form a composite can (or metal can in embodiments where the substrate and top and bottom lids are made only from a metal) with an upper opening to receive one or more items. For example, to form a tubular shaped sidewall that is circular or oval in shape in top plan view, blank **8000** may have a continuous sidewall. In some embodiments the sidewall may be divided by fold lines as described above. In other embodiments the sidewall is not divided by clearly defined vertical fold lines but can still be divided conceptually into portions B, C, D and minor side wall portions A and E as depicted in FIG. 52.

[0388] Minor side wall portions A and E may have a width that is less than the width of sidewall portion C. Portions D and B may have the same width as portion C or a width that is different than the width of portion C. Fold lines may or may not be provided between adjacent portions A-E. Portions A-E may be formed from one integral piece of material.

[0389] In one embodiment, side wall portion B may be located adjacent to and joined at a vertical side edge along a line (all lines shown in broken lines in FIG. 52 are for ease of reference in describing the folding of blank **8000** and can be fold lines in embodiments where blank **8000** comprises fold lines) to a vertical side edge of side wall portion C. Side wall portion C may be located adjacent to and joined at an opposite vertical side edge along a line to a vertical side edge of side wall portion D. Side wall portion D may be located adjacent to and joined at an opposite vertical side edge along a line to a side edge of minor side wall portion E. Another,

opposite side, minor side wall portion A may be located adjacent to and joined at an opposite vertical side edge along a line to a side edge of side wall portion B. Minor side wall portions A and E may have vertical outer side edge surfaces which as described below, may be brought into abutment with each other and sealed together to provide a continuous longitudinal seal along the abutting edge surfaces of portions A and E as well as and an inner horizontal seal along the inner facing surfaces of portions A and E. The outer and inner surfaces where portions A and E are joined to each other may be generally planar/flush with each other. This flush surface assists in securing and sealing a bottom end to the tubular shaped sidewall, as described below.

[0390] As will be described hereinafter, the side wall portions A, B, C, D and E, may be reconfigured from a flat configuration to a round vertical tubular configuration and sealed to form a fixed, round/cylindrical, vertical tubular configuration that can then be provided with a bottom component or cup to provide a sealed and suitably strong bottom. The open top formed composite can, which may be subsequently filled with one or more items, may be also be subsequently top sealed with one or more top components, such as a lid.

[0391] With reference now to FIG. 53, an example sequence of steps **8000(1)** to **8000(6)** are shown for folding/bending and sealing a blank **8000**, and adding a bottom component to form an open top composite can that is suitable for top loading of items which can thereafter be closed with a top component (not shown).

[0392] A plurality of case blanks **8000** may be presented in step **8000(1)** as a vertically stacked arrangement with each blank **8000** configured in a generally flat and planar configuration. A particular individual blank **8000** may be identified at/selected from the front of the stack of blanks for processing. In a first folding step **8000(2)**, central portion C of blank **8000** may remain in the initial flat orientation—although it may start be transformed into an arcuate shape—while side wall portion B and its connected minor portion A may be rotated together from the orientation shown at **8000(1)** in a clockwise direction about the vertically oriented line between side wall portions B and C to the configuration shown at **8000(2)**. Also, optionally at substantially the same time as portions A and B are being rotated, side wall portion D and its connected minor portion E can be rotated together from the orientation shown at **8000(1)** in a counter clockwise direction about the vertically oriented line between side wall portions D and C to the configuration shown at **8000(2)**.

[0393] In the next folding step, minor side wall portion A may be rotated clockwise about the vertically oriented line between side wall portions A and B to the configuration shown at **8000(3)**. Also, optionally at substantially the same time as portion A is being rotated, side wall portion E can be rotated from the orientation shown at **8000(2)** in a counter clockwise direction about the vertically oriented line between side wall portions D and E to the configuration shown at **8000(3)**. At the configuration shown at **8000(3)**, portions A and E may have their vertical longitudinal edges either in abutment with or proximate to each other and portions A-E may have been formed into a substantially round/circular tubular shape.

[0394] In other embodiments, the portions A/B may be rotated clockwise continuously to form with one part of portion C, one half of a circular tube. Portions D/E may be

rotated counter-clockwise continuously to form with other part of portion C, the other half of a circular tube. In the rotations of portions A/B and D/E, portion C will take also take a generally curved shape forming one part of the circular tubular shape for a sidewall.

[0395] A longitudinal sealing strip **894** made from a string (also referred to as a ribbon) of sealing material **899**, to be further described below, may be situated along and between the vertical longitudinal edges of portions A and E such that a substantially flat continuous outer surface **8000a** is formed across portions A and E. This type of connection of portions A and E may be particularly advantageous in connection with the attachment of a bottom cup **874** to blank **8000** when formed into a tubular sidewall.

[0396] Accordingly, in the next step **8000(4)**, the vertical longitudinal edges of portions A and E can be butt sealed together by activating the longitudinal sealing strip. The sealing strip **894** may be self-sealing such that when activated such as by heating and/or having pressure applied to it and the adjacent surface material of the portions A/E, the sealing strip **894** may bond to the portions A/E and form a seal therebetween. The sealing strip **894** may be activated by heat sealing (eg. using for example a heat-sealing bar), induction, high frequency vibrations (e.g. using an ultrasonic welding tool) and/or pressure sealing. The activation of the self-sealing material from which the sealing strip may be made, according to some embodiments, may be performed using an activation device to provide heat, pressure, or any ultrasonic emission required to enable a seal.

[0397] In the next step **8000(5)**, blank **8000**, having been formed into a generally tubular cylindrical side wall configuration, may optionally have its top end and/or bottom end flared out to assist in the accurate placing and seaming/sealing of the lid to the top opening end and the bottom cup to the bottom opening end. Blank **8000** may then be moved/translated (for e.g. vertically downwards) to a bottom forming station where bottom cup **874**, made from any suitable material or combination of materials, such as aluminium, tin, paperboard laminates or plant-based polymers, has been positioned. In some implementations, a circumferential edge region of bottom cup **874** may be pre-formed with a generally U-shaped circumferential channel. The movement/translation of blank **8000** to bottom forming station is such that surface to surface contact between a lower edge surface portion of the side wall of blank **8000** and edge surface of bottom cup **874** at the edges thereof occurs. The outside circumferential edge of the bottom cup **874** may be generally formed (and may be pre-formed) in a generally U-shape, to facilitate the receiving of the bottom edge portion of the sidewall of tubular shaped blank **8000**. These interfacing surfaces may then be interconnected such as by being seamed together such as by using a plurality of seaming rollers to form a high integrity seal capable of sealing against gases and liquids.

[0398] After the bottom portion of blank **8000** has been formed at step **8000(5)**, blank **8000** may be moved away from bottom forming station to another location and subsequently filled with one or more items. Thereafter, a top component/lid, may be inserted into and sealed to the top opening of blank **8000** to form the completed composite can.

[0399] With reference now to FIGS. **54-66c**, in overview, can forming system **800** may include a magazine **810**. Although only one case blank **8000** is shown for clarity in FIGS. **54** and **55**, magazine **810** may be adapted to hold a

plurality of blanks in a flat substantially flat vertical and transverse orientation. Magazine **810** may be configured to selectively, serially release single blanks **8000** from the front of the stack of plurality of blanks, in a manner as substantially as described above in other embodiments.

[0400] With particular reference to FIGS. **54**, **55**, **56** and **57**, can forming system **800** may also include a blank support apparatus (also referred to herein as a mandrel apparatus) **820** and a portion rotating sub-system **834**. Portion rotating sub-system **834** may be configured to engage blank **8000** on at least two transversely spaced apart outward facing portion surfaces of blank **8000** as blank **8000** is held in magazine **810**, and rotate portions of blank **8000** around a blank support device **837** (also referred to herein as a mandrel) of blank support apparatus **820** in such a manner that the blank surfaces that are engaged by portion rotating sub-system **834** become inner surfaces of the side wall for a tubular shaped composite can **8000'** (see FIG. **78**).

[0401] Portion rotating sub-system **834** may utilize at least two portion rotating apparatuses in order to engage with surfaces of a plurality of portions of blank **8000** as blank **8000** is held in a generally flat configuration in the magazine **810**, and rotate those portions (and possibly certain other portions of the same blank **8000** interconnected thereto) relative to each other and relative to one or more other portions which may be initially retained in magazine **810** in the initial position and orientation. For example, portion rotating sub-system **834** may include a first portion rotating apparatus **824a** and a second portion rotating apparatus **824b** (see also FIGS. **58a**, **58b** and **58c**). Portion rotating apparatus **824a** may be configured and operable to engage with a facing surface of portion B of blank **8000** held in magazine **810**. Portion rotating apparatus **824b** may be configured and operable to engage with a facing surface of portion D of blank **8000** held in magazine **810**.

[0402] Portion rotating sub-system **834** may also include a third portion rotating apparatus **830a** and a fourth portion rotating apparatus **830b** (see FIGS. **54** and **56**). Third portion rotating apparatus **830a** may be operable to engage a blank portion on an outer surface and rotate portion A in a clockwise direction relative to portion B about the line between portions A and B. Fourth portion rotating apparatus **830b** may be operable to engage a blank portion on an outer surface and rotate portion E in a counter-clockwise direction relative to D about the line between portions D and E.

[0403] Can forming system **800** may also include a generally vertically oriented support frame **840** which may support vertical blank support device apparatus **836** (mandrel movement apparatus) (see FIG. **54**) for vertical upward and downward movement and blank retention and delivery apparatus **8800** (see FIGS. **78** and **79**) for horizontal movement. It should be noted however, that while can forming system **800** is generally oriented for vertical movement of the mandrel movement apparatus **836** and horizontal movement of the blank retention and delivery apparatus **8800**, other orientations may be utilized in other embodiments.

[0404] In addition to the components described above, can forming system **800** may also include a can seaming apparatus **870** (designated generally in FIGS. **66b**, **66c**, **67-69b** and **77**). Can seaming apparatus **870** may generally include a seam mandrel **872** adapted and configured to hold a bottom cup **874** and a plurality of seam rollers **876a**, **876b**, **877a**,

877b adapted and operable for seaming bottom cup **874** to an open lower end of a sidewall of a cylindrical tubular shaped blank **8000**.

[0405] The operation of the components of can forming system **800** may be controlled by a controller such as a programmable logic controller (“PLC”) **832** which may be configured generally like PLC **132** described above. PLC **832** may communicate with various components including sensors so as to be in communication with and control all of the components/sub-systems of system **800** in a manner such as is generally depicted schematically in FIG. **80**, and may also control other components/sub-systems associated therewith. PLC **832** may also include a Human-Machine-Interface (HMI) such as the Allen Bradley Panelview **700** plus color touch screen graphic workstation so that the operation of system **800** can be monitored, started, operated, controlled, stopped, modified for different blank configurations, by an operator using a touch screen panel.

[0406] According to some implementations, the first portion rotating apparatus **824a** and the second portion rotating apparatus **824b** may be controlled by PLC **832** to operate concurrently and in tandem, such that the engagement with the facing surface of the blank, and movement of the blank, is mirrored and symmetrical. Symmetrical movement between first portion rotating apparatus **824a** and second portion rotating apparatus **824b** may minimize any slipping or sliding that could move blank **8000** out of an expected position and may assist such that during the rotation of the first portion rotating apparatus **824a** and the second portion rotating apparatus **824b** the blank wraps around semi-cylindrical portion **821a** or mandrel **837**.

[0407] According to some example implementations, the rotation of the first portion of a blank **8000** is an opposite rotational direction to the rotation of the second portion of the blank **8000**. A time period when the rotating of the first portion of the blank from a flat configuration around a first portion of the surface of the blank support device occurs, may overlap with a time period during which the rotating of the second portion of the blank around a second portion of the outward facing surface of said blank support occurs. The time period of the rotating of the first portion of the blank around a first portion of the outward facing surface of the blank support device may be substantially the same time period of the rotating of the second portion of said blank from the first orientation, around a second portion of the first outward facing surface of the blank support device. The first rotating apparatus **420a**, and the second rotating apparatus **420b** may have rotational members that rotate about a common axis of rotation.

[0408] As described above, magazine **810** may be configured to hold a plurality of case blanks **8000** in a stacked, vertically and transversely oriented, flat configuration on their bottom edges and adapted to present an outward facing surface of each case blank **8000**, individually in turn. Many different types and/or constructions of a suitable magazine **810** might be employed in system **800**. Thus, magazine **810** may comprise a large number of case blanks **8000** held in a generally vertically and transversely oriented, longitudinally extending stack by side walls of magazine **810**. In this configuration where case blanks **8000** are individually and selectively retrieved in series from the front of a stack of generally flat blanks, the stack of case blanks **8000** in the magazine can be moved forward by a longitudinally oriented

conveyor system which may be constructed like the conveyor systems in the magazines of systems **100** and **300** described above.

[0409] The purpose of moving the stack of blanks **8000** forward is so that the facing surface of portion C of the most forward case blank **8000** in the stack is positioned and held close to or against an outer generally adjacent surface of a transverse and vertical side wall **821a** of mandrel **837** (see FIG. **56**). This enables first portion rotating apparatus **824a** and second portion rotating apparatus **824b** to be able to engage other exposed facing surfaces of for example portions B and D respectively (see FIGS. **55** and **56**) of the forward most case blank **8000** in the stack held in magazine **810** as described further hereinafter. Additionally, a back-pressure device (not shown) may be provided that is adapted to apply a back pressure against the stack of blanks **8000** in a longitudinal direction toward the front of magazine **810** of a magnitude and direction sufficient to keep the stack upright.

[0410] Magazine **810** may be constructed and operate in a manner similar to magazines **110** and **310** described above. In overview, magazine **810** may have a magazine frame generally designated **827** (see FIG. **55**). Magazine **810** may include a conveyor system to move case blanks **8000** sequentially to a pick-up position. A wide variety of conveyor systems or other case blank movement systems may be employed. By way of example, conveyor system may include a conveyor **813** (see FIG. **54**) mounted to frame **827**, and having a generally horizontal floor plate **815**. Conveyor **813** may be operated in such a manner to longitudinally move case blanks **8000** forward in magazine **810** while being maintained in a generally transverse and vertical orientation.

[0411] A motor (not shown), such as a DC motor, in communication with PLC **832** may be inter connected to conveyor belts **812** of conveyor **813** to intermittently move a stack of blanks **8000** forward such that a front positioned blank **8000** in the stack of case blanks is continuously available in a pick-up position.

[0412] The stack of case blanks may be supported at vertically oriented side edges by longitudinally and vertically oriented side wall plates **814a**, **814b** that may be spaced apart from each other and oriented generally parallel to each other. One or both of side wall plates **814a**, **814b** may be mounted on transversely oriented and movable rods that are supported on magazine frame **827**. Actuation of the rods may be made by any suitable mechanism, such as by way of example only, servo drive motors with appropriate drive shafts and gear mechanisms or a hand operated gear and crank shaft mechanism. Side wall plates **814a**, **814b** serve to guide the case blanks **8000** within magazine **810** and can be accurately adjusted to be in close proximity to or in contact with the particular case blank size that is being handled at a particular time. This adjustability of the relative transverse spacing of side walls **814a**, **814b** allows for case blanks of different widths to be held in magazine **810** for processing.

[0413] Selected portions of the forward most blank **8000** may be pulled away from holding clips (not shown) associated with magazine **810** by first portion rotating apparatus **824a** and second portion rotating apparatus **824b**, and therefore from retention by magazine **810**, then rotated (wrapped) at least partially around mandrel **837**. As case blanks **8000** are taken from magazine **810** and formed, PLC **832** may cause the conveyor **813** of magazine **810** to move the entire

stack forward sequentially so that the most forward case blank **8000** has its outward facing surface of major portion **C** positioned against or very close to adjacent outer rear vertically and transversely oriented surface **821a** of mandrel **837**. A sensor (not shown) in communication with PLC **832** may be provided to monitor the level of case blanks **8000** in magazine **810** during operation of can forming system **800**. Magazine **810** can be loaded with additional flat case blanks **8000** at the rear of the magazine as needed.

[0414] Magazine **810** may be configured so that its position in a longitudinal direction (or at least the longitudinal pick-up position of the forward most blank **8000** when held in magazine **810**) may be altered such that if and when first and second portion rotating apparatuses **824a**, **824b** of portion rotating sub-system **834** are moved in a longitudinal direction, as referenced below, the longitudinal position of magazine **810**, and/or the forwardmost blank **8000** held therein, may also be adjusted to make sure that the forwardmost blank **8000** held in magazine **810** is an appropriate pick up location, when the size of the mandrel **837** needs to be changed. Various mechanisms may be employed to be able to adjust the longitudinal position of magazine **810** such as for example mounting the magazine on rails and providing a PLC controlled, double acting hydraulic piston mechanism having pistons to engage portions of the magazine and thus be operable to move the magazine backwards and forwards in a longitudinal direction towards and away from a mandrel on such rails.

[0415] Electronic sensors (not shown) in communication with PLC **832** may also be positioned to monitor the stack of blanks and ensure that blank **8000** at the front of the stack of blanks is always properly positioned at the pick-up position.

[0416] Clip mechanisms (not shown), similar to clip mechanisms **11a-111d** described above in system **100**, may be provided to releasably hold each case blank **8000** that is at the front of the stack within magazine **810**, and thus hold the stack in place. When first portion rotating mechanism **824a** and second portion rotating mechanism **824b** selectively engage blank portions **B** and **D** respectively, as described hereinafter, clip mechanisms allow for the engaged and interconnected portions **A/B** and **D/E** of the front blank **8000** in the stack to be pulled away from the same corresponding portions on a blank **8000** immediately behind the front blank **8000** in the stack held in the magazine. Also, clip mechanisms may hold portion **C** in magazine **810** while the portions **A/B** and **D/E** are being wrapped around the mandrel **837**, but will then allow for the release of portion **C** to allow the remaining portion of case blank **8000** to be removed from being held by magazine **810** and the reconfigured to also wrap around the outward facing surface of mandrel **837**.

[0417] With the blank **8000** released from the magazine it is able to be moved vertically downward once mandrel **837** to which it is secured moves vertically downwards as described further below.

[0418] With particular reference to FIGS. **54** and **55**, vertically oriented support frame **840** may support mandrel movement apparatus **836** to provide for vertical reciprocating upwards and downwards movement of mandrel **837**. It should be noted that although system **800** is shown in the Figures as being generally oriented for vertical movement of the mandrel **837**, alternative orientations can be utilized in other embodiments.

[0419] Mandrel movement apparatus **836** may include a generally vertically oriented linear rail **842**. Linear rail **842** may support a carriage block **844** for sliding upward and downward sliding vertical movement relative to support frame **840**. It should be noted that in some of the Figures depicting system **800**, for simplicity or clarity, support frame **840** and linear rail **842**, and/or some other components, have been omitted.

[0420] In a manner similar to systems **100** and **300** as described above, the movement of carriage block **844** on linear rail **842** may be driven by a continuous drive belt **843** interconnected to carriage block **844** supported on vertical support frame **840**. Drive belt **843** may be interconnected to and driven by a drive wheel **845a** of servo drive motor **845** which may be mounted at an upper end portion of vertical support frame **840** (see FIG. **70**). An encoder (not shown) may be associated with servo drive motor **845**, and the encoder and servo drive motor **845** may be in communication with PLC **832**. In this way PLC **832**, upon receiving signals from the encoder, may be able to monitor and control the vertical position of carriage block **844** (and the components interconnected thereto) by appropriately controlling and operating servo drive motor **845**.

[0421] Carriage block **844** may support and be rigidly connected to a carriage support arm **846** (see FIG. **54**) that may be generally oriented horizontally and longitudinally. The outer end of carriage support arm **846** may be rigidly connected to a mandrel support apparatus generally designated **848** (see FIG. **57**). Mandrel support apparatus **848** may generally support mandrel **837** (see FIGS. **54**, **55** and **57**).

[0422] First and second portion rotating apparatuses **824a**, **824b** may be one of numerous types of robotic systems or alternatively may be an apparatus that includes servo driven motors controlled by PLC **832** which includes a generally vertically oriented drive shaft with rotatable members attached thereto. First and second portion rotating apparatuses **824a**, **824b** may be capable of intermittent motion to rotate the rotatable members. The rotatable members may carry portion engagement devices.

[0423] With reference to FIGS. **54**, **56**, **58a**, **58b** and **58c**, first portion rotating apparatus **824a** may be generally laterally spaced apart from second portion rotating apparatus **824b** and both may be mounted to a fixed, transversely oriented support member **856**. Transverse support member **856** may be fixedly supported at opposed ends by, and at first ends of, a pair of transversely spaced, longitudinally oriented tubular robot support members **855a**, **855b**. Tubular robot support members **855a**, **855b** may each be held by respective longitudinal support brackets **857a**, **857b**. Tubular robot support members **855a**, **855b** may be operable for longitudinal sliding movement (together and with support member **856** and the robots supported thereon relative to longitudinal support brackets **857a**, **857b**. Longitudinal support brackets **857a**, **857b** may be fixedly secured to end regions of respective longitudinal frame support members **858a**, **858b**. The opposite ends of transversely spaced, longitudinally oriented frame support members **858a**, **858b** may be fixedly mounted to vertical support frame **840**. The relative longitudinal positions of tubular robot support members **855a**, **855b** may be adjusted by longitudinal sliding movement (together and with support member **856** and the robots supported thereon) relative to longitudinal support brackets **857a**, **857b** and may be releasably secured in a particular desired longitudinal position relative to the main

support frame by use of key slot devices **859a**, **859b** fixedly to side walls of support members **855a**, **855b** and with shafts receivable through slots **861a**, **861b**, in respective brackets **857a**, **857b**.

[0424] With particular reference to FIGS. **58a**, **58b**, first portion rotating apparatus **824a** may include a first rotational drive unit **860a** having one upper end fixedly mounted to longitudinal support member **858a**. Extending from an opposite lower end of first rotation drive unit **860a** is a first rotational drive that may comprise a drive shaft (not shown) that is operable for intermittent rotation clockwise and counter clockwise about a first vertical axis of rotation. Mounted to the end of the drive shaft of first rotation drive unit **860a** is a drive wheel.

[0425] Similarly, second portion rotating apparatus **824b** may include a first rotational drive unit **860b** having one upper end fixedly mounted to longitudinal support member **858b**. Extending from an opposite lower end of first rotation drive unit **860b** is a first rotational drive that may comprise a drive shaft (not shown) that is operable for intermittent rotation clockwise and counter-clockwise about a second vertical axis of rotation.

[0426] A mounting block **900** may be centrally and fixedly secured to transversely oriented support member **856**. Mounting block **900** supports a central fixed vertical shaft **901** about a third vertical axis. Mounted to shaft **901** for rotation about the shaft **901** and its vertical axis of rotation are a first articulating arm **862a** and a second articulating arm **862b**. A drive belt **903** interconnects the drive wheel of rotation drive unit **860b** and a first pulley that is mounted to and about shaft **901** and fixedly connects with first articulating arm **862a**. Accordingly, when the drive wheel of first rotation drive unit **860a** is rotated, the first pulley that is mounted to shaft **901** also rotates causing a rotation of first articulating arm **862a**.

[0427] Similarly, a drive belt **905** interconnects the drive wheel of second rotation drive unit **860b** and a second pulley that is mounted to and about shaft **901** and fixedly connects with second articulating arm **862b**. Thus, when the drive wheel of second rotation drive unit **860b** is rotated, the second pulley that is mounted to shaft **901** also rotates causing a rotation of second articulating arm **862b**.

[0428] Thus, when rotational drive unit **860a**, under the control of PLC **832**, causes the drive shaft of first rotation drive unit **860a** to rotate, first articulating arm **862a** is able to pivot clockwise or counter clockwise relative to the drive shaft about a vertical axis of shaft **901**, depending upon the direction of rotation of the drive shaft. Similarly, when rotational drive unit **860b**, under the control of PLC **832**, causes the drive shaft of second rotation drive unit **860b** to rotate, second articulating arm **862b** is able to pivot clockwise or counter clockwise relative to the drive shaft about a vertical axis of shaft **901**, depending upon the direction of rotation of the drive shaft.

[0429] Mounted to the outer end of articulating arm **862a** of first rotational drive **860a** is a vertically oriented end effector rod **866a** formed in a generally tubular cylinder and having one or more air suction cups **868a**.

[0430] Air suction cups **868a** may be interconnected through cavities in end effector **866a**, and in articulating arm **862a** to a fitting **863a** in articulating arm **862a**. Fitting **863a** may have a connector (like a hose quick-connect) that links to a hose (not shown) that communicates to a valve assembly **771**. Valve assembly **771** may be part of pressurized air

distribution unit **427** which is controlled by PLC **132**. Fitting **863a** may include a vacuum generator that may transform pressurized air selectively supplied through valve assembly **771** into vacuum which can be communicated to the air suction cups **868a**. The supply of vacuum supplied to suction cups **868a** can be turned on or off under the control of PLC **832**. A source of pressurized air may be provided to valve assembly **771** under the control of PLC **832**. Fitting **863a** may thus be used to selectively provide air suction to air suction cups **868a** through valve assembly **771**. Thus, air distribution unit **427** may include a plurality of valves or solenoids that may be operated by PLC **832**. In other embodiments, local vacuum generator apparatuses that may be integrated as part of, air suction cups **868a**. In other embodiments, a vacuum pump mounted externally may generate a vacuum externally and then a vacuum can be supplied through the aforementioned air channels. If local vacuum generators are utilized, pressurized air may be delivered from an external source through air distribution unit **427** to the vacuum generators. The local vacuum generators may then convert the pressurized air to a vacuum that can then be delivered to air suction cups **868a**.

[0431] The air suction force that may be developed at the outer surfaces of air suction cups **868a** will be sufficient such that, when activated by PLC **832**, they can engage and hold the internal surface of blank **8000**, namely portion B, and rotate portion B (along with portion A) of case blank **8000** from (i) the position shown in FIG. **56** to (ii) the position shown in FIG. **59**, and then (iii) after releasing a first engaged case blank **8000**, eventually return to the position shown in FIG. **56** to engage a portion B of the next case blank **8000** positioned at the pick-up position in magazine **810**. The vacuum generated at air suction cups **868a** can be activated and de-activated by PLC **832** through operation of air distribution unit **427**.

[0432] Second portion rotating apparatus **824b** may be constructed and configured in generally the same manner as first portion rotating apparatus **824a**. Second portion rotating apparatus **824b** may operate in opposite rotational directions to first portion rotating apparatus **824a** when engaging and rotating other portions of blank **8000** than the portions engaged and rotated by first portion rotating apparatus **824a**.

[0433] Mounted to the opposite end of articulating arm **862b** of rotational drive **860b** is a vertically oriented end effector rod **866b** formed in a generally tubular cylinder and having one or more air suction cups **868b**.

[0434] Air suction cups **868b** may, like air suction cups **868a**, may be interconnected for air communication through cavities in end effector **866b**, and in articulating arm **862b** to a fitting **863b** in articulating arm **862b**. Fitting **863a** may have a connector (like a hose quick-connect) that links to a hose (not shown) that communicates to the same valve assembly **771**. Fitting **863b** may also include a vacuum generator that may transform pressurized air selectively supplied through valve assembly **771** into vacuum which can be communicated to the air suction cups **868b**. Thus, the supply of vacuum supplied to suction cups **868b** can be provided to valve assembly **771** under the control of PLC **132**. Fitting **863b** may thus be used to selectively provide air suction to air suction cups **868b** through valve assembly **771**. Air distribution unit **427** may include a plurality of valves that may be operated by PLC **832**. In other embodiments, local vacuum generator apparatuses that may be integrated

as part of, air suction cups **868a**. In other embodiments, a vacuum pump mounted externally may generate vacuum externally and then a vacuum can be supplied through the aforementioned air channels. If local vacuum generators are utilized, pressurized air may be delivered from an external source through air distribution unit **427** to the vacuum generators. The local vacuum generators may then convert the pressurized air to a vacuum that can then be delivered to air suction cups **868b**.

[0435] The air suction force that may be developed at the outer surfaces of air suction cups **868b** will be sufficient, so that when activated, they can engage and hold portion D and rotate portion D (along with portion E) of a case blank **3000** from (i) the position shown in FIG. **56** to (ii) the position shown in FIG. **59**, and then (iii) after releasing a first engaged blank **8000**, eventually return to the position shown in FIG. **56** to engage the next case blank **8000** positioned at the pick-up position in magazine **810**. The vacuum generated at air suction cups **868b**, like air suction cups **868a**, can be activated and de-activated by PLC **832** through operation of air distribution unit **427** including valve assembly **771** (FIG. **80**).

[0436] Can forming apparatus **800** including first rotating apparatus **824a** and second rotating apparatus **824b** may be configured to be readily adjustable for different types/configurations/sizes of mandrel apparatus **820**, including in particular mandrel **837**, for forming different types/configurations/sizes of blanks such as blanks **8000** into tubular side wall of composite cans, including by suitable programming of PLC **832** appropriately to provide for appropriate movements of air suction cups **868a**, **868b**, through movement of the first and second rotational drives **860a**, **860b** respectively and by adjustment of first and second rotating apparatuses **824a**, **824b**. For example, the articulating arms **862a**, **862b** may be interchanged to provide for arms of different lengths. Similarly, the lengths of end effectors **866a**, **866b** (which may be detachably coupled at end portions of articulating arms **862a**, **862b**) and/or the vertical position of suction cups **868a**, **868b** on end effectors **866a**, **866b** may be varied. Thus, by an interchange of mandrel **837** to provide for alternate sized and/or configurations of the mandrel side wall, PLC **832** and its operation (and the configuration/size) of first rotating apparatus **824a** and second rotating apparatus **824b** may be appropriately modified and programmed and thus different sized and configurations of blanks may be processed.

[0437] The can forming apparatus **800** may be configured such that the blank's initial position (i.e. the position for pick-up of a blank from the magazine) including its magazine **810**, can move following the arm rotation centre again as a function of the blank tube diameter and corresponding mandrel diameter. That may be achieved in part by having the entire carton magazine assembly adjustable longitudinally—in and out—on a rail slide mechanism as described above. The relative different longitudinal and transverse positions of the carton magazine, portion rotating apparatuses **824a**, **824b**, and mandrel **837** can be appreciated in FIGS. **81A** and **81B**.

[0438] With reference now to FIGS. **81A-D**, the dimensional configuration relationship of the blanks **8000**, mandrel **837** and first and second portion rotating apparatuses **824a**, **824b** is illustrated. The rotating apparatuses **824a**, **824b** are configured to attach to blank **8000** at suction cup pick points P, transport the engaged portions B and D of

blank **8000** to near mandrel point A and rotate and release the portions B and D of blank **8000** at suction arm forming/release positions F. It can be seen that distance CP between center of picking rotation C and suction cup pick point P is the same as distance CF between center of picking rotation C and suction arm forming/release position F (i.e. the pick arm radius R_1). Further, the distance between center of picking rotation C and near mandrel point A represents an adjustable region for space in rotation apparatuses **824a**, **824b** operability. According to some embodiments, there may be a single, common centre of rotation C for the two articulating arms **862a**, **862b**. That centre of rotation accords with the vertical axis of central shaft **901** in the illustrated embodiment.

[0439] To ensure minimal overlap in a cylindrical formed blank, the pick arm radius R_1 may be optimized in relation to the mandrel radius R_2 in concert with distance to mandrel CA. The total pick arm radius R_1 suction cup rotating arm dimension is related to the involute of a quarter of the mandrel circumference by the relationship $R_1 = \frac{1}{4}(2\pi R_2)$. In other words, the pick arm radius R_1 is defined such allow the blank **8000** to wrap around $\frac{1}{4}$ the circumference of the mandrel on each side of the mandrel, and thus the end-points of the rotation of the articulating arms will be at 90 degrees on the mandrel (ie. at 3 o'clock and 9 o'clock as shown in FIGS. **81A-D**). Based on this relationship and the Pythagorean equation, one can determine the appropriate distance (i.e. CA) to position blanks **8000**, wherein $R_1^2 = R_2^2 + (R_2 + CA)^2$. Therefore the theoretical final square and solvable equation for the adjustment, being the function of tube dimension, is: $CA^2 + 2 * R_2 * CA + (2 * R_2^2 - R_1^2) = 0$.

[0440] Accordingly, to alter the diameter of a tubular blank **8000** to be formed, some adjustments to can forming system **800** can be made. First, blanks **8000** of different transverse widths (such as W1, W2) can be exchanged and held in magazine **810**. To change the corresponding diameter (and thus circumference) of a circular cylindrical mandrel **837**, one size diameter mandrel can be exchanged for a different size diameter mandrel. When substituting the different sized mandrels, the circle centre datum point T of the mandrels may be in the same longitudinal and transverse position in relation to the external frame of reference (ie. T is the constant datum). In order to adjust the distance R_1 one may substitute different length articulating arms **862a**, **862b** in portion rotating apparatuses **824a**, **824b**, or otherwise adjust the relative position of end effectors **866a**, **866b** along arms **862a**, **862b**, relative to centre shaft **901**.

[0441] To vary the distance CA, the position of the centre of rotation C relative to the frame of the apparatus (and thus relative to the position on the frame where the mandrel **837** is secured—as described below) may be made adjustable on slide mechanisms such that the centre of rotation C can be adjusted dependent upon the tube diameter (ie. the width of the blank **8000**). For example, the positioning of center of arms rotation C relative to the support frame may be adjusted by adjusting the longitudinal positions of support tubes **855a**, **855b** relative to the main support frame, as described above. By way of example the positioning of the center of rotation C, associated with one relatively larger tube diameter is shown in FIGS. **81A** and **81C**, and the positioning associated with a relatively smaller tube diameter is shown in FIGS. **81B** and **81D**.

[0442] Additionally, it may be in some embodiments also be appropriate to make a corresponding longitudinal adjust-

ment in the position of the blank magazine which is holding the blanks **8000** in their pick-up positions. This may be done by using an electromechanical means (such as an articulatable and adjustable stopper controlled by a controller such as the programmable logic controller **832** or using a purely physical means such as a stopper device). However, in some embodiments, it may not be necessary to also move the longitudinal pick up position of a blank **8000** held in the magazine. For example, it may be that the suction cups **868a**, **868b** on respective end effectors **866a**, **866b** can still engage a blank held at the front of the blank magazine, if there is not a significant separation between the end effectors **866a**, **866b** and the surface of the blank, if the blank is longitudinally a relatively small further distance away from the suction cups **868a**, **868b** at the pick-up position.

[0443] Mandrel apparatus **820** may have several components including mandrel **837** (see FIGS. **56** and **59**) and mandrel support apparatus **848** (see FIG. **57**). Mandrel **837** may be easily removable/releasable (eg. such as with threaded bolt type releasable connectors) from fixed connection to mandrel support apparatus **848** so that a mandrel of one size/configuration may be easily replaced with a mandrel of another size/configuration. It may also be necessary to modify components of mandrel support apparatus **848** (eg. the lengths of members **849a**, **849b**, to ensure that the center of each mandrel remains in the datum position T).

[0444] With particular reference to FIGS. **59-65**, mandrel **837** may comprise a generally arcuate and semi-circular, vertically oriented side wall **821a** that is fixedly interconnected or integrally formed, with a pair of opposed, generally arcuate, quarter-circular, spaced, vertically and longitudinally oriented, spaced, side walls **821b**, **821c**. Side walls **821a**, **821b** and **821c** may be connected/integrally formed to provide a generally circular or oval, open top and bottom, can shape support mandrel **837**. Side walls **821a**, **821b**, **821c** of mandrel **437** may have an intermittent, circumferential, upper, flared-out, ridge **821d** (FIG. **55**) which will prevent a blank **8000** from sliding upwards relative to mandrel **837** is moved downwards when a blank is formed/wrapped around it, as described hereinafter. Alternatively, substitutable mandrels **837** may be generally configured in a variety of different sizes and shapes, each selected for the particular type of case blank **8000** to be formed into a composite can. For example, side walls **821a**, **821b** and **821c** and an additional side wall **821** (not shown) may be connected/integrally formed to provide a generally rectangular or square, open top and bottom can shape (similar to the mandrels of other embodiments described above).

[0445] In some embodiments, the dimensions of the outer surfaces of mandrel **837** may be selected so that the specific can blank **8000** that is desired to be formed has, during the folding/bending/wrapping process, vertical fold lines that are located substantially along the surface of mandrel **837**. In other embodiments, the can blank **8000** may not have fold lines but may be sufficiently bendable to simply be wrapped/bent around the arcuate outer surfaces of side walls **821a**, **821b** and **821c**. Mandrel **837**, and surrounding components in system **800**, may be configured to permit for the easy interchange of mandrel **837** so that can forming system **800** can be readily adapted to form differently sized/shaped composite cans from differently sized/configured case blanks **8000**.

[0446] With particular reference now to FIGS. **55**, **56**, **59** and **61**, a vertical slot **823a** may be provided between an end

of side wall **821a** and an end of side wall **821c**, and may be configured to permit a lower portion of end effector **866a** and air suction cups **868a** thereon to move from the position shown in FIG. **56** and pass through slot **823a** to the position shown in FIGS. **59** and **61**. By allowing the end effector **866a** to pass through vertical slot **823a**, end effector **866a**, and in particular air suction cups **868a**, may engage the outer surface of portion B of blank **8000** when it is held in magazine **810** and bring portion B into face-to-face relation with the outward facing surface of mandrel side wall **821c**. The surface of portion B, being held by air suction cups **868a**, becomes an inner surface of the tubular shaped blank and side portion B may be held against the outside surface of side wall **821c** of mandrel **837** as shown.

[0447] Similarly, with reference to FIGS. **56**, **59** and **61**, a vertical slot **823b** may be provided between a side end of side wall **821a** and a side end of side wall **821b** and may be configured to permit a lower portion of end effector **866b**, and air suction cups **868b** thereon, to move from the position shown in FIG. **56** and pass through slot **823b** to the position shown in FIGS. **59** and **61**. By allowing the end effector **866b** to pass through vertical slot **823b**, end effector **866b**, and in particular air suction cups **868b**, may engage the outer surface of the side portion D of blank **8000** when it is held in magazine **810** and bring portion D into face to face relation with the outward facing surface of side wall **821b**. The surface of portion D, being held by air suction cups **868b**, becomes an inner surface of the tubular shaped blank and side portion D may be held substantially flat against the outside surface of side wall **821b** of mandrel **837** as shown.

[0448] Similar to mandrel **337** described above, mandrel **837** may have one or more laterally extending tabs (not shown) at the upper perimeter edge. This ensures that when mandrel **837** moves vertically downward with blank **8000** wrapped around it and formed into a tubular side wall configuration, the upper edge of the tubular shaped blank, with its side wall formed from portions A-E, will move vertically downwards with mandrel **837** as the upper edge of the sidewall engages the downward facing surfaces of the tabs of mandrel **837**.

[0449] Mandrel side walls **821a**, **821b** and **821c** may be configured to facilitate the support of mandrel **837** on mandrel support apparatus **848**. In particular, side walls **821b** and **821c** may be connected to a generally U-shaped support frame with side support arms **849a**, **849b** which may be supported at, and fixedly connected to, an outer end of carriage support arm **846** (See FIG. **60**). Mandrel side wall **821a** may be integrally connected to side wall **821b**, and **821c** as shown for example in FIG. **55**. A vertical slot **823c** is provided between the sidewall portion **821b** and **821c** of mandrel **837**. Support arm **849a** may have secured to a distal end thereof vertical attachment member **850a**. Similarly, support arm **849b** may have secured to a distal end thereof vertical attachment member **850b** (see FIG. **60**). Mandrel **837** may be connected to lower portions of vertical attachments members **850a**, **850b** with releasable nuts/bolts to permit relatively easy interchange of differently sized/configured mandrels that are suitable for processing differently sized/configured blanks.

[0450] With reference to FIGS. **54**, **55** and **57**, as noted above, mandrel support apparatus **848** is fixedly attached to a first end portion of longitudinally oriented and extending carriage arm **846**. The opposite end portion of longitudinally oriented and extending carriage arm **846** is fixedly con-

nected to carriage block **844**. Carriage block **844** is attached for sliding vertical upward and downward movement on vertically oriented linear rail **842**. Linear rail **842** may be, for example, a linear rail device of many types made, for example, by Bosch Rexroth AG and provides a vertical movement apparatus **836** for mandrel **837** and the mandrel support apparatus **848**.

[0451] Linear rail **842** may be mounted to vertical support frame **840**. As indicated above, linear rail **842** may have a carriage drive mechanism which is operable under the control of PLC **832** to move the carriage **844**, and thus also mandrel **837**, vertically upwards and downwards within a range of movement as required for completing the can forming operations described herein.

[0452] It will also be appreciated that in first portion rotation apparatus **824a** and second portion rotating apparatus **824b**, air suction cups **868a**, **868b**, respectively, are used to apply a force to engage and move portions of a blank **8000**. However alternative engagement mechanisms to suction cups could be employed in other embodiments to engage and rotate portions of blanks **8000**.

[0453] The next components of system **800** to be described in detail are third portion rotating apparatus **830a** and fourth portion rotating apparatus **830b** (see FIGS. **59** and **61**) which are respectively configured to cause portions A and E to be folded/bent relative to portions B and D respectively to complete the wrapping of the portions A-E around the outward facing surfaces of mandrel **837** and form a generally circular/cylindrical or oval tubular shape as shown in FIG. **62**. In particular, third portion rotating apparatus **830a** is operable to rotate portion E clockwise with at least part of portion D while fourth portion rotating apparatus **830b** is operable to rotate portion A counter-clockwise with at least a part of portion B. When portions A and E are so rotated, portion C may be released from being held in the magazine and become configured in an arcuate shape around the outward facing surface of mandrel **837**. In other implementations, portion C may be released during the initial rotation by first and second rotating apparatuses **824a**, **824b**. The vertical longitudinal side edges of the portions A and E are positioned proximate to and may come into abutment with each other. Third and fourth portion rotating apparatuses **830a**, **830b** may each be a reciprocating plough device as described further below.

[0454] Between the vertical longitudinal side edges and inner surface of the portions A and E (when they are rotated relative to portions B and D respectively, and have their vertical edges in close proximity to or in close abutment with each other) is provided a vertical sealing strip **894** of sealing material **899** (see FIGS. **55**, **57** and **62**). Sealing material **899** may be, for example, a metalized foil ribbon material such as the same material that is used in the intermediate metallic foil layer in the blank. In some embodiments, sealing material (which may be in the form of an elongated ribbon) **899** may be the same or a similar material to that used in the inner layer of blank **8000**, such as a polyolefin layer, which will bond to the polyolefin layer on the inner surface of the blank when appropriately heated, or it may be a material comprising a combination of these two materials from blank **8000**. In other embodiments, a plastic type material bearing a cold seal adhesive may be employed for the sealing material **899**. In still other embodiments, the sealing material **899** may be a thermoplastic material which can melt upon application of heat or high frequency vibration. In some

implementations, sealing material may have a thickness in the range of about 0.008 mm (0.3 mils) mm to 0.016 mm (0.63 mils).

[0455] Sealing material **899** may be wound around in a coil and delivered in a continuous string from a reel/spool **898** (FIG. **70**) which feeds sealing material **899** over wheels **897** and **896** and to a sealing support bracket guide device **895** (see FIGS. **57**, **63**, **64**, **65**, and **66a**). Bracket guide device **895** may be mounted to transverse support member **893** that is interconnected to the main frame (FIG. **65**) and bracket guide device **895** may include a vertically oriented guide channel which allows for sealing material **899** to provide a vertical sealing strip **894** at and across the vertical longitudinal edges and between inner facing surfaces of portions A and E of blank **8000**. Bracket guide device **895** may have an upper portion **895a**, and a lower portion **895b**. Upper portion **895a** may be generally T-shaped in cross section and lower portion **895b** may have a generally flat outward vertical and transverse surface **895b'** (FIG. **82**). Bracket guide device **895** may be made of any suitable material, such as a thermoplastic or polyurethane material.

[0456] In some implementations, sealing material **899** may be a flat string or ribbon-like material that can be applied to the inward surfaces of the blanks **8000**, across the vertical and longitudinal butt joint. In other implementations, sealing material **899** may have a cross-sectional T-shape corresponding in size and shape to be accommodated within the guide channel of upper bracket guide portion **895a**. Sealing material **899** may thus have a base (i.e. **1**, or trunk portion) and a top portion (i.e. the $\overline{\quad}$, or branch portion). The sealing material **899** may according to some embodiments be inverted into a \perp shape. Such an orientation enables sealing strip **894** of such T-shaped configuration of sealing material **899**, once activated to provide both a vertical and longitudinal seal between outer edges **642** and a horizontal seal across the inner surfaces of the blank at the vertical joint, and providing improved structural strength. The top portion of the T strip (ie. the top of the T) will seal on and vertically and across the interior surface of the sidewall of the tubular blank. An inner sealant layer inside the tubular side wall of the blank may be made from 50 micron LDPE metalized or non-metalized film. This provides a suitable bonding material for the top of the T portion of sealing material **899** to form a transverse seal portion of sealing strip **894**.

[0457] The base of the T-strip (the vertical portion of the T) will provide an internal end butt joint seal/connection extending vertically between the vertically extending facing end edge surfaces of substantially abutting end portions A and E. When heated and compressed, the base portion of the T of heating strip **894** may also form an outer ridge/bulge at the outside surface of the blank **8000**, over the vertical butt seal, to help rigidize the seal and help protect the butt seal from failing and delamination.

[0458] The result is that by including a T-strip as a bonding element, the T-strip acts as a spine component providing strength to the connection and acts as a vertical column. The top of the T bond provides enhanced resistance to shearing forces by securing the horizontal edge to the internal end butt joint seal. The internal vertical end butt joint seal adds additional reinforcement by providing internal structure in lateral and transverse directions using its own structural integrity and shape in direct contact with the tubular shaped blank's walls.

[0459] As the sealing material **899** is fed from wheel **896** and enters upper guide portion **895a**, the configuration of the T-shaped channel is such that it ensures that the material **899** will be re-configured from a flattened configuration, to an upright T-shaped configuration. During movement of the mandrel **837** downwards (as described further below) the T-shaped sealing material **899** is further pulled, fed downward along the lower guide portion **895b**. The rigidity of sealing material **899**, along with the nature of the movement being of the mandrel **837** during this downward movement, being unidirectional, maintain the cross sectional T-shape (i.e. limiting any axial twisting that may change the cross-sectional T-shape or positioning) before a new blank is wrapped around the mandrel. After sealing, the sealing material **899** remains connected to both the blank **8000** and the string/ribbon of sealing material **899**. As the mandrel moves downward to the discharge position, the uncut ribbon/string is pulled down and into the sealing position for the next tubular blank to be formed and sealed. Once the next tubular blank **8000** is sealed, the ribbon is then cut at the top of the tubular blank allowing that lower tubular blank to be discharged. Throughout, the sealing material remains in its T-shape and position until and while the mandrel returns to the tubular blank forming position.

[0460] As illustrated in FIG. **65**, third portion rotating apparatus **830a** and fourth portion rotating apparatus **830b** may each include a respective transversely oriented plough device, **831a**, **831a**, each plough device having a generally arcuate plough plate **835a**, **835b** that may be moved transversely in intermittent, reciprocating transverse movement outwards and inwards a desired amount by corresponding actuating double acting pneumatic cylinders **812a**, **812b** and movable piston arms connected to plough devices **831a**, **831b**. The transverse movement of plough devices **831a**, **831b** may be controlled by valves in an air distribution unit **427** (FIG. **80**) that selectively deliver pressurized air through hoses (not shown) to respective double acting pneumatic cylinders **812a**, **812b** under the control of PLC **832**. The plough plates **835a**, **835b** of plough devices **831a**, **831b** may be configured with curved surfaces **891a**, **891b** such that the movement of the plough plates of plough devices **831a**, **831b** may engage and push on portions E and A respectively causing rotation of portions E and A relative to portions D and B respectively, such that the portions E and A can be wrapped around the outer surfaces of side wall portions **821b**, **821c** respectively to complete the generally round or oval tubular shape. Plough devices **831a**, **831b** may be configured for releasable engagement with respective piston arms of double acting pneumatic cylinders **812a**, **812b** such that if a mandrel of a different radius is substituted for an existing mandrel, then a corresponding change can be made to plough devices **831a**, **831b** to ensure the appropriate size and positioning of the curved surfaces **891a**, **891b** to ensure it can perform the functions described herein.

[0461] Can system **800** may also include a sealing device **890** (FIGS. **59**, **62** and **63**) which may include a vertically oriented sealing jaw (aka sealing bar) **881** that may be moved longitudinally in intermittent, reciprocating movement by double acting pneumatic cylinder **882** with movable piston arm **883** (see FIG. **62**) within a desired outwards and inwards range. The transverse reciprocating intermittent movement of sealing jaw **881** may be controlled by valves (not shown) that selectively deliver pressurized air through hoses (not shown) to pneumatic cylinder **882** that may be

supplied by pressurized air controlled by valves in the air distribution unit **427** under the control of PLC **832**. With reference to FIGS. **62** and **82**, when piston arm **883** is extended, sealing jaw **881** will be received into a vertical longitudinal gap between the extended vertical edges of plough devices **831a**, **831b** (not shown in FIG. **82**) and be able to engage the outward facing edges surfaces of abutting portions A and E and push the edges into engagement with the base portion of T shaped sealing strip **894**, and push against the outward facing vertical and transverse surface **895b'** of lower guide portion **895b** (FIG. **82**).

[0462] Welding or gluing or other activation of sealing strip **894** to abutting portions A and E can be accomplished by known means, such as by using one or more of heat, induction, a high frequency (for e.g. ultrasonic) electromagnetic field and/or pressure. For example, heating may be provided by sealing jaw **881** which may contain therein electrical heating elements, such as induction heating components that may be powered by electrical current supplied to sealing device **890**.

[0463] Once sealing strip **894** of sealing material **899** has bonded to the vertical longitudinal edges and inner facing surfaces of portions A and E, the tubular sidewall shape for a composite can has been formed and fixed. Thereafter, as mandrel **837** is moved vertically downwards by mandrel movement apparatus **836**, the sealing strip **894** of sealing material **899** that has bonded to the longitudinal/vertical edges and inner facing surfaces of portions A/E will also be moved downwards with mandrel **837** and the tubular shaped blank **8000**. This downward movement will pull down an additional sealing strip **894** portion of sealing material **899** from reel **898** that will be retained in the guide channel defined by upper and lower portions **895a**, **895b** of bracket device **895** and be available for use to seal the longitudinal edge and inner facing surfaces of portions A/E on the next blank **8000** that will be processed by can forming system **800**.

[0464] When one sealing strip **894**, welded to portions A and E of blank **8000**, has been moved down sufficiently to provide for the next portion of sealing strip **894** to be appropriately positioned in guide device **895**, a cutting device (not shown) can be employed to cut the sealing strip **894** to the appropriate height for the can. The cutting device may be a scissor style cutting device and its operation may be controlled by PLC **832**. The cutting device may also be configured to trim any excess sealing material at the top and bottom ends of the tubular blank.

[0465] It should be noted that when the mandrel returns upwards to the forming station where the next blank **8000** is to be formed around it, the sealing material will be received in an appropriate position within the vertical gap/slot **823c** between mandrel wall portions **821b**, **821c**.

[0466] The aforementioned components of third portion rotating apparatus **830a**, fourth portion rotating apparatus **830b**, and sealing device **890** may be mounted to frame members (not shown for simplicity) of support frame **840**. In some embodiments, the horizontal longitudinal/transverse positions, and also their vertical positions, may be adjustable on the frame to enable the components thereof to accommodate/substitute different sized/configured mandrel apparatuses **820** and corresponding different size and configuration of blanks. The adjustment may be made by hand and/or by servo motors operating moving support components under control of PLC **832**.

[0467] Pneumatic cylinders **812a**, **812b** and **822** may each be a conventional double/two way acting pneumatic reciprocating cylinder with piston arms that are operable to move in a reciprocal movement between fully extended positions and fully retracted positions. Compressed air may be delivered to pneumatic cylinders **812a**, **812b**, **822**, by hoses (not shown) in communication with a source of pressurized air through the air distribution unit **427**. To channel the compressed air appropriately, valves (not shown) in distribution unit **427** can be driven between open and closed positions by solenoids responsive to signals from PLC **832**. The valves could be located proximate the pneumatic cylinders or be disposed elsewhere. Electrical communication lines carrying signals to and from PLC **832** could also be provided to operate the valves.

[0468] It should also be noted that during downward vertical movement of case blank **8000** secured to mandrel **837**, one or more compression rails (not shown) supported on part of vertical support frame **840** may be configured and positioned to apply pressure to the portions A and E and push against the outward surface of side walls **821b**, **821c** of mandrel **837** to ensure appropriate sealing of portions A and E to sealing strip **894**.

[0469] With reference now to FIGS. **65**, **66a**, **71**, **72**, **74**, **75** and **76**, a bottom end flaring apparatus may be provided to flare outwardly the bottom edge of the tubular formed blank **8000**. Flaring the bottom edge of the tubular formed blank **8000** may assist in forming a structured seal between tubular formed blank **8000** and the bottom cup **874**. Flaring apparatus may include a pair of spaced flaring mandrels **980a**, **980b** which may be moved in reciprocating transverse movement to engage the lower edge of the blank **8000**. The flaring mandrels **980a**, **980b** may be moved by respective piston arms of double acting piston devices **981a**, **981b**. Compressed air may be delivered to pneumatic devices **981a**, **981b**, by hoses (not shown) in communication with a source of pressurized air through the air distribution unit **427**. To channel the compressed air appropriately, valves (not shown) in distribution unit **427** can be driven between open and closed positions by solenoids responsive to signals from PLC **832**. The valves could be located proximate the pneumatic cylinders or be disposed elsewhere. Electrical communication lines carrying signals to and from PLC **832** could also be provided to operate the valves.

[0470] With particular reference now to FIGS. **70**, **77**, **78** and **79**, a can discharge conveyor **8102** (for simplicity not shown in the other Figures) may be provided with a continuous conveyor belt **8105** driven in a conventional manner by a drive motor and drive wheel under control of PLC **832**. Conveyor belt **8105** may be configured with a top run to support and move open topped cans **8000'** formed from blanks **8000** by case forming system **800**. Can discharge conveyor **8102** may be supported on frame support leg components **840a**, **840b** which may be part of frame **840**.

[0471] With particular reference now to FIGS. **70**, **77**, **78** and **79**, a bottom cup delivery conveyor **8501**, which may be under control of PLC **832** that may be provided with inputs from appropriately positioned sensors, may be provided with a continuous conveyor belt **8502** driven in a conventional manner by a drive motor and a drive wheel under control of PLC **832** and configured to support and deliver a plurality of bottom cups **874** in series to a bottom forming

station generally designated **8506**. Bottom cup delivery conveyor **8501** may be supported on frame support leg components **8540a**, **8540b**.

[0472] A linear transfer robot generally designated **8900** under control of PLC **832** (that may be provided with inputs from appropriately positioned sensors) may include a moveable suction cup block **8901** with a plurality of suction cups **8902**. Linear transfer robot may be constructed and operate in a manner similar to the construction and operation of blank retention and delivery apparatus **8800** as described below. Suction cup block **8901** may repeatedly move backward and forward along a linear rail between a pick-up location at the end of bottom cup delivery conveyor **8501** and a mandrel drop off location above an upper surface of a seaming mandrel **872**. Suction cup block **8901** may pick up a bottom cup **874** at the pick-up location at the end of bottom cup delivery conveyor **8501** and move the bottom cup **874** to the mandrel drop off location above mandrel **872** where the bottom cup **874** is released onto the upper surface of seaming mandrel **872**. This movement can be repeated whenever it is required to place a bottom cup **874** so it can be secured to a tubular blank as described hereinafter.

[0473] With reference to FIGS. **66b**, **66c**, **67-69b** and **77**, can forming apparatus **870** may be provided with a seaming mandrel **872** (or seaming chuck) mounted on a top end of a rotating shaft **871** and a plurality of seaming heads **876**, **877**. The can forming apparatus **870** may use seaming heads **876**, **877**, which have seaming rollers **876a**, **876b**, **877a**, **877b** attached thereto, for performing the seaming function. According to some embodiments, seaming occurs by rotating the mandrel **872**. According to some embodiments, in the can seaming process, the tubular blank body **8000** and bottom cup **874** may rotate together to complete the seam between the bottom circumferential edge portion of the sidewall of tubular blank **8000**, and a circumferential edge portion of bottom cup **874**, through seaming rollers **876a**, **876b**, **877a**, **877b** (as will be described hereinafter). In other alternative embodiments, the seaming mandrel **874**, tubular blank **8000** and bottom cup **874** may remain stationary, and mechanical drives may rotate the seaming rollers **876a**, **876b**, **877a**, **877b** around the tubular blank **8000** and bottom cup **874**.

[0474] The can seaming apparatus **870** may be adapted and configured such that seaming mandrel **872** can hold bottom cup **874** firmly against the bottom end of can blank **8000** so that bottom cup **874** is held in contact with the bottom end of blank **8000** (FIG. **68**). The outside circumferential edge portion of the bottom cup **874** may be generally formed in a U-shape in order to facilitate the receiving of the bottom edge portion of the sidewall of tubular shaped blank **8000** (see FIG. **69a**). A first mechanical drive and second mechanical drive can be provided to position the plurality of seaming rollers **876a**, **876b**, **877a**, **877b** with respect to a circumferential flared edge of tubular blank **8000**. A third mechanical drive can be provided to rotate seaming mandrel **872** which in turn rotates tubular blank **8000** and bottom cup **874**.

[0475] Seaming rollers **876a**, **876b**, **877a**, **877b** are adapted to form a sanitary, mechanical seal and seam between case blank **8000** and bottom cup **874**. The first seaming rollers (i.e. seaming rollers **876a**, **876b**) may be operable to begin to roll bottom cup **874** and case blank **8000** forming a first operation roll seam, and the second seaming rollers (i.e. seaming rollers **877a**, **877b**) may be operable to

complete the seam forming the second operation roll seam, in a conventional type of can seam such as for example where two end regions of material are overlapped/folded to form a hook type configuration and are thereafter compressed together. In other embodiments, seaming rollers **876a**, **876b**, **877a**, **877b** may be operable to each simply pinch a pre-formed U-shaped channel **874a** (FIG. **69a**) of a bottom cup **874** containing the lower circumferential edge of the tubular body of blank **8000**, trapping and securing that lower circumferential edge of the tubular body of blank **8000** in the channel **874a**. In all such embodiments, the resultant seam, such as for example as shown in FIG. **69b**, may be airtight and may also prevent liquid from escaping from the interior of the can, once filled. At least in part, the sealing integrity of this seal may be due to the vertical seal strip **894** that is used to form the single vertical seal in the body of the sidewall of the tubular shaped blank **8000**. By having a single vertical seal formed in the tubular blank wall with seal strip **894**, and having a bottom edge of the tubular sidewall of blank **8000** which is continuous and uniform (e.g. not formed from spiral, connected layers of materials) an airtight and liquid-tight seam and seal is more likely to be formed between the lower edge of the sidewall of the blank **8000** and the bottom cup **874**.

[**0476**] Seaming rollers **876a**, **876b**, **877a**, **877b** may be generally of a conventional type of design used in providing a seam between a can side wall and a bottom or top lid. While can forming apparatus depicts four seaming rollers, some embodiments of a can seaming apparatus **870** may have only two seaming rollers.

[**0477**] The first mechanical drive and second mechanical drive for positioning seaming rollers **876a**, **876b**, **877a**, **877b** may be coordinated with the third mechanical drive that rotates seaming mandrel **874** with respect to a circumferential edge of tubular blank **8000** to be seamed to bottom cup **874**. In the present disclosure, this coordination may be performed by PLC **832**.

[**0478**] With reference to FIGS. **67** and **68**, the first mechanical drive may include a first positioning roller drive **900**. First positioning roller drive **900** may be linked via a roll shaft (not pictured) to seaming head **876**. Similarly, second mechanical drive may include a second positioning roller drive **901**. Second positioning roller drive **901** may be linked via a roll shaft (not pictured) to seaming head **877**. First and second mechanical drives may include pneumatic cylinders **905**, **906** and movable piston rods (not shown) for moving/translating seaming rollers **876a**, **876b**, **877a**, **877b** in a horizontal direction. Pneumatic cylinders **905**, **906** may operate similar to, and include the same components as pneumatic cylinders **812a**, **812b** and **822** as described above. Thus, first and second mechanical drives are configured and adapted to adjustably position the circumferential edge of the respective seaming rollers **876a**, **876b**, **877a**, **877b** toward and away from a center axis of the tubular blank **8000** thereby positioning seaming rollers **876a**, **876b**, **877a**, **877b**, with respect to the circumferential edge of bottom cup **874**, in a position to perform the seaming operation.

[**0479**] The third mechanical drive may include a servo motor (with appropriate drive shaft and gear mechanism) operable to rotate shaft **871**, which is connected to seaming mandrel **872**, around a vertical axis of rotation at a sufficient speed to accomplish a selected number of complete revolutions in a given time frame as required for the fabrication of an acceptable seam.

[**0480**] Thus, can seaming apparatus **870** may be of the type where the seaming mandrel **872** holds bottom cup **874** firmly against the bottom end of case blank **8000** during the seaming operation, and a servo motor rotates the seaming mandrel **872**, thereby causing rotation of the tubular blank **8000** and bottom cup **874** (and seaming mandrel **872**) in unison. Alternatively, can seaming apparatus **870** may be of the type where a seaming mandrel **872** holds bottom cup **874** firmly against the bottom end of tubular blank **8000** during the seaming operation, and mechanical drives rotate the seaming rollers **876a**, **876b**, **877a**, **877b** around tubular blank **8000** and bottom cup **874**.

[**0481**] In use, an unattached bottom cup **874** is positioned on seaming mandrel **872**. Case blank **8000** is moved vertically downward by mandrel movement apparatus **836** toward seaming mandrel **872** a predetermined vertical distance until the bottom end of tubular blank **8000** and bottom cup **874** are held firmly against the seaming mandrel **872**. Thus, the bottom end of case blank **8000** and bottom cup **874** exert a force against each other which is determined by the final position of case blank **8000** as determined by the action of mandrel movement apparatus **836**. Case blank **8000**, bottom cup **874** and seaming mandrel **872** may remain in this position during the seaming operation. After the seaming operation is completed, the mandrel movement apparatus **836** moves the bottom lidded case blank **8000** upward to allow the lidded case blank **8000** to be released and to allow a new bottom cup **874** to be positioned on seaming mandrel **872**.

[**0482**] Seaming rollers **876a**, **876b**, **877a**, **877b** may typically not move vertically during seaming. Accordingly, when a tubular blank **8000** is properly positioned on seaming mandrel **872**, it is only necessary to move the seaming rollers **876a**, **876b**, **877a**, **877b** toward the center axis of case blank **8000** to properly position the seaming rollers **876a**, **876b**, **877a**, **877b** to perform a seaming operation.

[**0483**] With reference again to FIGS. **69a** and **69b**, cross-sections of a bottom cup **874**, tubular blank **8000**, seaming mandrel **872** and seaming roller **876a** show the features of the bottom edge of tubular blank **8000** and bottom cup **874** during a seaming operation. Case blank **8000** is placed over bottom cup **874** and the bottom edge is received in channel **874a**. Seaming roller **876a** is moved laterally into engagement with the bottom edge of case blank **8000** and forms a seam.

[**0484**] Seaming roller **876** applies pressure between tubular blank **8000** and bottom cup **874**, such that there is a pinching or crimping of materials between bottom cup **874** and blank **8000** to form a seal as shown in FIG. **69**. The lateral movement of seaming roller **876** traverses the lower edge of the entire tubular blank **8000**, generating a lower crimped seam that will contact entire bottom edge of the tubular blank **8000**. The other seaming rollers may also perform substantially the same function in some implementations.

[**0485**] With reference now to FIGS. **70** and **77-79**, a blank retention and delivery apparatus **8800** (FIG. **78**) under control of PLC **832** may also be provided at bottom forming station **8506**. Blank retention and delivery apparatus **8800** may include delivery movement apparatus **8536** that may include a generally horizontally oriented linear rail **8542**. Linear rail **8542** may support a carriage block **8544** for sliding horizontal movement relative to support frame **840**.

[0486] The movement of carriage block **8544** on linear rail **8542** may be driven by a continuous drive belt **8543** interconnected to carriage block **8544**. Drive belt **8543** may be interconnected to, and driven by, a drive wheel (not shown) of servo drive motor **8545**. An encoder (not shown) may be associated with servo drive motor **8545**, and the encoder and servo drive motor may be in communication with PLC **832**. In this way, PLC **832**, on receiving signals from the encoder, may be able to monitor and control the horizontal position of carriage block **8544** (and the components interconnected thereto) by appropriately controlling and operating servo drive motor **8545**.

[0487] Carriage block **8544** may support and be rigidly connected to a pneumatic cylinders **8546a**, **8546b** having one or more moveable piston arms (not shown). The outer ends of pneumatically cylinders **8546a**, **8546b** may be connected to an air suction cup block **8588** which may have mounted thereto a plurality of air suction cups **8587**. Pneumatic cylinder **8546a**, **8546b** and piston arms may move air suction cup block **8588** in reciprocating transverse horizontal movement, and may also be activated by valves controlled by PLC **832** between a blank engagement position, a blank delivery position and a disengaged position. In the engagement position, air suction cups **8588** have a suction force that engages a facing surface of blank **8000**. This may assist in holding the blank **8000** in a fixed position while a bottom cup **874** is being installed in the blank **8000**. In the engaged position, air suction cups **8588** may also hold the blank in a fixed position when mandrel **837** is moved to a vertical position as it is being disengaged from blank **8000**, after bottom cup **874** has been seamed into the bottom end of blank **8000**.

[0488] In the delivery position, air suction cups **8588** may be moved by piston arms and suction cup block **8588** in a transverse direction toward discharge conveyor **8102** so that case blank **8000**, which is now formed into an open top can **8000'** with bottom cup **874** installed, is moved to a delivery transfer position. At the delivery transfer position air suction cups **8588** can be deactivated allowing composite can **8000'** to be deposited onto conveyor belt **8105** such that composite can **8000'** can be moved for further processing. That further processing will typically include filling the interior space of composite can **8000'** with one or more items/products and then closing the top, including creating a top seal.

[0489] With particular reference to FIGS. 70-79, in operation, can forming system **800** is operable to perform the sequence of steps **8000(1)** to **8000(6)** illustrated in FIG. 53 of folding and sealing a bottom end of case blank **8000** to form an open top composite can **8000'**. At the beginning of a cycle of operation, magazine **810** which has a plurality of blanks **8000** held therein has a blank **8000** at the front of the magazine in a pick-up position (see FIG. 71).

[0490] First portion rotating apparatus **824a** may then be operated by PLC **832** to engage with the facing surface of portion D of the front blank **8000** held in magazine **810** and releasing portions D and E from being held by magazine **810**, rotate portions D and E in a counter clockwise direction such that they are in engagement with a surface of side wall **821b** of mandrel **837** (see FIGS. 71 and 72). Second portion rotating apparatus **824b** may also be operated to engage with a facing surface of a portion B of a blank held in magazine **810** and releasing them portions D and E from being held by magazine **810**, rotate portions A and B such that they are in engagement with a surface of side wall **821c** of mandrel **837**.

Vertical slot **823a** of mandrel **837** permits a lower portion of end effector rod **866a** and air suction cups **868a** thereon to move from the position shown in FIG. 71 and pass through slot **823a** to the position shown in FIG. 72. By allowing the end effector rod **866a** to pass through vertical slot **823a**, end effector rod **866a**, and in particular air suction cups **868a**, may engage the outer surface of the portion D of blank **8000** when it is held in magazine **810** and bring portion D into face to face relation with the outward facing surface of mandrel side wall **821b**. The surface of portion D being held by suction cups **868a** becomes an inner surface of the tubular formed blank and side portion D may be held substantially flat against the outside surface of side wall **821a** of mandrel **837**, as shown.

[0491] Similarly, vertical slot **823b**, transversely opposite of vertical slot **821a**, of mandrel **837** permits a lower portion of end effector rod **866b**, and suction cups **868b** thereon, to move from the position shown in FIG. 71 to pass through slot **823b** to the position shown in FIG. 72. By allowing the end effector rod **866b** to pass through vertical slot **823b**, end effector **866b**, and in particular air suction cups **868b**, may engage the outer surface of the major side portion B of blank **8000** when it is held in magazine **810** and bring portion B into face to face relation with the outward facing surface of side wall **821c**. The surface of portion B being held by air suction cups **868b** becomes an inner surface of the tubular formed blank and side portion B may be held substantially flat against the outside surface of side wall **821b** of mandrel **837**, as shown. During the rotation of blank portions D/E and B/A, blank portion C may be also released from being held by magazine **810** and become drawn into the facing surface of mandrel portion **821a**.

[0492] Next, with reference to FIGS. 72 and 73, third portion rotating apparatus **830a** may be operated to rotate portion E and possibly part of portion D around the mandrel portion **821c**, in a counter clockwise direction. Similarly, fourth portion rotating apparatus **830b** may be operated to rotate portion A and possibly part of portion B in a clockwise direction. Central portion C may also as a result of the movement of portions A/B and D/E, also be formed into a generally arcuate shape. The result is a generally circular shaped tubular blank formed generally around the outer surfaces of mandrel **837**. When portions A and E are so rotated, the vertical longitudinal edges of the portions are in close proximity to or in abutment with each other. But, in certain implementations, between the inner surface of the portions A and E (when they are rotated relative to portions B and D respectively, and have their vertical edges proximate to or in abutment with each other) and the outward facing surface of side walls **821b** and **821c** of mandrel **837**, is sealing strip **894** of sealing material **899** (see FIGS. 72 and 73).

[0493] Next, sealing device **890** (see FIG. 73) may be operated such that vertically and longitudinally oriented sealing jaw **881** may be moved under control of PLC **832** in longitudinally inward direction by double acting pneumatic cylinder. With the piston arm extended, sealing jaw **881** can be received into the vertical longitudinal gap between the extended vertical edges of plough devices **831a**, **831b** and may engage the abutting outward faces of the edges of portions A and E (see FIG. 82).

[0494] Heat can be applied to the sealing strip **894** to thereby melt the sealing strip **894** in the proximate or abutting edge regions. The melted sealing strip **894** will then

bond to the vertical edges of proximate or abutting portions A and E and the inner facing surfaces of portions A and E. Once the sealing strip **894** that extends down the entire vertical joint and a portion of the inner facing surfaces of the sealing strip has bonded to inner surface regions of portions A and E, the tubular sidewall for the composite can has been formed.

[0495] With reference now to FIGS. **74**, **75** and **76**, PLC **832** may operate mandrel movement apparatus **836** to move mandrel **837** vertically downwards, with the result that the sealing strip **894** of sealing material **899** which is bonded to portions A/E to also be pulled down with the mandrel **837** and case blank **8000**. This downward movement will pull down an additional, next strip portion **894** of sealing material **899** that will be retained in the guide in bracket device portions **895a** and **895b**, and will be available to seal portions A/E on the next blank **8000** that will be processed by can forming system **800**.

[0496] When next sealing strip **894** attached to a blank **8000** formed into a tubular shape on mandrel **837** has been pulled down sufficiently to provide for the next sealing strip **894**, the cutting device (not shown) is employed to cut the sealing strip **894** that is attached to portions A/E of the tubular blank **8000** that has moved downward vertically, so that the sealing strip **894** attached to that tubular blank **8000** that has moved downward, is detached from the rest of the sealing material **899** being fed from the spool and any excess sealing material **899** at the upper and lower edges of the blank **8000** are trimmed away.

[0497] Now with reference to FIGS. **76-79**, PLC **832** continues to operate vertical movement apparatus **836** to move mandrel **837** and the tubular shaped blank **8000** wrapped around it, to the bottom forming station **8506** where a bottom cup **874** may be installed using the apparatuses described above, including the seaming apparatuses.

[0498] Next, under control of PLC **332**, air suction cups **8588** are moved in a transverse direction toward discharge conveyor **8102** and the can **8000'** is moved to a delivery transfer position where the suction cups **8587** can be deactivated by PLC **832** thus allowing the blank to be deposited onto conveyor belt **8105** such that the can **8000'** can be moved for further processing.

[0499] Mandrel **837** will in the meantime be moved upwards by mandrel movement apparatus **836** under the control of PLC **832** to the blank pick-up engagement position where the next blank **8000** held magazine **810** can be engaged and processed. As the mandrel **837** is moving vertically upwards to the blank pick-up engagement position where the next blank **8000** is to be formed around it, the sealing material **899** will be received in an appropriate position within the vertical gap/slot **823c** between mandrel wall portions **821b**, **821c** and a in a position such that the next blank **8000** can be formed into the position shown in FIG. **82**.

[0500] The foregoing process can be performed on multiple blanks **8000** in series. It is expected that in the range of approximately 20-40 blanks **8000** may be processed per minute with such a can forming system **800**, depending upon the configuration and construction of the blank to be processed.

[0501] 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.

[0502] 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.

1. A method for forming a cylindrical container from a re-configurable blank that is supported in a first generally flat configuration with a first wall surface and an opposite second wall surface; wherein said method comprises:

- (a) positioning a blank support device proximate said first wall surface of said blank while said blank is in said first configuration, said blank support device having a generally cylindrical outward facing surface;
- (b) engaging said first wall surface of said blank and rotating a first portion of said blank, around a first portion of the outward facing surface of said blank support device, such that said first portion of said blank wraps around a first quarter surface area of the generally cylindrical outward facing surface of the blank support device;
- (c) engaging the first wall surface and rotating a second portion of said blank around a second portion of the outward facing surface of said blank support such that said section portion of said blank wraps around a second quarter surface area of the generally cylindrical outward facing surface of said blank support device, said first and second quarter surface areas of the generally cylindrical outward facing surface of said blank support device being adjacent to each other;
- (d) rotating a part of said first portion of the blank around a third quarter surface area of the generally cylindrical outward facing surface of said blank support device, said second and third quarter surface areas of the generally cylindrical outward facing surface of said blank support device being adjacent to each other;
- (e) rotating a part of said second portion of the blank around a fourth quarter surface area of the generally cylindrical outward facing surface of said blank support device, said third and fourth quarter surface areas of the generally cylindrical outward facing surface of said blank support device being adjacent to each other;

to thereby form a blank that has a generally cylindrical tubular side wall configuration for said container around the generally cylindrical outward facing surface of said blank support device;

wherein said first wall surface of said blank forms an inner surface of said blank when said blank is in said generally cylindrical tubular side wall configuration around said blank support device.

2. A method as claimed in claim **1** wherein said generally cylindrical outward facing surface of said blank support device has a first recess and a second recess, said first recess being configured to receive a portion of a first rotating apparatus therein, and said second recess being configured to receive a portion of a second rotating apparatus therein; and wherein when said first rotating apparatus rotates said first portion of said blank from said first orientation around said blank support device, at least part of the first portion of the blank is held against the first quarter surface area of the

generally cylindrical outward facing surface of said blank support device and a portion of said first rotating apparatus is received in said first recess, and wherein when said second rotating apparatus rotates said second portion of said blank from said first orientation around said blank support device, at least part of the second portion of the blank is held against the second quarter surface area of the generally cylindrical outward facing surface of said blank support device and a portion of said second rotating apparatus is received in said second recess.

3. A method as claimed in claims 1 or 2 wherein the rotation of the first portion of the blank is an opposite rotational direction to the rotation of the second portion of the blank.

4. A method as claimed in claim 2 or 3, wherein said first rotating apparatus and said second rotating apparatus, comprise rotational members that rotate about a common axis of rotation.

5. A method as claimed in any of claims 1, 2, 3 or 4, wherein a time period when the rotating of the first portion of said blank from said first configuration, around a first portion of the first facing surface of said blank support device occurs, overlaps with a time period during which the rotating of the second portion of said blank from said first orientation, around a second portion of the first outward facing surface of said blank support occurs.

6. A method as claimed in claim 5, wherein the time period of the rotating of the first portion of said blank from said first configuration, around a first portion of the first facing surface of said blank support device is substantially the same time period of the rotating of the second portion of said blank from said first orientation, around a second portion of the first outward facing surface of said blank support.

7. A method as claimed in any one of claim 1 to 6, wherein said blank support device comprises a first blank support device having a first cylindrical radius, and further comprising a second blank support device having a second cylindrical radius that is different than said first cylindrical radius, said first blank support device being interchangeable with said blank support device, such that a first blank having substantially said first cylindrical radius is formed around said first blank support device and said second cylindrical radius is formed around said second blank support device to form first and second blanks of differing size radius side walls.

8. A method as claimed in any one of claims 1 to 6, further comprising: after (e),

(f) interconnecting the first and second portions of the blank to secure said blank in said generally tubular side wall configuration;

wherein (f) comprises bringing a free edge of the first portion and a free edge of the second portion of said blank into close proximity with each other and interconnecting the free edges of the first and second portions of the blank to thereby form said blank to provide a generally tubular cylindrical side wall configuration around said outward facing surface of said blank support device.

9. A method as claimed in claim 8, wherein said free edges of said first and second portions of said blank are interconnected by a sealing strip that is interconnected to both said first and second portions.

10. A method as claimed in claim 9 wherein said sealing strip has a generally T-shape in cross section and comprises a first top portion that bonds to inner surfaces of first and second portions of said blank and across a joint between the first and second portions of the blank, and said sealing strip comprises a base portion that is received between and bonds opposing edge faces of said first and second portions of said blank.

11. A method as claimed in claim 10 wherein said top of said sealing strip is positioned against inner surface regions of said first and second portions of said blank.

12. A method as claimed in claim 11, wherein said top of said sealing strip is positioned within a slot of said blank support device.

13. A method as claimed in any one of claims 8 to 12 wherein said sealing strip is delivered from a supply of sealing material.

14. A method as claimed in claim 13 wherein said supply of sealing material is a ribbon of sealing material delivered from a reel.

15. A method as claimed in claim 14 wherein said blank comprises an inner layer formed from a material that is bondable to said sealing material when heat is applied to said inner layer and said sealing strip.

16. A method as claimed in any one of claims 7 to 15, wherein after (f), further comprising (g) moving said blank with said case blank support device to a bottom forming station for forming a bottom portion of said container by installing a bottom cup in a bottom opening of said tubular side wall configuration of said blank.

17. A method as claimed in claim 16 wherein said bottom cup is installed in said bottom opening by a seaming apparatus that performs a seaming process to create a seam between a bottom circumferential edge of said tubular side wall configuration of said blank and a circumferential edge region of said bottom cup.

18. A method as claimed in claims 16 or 17 wherein during said moving of said blank with said case blank support device to said bottom forming station, said sealing strip is moved therewith and said supply of sealing material delivers another sealing strip for use with a subsequent blank to be formed.

19. A method as claimed in any one of claims 1 to 18 wherein said blank comprises a multi-layered structure material.

20. A method as claimed in claim 19 wherein said blank comprises: (i) a first paper based substrate; and (ii) a bondable plastic inner layer.

21. A method as claimed in any one of claims 1 to 20 wherein said container is a composite can.

22. A method comprising automatically and successively repeating the methods of any one of claim 1 to 21 to form multiple cans.

23. A method for forming a cylindrical container from a re-configurable blank comprising:

(a) Forming a cylindrical tubular side wall around a mandrel with a single vertical sealed joint;

(b) Installing a cup into an end opening of said cylindrical tubular side wall with a seaming apparatus to form a circumferential seamed sealed joint.

24. A method as claimed in claim 23 wherein (a) comprises:

(i) Forming a cylindrical tubular side wall by wrapping first and second portions of a blank around a mandrel;

(ii) After (i), forming a vertical sealed joint between two free edges of first and second portions of said blank.

25. A method as claimed in claim **24** wherein (ii) comprises providing a sealing strip that is interconnected to both said first and second portions.

26. A method as claimed in claim **25** wherein said sealing strip has a generally T-shape in cross section and comprises a first top portion that bonds to inner surfaces of first and second portions of said blank and across a joint between the first and second portions of the blank, and said sealing strip comprises a base portion that is received between and bonds the opposing edge faces of said first and second portions of said blank.

27. A method as claimed in claim **26** wherein said top of said sealing strip is positioned between an outward facing surface portion of said blank support device and an inner surface portions of said first and second portions of said blank.

28. A method as claimed in any one of claims **24** to **27**, wherein said sealing strip is provided from a supply of sealing material.

29. A method of claim **28** wherein said supply of sealing material is a ribbon of sealing material delivered from a reel.

30. A method as claimed in any one of claims **23** to **29** wherein said container is a composite can.

31. A method for forming a container from a re-configurable blank comprising:

- a. forming a tubular side wall by wrapping first and second portions of a blank around a mandrel;
- b. after (a), forming a vertical sealed joint between two free edges of said first and second portions of said blank by providing a sealing strip that is interconnected to both said first and second portions;

and wherein said sealing strip has a generally T-shape in cross section and comprises a first top portion that bonds to inner surfaces of first and second portions of said blank and across a joint between the first and second portions of the blank, and said sealing strip comprises a base portion that is received between and bonds the opposing edge faces of said first and second portions of said blank.

32. A method as claimed in claim **31** wherein said top of said sealing strip is positioned between an outward facing surface portion of said blank support device and an inner surface portions of said first and second portions of said blank.

33. A method as claimed in claims **31** or **32** wherein said sealing strip is provided from a supply of sealing material.

34. A method of claim **33** wherein said supply of sealing material is a ribbon of sealing material delivered from a reel.

35. A method as claimed in any of claims **31** to **34** further comprising installing a cup into an end opening of said cylindrical tubular side wall with a seaming apparatus to form a circumferential seamed sealed joint.

36. A method as claimed in claim **35** wherein said cup is a bottom cup installed into a bottom end opening of said cylindrical tubular side wall.

37. A method as claimed in any one of claims **30** to **36**, wherein said container is a composite can.

38. A method comprising automatically and successively repeating the methods of any one of claim **30** to **37** to form multiple cans.

39. A method for forming a container from a re-configurable blank comprising:

- (a) positioning part of an outward facing surface of a blank support device proximate a first surface of said blank while said blank is in a first orientation;
- (b) rotating a first portion of said blank with a rotating sub-system in a clockwise direction around a first semi-cylindrical portion of an outward facing surface of said blank support device;
- (c) rotating a second portion of said blank with said rotating sub-system in a counterclockwise direction around a second semi-cylindrical portion of said outward facing surface of said blank support device;

wherein a generally cylindrical tubular side wall configuration is formed around said outward surface of said blank support device.

40. A method as claimed in claim **39**, wherein a time period when the rotating of the first portion of said blank from said first configuration, around a first semi-cylindrical portion of the outward facing surface of said blank support device occurs, overlaps with a time period during which the rotating of the second portion of said blank from said first orientation, around a second portion of the outward facing surface of said blank support device occurs.

41. A method as claimed in claims **39** or **40**, wherein the rotating sub-system comprises a first rotating apparatus operable to rotate about a turning radius; and wherein said rotating sub-system comprises a second rotating apparatus operable to rotate about said turning radius, said turning radius is mathematically related to the width of the reconfigurable blank and the radius of the cylindrical outer surface of said blank support device.

42. A method as claimed in claim **41** wherein said turning radius is further mathematically related to the proximate distance from the reconfigurable blank to the outer surface of the blank support device.

43. A method as claimed in any one of claims **38** to **42** wherein said container is a composite can.

44. A method comprising automatically and successively repeating the methods of any one of claim **38** to **43** to form multiple cans.

45. A system for forming a container from a re-configurable blank, said system comprising:

- (a) a blank support device having a generally cylindrical outward facing surface, said blank support device being positioned such that in operation said blank support device is located proximate said blank while said blank is in a first generally flat configuration;
- (b) a rotating sub-system operable to:
 - i. engage a first wall surface of said blank and rotate a first portion of said blank around a first portion of a first facing surface of said blank support device, such that said first portion of said blank wraps around a first quarter surface area of the generally cylindrical outward facing surface of the blank support device;
 - ii. engage the first wall surface and rotate a second portion of said blank around a second portion of the first outward facing surface of said blank support such that said section portion of said blank wraps around a second quarter surface area of the generally cylindrical outward facing surface of said blank support device, said first and second quarter surface areas of the generally cylindrical outward facing surface of said blank support device being adjacent to each other;

- iii. rotate a part of said first portion of the blank around a third quarter surface area of the generally cylindrical outward facing surface of said blank support device, said second and third quarter surface areas of the generally cylindrical outward facing surface of said blank support device being adjacent to each other;
- iv. rotate a part of said second portion of the blank around a fourth quarter surface area of the generally cylindrical outward facing surface of said blank support device, said third and fourth quarter surface areas of the generally cylindrical outward facing surface of said blank support device being adjacent to each other;
- to thereby form a blank that has a generally cylindrical tubular side wall configuration around the generally cylindrical outward facing surface of said blank support device;
- wherein said first wall surface of said blank forms an inner surface of said blank when said blank is in said generally cylindrical tubular side wall configuration around said blank support device.
- 46.** A system as claimed in claim **45** further comprising:
- (c) a holding apparatus operable for releasably holding said reconfigurable blank in a generally flat configuration and a generally vertical and transversely extending orientation;
- and wherein said system is operable to position a first portion of said outward facing surface of said blank support device proximate said blank while said blank is held by said holding apparatus in said generally flat configuration and said generally vertical and transversely extending orientation.
- 47.** A system as claimed in claims **45** or **46**, wherein said rotating sub-system comprises a first rotating apparatus and a second rotating apparatus, and wherein said generally cylindrical outward facing surface of said blank support device has a first recess and a second recess, said first recess being configured to receive a portion of said first rotating apparatus therein, and said second recess being configured to receive a portion of said second rotating apparatus therein; and wherein during operation, when said first rotating apparatus rotates said first portion of said blank from said first orientation around said blank support device, at least part of the first portion of the blank is held against the first quarter surface area of the generally cylindrical outward facing surface of said blank support device and a portion of said first rotating apparatus is received in said first recess, and wherein when said second rotating apparatus rotates said second portion of said blank from said first orientation around said blank support device, at least part of the second portion of the blank is held against the second quarter surface area of the generally cylindrical outward facing surface of said blank support device and a portion of said second rotating apparatus is received in said second recess.
- 48.** A system as claimed in claim **47** wherein said first rotating apparatus and said second rotating apparatus having rotating members that rotate about a common axis of rotation, said rotating members having engagement devices that are operable to engage the wall surfaces of the blank.
- 49.** A system as claimed in any of claims **45** to **48** wherein, in operation, a time period when the rotating of the first portion of said blank from said first configuration, around a first portion of the first facing surface of said blank support

device occurs, overlaps with a time period during which the rotating of the second portion of said blank from said first orientation, around a second portion of the first outward facing surface of said blank support occurs.

50. A system as claimed in claim **49**, wherein the time period of the rotating of the first portion of said blank from said first configuration, around a first portion of the first facing surface of said blank support device is substantially the same time period of the rotating of the second portion of said blank from said first orientation, around a second portion of the first outward facing surface of said blank support.

51. A system as claimed in any one of claims **45** to **50**, wherein said blank support device comprises a first blank support device having a first cylindrical radius, and further comprising a second blank support device having a second cylindrical radius that is different than said first cylindrical radius, said first blank support device being interchangeable with said blank support device, such that a first blank having substantially said first cylindrical radius is formed around said first blank support device and said second cylindrical radius is formed around said second blank support device to form first and second blanks of differing size radius side walls.

52. A system as claimed in claim **51** wherein said rotating subsystem is adjustable to accommodate the interchange of said first and second support devices.

53. A system as claimed in any one of claims **45** to **52** wherein said rotating subsystem is further operable to: after (iv), (v) interconnect the first and second portions of the blank to secure said blank in said generally tubular side wall configuration; wherein (v) comprises bringing a free edge of the first portion and a free edge of the second portion of said blank into close proximity with each other and interconnecting the free edges of the first and second portions of the blank to thereby form said blank to provide a generally tubular cylindrical side wall configuration around said outward facing surface of said blank support device.

54. A system as claimed in claim **53**, wherein said free edges of said first and second portions of said blank are interconnected by a sealing strip that is interconnected to both said first and second portions.

55. A system as claimed in claim **54** wherein said sealing strip has a generally T-shape in cross section and comprises a first top portion that bonds to inner surfaces of first and second portions of said blank and across a joint between the first and second portions of the blank, and said sealing strip comprises a base portion that is received between and bonds opposing edge faces of said first and second portions of said blank.

56. A system as claimed in claim **55** wherein said top of said sealing strip is positioned against inner surface regions of said first and second portions of said blank.

57. A system as claimed in claim **56** wherein said top of said sealing strip is positioned within a slot of said blank support device.

58. A system as claimed in claims **54** or **55**, further comprising a reel operable to deliver a supply of sealing material.

59. A system as claimed in claim **58** wherein said supply of sealing material is a ribbon of sealing material.

60. A system as claimed in claim **59**, wherein said blank comprises an inner layer formed from a material that is

bondable to said sealing material when heat is applied to said inner layer and said sealing strip.

61. A system as claimed as claimed in any one of claims **54** to **60**, further comprising a bottom forming station, and a blank support movement subsystem, wherein in operation, after (v), said blank support movement subsystem is operable to move said blank on said case blank support device to said bottom forming station, at which a bottom forming subsystem is located and is operable for forming a bottom portion of said container by installing a bottom cup in a bottom opening of said tubular side wall configuration of said blank.

62. A system as claimed in claim **61** wherein said bottom forming subsystem comprises a seaming apparatus, and wherein in operation, said bottom cup is installed in said bottom opening by said seaming apparatus that is operable to perform a seaming process to create a seam between a bottom circumferential edge of said tubular side wall configuration of said blank and a circumferential edge region of said bottom cup.

63. A system as claimed in claims **61** or **62**, wherein said system is operable such that during said movement of said blank with said case blank support device to said bottom forming station, said sealing strip is moved therewith and said supply of sealing material delivers another sealing strip for use with a subsequent blank to be formed.

64. A system as claimed in any one of claims **45** to **63**, wherein said blank comprises a multi-layered structure material.

65. A system as claimed in claim **64** wherein said blank comprises: (i) a first paper-based substrate; (ii) a bondable plastic inner layer.

66. A system as claimed in any one of claims **45** to **65** wherein said container is a composite can.

67. A system as claimed in any one of claims **45** to **66** that is operable to form multiple cans.

68. A system for forming a container from a re-configurable blank, said system comprising:

- (a) a blank support device having a generally cylindrical outward facing surface, said blank support device being positioned such that during operation, said outward facing surface of said blank support device is located proximate said blank while said blank is in a first configuration;
- (b) a rotating sub-system operable to rotate said blank around the outward facing surface of said blank support device to form a generally cylindrical tubular side wall configuration around said outward surface of said blank support device;
- (c) a bottom forming subsystem and a blank support movement subsystem;

wherein in operation, after said blank is formed into said generally cylindrical tubular side wall configuration by said rotating sub-system, said blank support movement subsystem is operable to move said blank on said case blank support device to a bottom forming station, where said bottom forming subsystem is located, and said bottom forming sub-system is operable for forming a bottom portion of said container by installing a circular bottom cup in a circular bottom opening of said tubular side wall configuration of said blank.

69. A system as claimed in claim **68** wherein said bottom forming subsystem comprises a seaming apparatus, and wherein in operation, said bottom cup is installed in said

bottom opening by said seaming apparatus that is operable to perform a seaming process to create a seam between a bottom circumferential edge of said tubular side wall configuration of said blank and a circumferential edge region of said bottom cup.

70. A system as claimed in claims **68** or **69** wherein during said movement of said blank with said case blank support device to said bottom forming station, said sealing strip is moved therewith and said supply of sealing material delivers another sealing strip for use with a subsequent blank to be formed.

71. A system as claimed in any one of claims **68** to **70** wherein said rotating subsystem is further operable to interconnect the first and second portions of the blank to secure said blank in said generally cylindrical tubular side wall configuration; wherein in operation, said rotating subsystem brings a free edge of the first portion and a free edge of the second portion of said blank into close proximity with each other and interconnecting the free edges of the first and second portions of the blank to thereby form said blank to provide a generally tubular cylindrical side wall configuration around said outward facing surface of said blank support device.

72. A system as claimed in claim **71**, wherein said free edges of said first and second portions of said blank are interconnected by a sealing strip that is interconnected to both said first and second portions.

73. A system as claimed in claim **72** wherein said sealing strip has a generally T-shape in cross section and comprises a first top portion that bonds to inner surfaces of first and second portions of said blank and across a joint between the first and second portions of the blank, and said sealing strip comprises a base portion that is received between and bonds opposing edge faces of said first and second portions of said blank.

74. A system as claimed in claim **73** wherein said top of said sealing strip is positioned against inner surface regions of said first and second portions of said blank.

75. A system as claimed in claim **74** wherein in operation, during the rotation of said blank around the outward facing surface of said blank support device to form a generally cylindrical tubular side wall configuration, said top of said sealing strip is positioned within a slot of said blank support device.

76. A system as claimed in any one of claims **72** to **75**, further comprising a reel operable to deliver a supply of sealing material.

77. A system as claimed in claim **76** wherein said supply of sealing material is a ribbon of sealing material.

78. A system as claimed in claim **77**, wherein said blank comprises an inner layer formed from a material that is bondable to said sealing material when heat is applied to said inner layer and said sealing strip.

79. A system as claimed in any one of claims **68** to **78**, wherein said blank comprises a multi-layered structure material.

80. A system as claimed in claim **79** wherein said blank comprises: (i) a first paper-based substrate; (ii) a bondable plastic inner layer.

81. A system as claimed in any one of claims **68** to **80**, wherein said container is a composite can.

82. A system for forming a cylindrical container from a re-configurable blank comprising:

an apparatus operable for forming a cylindrical tubular side wall around a mandrel with a single vertical sealed joint;

an apparatus operable for locating a bottom cup into a bottom opening of said cylindrical tubular side wall; and

a seaming apparatus operable to form a circumferential seamed sealed joint between a circumferential edge region of said bottom cup and a circumferential lower edge region of said cylindrical tubular side wall.

83. A system for forming a container from a re-configurable blank comprising:

(i) an apparatus operable for forming a tubular side wall around a mandrel with a single vertical sealed joint at opposed vertical free edges of said blank;

(ii) an apparatus operable to place a vertically extending sealing strip that extends across and between said joint to form a seal, wherein said sealing strip has a generally T-shape in cross section and comprises a first top portion that bonds to inner surfaces of the opposed free edges of said blank and across said joint and said sealing strip comprises a base portion that is received between and bonds opposing edge faces of said free edges of said blank.

84. A system as claimed in claim **83** further comprising a sealing activation apparatus operable to activate the seal between the sealing strip and the free vertical edges of the tubular sidewall.

85. A system as claimed in any of claims **45** to **84** which is operable to automatically and successively form multiple composite cans.

86. A blank for a can comprising a generally cylindrical tubular side wall having a single vertical joint at opposed vertical free edges of said blank;

wherein said opposed vertical free edges of said blank are interconnected by a vertically extending sealing strip that extends across said joint; and

wherein said sealing strip has a generally T-shape in cross section and comprises a first top portion that bonds to inner surfaces of the opposed free edges of said blank and across said joint and said sealing strip comprises a base portion that is received between and bonds opposing edge faces of said free edges of said blank.

87. A blank as claimed in claim **86**, wherein the side wall has a bondable plastic layer that provides an inner layer for said can and said sealing strip is formed of a sealable material that is bondable to said inner layer.

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