US 20080276867A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2008/0276867 A1
(43) Pub. Date: Nov. 13, 2008
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(54) TRANSFER CHAMBER WITH VACUUM EXTENSION FOR SHUTTER DISKS

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(21) Appl. No.: 12/117,945

(22) Filed: May 9, 2008

Related U.S. Application Data

(60) Provisional application No. 60/916,921, filed on May 9, 2007, provisional application No. 60/916,924, filed on May 9, 2007, provisional application No. 60/916,932, filed on May 9, 2007.

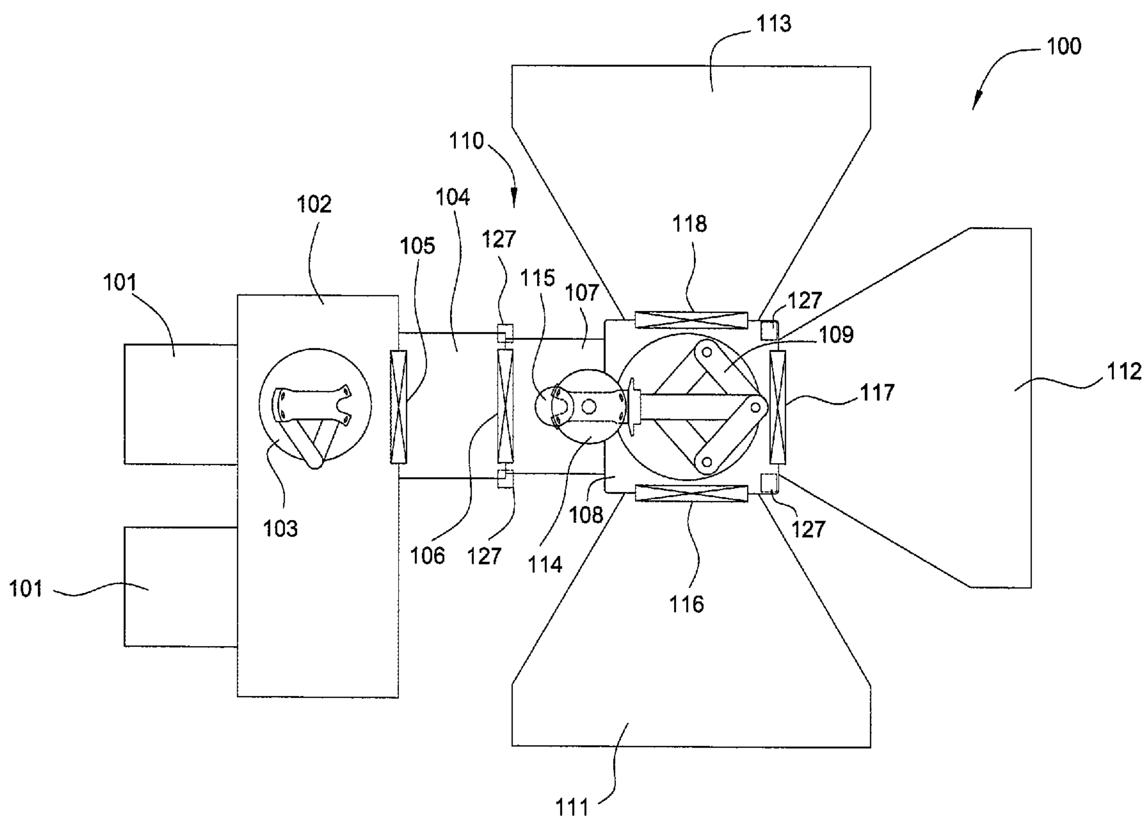
Publication Classification

(51) Int. Cl.
C23C 16/00 (2006.01)

(52) U.S. Cl. 118/719

(57) ABSTRACT

The present invention relates to a cluster tool for processing semiconductor substrates. One embodiment of the present invention provides a mainframe for a cluster tool comprising a transfer chamber having a substrate transferring robot disposed therein. The substrate transferring robot is configured to shuttle substrates among one or more processing chambers directly or indirectly connected to the transfer chamber. The mainframe further comprises a shutter disk shelf configured to store one or more shutter disks to be used by the one or more processing chambers, wherein the shutter disk shelf is accessible to the substrate transferring robot so that the substrate transferring robot can transfer the one or more shutter disks between the shutter disk shelf and the one or more processing chambers directly or indirectly connected to the transfer chamber.



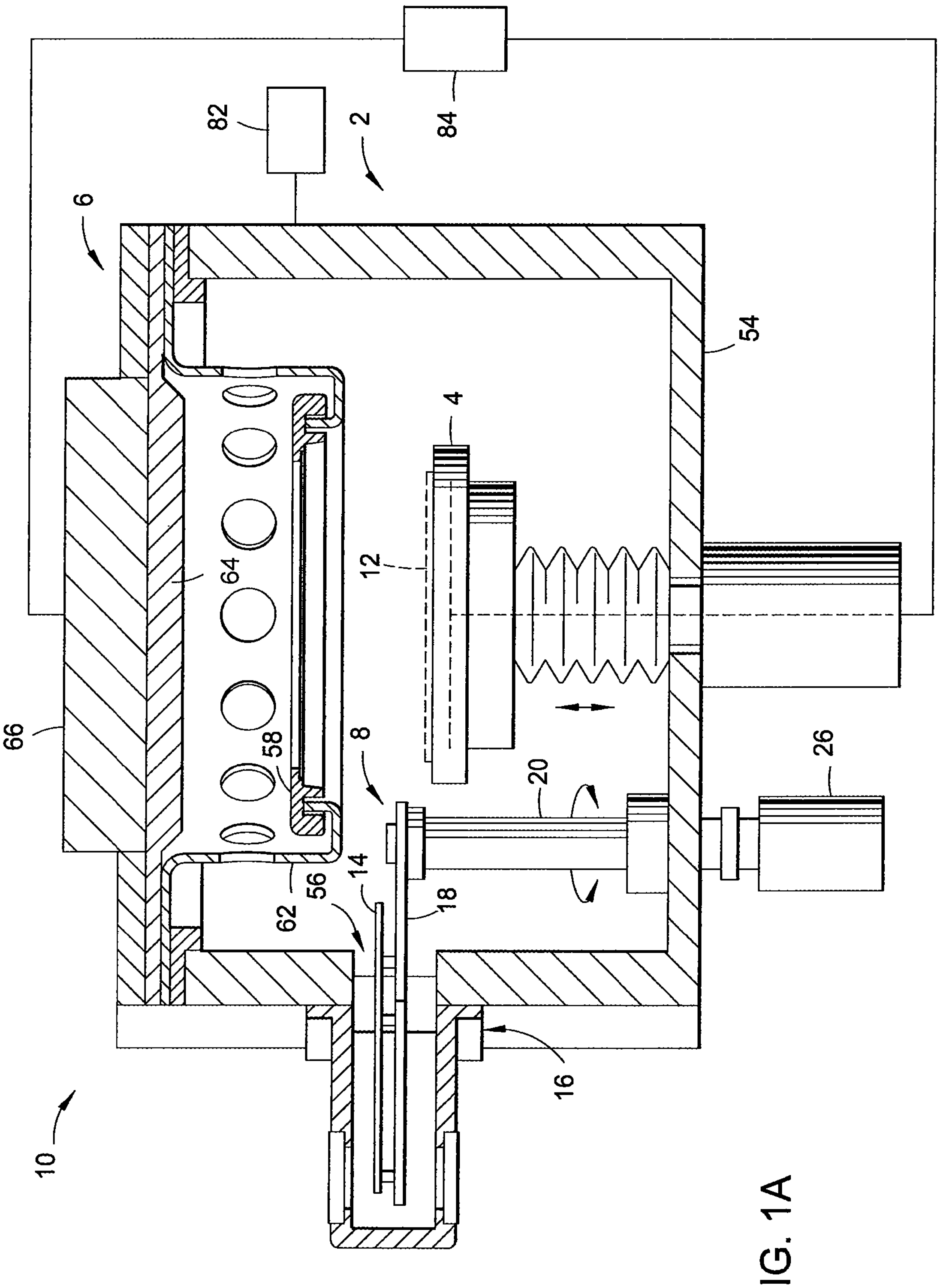


FIG. 1A

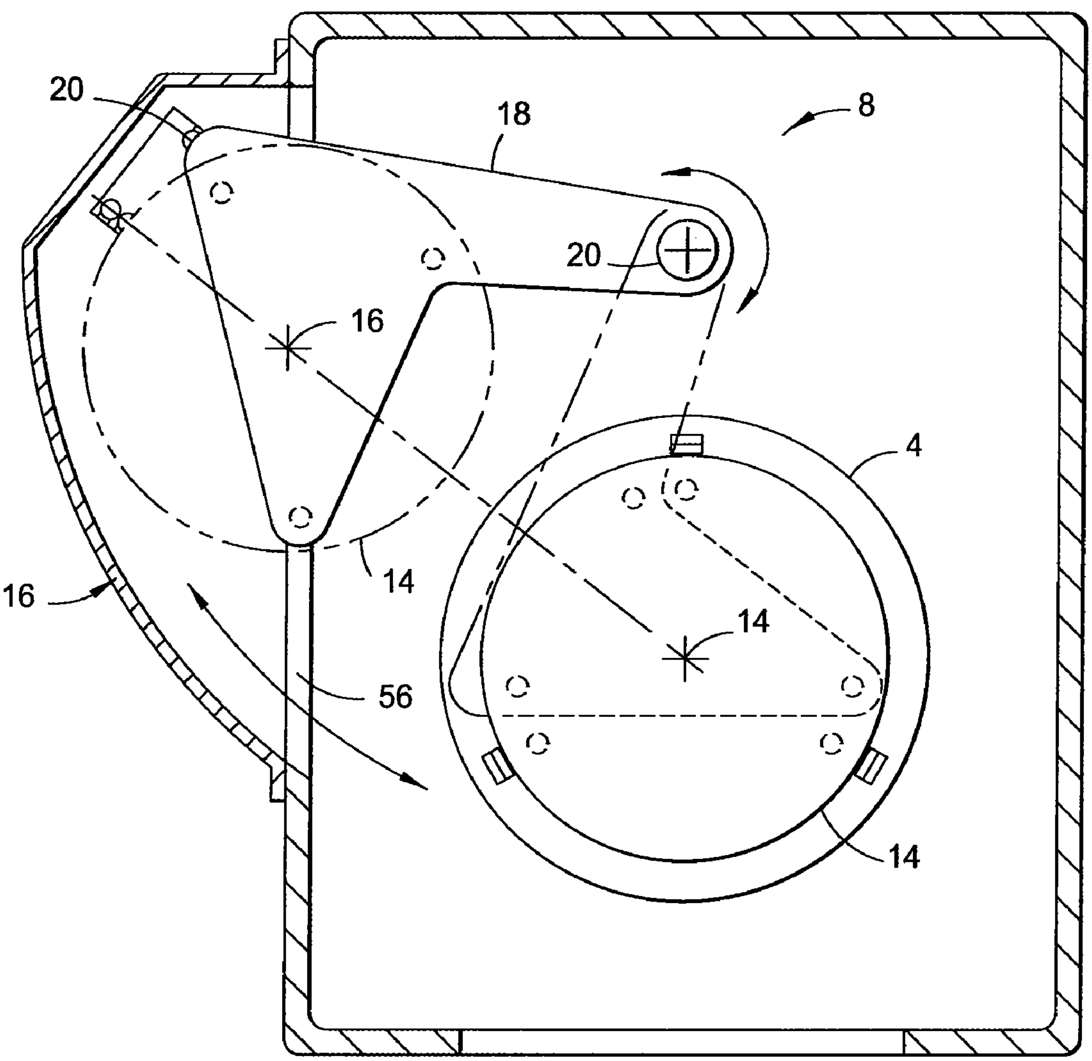


FIG. 1B

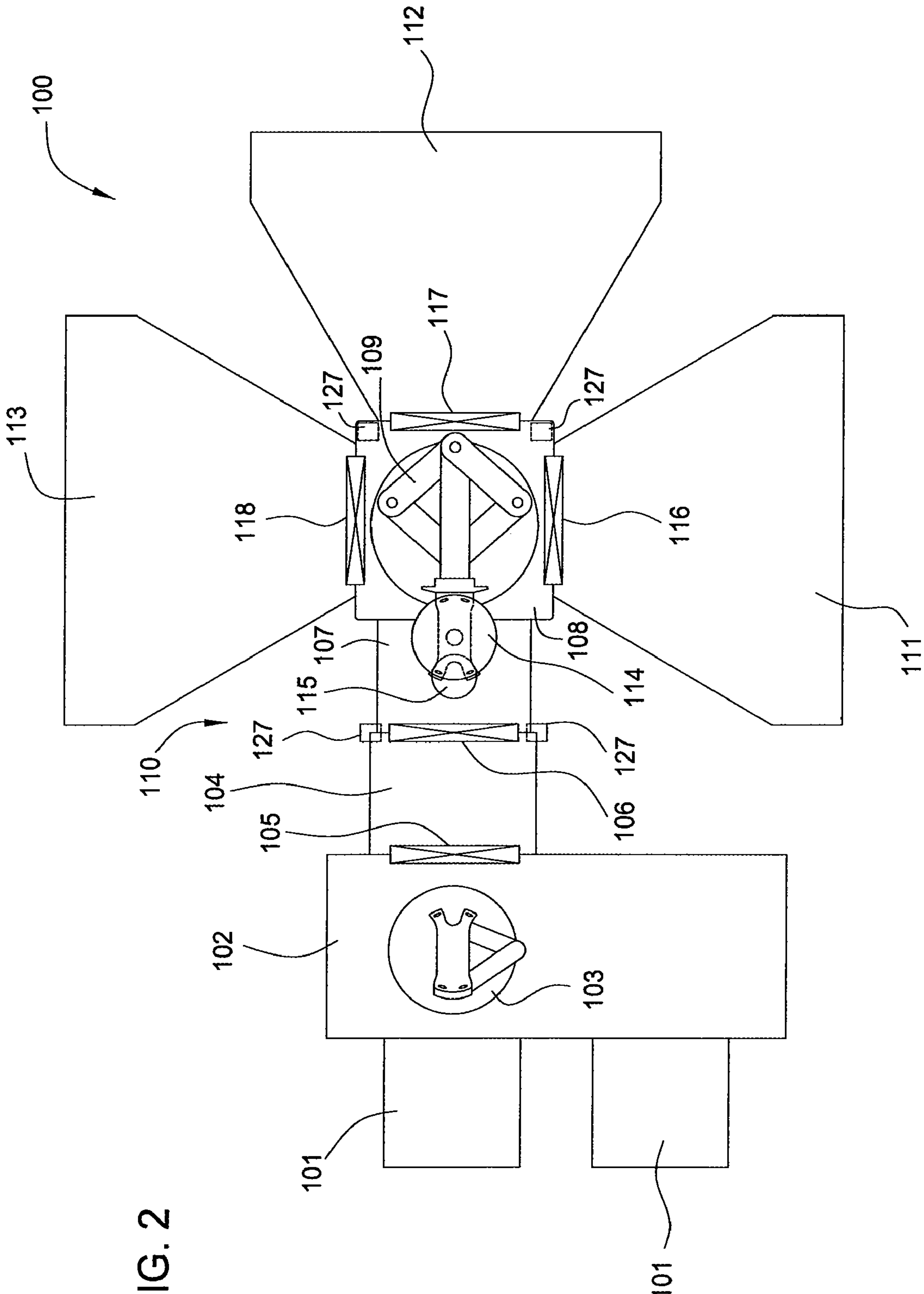

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FIG. 2

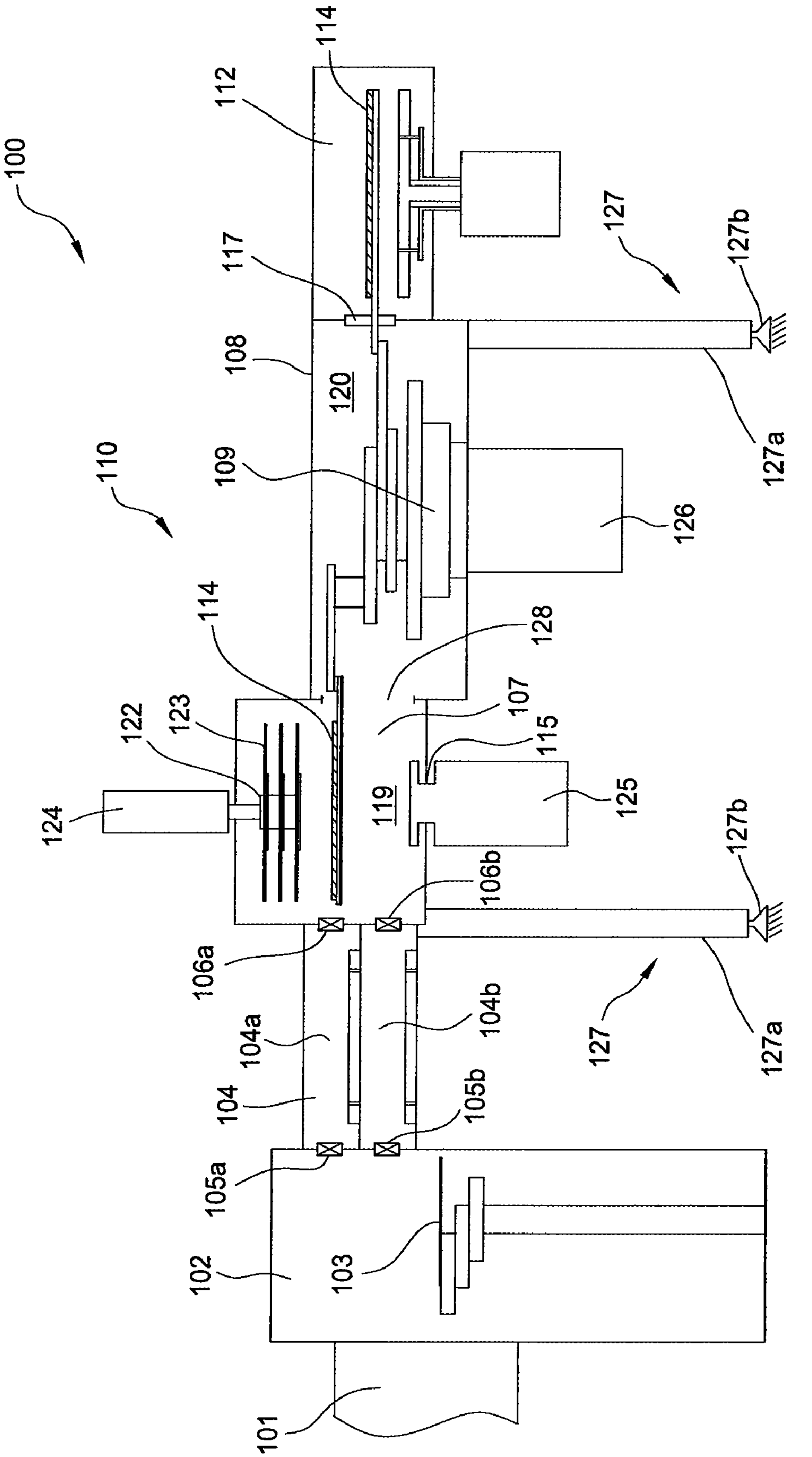
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FIG. 3A

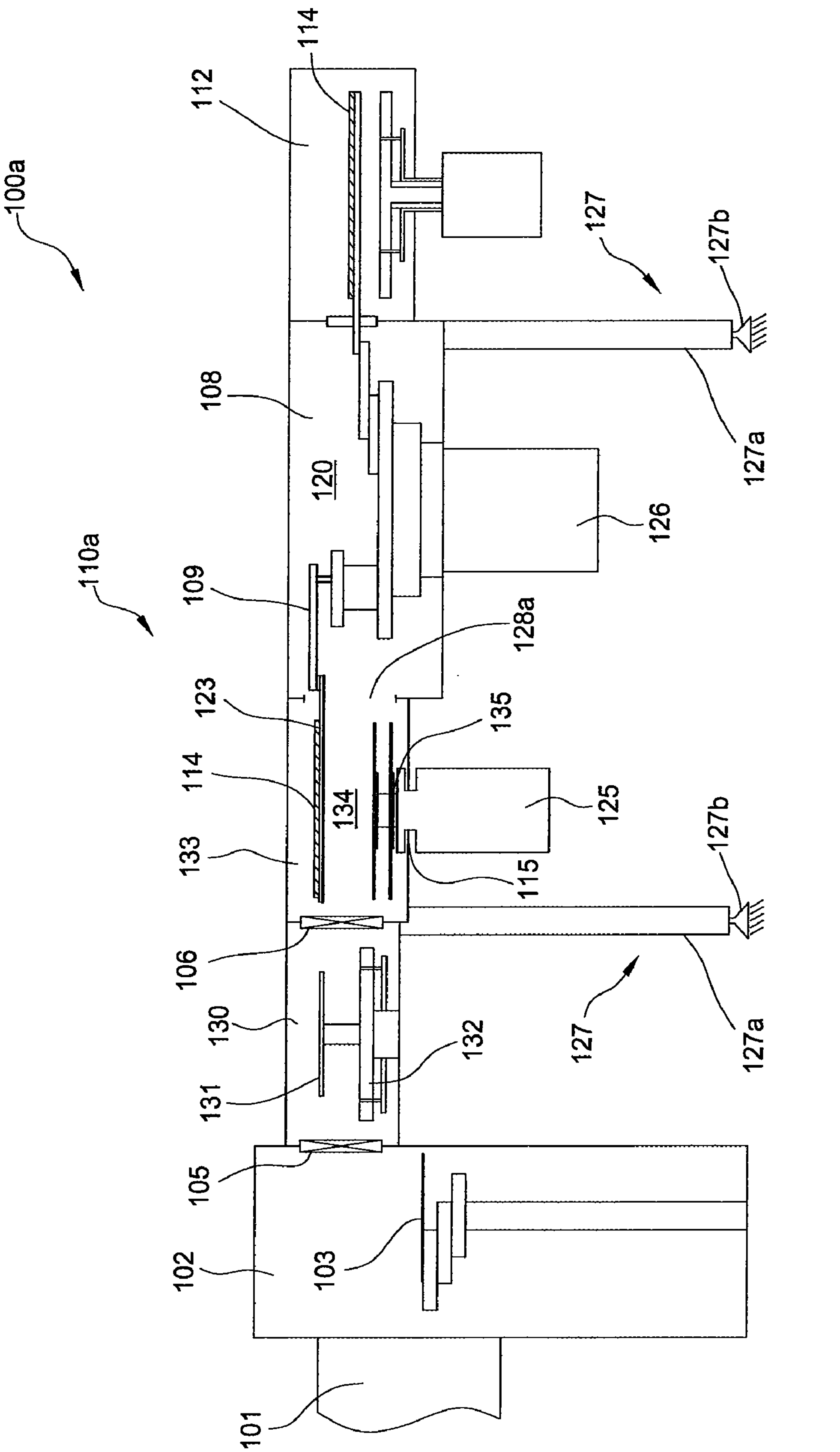

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FIG. 3B

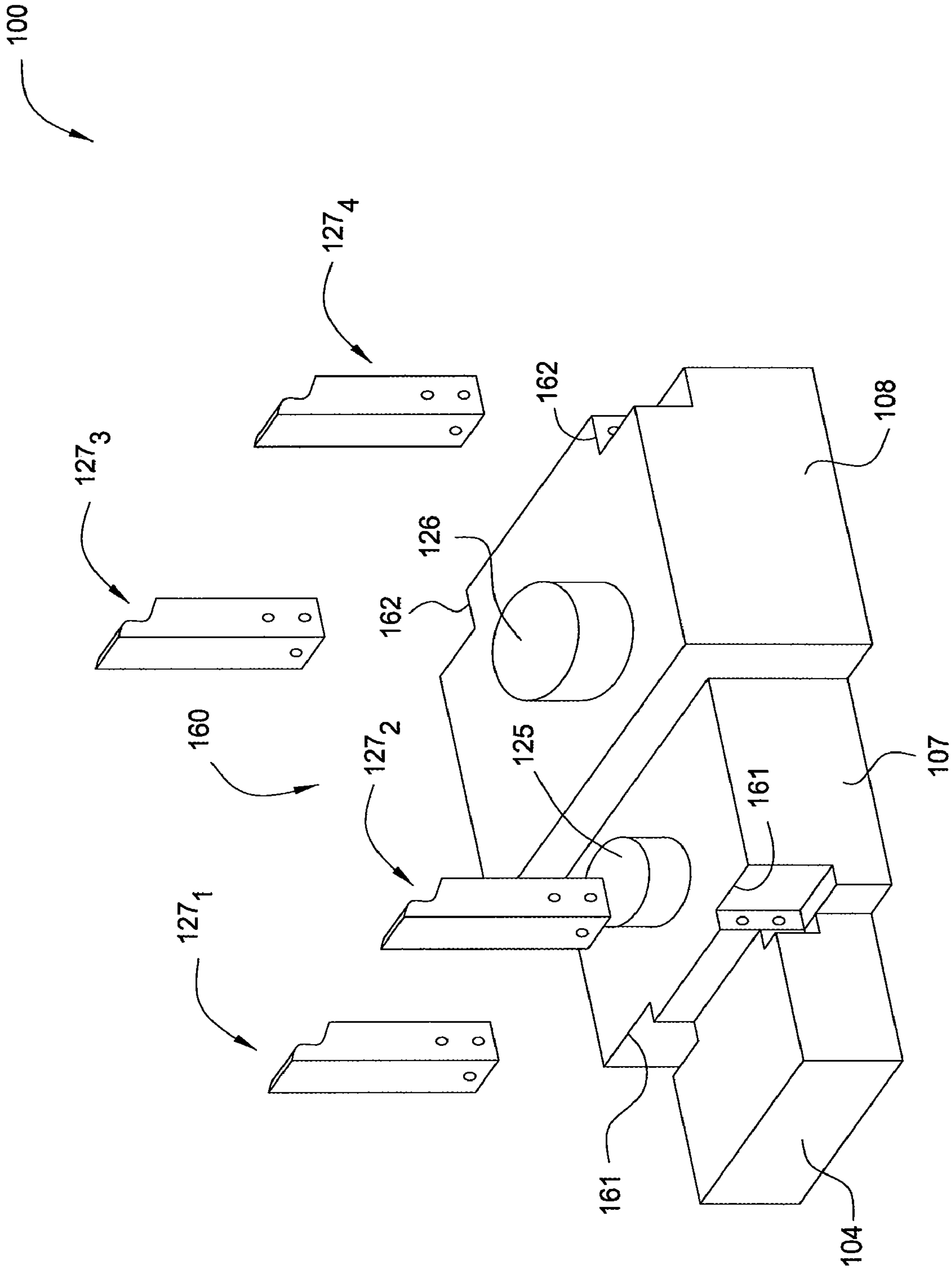

FIG. 3C

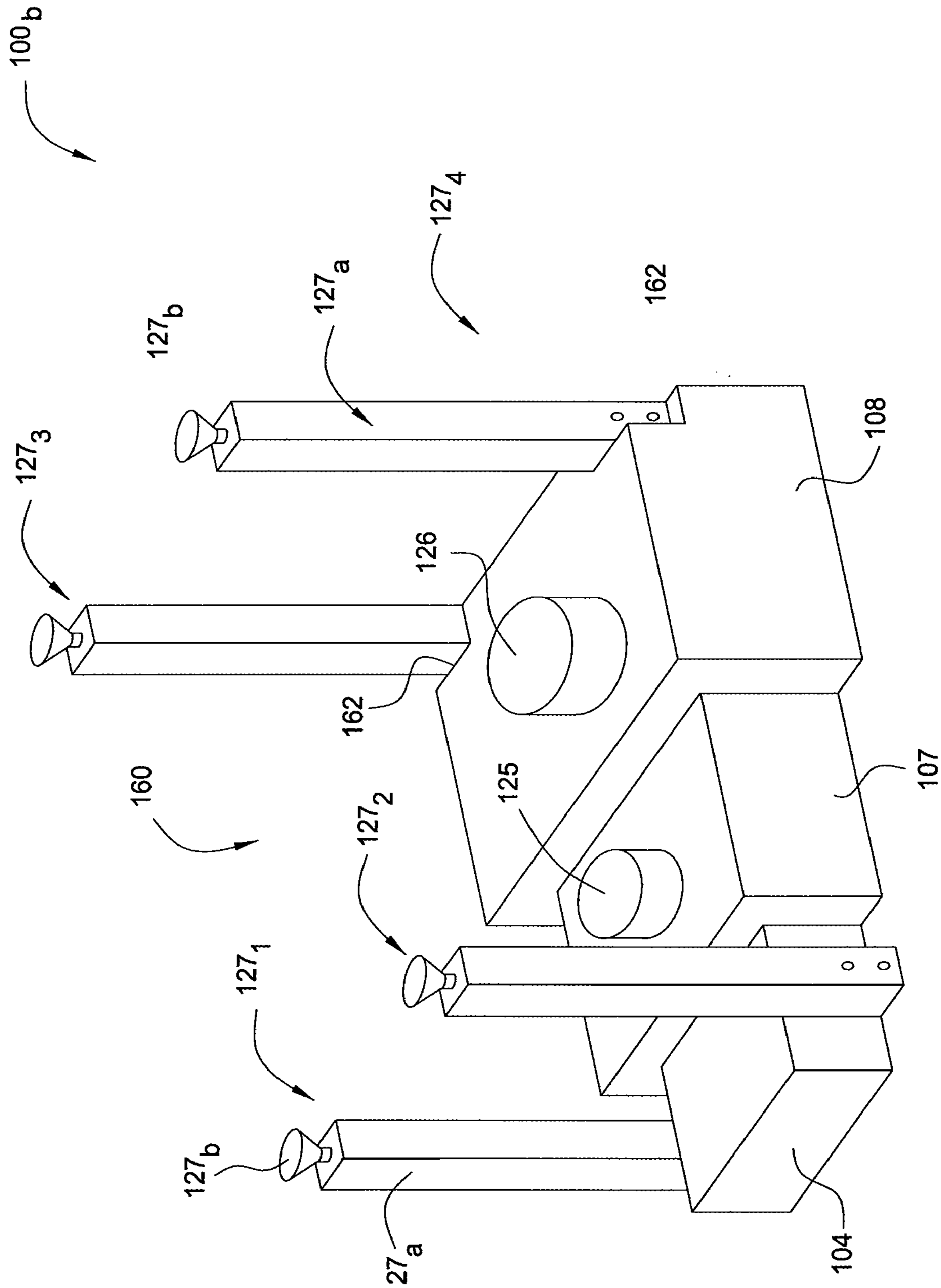
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FIG. 3D

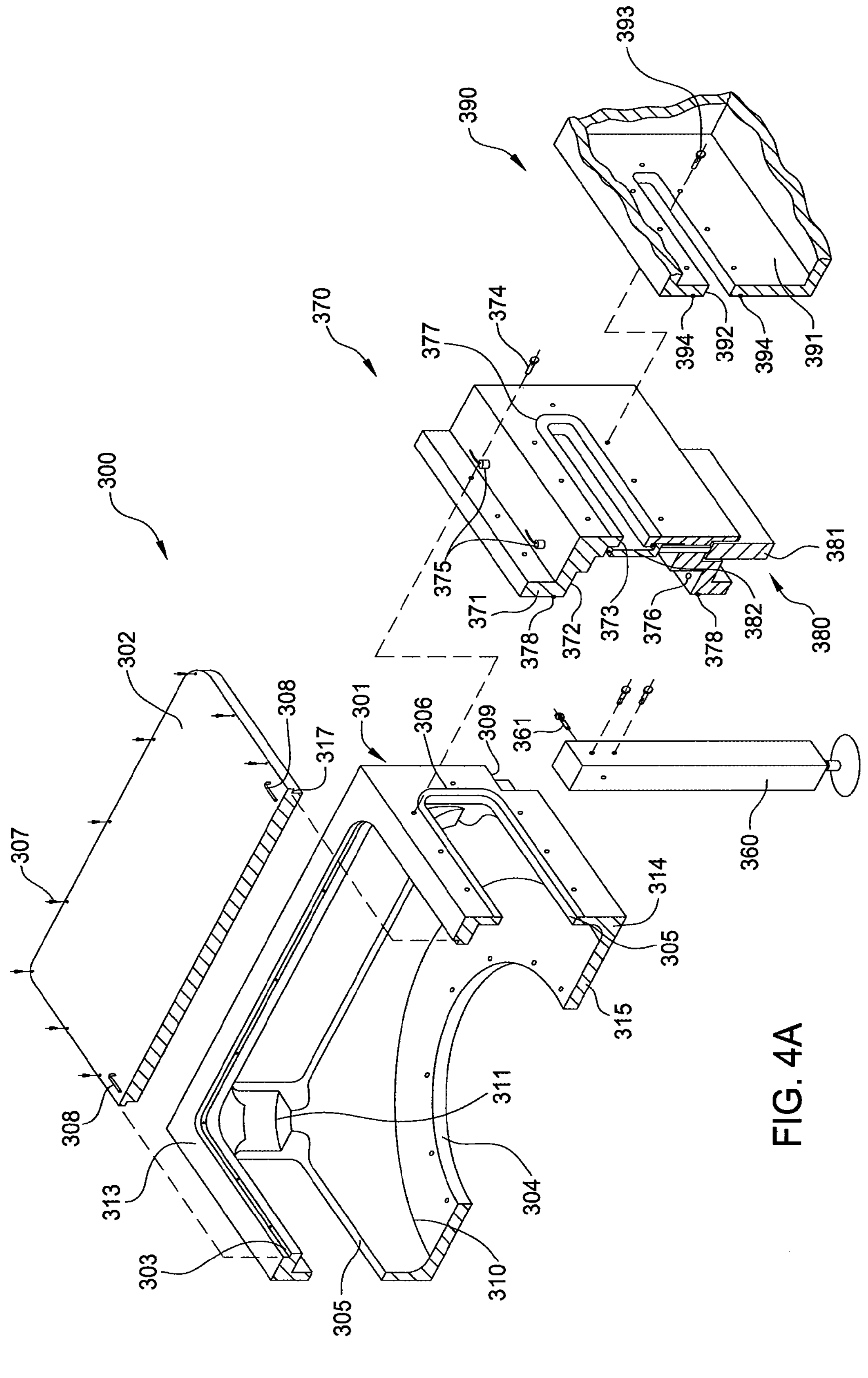
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FIG. 4A

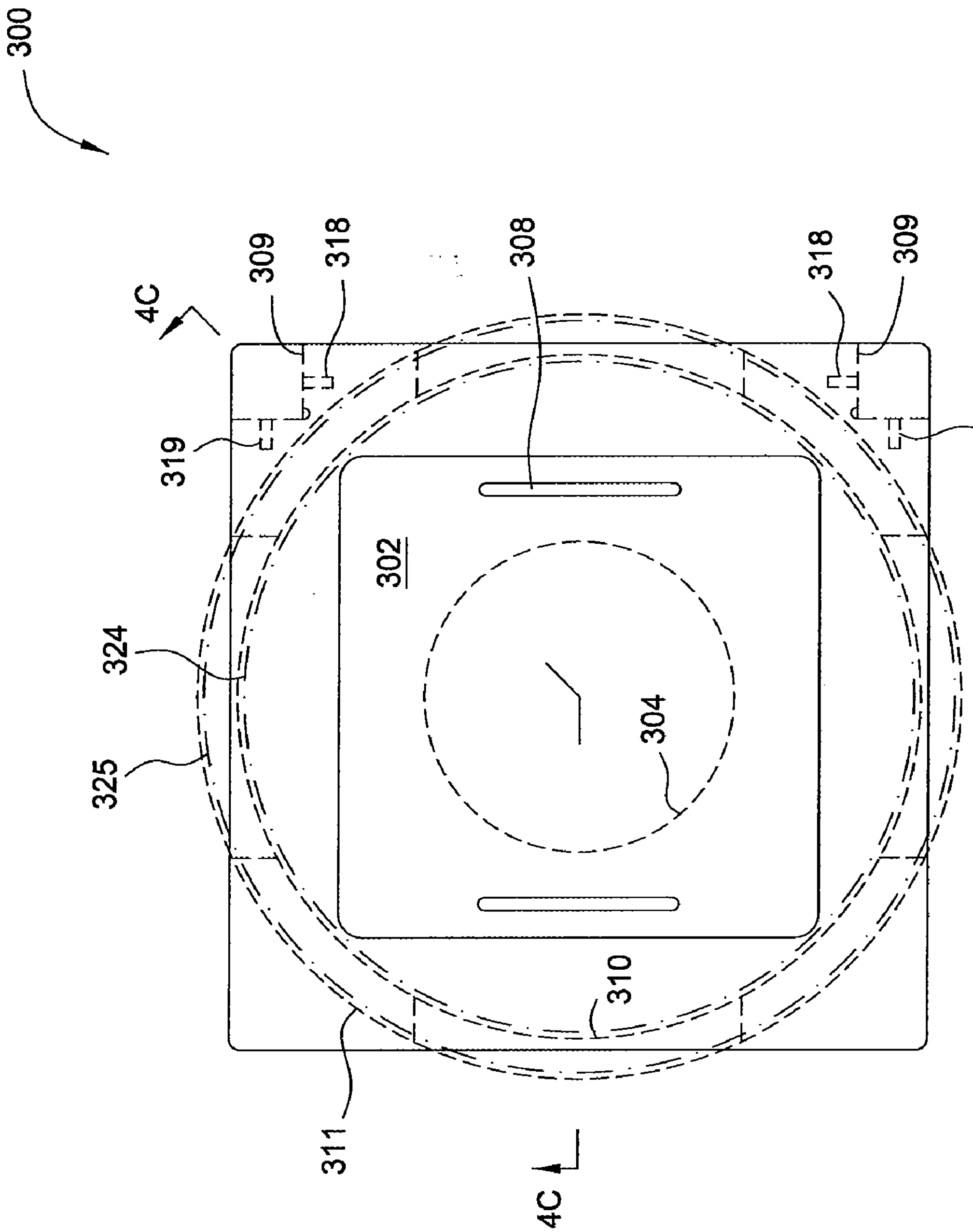

FIG. 4B

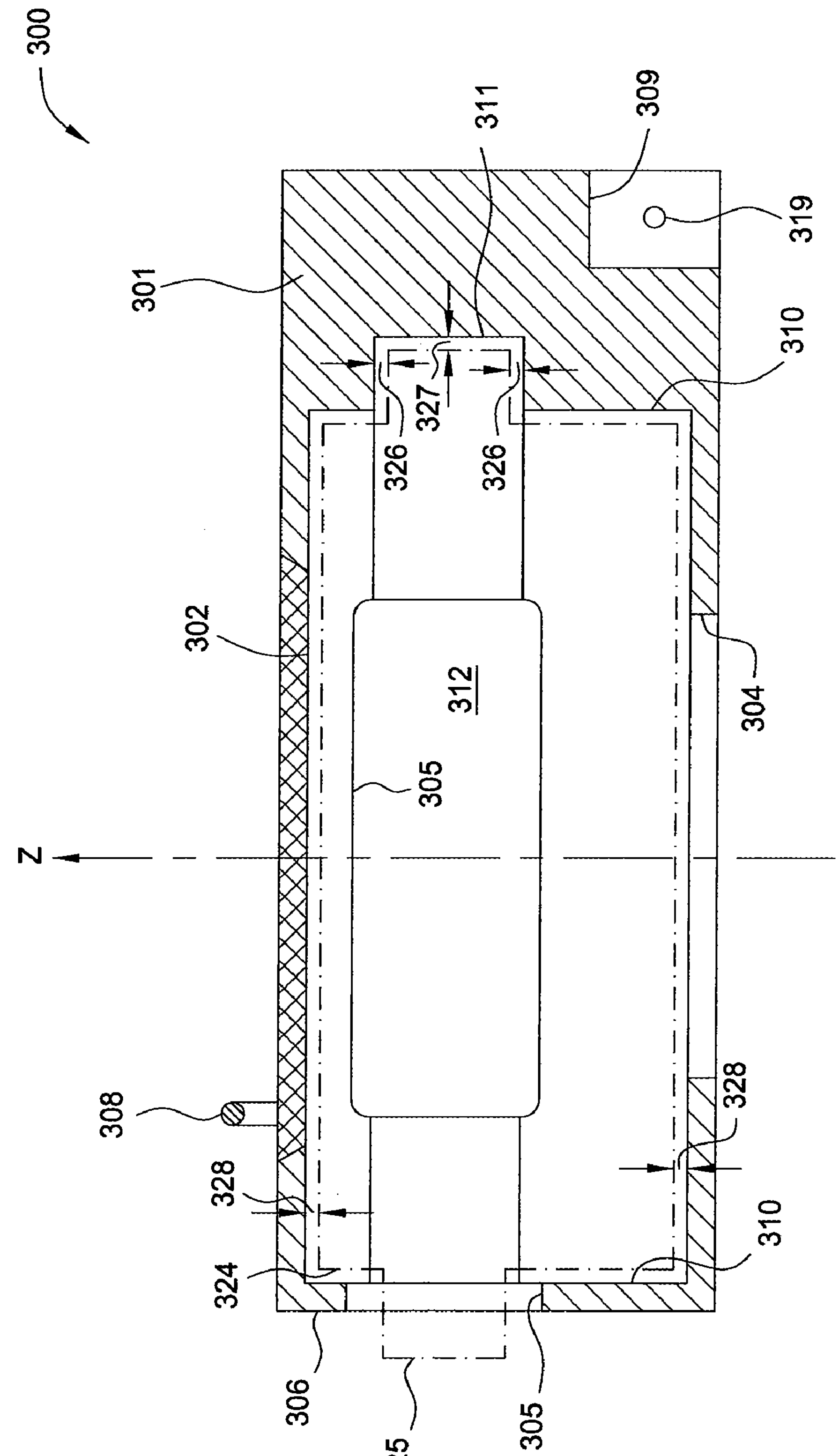
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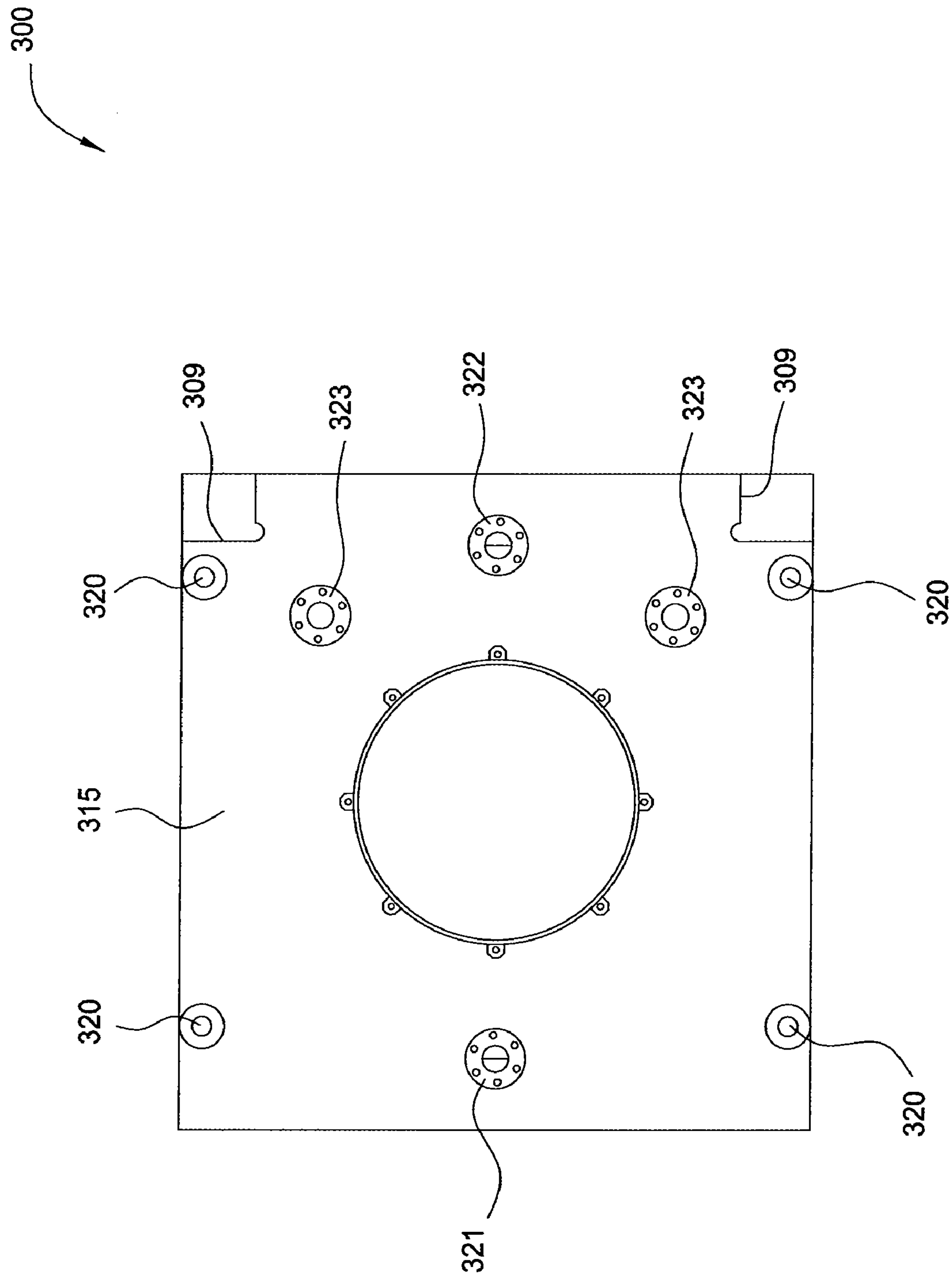
FIG. 4C



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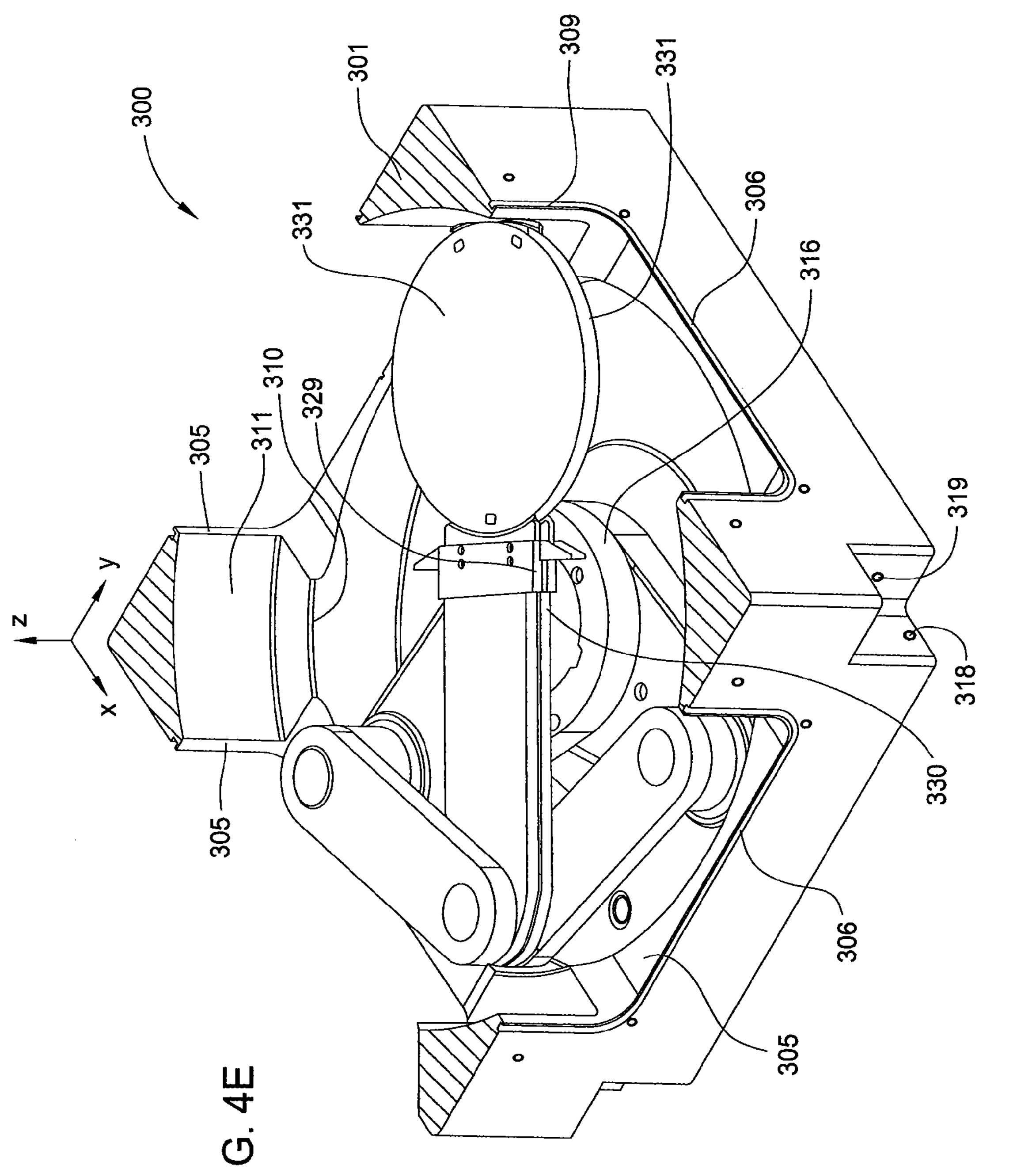
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FIG. 4E

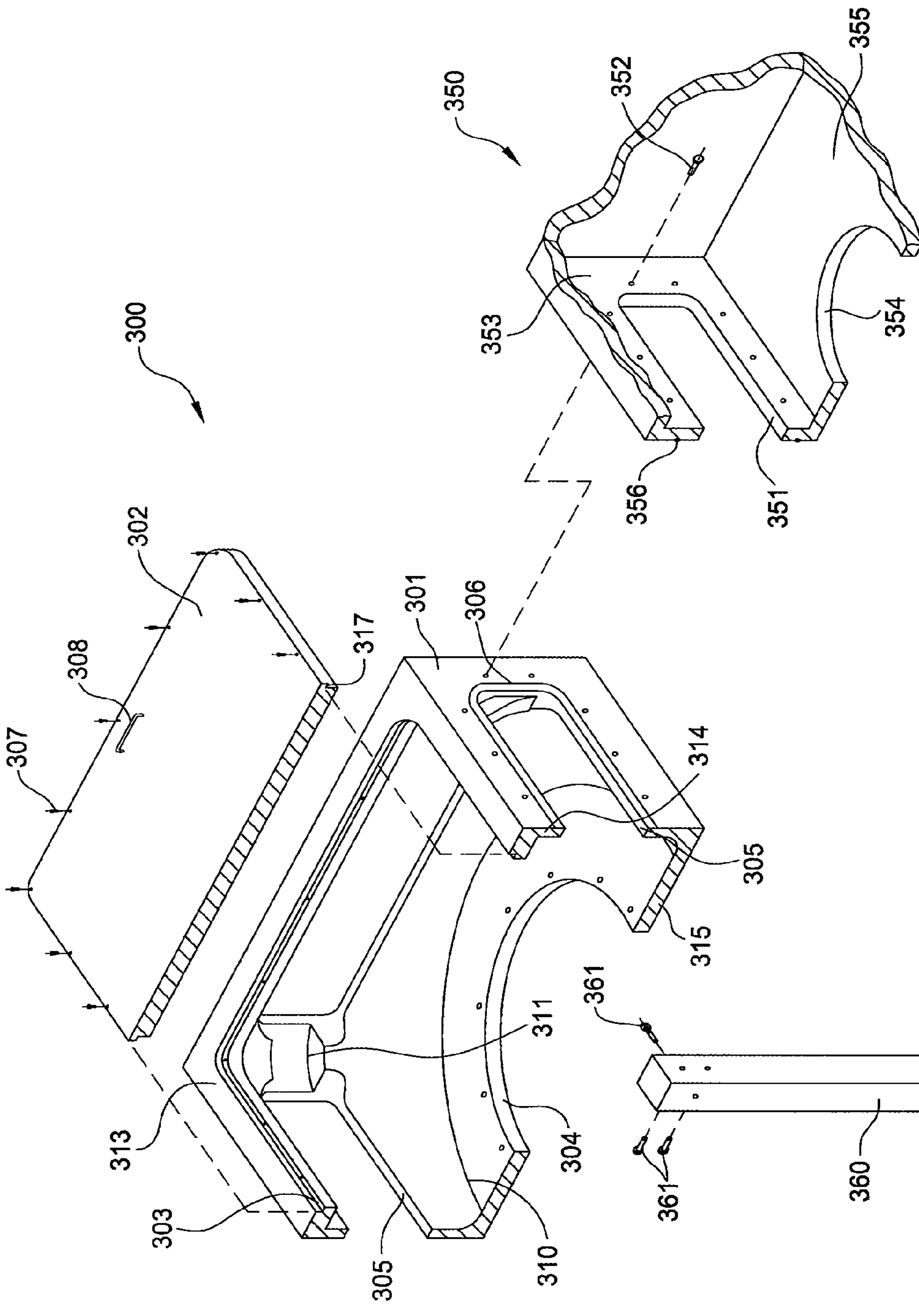
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FIG. 4F

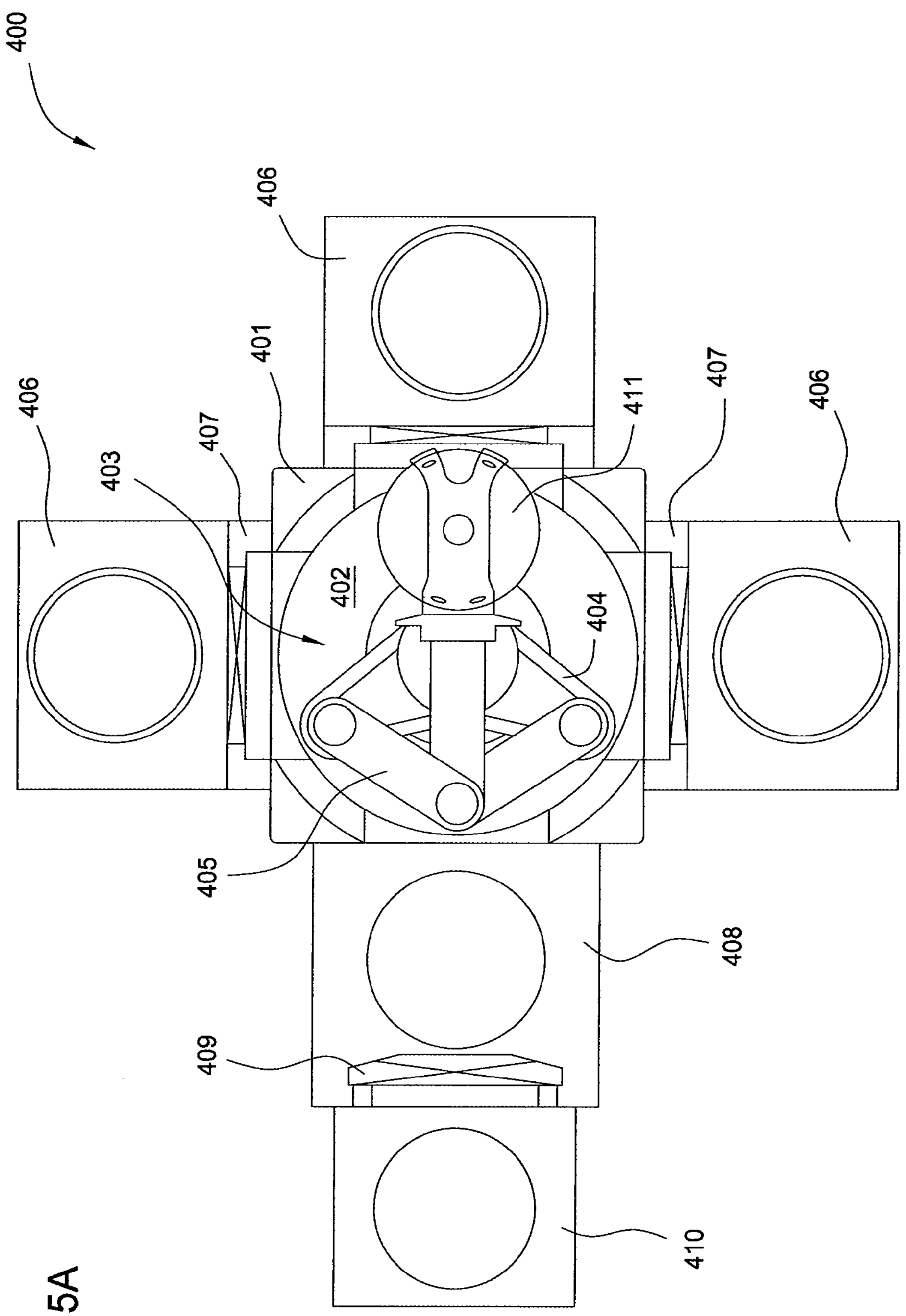

FIG. 5A

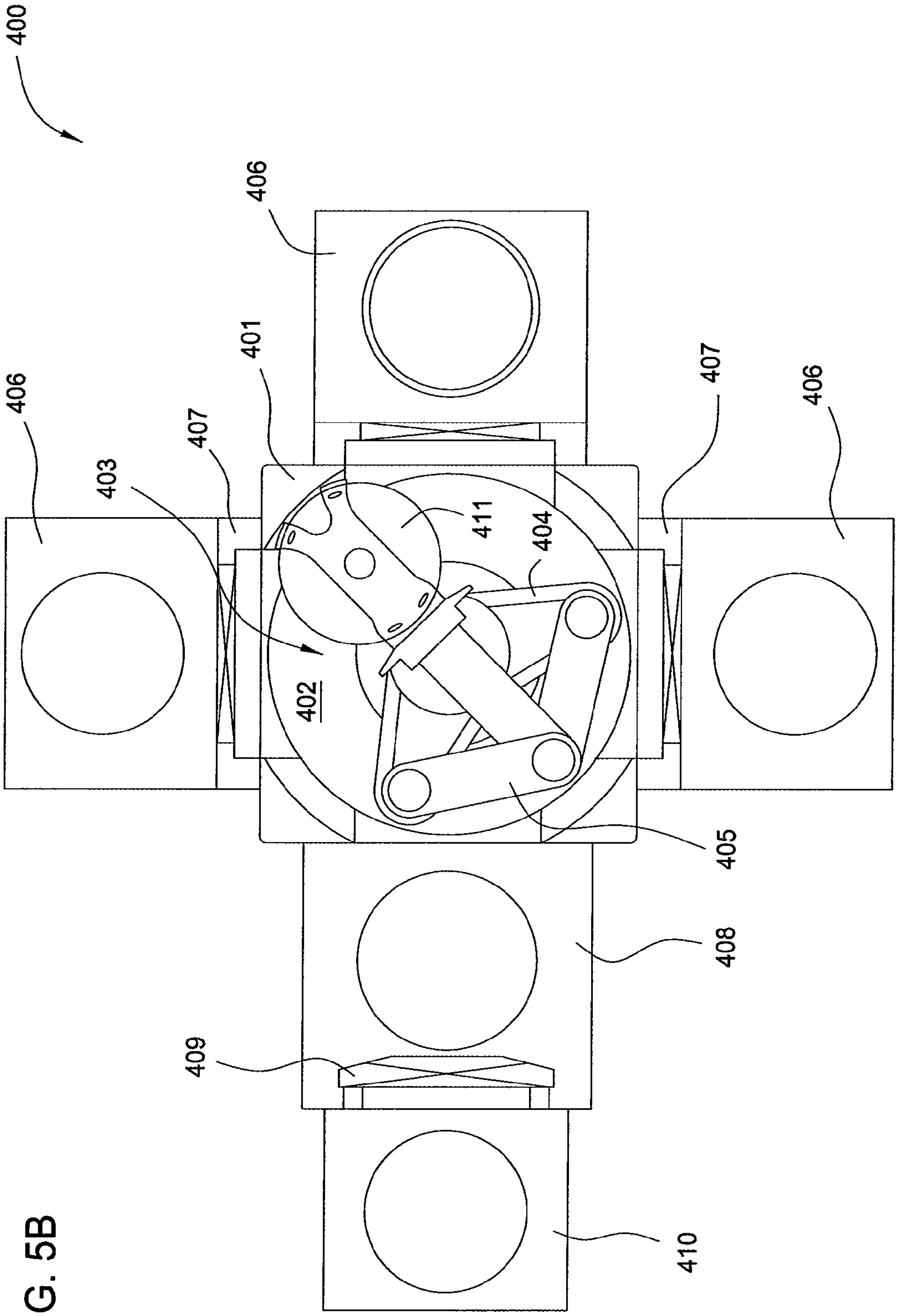

FIG. 5B

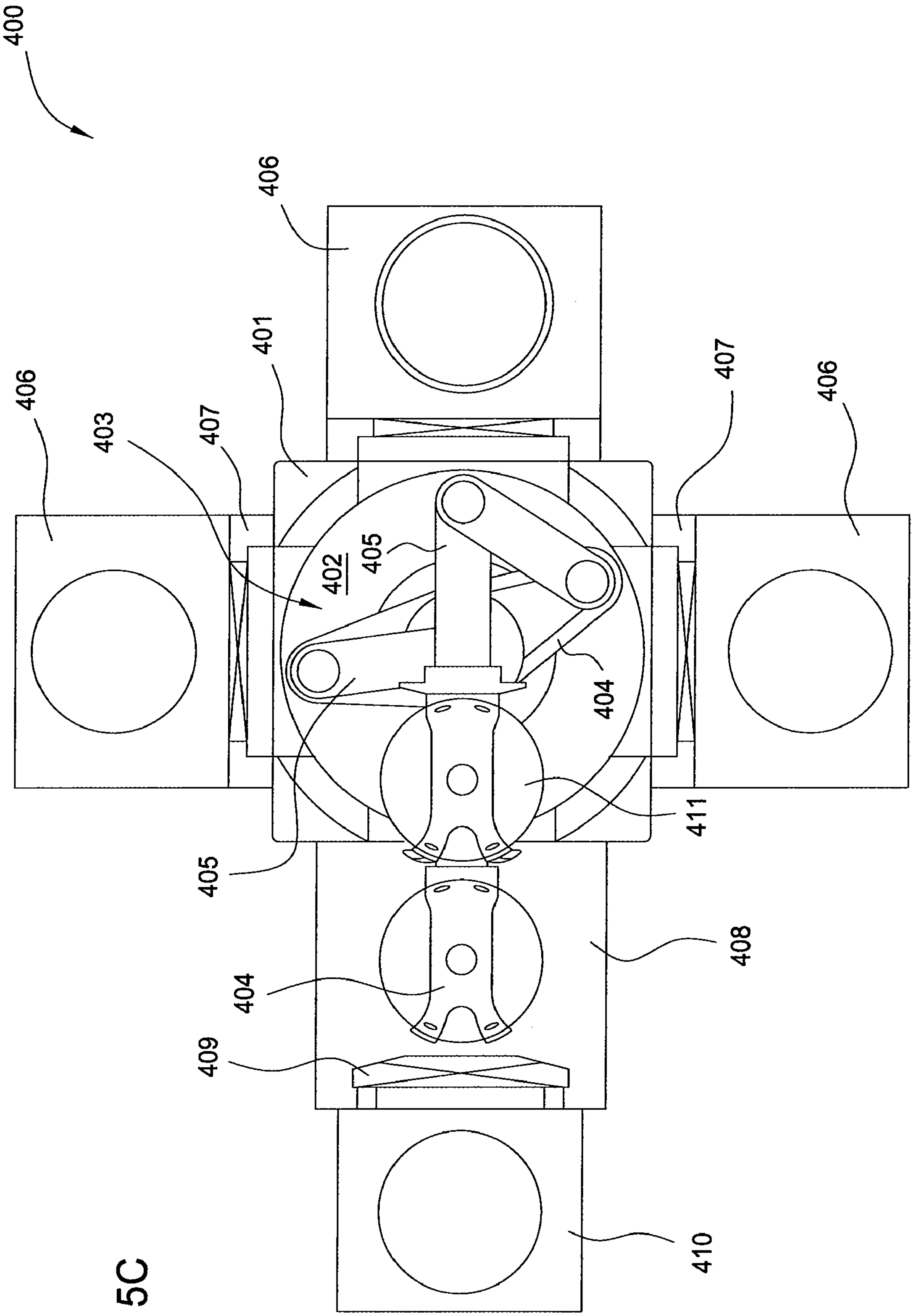
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FIG. 5C

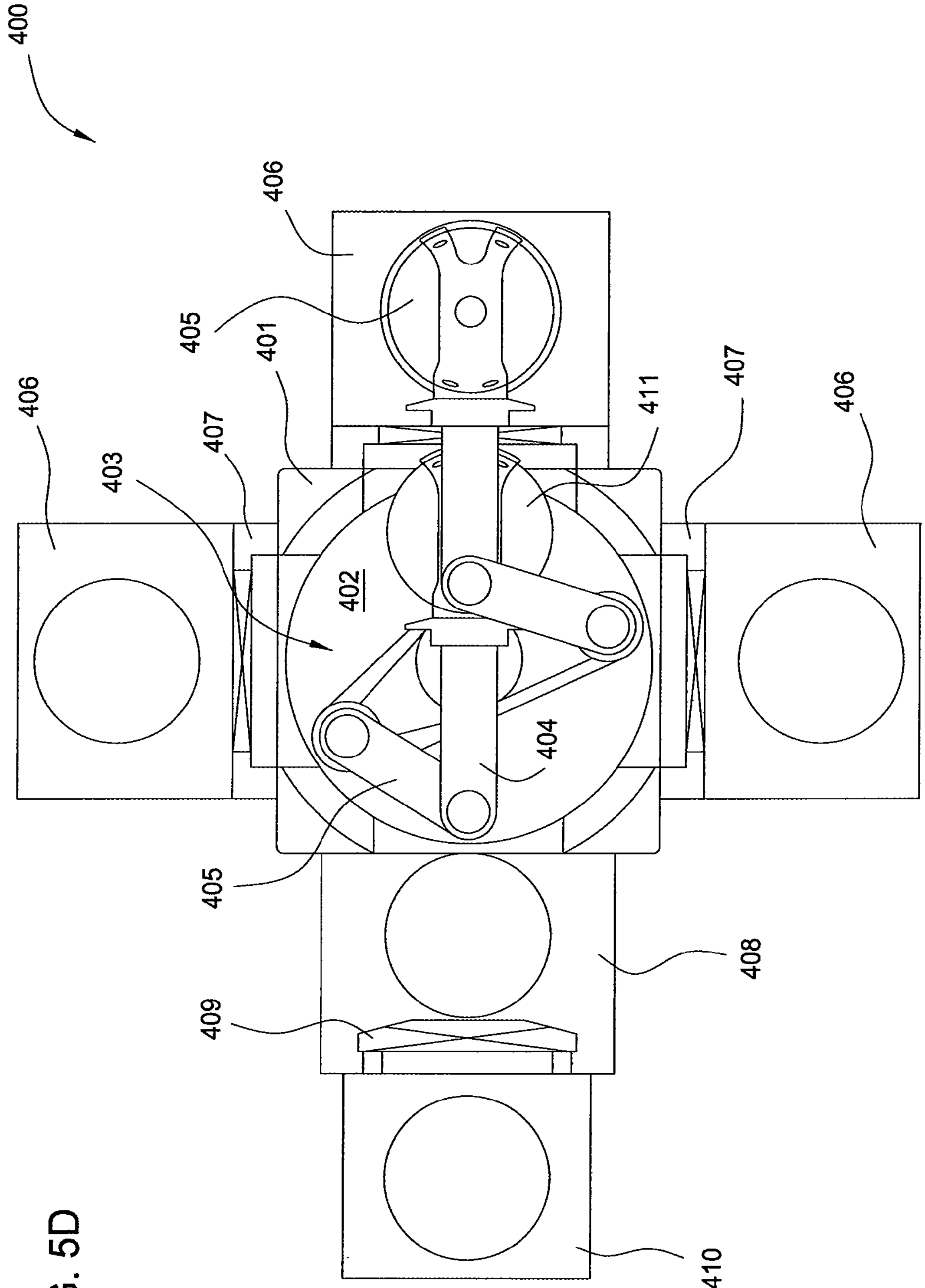

FIG. 5D

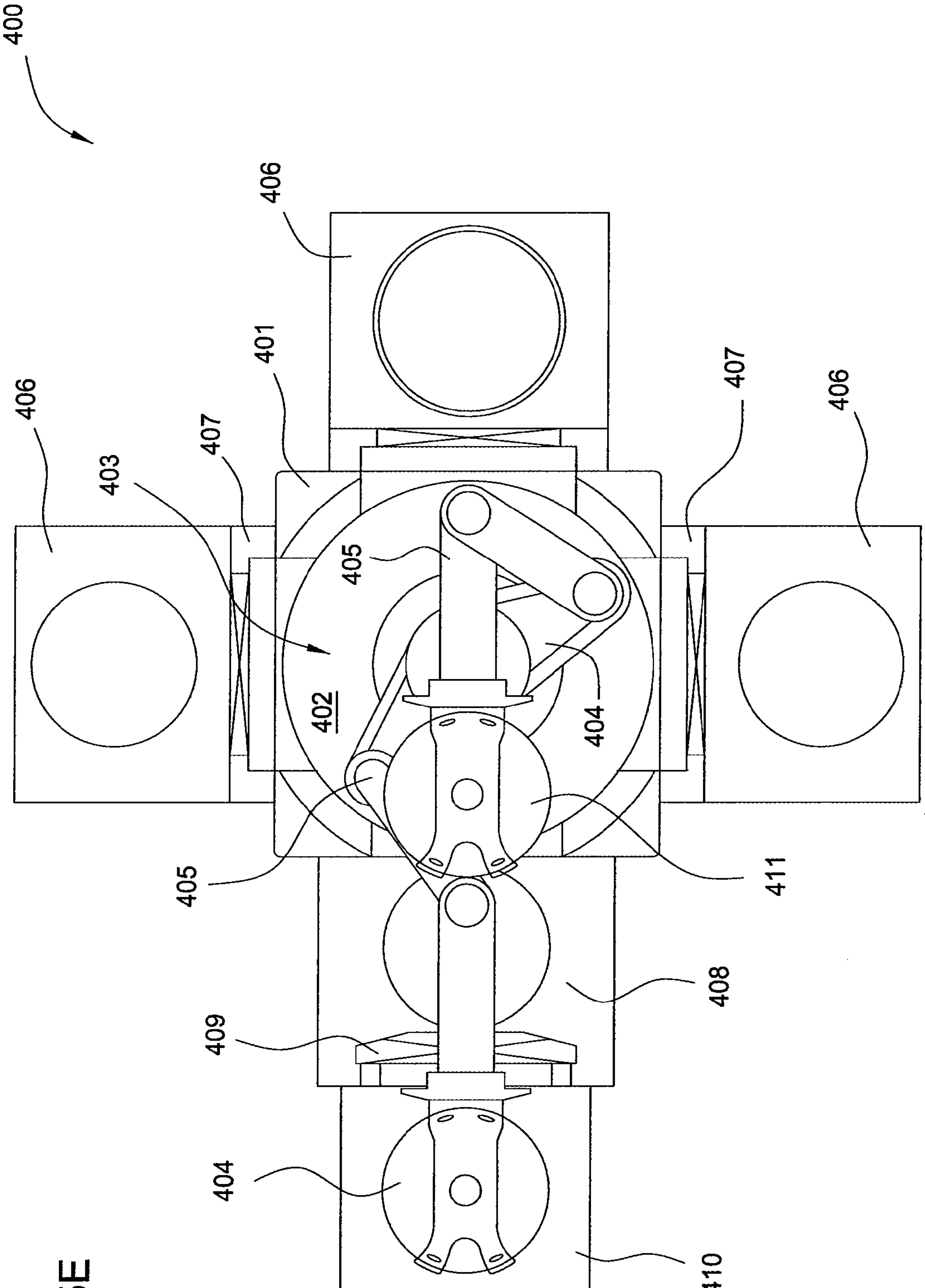
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FIG. 5E

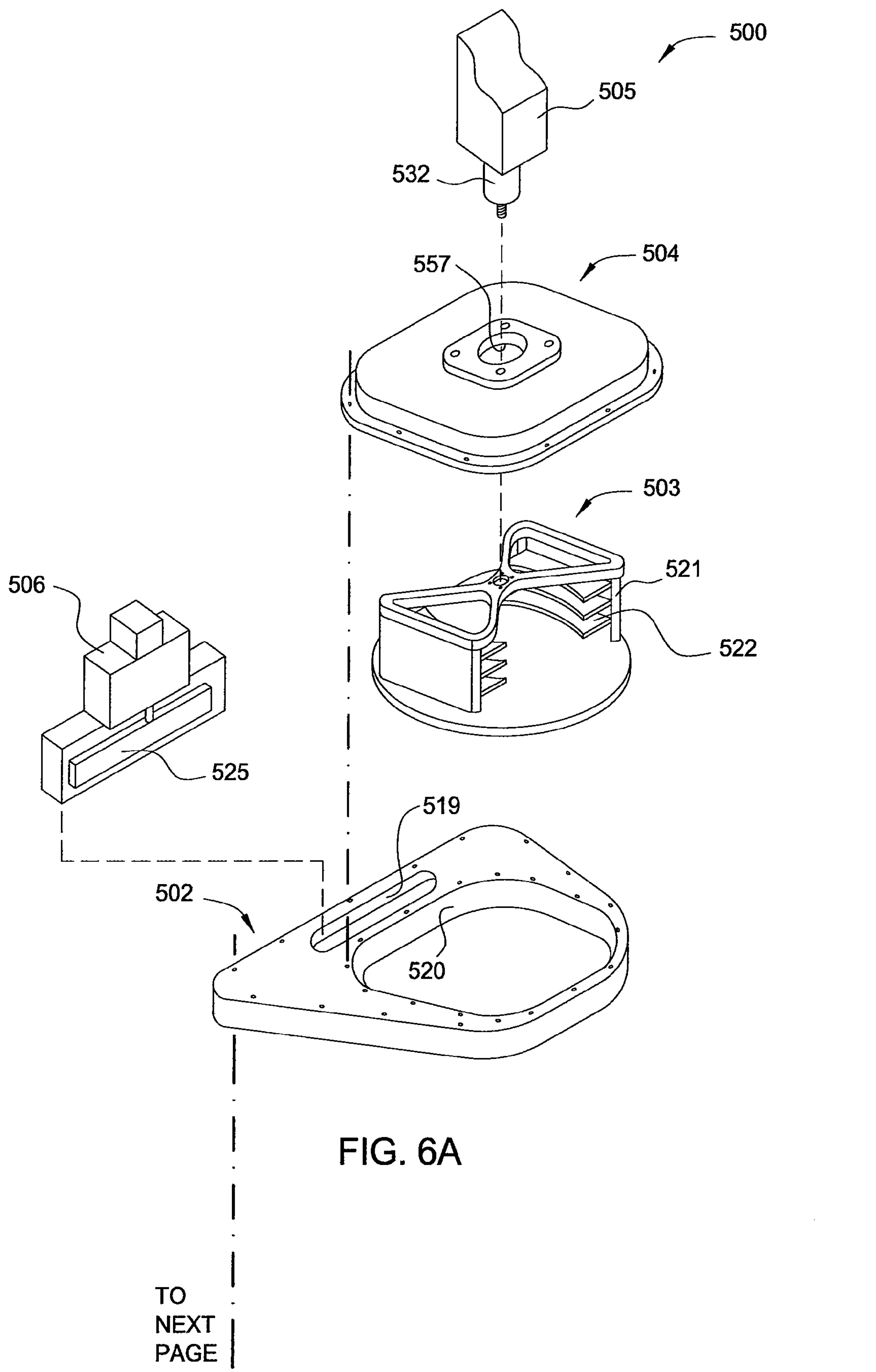

FIG. 6A

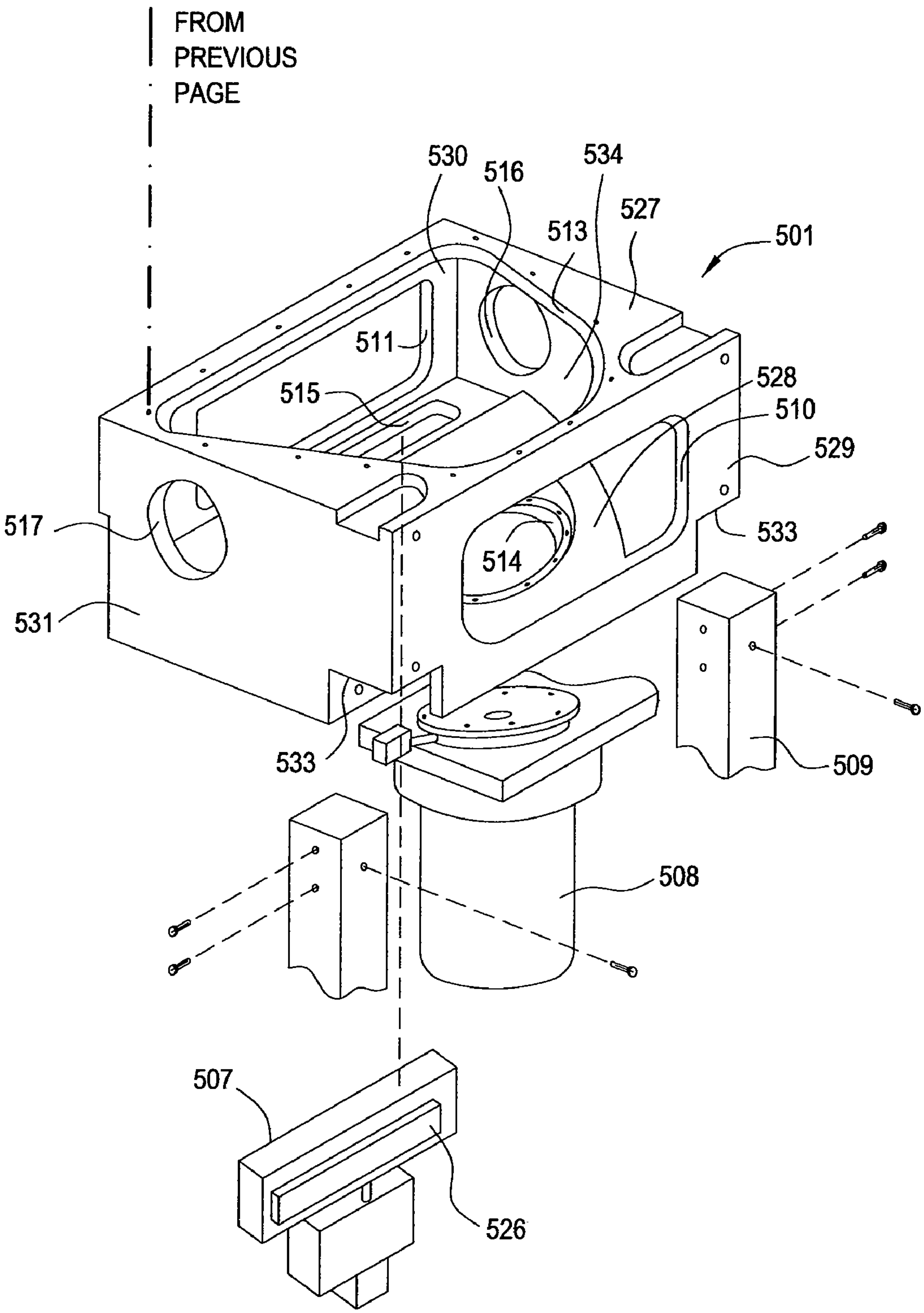

FIG. 6A
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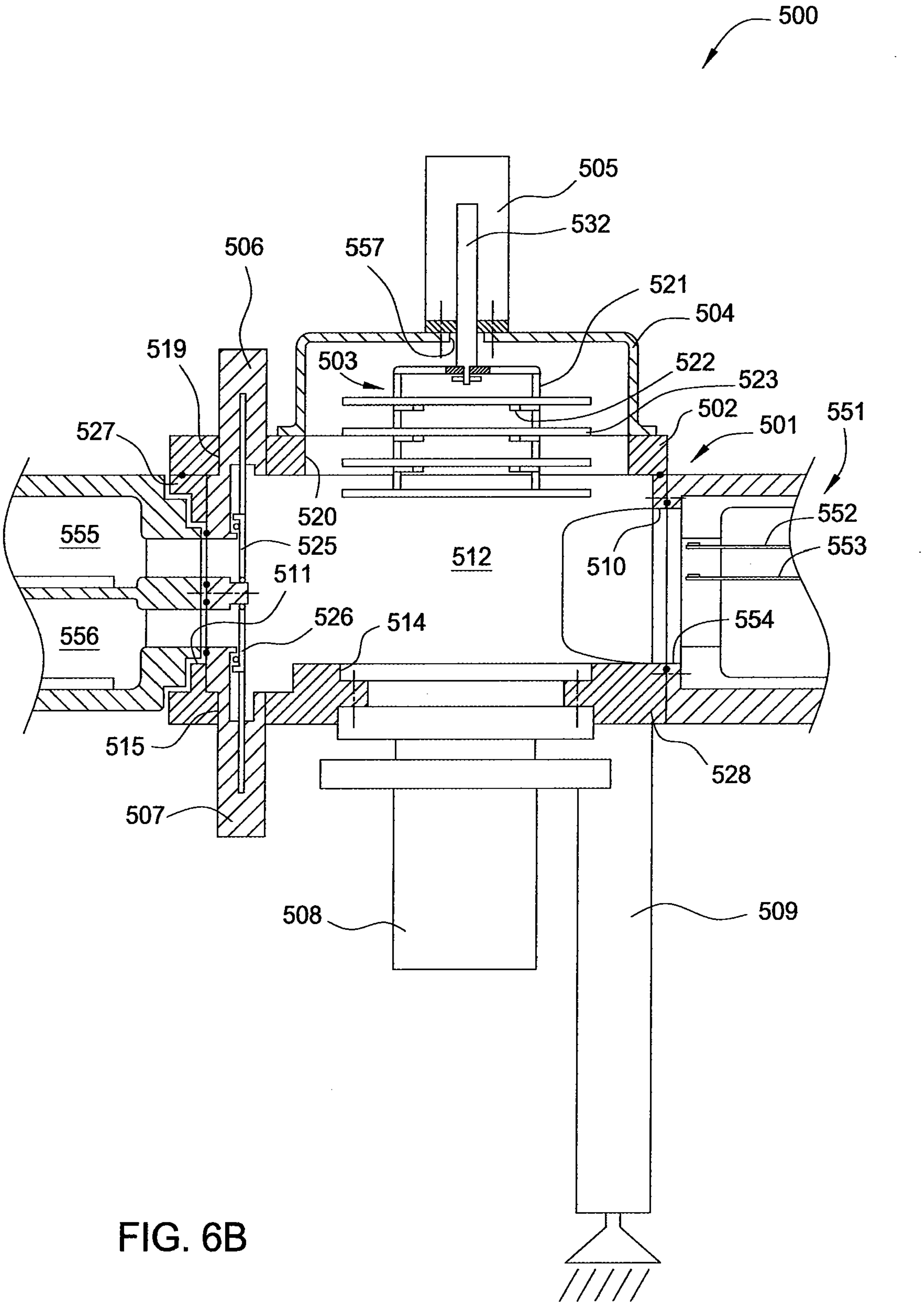
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FIG. 6B

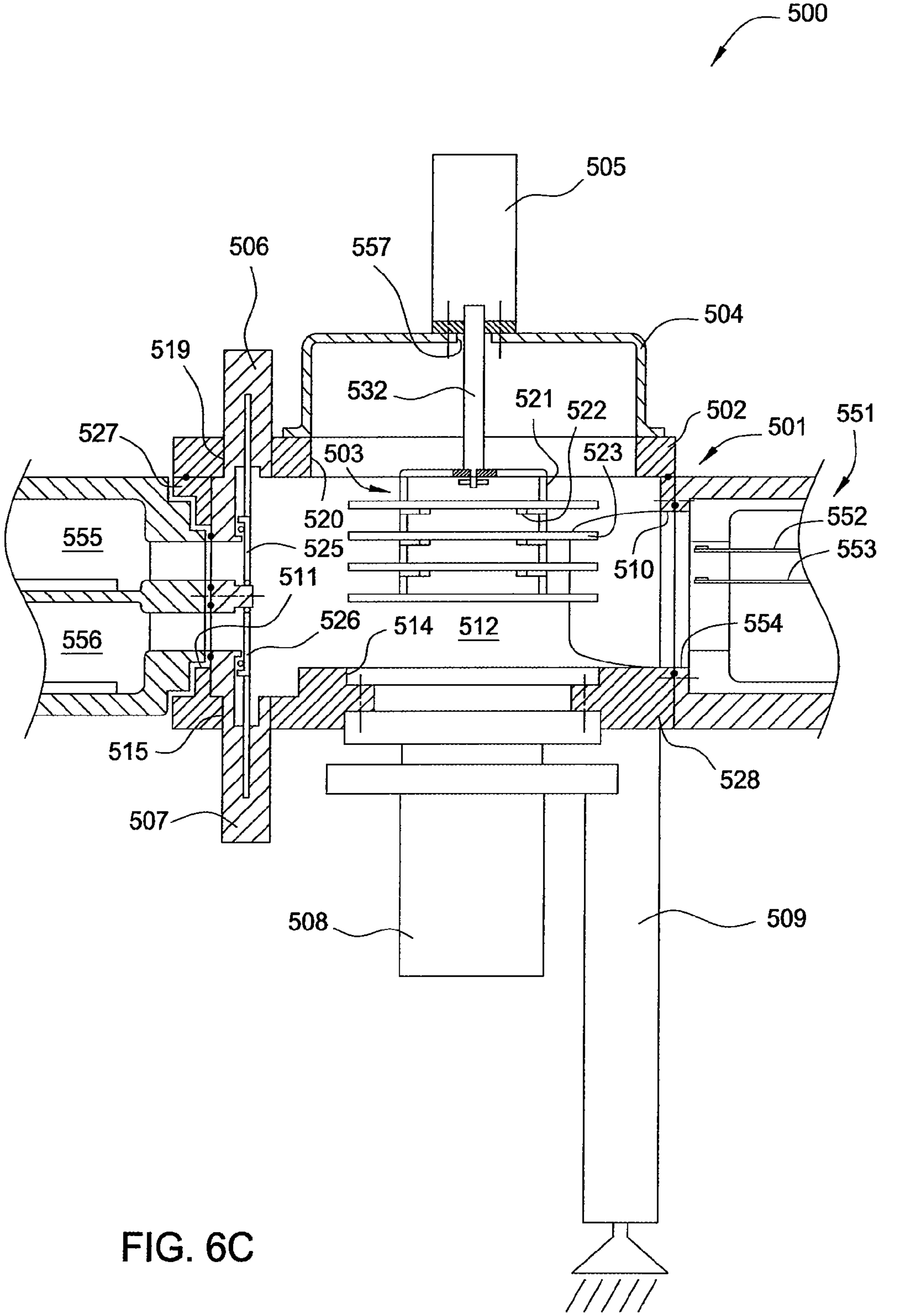
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FIG. 6C

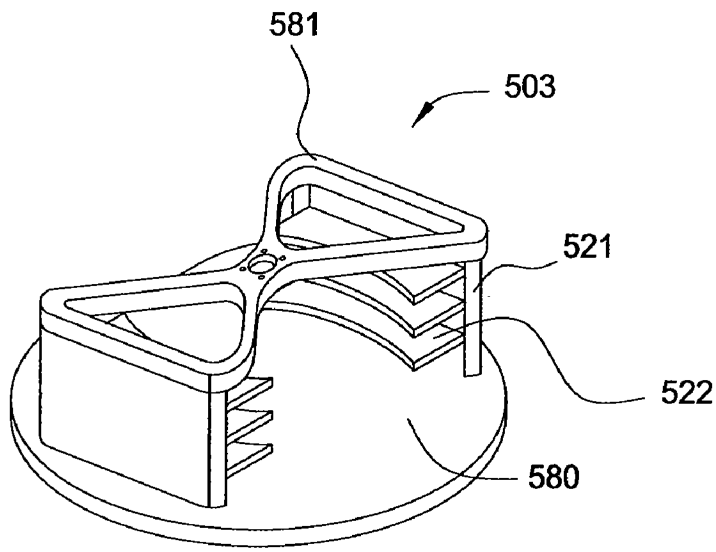

FIG 7A

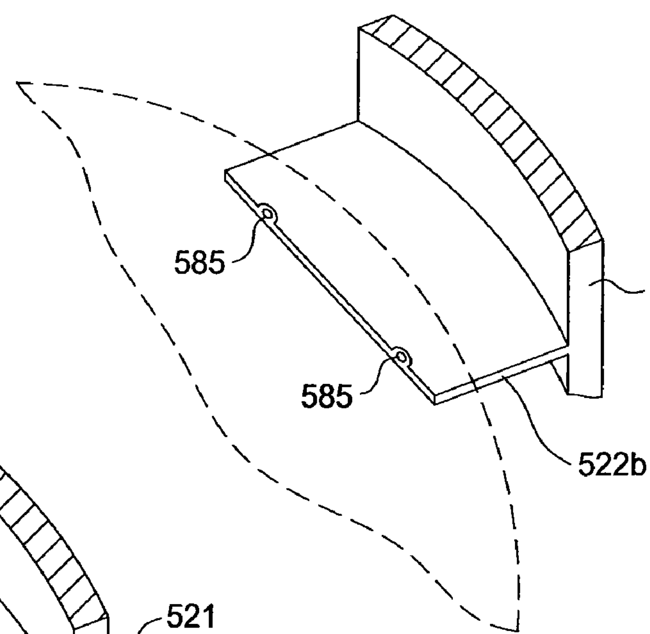

FIG 7C

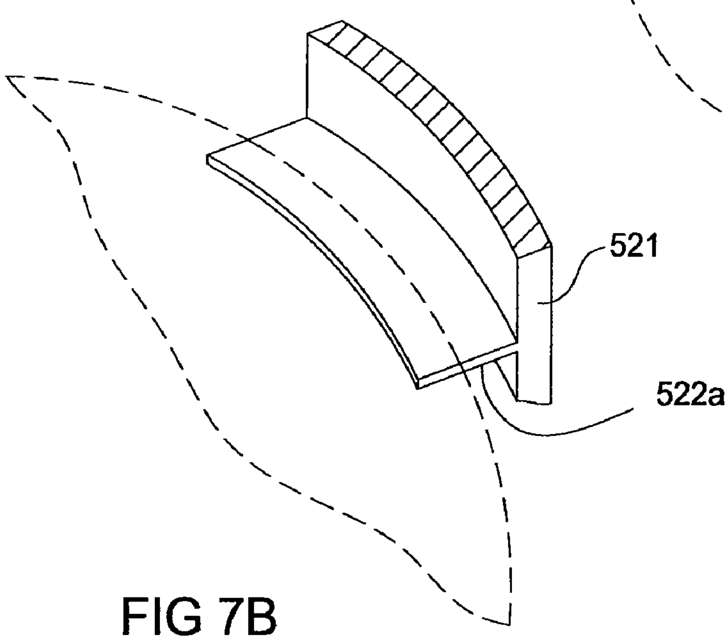

FIG 7B

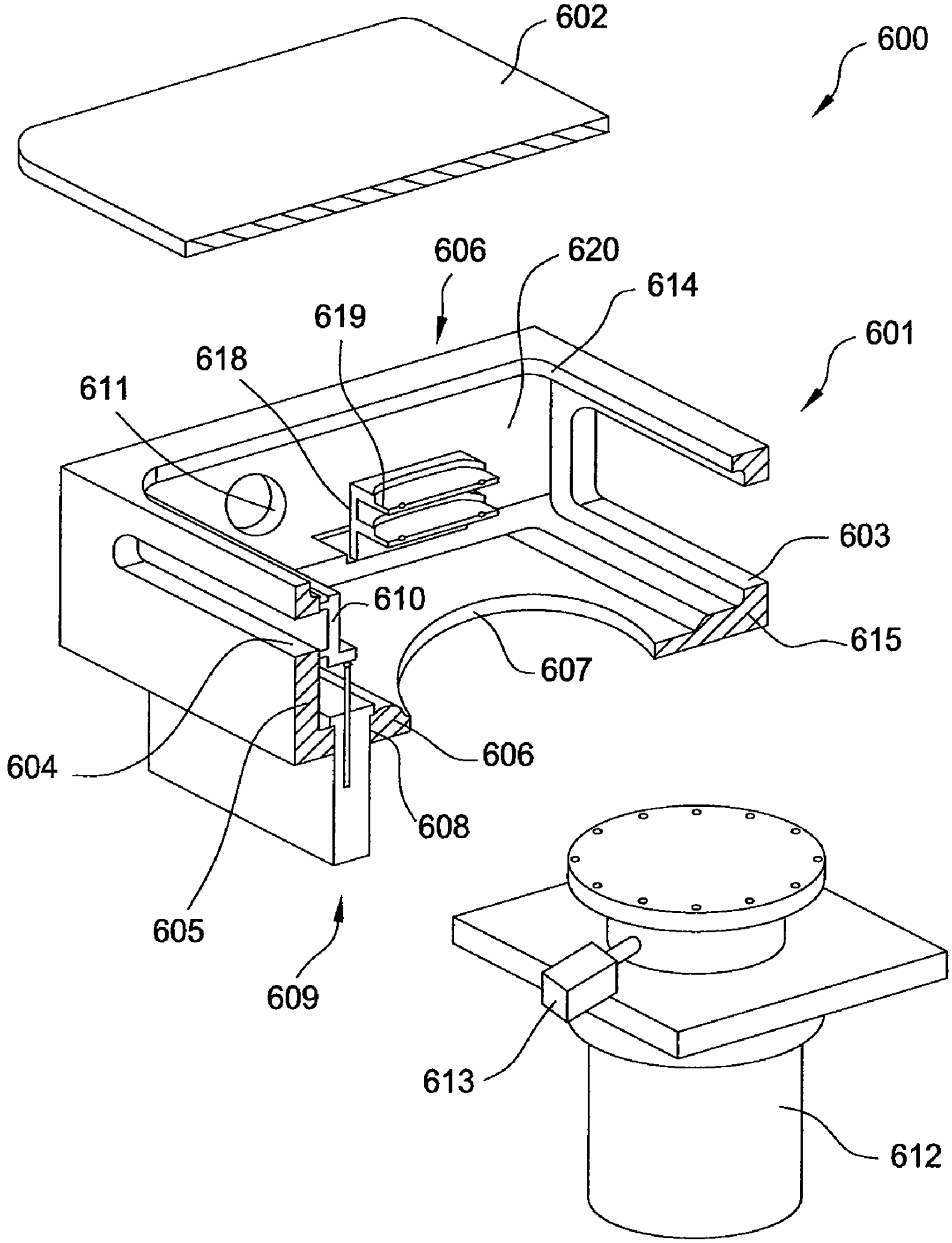
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FIG 8A

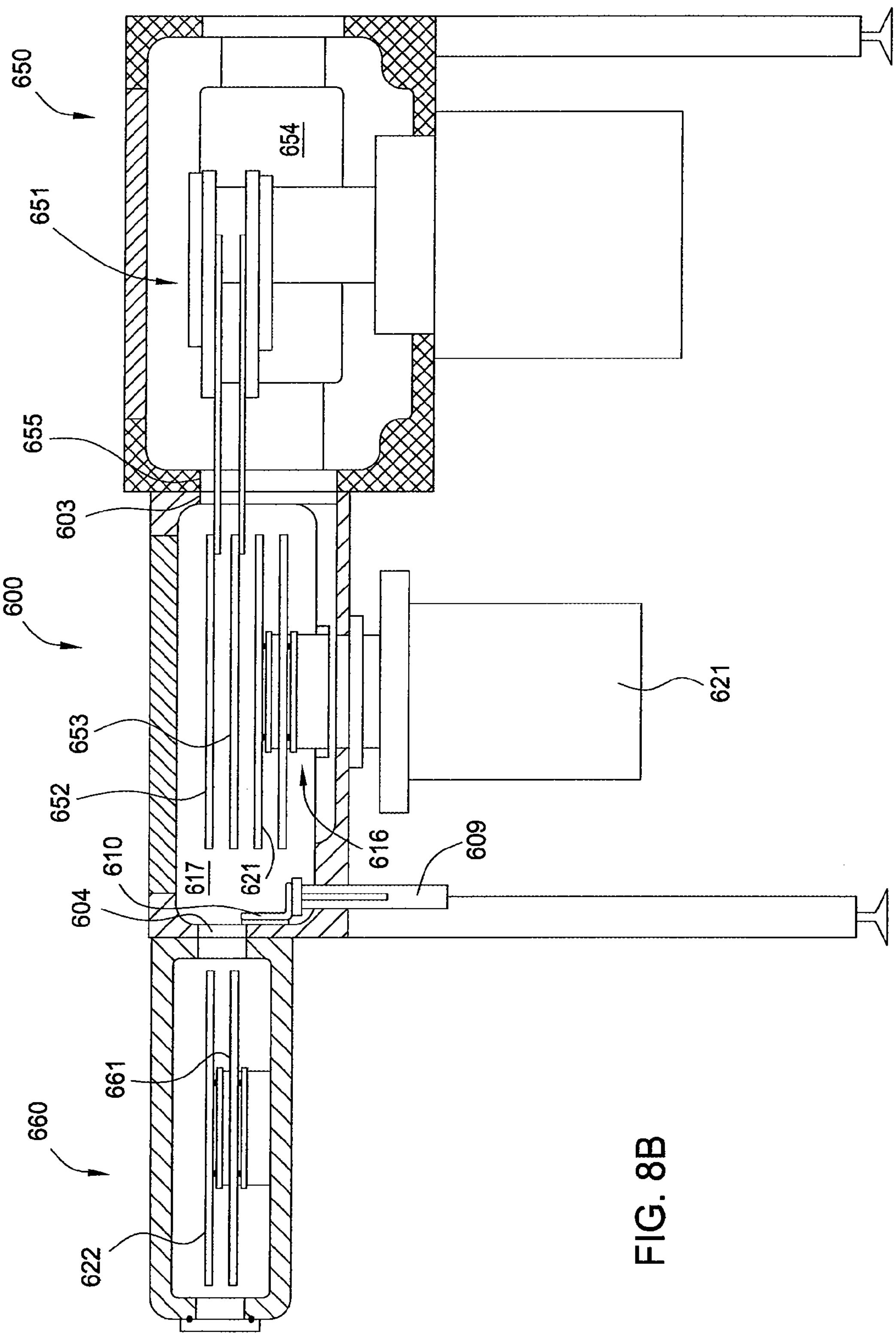
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FIG. 8B

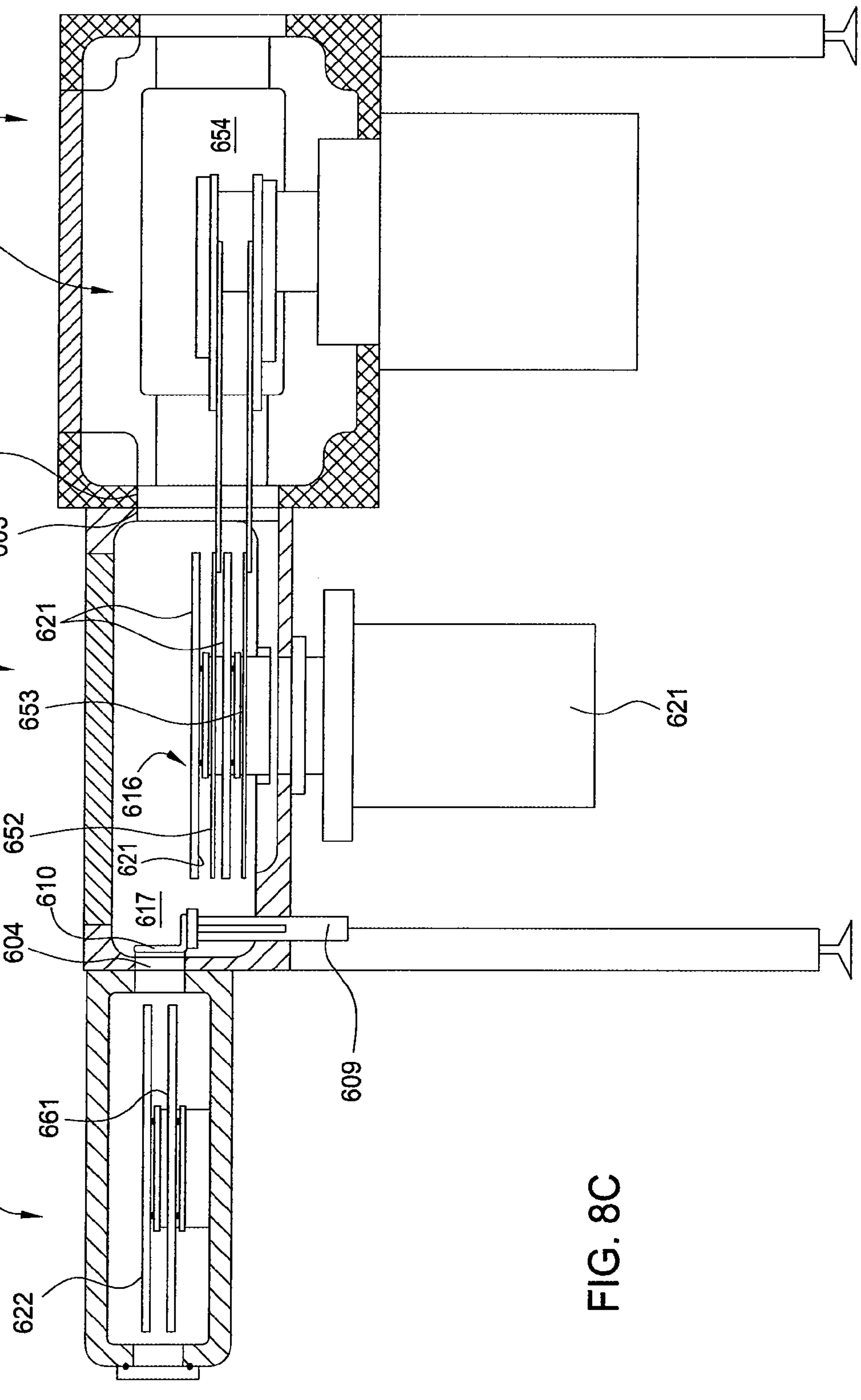
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FIG. 8C

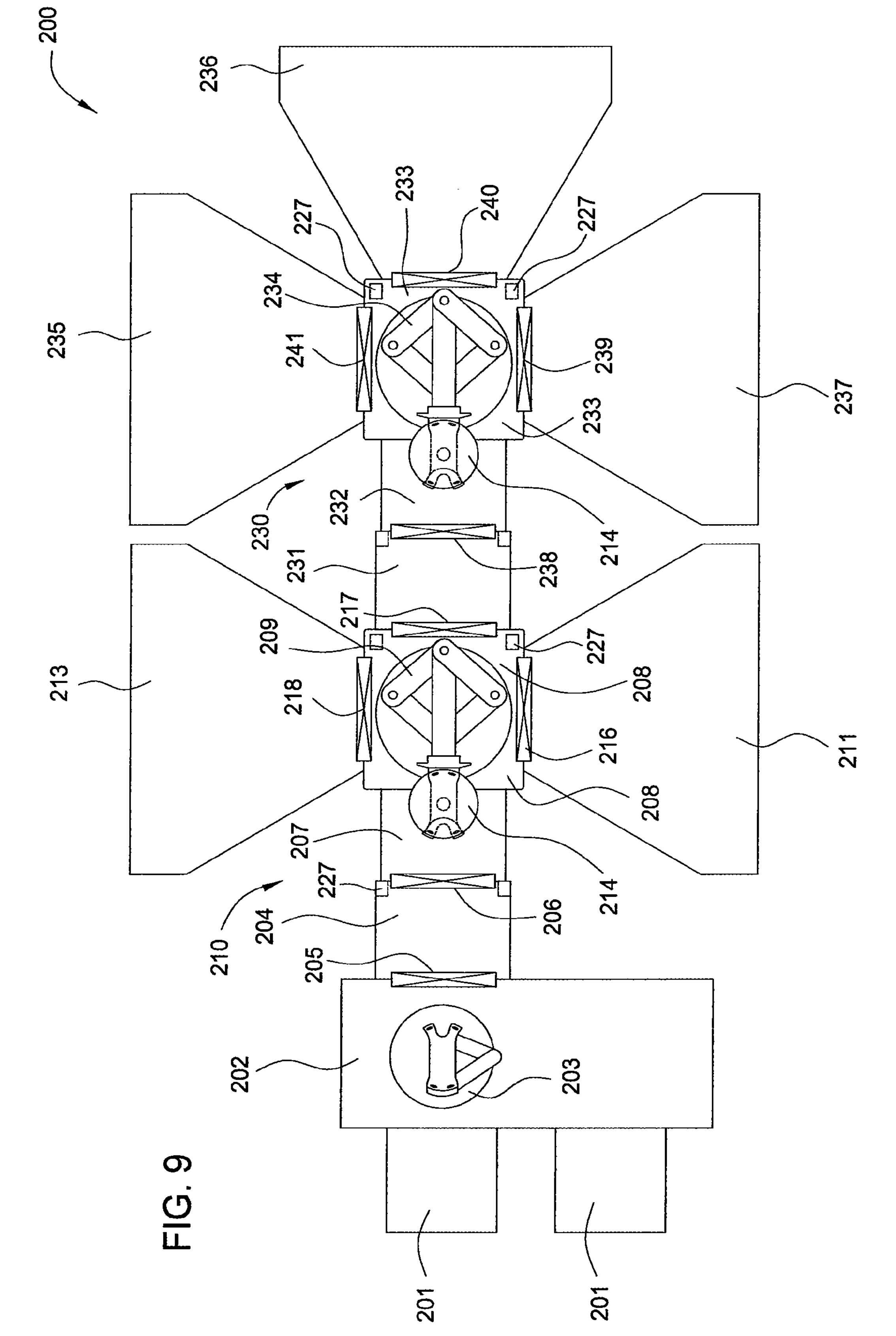
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FIG. 9

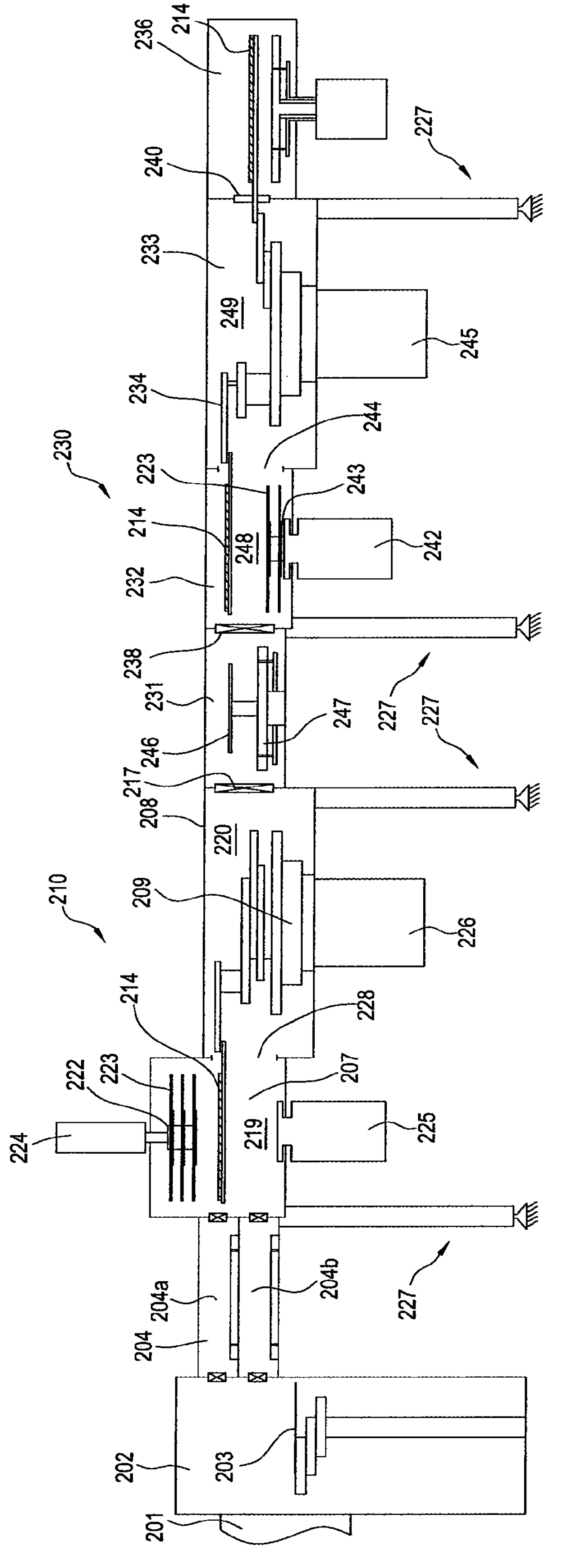
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FIG. 10

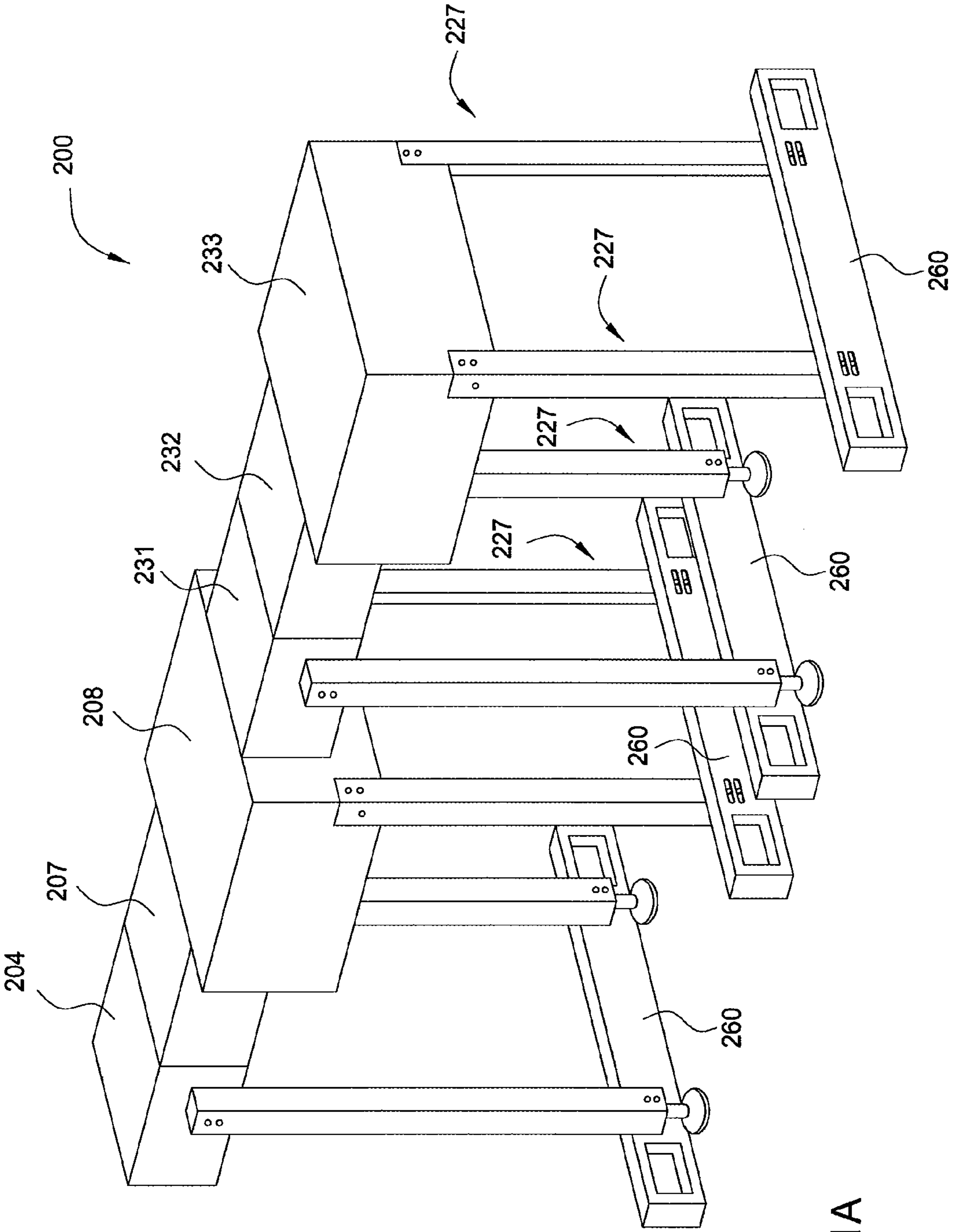

FIG. 11A

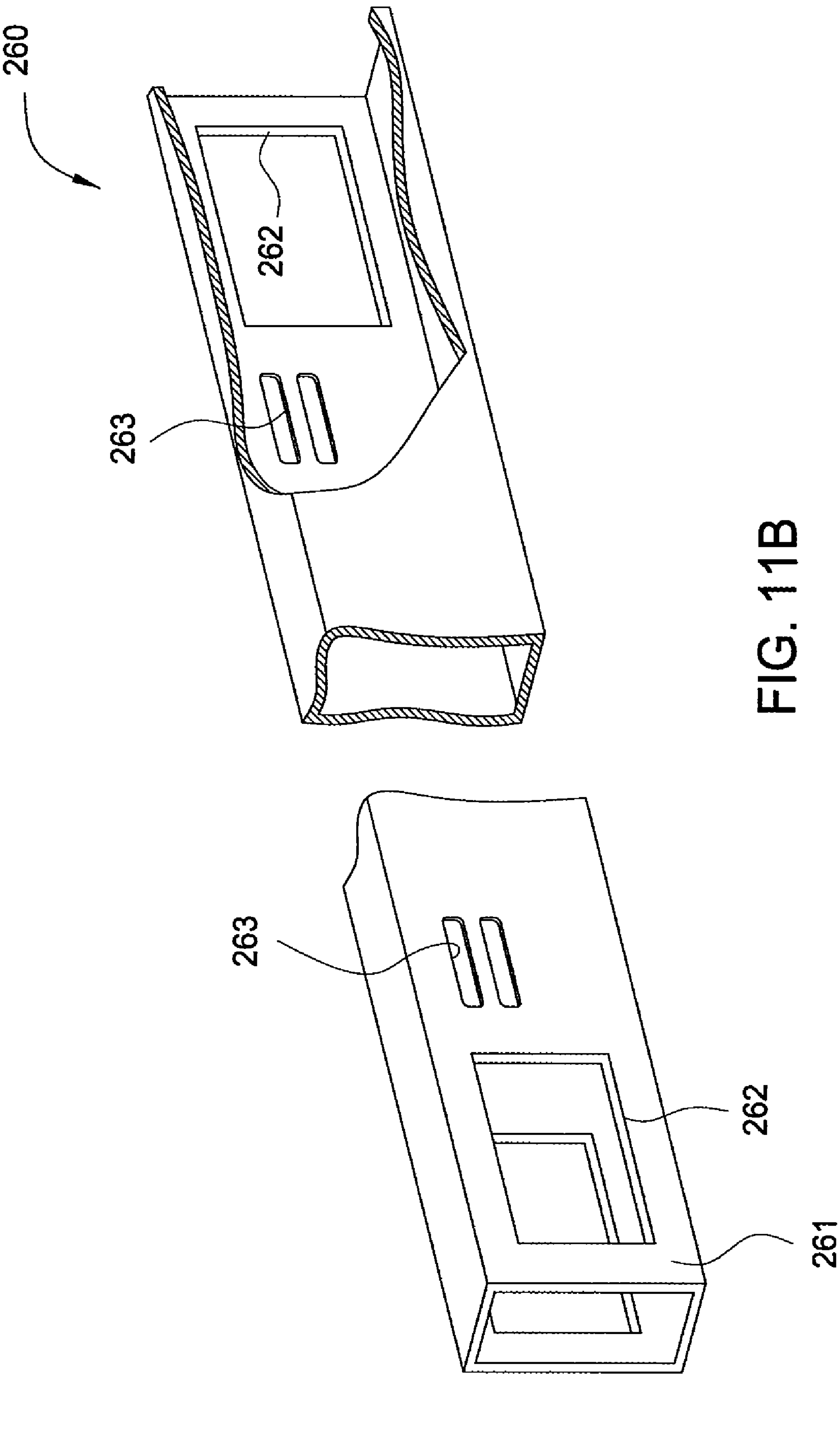

FIG. 11B

TRANSFER CHAMBER WITH VACUUM EXTENSION FOR SHUTTER DISKS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of U.S. Provisional Patent Application Ser. No. 60/916,921 (Attorney Docket No. 011776), filed May 9, 2008, U.S. Provisional Patent Application Ser. No. 60/916,924 (Attorney Docket No. 011803), filed May 9, 2008, and U.S. Provisional Patent Application Ser. No. 60/916,932 (Attorney Docket No. 011804), filed May 9, 2008. Each of the aforementioned patent applications is herein incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] Embodiments of the invention generally relate to an integrated processing system configured to process semiconductor substrates. More particularly, the invention relates a cluster tool has a mainframe including a transfer chamber and an extension chamber configured to store shutter disks therein.

[0004] 2. Description of the Related Art

[0005] The process of forming semiconductor devices is commonly done in a multi-chamber processing system (e.g., a cluster tool) which has the capability to process substrates, (e.g., semiconductor wafers) in a controlled processing environment. A typical controlled processing environment includes a system that has a mainframe which houses a substrate transfer robot configured to transport substrates among a load lock chamber and multiple vacuum processing chambers, which are connected to the mainframe. The controlled processing environment has many benefits, such as minimizing contamination of the substrate surfaces during transfer and during completion of the various substrate processing steps. Processing in a controlled environment thus reduces the number of generated defects and improves device yield.

[0006] A mainframe for a cluster tool generally includes a central transfer chamber housing a robot adapted to shuttle one or more substrates. Processing chambers and load locks are mounted on the central transfer chamber. During processing, an internal volume of the central transfer chamber is typically maintained at a vacuum condition to provide an intermediate region in which substrates may be shuttled from one processing chamber to another, and/or to a load lock chamber positioned at a front end of the cluster tool.

[0007] Some processing chambers, such as a physical vapor deposition (PVD) chamber, comprise a shutter disk which may be used to protect a substrate support during conditioning operation. Typically, a PVD processing is performed in a sealed chamber having a pedestal for supporting a substrate disposed thereon. The pedestal typically includes a substrate support that has electrodes disposed therein to electrostatically hold the substrate against the substrate support during processing. A target, generally comprised of a material to be deposited on the substrate, is supported above the substrate, typically fastened to a top of the chamber. A plasma formed from a gas, such as argon, is supplied between the substrate and the target. The target is biased, causing ions within the plasma to be accelerated toward the target. Ions impacting the target cause material to become dislodged from the target. The dislodged material is attracted towards the substrate and deposit a film of material thereon.

[0008] Conditioning operations, such as burn-in process, pasting, and/or cleaning operations, are performed periodically to ensure processing performance of the PVD chamber. During conditioning operations, a dummy substrate or a shutter disk is disposed on the pedestal to protect the substrate support from any deposition or particle contamination. The state of the art PVD chambers generally include a shutter disk storage space designated storing a shutter disk during process, and a robotic arm configured to transfer the shutter disk between the shutter disk storage space and the substrate support for conditioning operations. The shutter disk stays in the shutter disk storage space within the PVD chamber during deposition, and covers the substrate support during conditioning operations. The shutter disk storage space and the robotic arm designed to transfer the shutter disk increases complexity and volume of the PVD chamber.

[0009] FIG. **1**A schematically illustrates a PVD processing chamber **10** of prior art. The PVD processing chamber **10** includes a chamber body **2** and a lid assembly **6** that defines an evacuable process volume. The chamber body **2** generally includes sidewalls and a bottom **54**. The sidewalls generally contain a plurality of apertures that include an access port, pumping port and a shutter disk port **56** (access and pumping ports not shown). The sealable access port provides for entrance and egress of the substrate **12** from the PVD processing chamber **10**. The pumping port is coupled to a pumping system (also not shown) that evacuates and controls the pressure within the process volume. The shutter disk port **56** is configured to allow at least a portion of a shutter disk **14** therethrough when the shutter disk **14** is in the cleared position. A housing **16** generally covers the shutter disk port **56** to maintain the integrity of the vacuum within the process volume.

[0010] The lid assembly **6** of the body **2** generally supports an annular shield **62** suspended therefrom that supports a shadow ring **58**. The shadow ring **58** is generally configured to confine deposition to a portion of the substrate **12** exposed through the center of the shadow ring **58**.

[0011] The lid assembly **6** further includes a target **64** and a magnetron **66**. The target **64** provides material that is deposited on the substrate **12** during the PVD process while the magnetron **66** enhances uniform consumption of the target material during processing. The target **64** and substrate support **4** are biased relative each other by a power source **84**. A gas such as argon is supplied to the process volume **60** from a gas source **82**. A plasma is formed between the substrate **12** and the target **64** from the gas. Ions within the plasma are accelerated toward the target **64** and cause material to become dislodged from the target **64**. The dislodged target material is attracted towards the substrate **12** and deposits a film of material thereon.

[0012] The substrate support **4** is generally disposed on the bottom **54** of the chamber body **2** and supports the substrate **12** during processing. A shutter disk mechanism **8** is generally disposed proximate the substrate support **4**. The shutter disk mechanism **8** generally includes a blade **18** that supports the shutter disk **14** and an actuator **26** coupled to the blade **18** by a shaft **20**. Typically, the blade **18** is moved between the cleared position shown in FIG. **1**A and a second position that places the shutter disk **114** substantially concentric with the substrate support **4**. In the second position, the shutter disk **14** may be transferred (by utilizing the lift pins) to the substrate support **4** during the target burn-in and chamber pasting process. Typically, the blade **18** is returned to the cleared position during the target burn-in and chamber pasting process. The actuator **26** may be any device that may be adapted to rotate the shaft **20** through an angle that moves the blade **18** between the cleared and second positions.

[0013] FIG. **1**B schematically top and sectional plan views of the PVD processing chamber. FIG. **1**B illustrates the housing **16** relative to the shutter disk **14**, the blade **18** and the substrate support **4**.

[0014] Therefore, the state of the art PVD processing chambers with built-in shutter disk storage and transfer mechanism are not only complex but also bulky. There are usually multiple processing chambers require a shutter disk in a cluster tool configured to perform one or more PVD process steps. With multiple chambers having shutter disk storage and transferring mechanisms, footprint and cost of a cluster tool can be increased greatly.

[0015] Therefore, there is need for an efficient shutter disk storage and transferring mechanism in a cluster tool.

SUMMARY OF THE INVENTION

[0016] The present invention generally provides an apparatus and method for processing semiconductor substrates. Particularly, the present invention provides a cluster tool having an extension chamber connected to a transfer chamber, wherein the extension chamber comprises a shutter disk shelf to store shutter disks to be used in processing chambers connected to the transfer chamber.

[0017] One embodiment of the present invention provides a mainframe for a cluster tool comprising a transfer chamber having a substrate transferring robot disposed therein, wherein the substrate transferring robot is configured to shuttle substrates among one or more processing chambers directly or indirectly connected to the transfer chamber, and a shutter disk shelf configured to store one or more shutter disks to be used by the one or more processing chambers, wherein the shutter disk shelf is accessible to the substrate transferring robot so that the substrate transferring robot can transfer the one or more shutter disks between the shutter disk shelf and the one or more processing chambers directly or indirectly connected to the transfer chamber.

[0018] Another embodiment of the present invention provides a transfer chamber assembly for a cluster tool comprising a main chamber having a central robot disposed therein, wherein the main chamber configured to connect to a plurality of chambers, the central robot is configured to shuttle one or more substrates among the plurality of chambers connected to the main chamber, an extension chamber connected to the main chamber, a shutter disk shelf disposed in the extension chamber, wherein the shutter disk shelf is configured to support one or more shutter disks therein, and the shutter disk shelf is accessible to the central robot.

[0019] Yet another embodiment of the present invention provides a cluster tool configured to process semiconductor substrates comprising a first transfer chamber having a first central robot disposed therein, a first extension chamber connected to the first transfer chamber, the first extension chamber having a first shutter disk shelf positioned therein, wherein the first shutter disk shelf is configured to support one or more shutter disks thereon, and the first shutter disk shelf is accessible by the first central robot, one or more processing chambers connected to the first transfer chamber, and a load lock chamber connected to the first extension chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0021] FIG. **1**A schematically illustrates a sectional side view of a PVD processing chamber of prior art.

[0022] FIG. **1**B schematically illustrates a top view of the PVD processing chamber of prior art.

[0023] FIG. **2** schematically illustrates a plan view of a cluster tool in accordance with one embodiment of the present invention.

[0024] FIG. **3**A schematically illustrates a sectional side view of a cluster tool having a vacuum extension with a movable shelf to store shutter disks in accordance with one embodiment of the present invention.

[0025] FIG. **3**B schematically illustrates a sectional side view of a cluster tool having a vacuum extension with a stationary shelf to store shutter disks in accordance with one embodiment of the present invention.

[0026] FIG. **3**C schematically illustrates a partial isometric bottom view showing one embodiment of supporting legs of the cluster tool of FIG. **3**A.

[0027] FIG. **3**D schematically illustrates a partial isometric bottom view showing another embodiment of supporting legs of the cluster tool of FIG. **3**A.

[0028] FIG. **4**A schematically illustrates an isometric sectional view of a transfer chamber in accordance with one embodiment of the present invention.

[0029] FIG. **4**B schematically illustrates a top view of the transfer chamber of FIG. **4**A.

[0030] FIG. **4**C schematically illustrates a sectional side view of the transfer chamber of FIG. **4**A.

[0031] FIG. **4**D schematically illustrates a bottom view of the transfer chamber of FIG. **4**A.

[0032] FIG. **4**E schematically illustrates an isometric sectional view of the transfer chamber of FIG. **4**A with a central robot in a rotation mode.

[0033] FIG. **4**F schematically illustrates an isometric sectional view of the transfer chamber of FIG. **4**A in connection with a vacuum extension of the present invention.

[0034] FIG. **5**A schematically illustrates a plan view a cluster tool having a transfer chamber in accordance with one embodiment of the present invention.

[0035] FIG. **5**B schematically illustrates a plan view of the cluster tool of FIG. **5**A wherein a central robot in a transfer chamber is in a rotation mode.

[0036] FIG. **5**C schematically illustrates a plan view of the cluster tool of FIG. **5**A wherein a central robot in a transfer chamber is accessing a vacuum extension connected to the transfer chamber.

[0037] FIG. **5**D schematically illustrates a plan view of the cluster tool of FIG. **5**A wherein a central robot in a transfer chamber is accessing a load lock chamber connected with the transfer chamber.

[0038] FIG. 5E schematically illustrates a plan view of the cluster tool of FIG. 5A wherein a central robot in a transfer chamber is accessing processing chamber connected to the transfer chamber

[0039] FIG. 6A schematically illustrates an exploded view of a vacuum extension in accordance with one embodiment of the present invention. The vacuum extension has a movable shelf.

[0040] FIG. 6B schematically illustrates a sectional side view of the vacuum extension shown in FIG. 6A.

[0041] FIG. 6C schematically illustrates a sectional side view of the vacuum extension of FIG. 6A with the movable shelf in a down position.

[0042] FIG. 7A schematically illustrates an isometric view of the movable shelf of FIG. 6A.

[0043] FIG. 7B schematically illustrates a supporting finger in accordance with one embodiment of the present invention.

[0044] FIG. 7C schematically illustrates a supporting finger in accordance with another embodiment of the present invention.

[0045] FIG. 8A schematically illustrates an isometric sectional view of a vacuum extension having a stationary shelf in accordance with one embodiment of the present invention.

[0046] FIG. 8B schematically illustrates a sectional side view of a mainframe having a vacuum extension of FIG. 8A.

[0047] FIG. 8C schematically illustrates a sectional side view of the mainframe of FIG. 8B showing a robot accessing shutter disks disposed in the vacuum extension.

[0048] FIG. 9 schematically illustrates a plan view of a cluster tool in accordance with one embodiment of the present invention.

[0049] FIG. 10 schematically illustrate a sectional side view of the cluster tool of FIG. 9.

[0050] FIG. 11A schematically illustrates an isometric view of the cluster tool of FIG. 9 with transporting braces.

[0051] FIG. 11B schematically illustrates a transporting brace in accordance with one embodiment of the present invention.

[0052] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements disclosed in one embodiment may be beneficially utilized on other embodiments without specific recitation.

DETAILED DESCRIPTION

[0053] The present invention generally provides an apparatus and method for processing substrates using a multi-chamber processing system. Embodiments of the present invention include a mainframe comprising a transfer chamber configured to host a substrate transferring robot and an extension chamber configured to provide a low pressure environment to the mainframe. Extension chambers in accordance with embodiments of the present invention also comprise a shelf for storing and support shutter disks used by processing chambers connected to the mainframe.

[0054] FIG. 2 schematically illustrates a plan view of a cluster tool **100** in accordance with one embodiment of the present invention. The cluster tool **100** comprises multiple processing chambers coupled to a single mainframe.

[0055] The cluster tool **100** comprises a front-end environment **102** (also referred to as a factory interface, or FI) in selective communication with a load lock chamber **104**. One or more pods **101** are coupled to the front-end environment **102**. The one or more pods **101** are configured to store and transport substrates. A factory interface robot **103** is disposed in the front-end environment **102**. The factory interface robot **103** is configured to transfer substrates between the pods **101** and the load lock chamber **104**.

[0056] The load lock chamber **104** provides a vacuum interface between the front-end environment **102** and a mainframe **110**. An internal region of the mainframe **110** is typically maintained at a vacuum condition and provides an intermediate region to shuttle substrates from one chamber to another and/or to a load lock chamber.

[0057] In one embodiment, the mainframe **110** is divided into two parts to minimize the footprint of the cluster tool **100**. In one embodiment of the present invention, the mainframe **110** comprises a transfer chamber **108** and a vacuum extension chamber **107**. The transfer chamber **108** and the vacuum extension chamber **107** are coupled together and in fluid communication with one another and form an inner volume in the mainframe **110**. An inner volume of the mainframe **110** is typically maintained a low pressure or vacuum condition during processing. The load lock chamber **104** may be connected to the front-end environment **102** and the vacuum extension chamber **107** via slit valves **105** and **106** respectively.

[0058] The transfer chamber **108** is configured to house a central robot **109** and provide interfaces to a plurality of processing chambers, and/or pass through chambers for connecting to additional mainframes to extend the cluster tool **100**. In one embodiment, the transfer chamber **108** may be a polygonal structure having a plurality of sidewalls, a bottom and a lid. The plurality sidewalls may have opening formed therein and are configured to connect with processing chambers, vacuum extension chambers and/or pass through chambers. The transfer chamber **108** shown in FIG. 2 has a square horizontal profile and is coupled to processing chambers **111**, **112**, **113**, and the vacuum extension chamber **107**. In one embodiment, the transfer chamber **108** may be in selective communication with the processing chambers **111**, **112**, **113** via slit valves **116**, **117**, **118** respectively. In one embodiment, the central robot **109** may be mounted in the transfer chamber **108** at a robot port formed on the bottom of the transfer chamber **108**.

[0059] The central robot **109** is disposed in an internal volume of the transfer chamber **108** and is configured to shuttle substrates **114** in a substantially horizontal orientation among the processing chambers **111**, **112**, **113** and to and from the load lock chamber **104** through the vacuum extension chamber **107**. Details of suitable robots may be found in commonly assigned U.S. Pat. No. 5,469,035, entitled "Two-axis magnetically coupled robot", filed on Aug. 30, 1994; U.S. Pat. No. 5,447,409, entitled "Robot Assembly" filed on Apr. 11, 1994; and U.S. Pat. No. 6,379,095, entitled "Robot for Handling Semiconductor Substrates", filed on Apr. 14, 2000, which are hereby incorporated by reference in their entireties. In one embodiment, the central robot **109** may comprise two blades for holding substrates, each blade mounted on an independently controllable robot arm coupled to the same robot base. In another embodiment, the central robot **109** is configured to control the vertical elevation of the blades.

[0060] The vacuum extension chamber **107** is configured to provide an interface to a vacuum system to the transfer chamber **108**. In one embodiment, the vacuum extension chamber

107 comprises a bottom, a lid and sidewalls. A pressure modification port **115** may be formed on the bottom of the vacuum extension chamber **107** and is configured to adapt to a vacuuming pump system, such as a cryogenic pump, which is required to maintain high vacuum in the transfer chamber **108**. The pressure modification port **115** may be blocked with a blank off when only a smaller vacuum pump is needed. A smaller vacuum pump may be coupled to the transfer chamber **108** through a smaller port formed in on the transfer chamber **108**.

[0061] It should be noted that the vacuum extension chamber **107** is much smaller/narrower compared to the transfer chamber **108** since the vacuum extension chamber **107** only needs to be wide enough to allow a substrate pass through.

[0062] Openings may be formed on the sidewalls so that the vacuum extension chamber **107** is in fluid communication with the transfer chamber **108**, and in selective communication with chambers connected thereon, such as load lock chambers, pass through chambers, and/or processing chamber.

[0063] In one embodiment, the cluster tool **100** may be configured to deposit a film on semiconductor substrates using physical vapor deposition (PVD) process.

[0064] Typically, PVD is performed in a sealed chamber having a pedestal for supporting a substrate disposed thereon. The pedestal typically includes a substrate support that has electrodes disposed therein to electrostatically hold the substrate against the substrate support during processing. A target, generally comprised of a material to be deposited on the substrate, is supported above the substrate, typically fastened to a top of the chamber. A plasma formed from a gas, such as argon, is supplied between the substrate and the target. The target is biased, causing ions within the plasma to be accelerated toward the target. Ions impacting the target cause material to become dislodged from the target. The dislodged material is attracted towards the substrate and deposit a film of material thereon.

[0065] Conditioning operations, such as burn-in process, pasting, and/or cleaning operations, are performed periodically to ensure processing performance of the PVD chamber. During conditioning operations, a dummy substrate or a shutter disk is disposed on the pedestal to protect the substrate support from any deposition or particle contamination. The state of the art PVD chambers generally include an integral shutter disk storage space designated storing a shutter disk during the PVD process, and a robotic arm configured to transfer the shutter disk between the shutter disk storage space and the substrate support for conditioning operations. The shutter disk stays in the shutter disk storage space within the PVD chamber during deposition, and covers the substrate support during conditioning operations. The shutter disk storage space and the robotic arm designed to transfer the shutter disk increases complexity and volume of the PVD chamber.

[0066] In one embodiment of the present invention, the vacuum extension chamber **107** comprises a shutter disk shelf, further described in FIGS. **3**A-B, configured to store one or more shutter disks. PVD chambers connected to the transfer chamber **108** may store their shutter disks in the shutter disk shelf and use the central robot **109** to transfer the shuttle disks. It is also contemplated that the PVD chambers may share one or more shutter disks. In one embodiment, the shutter disk shelf may be configured to store one shutter disk for each processing chambers connected to the transfer chamber **108**.

[0067] The shutter disk shelf positioned in the vacuum extension chamber may also be used for storage, queuing, and/or accommodating any other disks used in the system. Additionally, the shutter disk shelf may be used to store and facilitate quick access to any substrate form devices, i.e. 300 mm disk, that are reusable in the system. The vacuum extension chamber of the present invention may also provide space for an inspection station, or cooling/heating station during a process.

[0068] In one embodiment, the shutter disk shelf may provide a recharging station for a vision calibration substrate. The vision calibration substrate is a reusable device having one or more wireless cameras disposed thereon. The vision calibration substrate may be used to measure, inspect and calibration interiors of a cluster tool accessible to the central robot, including the transfer chambers, extension chambers, load lock chambers, pass through chambers, and the processing chambers. The vision calibration substrate may also be used to calibrate the central robot. A detailed description of the vision calibration substrate may be found in the U.S. Pat. No. 7,085,622, entitled "Vision System", which is hereby incorporated by reference.

[0069] The vision calibration substrate comprises one or more wireless cameras, which have rechargeable power supplies so that the cameras can work wirelessly in the interior of the cluster tool. Currently, the power supplies to the wireless cameras are charged and recharged outside the cluster tool. The charged vision calibration substrate is generally fed into the cluster tool from the front-end environment while halting the process. The vision calibration substrate is taken out of the cluster tool after the task is completed or the power supplies are depleted. In one embodiment of the present invention, electrical contacts may be formed in one or more slots of the shutter disk shelf for charging a vision calibration substrate. One or more vision calibration substrates may be stored in the shutter disk shelf and are ready to use at any time. The measurement using the vision calibration substrates may be performed with much reduced interruption to the processing in the cluster tool.

[0070] Positioning shutter disks within a mainframe of a cluster tool simplifies processing chambers that require shutter disks by eliminating a designated region for shutter disks within the processing chambers, and devices for transferring and/or monitoring the shutter disks, hence reducing cost of the processing chambers. Positioning shutter disks within a mainframe of a cluster tool may also improves gas flows and electrical characteristics, and thus processing. Additionally, cost of ownership may also be reduced due to decrease of the overall volume of the cluster tool since the processing chambers are smaller.

[0071] In one embodiment, the cluster tool **100** may comprises a pre-clean chamber, a PVD chamber and a degassing chamber connected to the transferring chamber **108** at positions for processing chambers **111**, **112**, **113**.

[0072] FIG. **3**A schematically illustrates a sectional side view of the cluster tool **100** of FIG. **2**. The vacuum extension chamber **107** comprises a movable shutter disk shelf **122** configured to support at least one shutter disk **123** therein.

[0073] In one embodiment of the present invention, the load lock chamber **104** comprises an upper load lock chamber **104***a* stacked over a lower load lock chamber **104***b*. The upper load lock chamber **104***a* and the lower load lock chamber **104***b* may be operated independently so that transferring of substrates between the front-end environment **102** and the mainframe **110** can be conducted in both directions simultaneously.

[0074] The load lock chambers **104***a*, **104***b* provide a first vacuum interface between the front-end environment **102** and the mainframe **110** via slit valves **105***a*, **106***a*, **105***b*, **106***b* respectively. In one embodiment, the two load lock chambers **104***a*, **104***b* are provided to increase throughput by alternatively communicating with the mainframe **110** and the front-end environment **102**. While one load lock chamber **104***a* or **104***b* communicates with the mainframe **110**, a second load lock chamber **104***b* or **104***a* can communicate with the front-end environment **102**.

[0075] In one embodiment, one of the load lock chambers **104***a*, **104***b* may be used as a processing chamber, such as a degas chamber, an inspection station, a pre-heat chamber, a cooling chamber, or curing chamber. For example, the slit valve **105***b* may be replaced by a permanent blocker so that the lower load lock chamber **104***b* only opens to the mainframe **110**. The central robot **109** may shuttle substrates to and from the lower load lock chamber **104***b* prior to and after a degassing process through the slit valve **106***b*.

[0076] Referring to FIG. **3**A, the internal volume of the mainframe **110** is defined by an internal volume **119** of the vacuum extension chamber **107** connected to an internal volume **120** of the transfer chamber **108**. An opening **128** is formed between the transfer chamber **108** and the vacuum extension chamber **107**. The opening **128** provides fluid communication between the vacuum extension chamber **107** and the transfer chamber **108**, and are large enough to allow the central robot **109** to shuttle substrates to and from the load lock chamber **104**.

[0077] A vacuum system **125** is coupled the vacuum extension chamber **107** and is configured to provide a low pressure environment to both the internal volume **119** and the internal volume **120**. A robotic mechanism **126** is coupled to the transfer chamber **108**. The transfer chamber **108** and the vacuum extension chamber **107** are constructed to minimize the foot print of the cluster tool **100**.

[0078] For a cluster tool, when a vacuum system, such as a cryogenic pump, is required to maintain vacuum, usually high vacuum, within a transfer chamber, a large vacuum port is generally formed in the transfer chamber. The transfer chamber, thus, has both a robot port configured to adapt to a robotic transport mechanism and a vacuum port for the vacuum system. The robot port is generally positioned near a center of the transfer chamber, while the vacuum port positioned in a satellite position relative to the robot port leaving enough space for both the robotic transport mechanism and the vacuum pump. As a result, the transfer chamber has a large foot print and a large internal volume. The large foot print of the transfer chamber greatly enlarges the foot print of the cluster tool as a whole since processing chambers, load lock chambers and/or pass through chambers are distributed around the transfer chamber.

[0079] Embodiments of the present invention provides a vacuum system connection to the transfer chamber for obtaining high vacuum without greatly enlarge the foot print of the transfer chamber and the cluster tool. By "outsourcing" the pressure modification port to a separated extension chamber, size of the transfer chamber may be minimized to be just enough to provide space for the central robot. Size of the extension chamber may be determined by the size of the vacuum system needed. The combined footprint of a transfer chamber with a robot port only and its extension chamber with a robot port is much smaller compared to the state of a state of the art transfer chamber with both a vacuum port and a robot port. The decrease of the foot print of a cluster tool is more pronounced since a cluster tool may be built around a minimized transfer chamber when the extension chamber is positioned to take a space of a load lock chamber around the transfer chamber.

[0080] It should be noted that the size of the extension chamber is usually much smaller than the size of the transfer chamber since the extension chamber only needs to be large enough to accommodate passage of a substrate, while the transfer chamber generally needs to host the central robot.

[0081] Additionally, internal volume of a transfer chamber and extension chamber of the present invention is reduced compared to the state of the art transfer chambers. This allows fast pump downs, requires less energy to maintain vacuum and smaller, less costly pumps.

[0082] In one embodiment, an indexer **124** is coupled to the movable shutter disk shelf **122** and is configured to vertically move the movable shutter disk shelf **122**. The movable shutter disk shelf **122** may be positioned on an upper portion of the internal volume **119** of the vacuum extension chamber **107** when the central robot **109** transfers substrates to and from the load lock chamber **104** through a lower portion of the internal volume **1 19**. The movable shutter disk shelf **122** may be lowered to the lower portion of the internal volume **119** by the indexer **124** so that the central robot **109** can pick up a shutter disk from the movable shutter disk shelf **122** or drop a shutter disk on the movable shelf **122**.

[0083] FIG. **3**B schematically illustrates a sectional side view of a cluster tool **100***a* having a mainframe **110***a* in accordance with one embodiment of the present invention. The mainframe **110***a* comprises a vacuum extension chamber **133** with a stationary shelf **135** configured for storing one or more shutter disks.

[0084] A load lock chamber **130** provides a first vacuum interface between the front-end environment **102** and the mainframe **110***a*. In one embodiment, the load lock chamber **130** comprises an upper substrate support **131** and a lower substrate support **132** stacked within the load lock chamber **130**. The upper substrate support **131** and the lower substrate support **132** are configured to support substrates thereon. In one embodiment, the upper substrate support **131** and the lower substrate support **132** may be configured to support incoming and outgoing substrates respectively. The upper substrate support **131** and the lower substrate support **132** may comprise features for temperature control, such as a built-in heater or cooler to heat or cool substrates during transferring.

[0085] The internal volume of the mainframe **110***a* is defined by an internal volume **134** of the vacuum extension chamber **133** connected to the internal volume **120** of the transfer chamber **108**. An opening **128***a* is formed between the transfer chamber **108** and the vacuum extension chamber **133**. The opening **128***a* provides fluid communication between the vacuum extension chamber **133** and the transfer chamber **108**, and are large enough to allow the central robot **109** to shuttle substrates to and from the load lock chamber **130**, as well as access the stationary shelf **135** of the vacuum extension chamber **133**.

[0086] In one embodiment, the stationary shelf **135** may be positioned on a lower portion of the internal volume **134** of the vacuum extension **133** while the central robot **109** is configured to transfer substrates to and from the load lock chamber **130** through an upper portion of the internal volume **134**.

[0087] In one embodiment, the stationary shelf **135** may comprise supporting fingers extending from posts positioned on opposite sides of the internal volume **134**.

[0088] It should be noted that the robot **109** may be suspended from a top wall of the transfer chamber **108**. Embodiments of the present invention may include robots capable of vertical or z-motion.

[0089] Referring back to FIG. **3**A, the mainframe **110** of the cluster tool **100** is supported by supporting legs **127**. The supporting legs **127** provide vertical and lateral support to the mainframe **110** and chambers connected to the mainframe **110**. Each of the supporting legs **127** is configured to support at least a portion of the weight of the mainframe **110** including the transfer chamber **108**, the vacuum extension chamber **107**, and optionally the processing chambers connected thereon. Each of the supporting legs **127** may be vertically adjustable so that the mainframe **110** and chambers connected thereon may be leveled on site. The supporting legs **127** are coupled to sidewalls of the mainframe **110** and/or chambers coupled to the mainframe **110** to provide lateral support to the cluster tool **100**.

[0090] In one embodiment, each of the supporting legs **127** may comprise a foot **127***b* connected to a steel tube body **127***a*. The steel tube body **127***a* is configured to be coupled to the mainframe **110**. The foot **127***b* is configured to contact the ground and adjustable relative to the steel tube body **127***a*. Vertical dimension of the supporting leg **127** may be adjusted by adjusting the foot **127***b* to provide tolerance in supporting the cluster tool **100**.

[0091] In one embodiment, the mainframe **110** may be supported by for supporting legs **127** independently mounted on opposite sides of the mainframe **110**, as shown in FIG. **2**, and FIGS. **3**C-**3**D. Two of the supporting legs **127** are independently fastened to sidewalls of the transfer chamber **108** and two of the supporting legs **127** are independently fastened to sidewalls of the vacuum extension chamber **107**. In another embodiment, two of the supporting legs **127** may be positioned near the joint region of the vacuum extension chamber **107** and the load lock chamber **104**. In one embodiment, notches may be formed on sidewalls of the mainframe **110** for the supporting legs **127** to engage with.

[0092] Screws may be used to fasten each supporting leg **127** to a corresponding location in the mainframe **110**. FIG. **4**E illustrates screw holes **318**, **319** formed in the chamber body **301** configured to secure supporting legs in the notches **309**.

[0093] FIG. **3**C schematically illustrates a partial isometric bottom view showing one embodiment of supporting legs of a cluster tool **100***b* similar to the cluster tool **100** of FIG. **3**A. As shown in FIG. **3**C, the cluster tool **100***b* is supported by four independent supporting legs **1271-4**. Each of the supporting legs **1271-4** is independently mounted on the cluster tool **100**. FIG. **3**C shows a central structure **160**, which includes the transfer chamber **108** and the vacuum extension chamber **107**, and the load lock chamber **104** coupled together. Additional components, such as processing chambers, pass through chambers, and front end interface may be extended from the central structure **160**. The supporting legs **1271-4** are coupled to the central structure **160** providing support to the cluster tool **100** in a whole. A pair of notches **161** may be formed in the bottom walls near a joint region of the load lock chamber **104** and the vacuum extension chamber **107**. The notches **161** are configured to provide lateral support to the supporting leg **127** mounted therein. A pair of notches **162** may be formed in the transfer chamber **108** and configured to engage supporting legs **1273-4**. The notches **162** also provide lateral support to the supporting legs **127** mounted therein. The notches **161**, **162** may be placed in locations such that the supporting legs **1271-4** provide balanced support to the cluster tool **100**, including the central structure **160** and/or chambers connected to the central structure **160**.

[0094] FIG. **3**D schematically illustrates a partial isometric bottom view showing another embodiment of supporting legs of the cluster tool **100** of FIG. **3**A. In this embodiment, the supporting legs **1271-4** may be mounted on sidewalls of the load lock chamber **104**, or the vacuum extension chamber **107**.

[0095] The design of independent supporting legs has several advantages over conventional cluster tool support, which generally includes a welded base used to provide a ridged support. The conventional base is typically in an integral form and is configured to provide support to multiple components of a cluster tool. The conventional base is costly to build providing high precision demanded by the semiconductor processing. The conventional base is also difficult to assemble because it has to be coupled to multiple components of a cluster tool. The conventional base usually poses clearance issues for other components in a cluster tool causing disconnection of utility during utility routing or removal of chamber components from the base.

[0096] The independent leg supporting of the present invention largely reduces cost over conventional base. Each supporting leg is manufactured separately avoiding manufacture cost of a high precision structure. Each supporting leg is generally coupled to one component, which makes leveling and other adjustment much easier. The supporting leg is not limited to any cluster tool configuration. When one or more components, such as a load lock chamber, are altered, the supporting legs do not need to be replaced. Furthermore, the supporting leg of the present invention is much easier to transport.

[0097] FIG. **4**A schematically illustrates an exploded sectional view of a transfer chamber **300** in accordance with one embodiment of the present invention. The transfer chamber **300** may be used as the transfer chamber **108** of FIGS. **2**, and FIGS. **3**A-B. The transfer chamber **300** comprises a chamber body **301** having a top wall **313**, a plurality of sidewalls **314** and a bottom wall **315**. The chamber body **301** defines an inner volume **312** (shown in FIG. **4**C) configured to accommodate a substrate transferring means, such as a robot, therein. In one embodiment, a central robot may be disposed in a robot port **304** formed on the bottom wall **315** of the transfer chamber **300**.

[0098] The transfer chamber **300** further comprises a chamber lid **302** configured to seal an opening **303** formed on the top wall **313** of the chamber body **301**. The opening **303** may be configured to assist installation and/or maintenance of the substrate transferring means. In one embodiment, the chamber lid **302** may be coupled to the chamber body **301** with a seal ring **317** and a plurality of screws **307**. The chamber lid **302** may have a pair of handles **308**.

[0099] In one embodiment, the chamber body **301** has a rectangular profile and comprises four sidewalls **314**. Each of the sidewalls **314** has an opening **305** formed therein. The openings **305** are configured to provide selective communication between the inner volume **312** and processing chambers, load lock chambers, and/or vacuum extensions coupled to the transfer chamber **300**. A gland **306** may be formed around the opening **305** and configured to accommodate a seal ring (not shown) to maintain a pressure barrier around the inner volume **312**.

[0100] FIG. **4**A schematically illustrates a processing chamber **390** mounted to the transfer chamber **300** via a chamber port assembly **370** in accordance with one embodiment of the present invention. The chamber port assembly **370** provides an interface between the transfer chamber **300** and the processing chamber **390**. In one embodiment, the chamber port assembly **370** provides a housing for a slit valve assembly **380** configured to open and close a substrate opening **392** formed through a sidewall **391** of the processing chamber **390**. The substrate opening **392** is configured to provide a passage to allow entry and egress of substrates from the processing chamber **390**. Additionally, the chamber port assembly **370** allows mismatch between the opening **305** of the transfer chamber **300** and the substrate opening **392** of the processing chamber **390**.

[0101] The chamber port assembly **370** comprises a body **371** having a transfer chamber opening **372** open towards one side of the body **371**. The transfer chamber opening **372** is configured to cover the opening **305** of the transfer chamber **300**. The transfer chamber opening **372** is connected to a chamber opening **373** which opens on an opposite side of the body **371** to define a substrate passage through the chamber port assembly **370**. The chamber opening **373** is configured to align with the substrate opening **392** of the processing chamber **390**. A gland **377** may be formed on an outer side of the substrate opening **392** to accommodate a seal ring (not shown) to prevent leakage between the chamber port assembly **370** and the processing chamber **390**.

[0102] The slit valve assembly **380** generally comprises a slit valve door **382** activated by an activation member **381** configured to move the slit valve door **382** between an opening position and a closed position. The slit valve door **382** of the slit valve assembly **380** may be positioned on an inner side of the chamber opening **373** and selectively connects and disconnects the transfer chamber opening **372** and the chamber opening **373**, hence, selectively connecting the transfer chamber **300** and the processing chamber **390**.

[0103] In one embodiment, a plurality of screws **374** may be used to fasten the chamber port assembly **370** to the transfer chamber **300**. In one embodiment, a seal ring **378** may be used in the gland **306** circumscribing the opening **305** between the transfer chamber **300** and the chamber port assembly **370** to fluidly isolate the inner region of the chamber port assembly **370** and the transfer chamber **300** from an outside environment. A plurality of screws **393** and a seal ring **394** may be used to mount the processing chamber **390** to the chamber port assembly **370**.

[0104] Additionally, the transfer chamber opening **372** may provide a pocket of extra room that accommodates the tip of a robot positioned in the transfer chamber **300** as the blade is rotated in a horizontal plane (further described with FIG. **4**B). The pocket of extra room in the chamber port assembly **370** allows further reducing in size of the transfer chamber **300**, hence reducing foot print of the system. In one embodiment, the chamber port assembly **370** may comprise one or more sensors configured to detect substrate and/or robot parts within the transfer chamber opening **372**. FIG. **4**A schematically shows optical sources **376** and optical receivers **375** used as sensors to detect substrates and/or robot parts.

[0105] It should be noted that a load lock chamber may be coupled to one of the sidewall **314** of the transfer chamber **300** directly or via a chamber port assembly similarly to the chamber port assembly **370**.

[0106] In one embodiment, two notches **309** may be formed near corners of the bottom wall **315**. Each of the notches **309** is configured to receive a supporting leg **360** therein. Each of the supporting legs **306** is configured to bear at least part of the weight of the transfer chamber **300** and devices mounted thereto. The supporting leg **360** may be fastened against the transfer chamber **300** by screws **361**. The notch **309** provides two planes for lateral support for the supporting leg **360**.

[0107] FIG. **4**B schematically illustrates a plan view of the transfer chamber **300** of FIG. **4**A. FIG. **4**C schematically illustrates a sectional side view of the transfer chamber **300** of FIG. **4**A. Referring to FIG. **4**C, the chamber body **301** may be formed by cast aluminum and defining the inner volume **312** configured to provide space for movement of a central robot position therein. In one embodiment, the inner volume **312** may be minimized to be just large enough to accommodate required movement of a robot disposed therein.

[0108] FIG. **4**E schematically illustrates an isometric sectional view of the transfer chamber **300** of FIG. **4**A with a central robot **316** in a rotation mode. The central robot **316** comprises a top blade **329** and a bottom blade **330**, each configured to transfer a substrate **331** independently. The central robot **316** is capable of rotating about z axis, translating along the z axis, and translating parallel to x-y plane. Other suitable robots may be used in the transfer chamber **300**. The central robot **316** may be suspended from the top wall **313** of the transfer chamber **300** as well with corresponding changes of other structures.

[0109] During processing, the central robot **316** may extend the top blade **329** or the bottom blade **330** through one of the openings **305** on the sidewalls **314** of the transfer chamber **300** to retrieve a substrate in a processing chamber/load lock chamber connected to the transfer chamber **300**, or a shutter disk stored in a vacuum extension chamber connected to the transfer chamber **300**. The central robot **316** may need to translate vertically, i.e. along z axis, so that the top blade **329** or the bottom blade **330** is aligned with the target substrate or shutter disk. Upon picking up the substrate/shutter disk, the central robot **316** retrieves the top blade **329** or the bottom blade **330** back to the inner volume **312** of the transfer chamber **300**, and rotates the top blade **329** or the bottom blade **330** within the inner volume **312** so that the top blade **329** or the bottom blade **330** is align with an opening **305** connecting a target chamber for the substrate/shutter disk. The central robot **316** then extends the top blade **329** or the bottom blade **330** to access the target chamber and drops the substrate/shutter disk therein.

[0110] It is desirable to minimize the inner volume **312** of the transfer chamber **300** to reduce system foot print and to reduce volume of the controlled environment. In one embodiment, the inner volume **312** of the transfer chamber **300** is defined to match a motion envelop described by circles **324** and **325**, shown in FIGS. **4**B and **4**C, necessary for the central robot **316** to perform required functions. The motion envelop of cylindrical with a large center portion having a radius of the circle **325**, and small upper and lower portions having a radius of the circle **324**. The large center portion of the motion envelop is partially accommodated by a large middle portion with a radius of **311** in the inner volume **312** and extra room in the chamber port assembly **370** and the vacuum extension chamber **350** connected to the transfer chamber **300**.

[0111] In one embodiment, the motion envelop includes space needed for the central robot **316** to perform rotation and required vertical movement therein. The motion envelop has a substantially cylindrical shape with an enlarged middle portion marked by circle **325** configured to allow tips of the blades **329**, **330** during rotation. Accordingly, the inner volume **312** is substantially cylindrical with a radius marked by line **310** and an enlarged middle portion having a radius marked by line **311**. To further reduce size of the transfer chamber **300**, part of the enlarged middle portion **325** may be outside the transfer chamber **300** and extends to a vacuum extension chamber and/or chamber port assemblies **370** connected to the transfer chamber **300**, for example, to the transfer chamber opening **372** of the chamber port assembly **370**.

[0112] In one embodiment, a radial clearance **327**, shown in FIG. **4**C, between the inner volume **312** and the motion envelop may be about 0.25 inch and the vertical clearances **326**, **328** may be about 0.338 inch.

[0113] In one embodiment, software constraints may be used in a control system so that the central robot **316** stays within the motion envelop.

[0114] FIG. **4**D schematically illustrates a bottom view of the transfer chamber **300** of FIG. **4**A. One or more heater ports **320** may be formed on the bottom wall **315** and configured to connect to cartridge heaters for heating the chamber body **301** during processing. A gage port **321** may be formed in the bottom wall **315**. The gage port **321** may be used to adapt sensors, such as a pressure sensor, therein. An optional pressure modification port **322**, and vents **323** may also be formed on the bottom wall **315** for connection to suitable pumping devices. The gage port **321**, the pressure modification port **322**, and the vents **323** may be sealed off when not needed.

[0115] FIG. **4**F schematically illustrates an exemplary vacuum extension chamber **350** configured to couple with one of the sidewalls **314** of the transfer chamber **300**. In one embodiment, the vacuum extension chamber **350** is configured to provide the transfer chamber **300** an extra space for connection to a vacuum system to keep the inner volume **312** of the transfer chamber **300** in a vacuum condition during processing while minimizing the volume of the transfer chamber **300** and overall internal volume of the mainframe. The vacuum extension chamber **350** may also provide a pass way for a robot positioned in the transfer chamber **300** to a factory interface via a load lock chamber or another transfer chamber via a pass through chamber.

[0116] A pressure modification port **354** configured to adapt to a vacuum pump, such as a cryogenic pump, may be formed on a bottom wall **355** of the vacuum extension chamber **350**. An opening **351** configured to connect the transfer chamber **300** is formed in a sidewall **353** of the vacuum extension chamber **350**. The sidewall **353** of the vacuum extension chamber **350** is secured against the sidewall **314** of the transfer chamber **300**, for example by a plurality of screws **352**, when the vacuum extension chamber **350** is mounted on the transfer chamber **300**. The opening **351** is aligned with the opening **305** to facilitate fluid communication and/or substrate traffic between the transfer chamber **300** and the vacuum extension chamber **350**. In one embodiment, a seal ring **356** disposed in the gland **306** circumscribing the opening **305** may be used to fluidly isolate the inner volume of the vacuum extension chamber **350** and the transfer chamber **300** from an outside environment.

[0117] FIG. **5**A schematically illustrates a plan view a cluster tool **400** having a transfer chamber in accordance with one embodiment of the present invention. The cluster tool **400** comprises a transfer chamber **401**, similar to the transfer chamber **300** of FIG. **4**A. The transfer chamber **401** is connected to a vacuum extension chamber **408**, which is further connected to a load lock chamber **410** via a slit valve assembly **409**. Three processing chambers **406** are connected to the transfer chamber **401** via chamber port assemblies **407**, similar to the chamber port assembly **370** of FIG. **4**A. The transfer chamber **401** defines an inner volume **402** which may be maintained in a vacuum condition during processing by a pump system coupled to the vacuum extension chamber **408**. The vacuum extension **401** may be configured to store one or more shutter disks to be used by the processing chambers **406**.

[0118] A central robot **403** is disposed in the inner volume **402** of the transfer chamber **401**. The central robot **403** is configured to transfer substrates and/or shutter disks among the processing chambers **406**, the vacuum extension chamber **408** and the load lock chamber **410**. The central robot **403** comprises a top arm **405** and a bottom arm **404**, each having a blade configured to carry a substrate or shutter disk **411** thereon. Shown in FIG. **5**A, both the top arm **405** and the bottom arm **404** are positioned in the transfer chamber **401**.

[0119] FIG. **5**B schematically illustrates a plan view of the cluster tool **100** of FIG. **5**A wherein the central robot **403** in the transfer chamber **401** rotates an angel from the central robot **403** shown in FIG. **5**A. The central robot **403** may rotate both arms **404**, **405** together or independently within the inner volume **402**.

[0120] FIG. **5**C schematically illustrates a plan view of the cluster tool **100** of FIG. **5**A wherein the bottom arm **404** of the central robot **403** is accessing the vacuum extension chamber **408** connected to the transfer chamber **401**.

[0121] FIG. **5**D schematically illustrates a plan view of the cluster tool **100** of FIG. **5**A wherein the bottom arm **404** of the central robot **403** is accessing a load lock chamber **410** connected with the transfer chamber **401** through the vacuum extension chamber **408**.

[0122] FIG. **5**E schematically illustrates a plan view of the cluster tool **100** of FIG. **5**A wherein the top arm **405** of the central robot **403** is accessing the processing chamber **406** connected to the transfer chamber **401**.

[0123] FIG. **6**A schematically illustrates an exploded view of a vacuum extension assembly **500** in accordance with one embodiment of the present invention. The vacuum extension assembly **500** is configured to connect to a transfer chamber, such as the transfer chamber **300** of FIG. **4**A, and to provide an interface between the transfer chamber and a load lock chamber and a fluid communication between the transfer chamber and a vacuum system.

[0124] The vacuum extension assembly **500** comprises a body **501** defining an inner volume **512** (marked in FIG. **6**B), a top plate **502** disposed on a top wall **527** of the body **501**, and a shelf cover **504** disposed on the top plate **502**.

[0125] A pressure modification port **514** may be formed on a bottom wall **528** of the body **501**. The pressure modification port **514** is configured to connect a vacuum pump **508** to provide a low pressure environment to the inner volume **512** and volumes in fluid communication with the inner volume **512**. In one embodiment, an opening **513** may be formed on the top wall **527** of the body **501**. The opening **513** may be used to access the inner volume **512** during installation and/or maintenance of the vacuum pump **508**.

[0126] As shown in FIG. **6**A, the top plate **502** is configured to cover the opening **513** on the top wall **527**. The top plate **502** may have a slit valve opening **519** and a shelf opening **520** formed therein. The slit valve opening **519** is configured for installation of a slit valve **506**. The shelf opening **520** is configured to allow a movable shelf **503** to be positioned at a selected elevation within the inner volume **512**.

[0127] In one embodiment, a chamber opening **510** may be formed on a sidewall **529** which is configured to be coupled with a transfer chamber, such as the transfer chamber **300** of FIG. **4**A. The chamber opening **510** is configured to provide fluid communication with the transfer chamber and to provide passage for robot blades coupled to a robot disposed in the transfer chamber, to transfer substrates, and/or shutter disks. Therefore, width of the chamber opening **510** is generally slightly larger than a diameter of the largest substrate configured to be processed in a cluster tool. The height of the chamber opening **510** is determined by the motion range of the robot blades.

[0128] In one embodiment, a load lock opening **511** may be formed on a sidewall **530** opposite to the sidewall **529**. The load lock opening **511** is configured to provide selective communication between the inner volume **512** and one or more load lock chambers coupled to the side wall **529**. In one embodiment, one or more slit valves may be used to selectively seal the load lock opening **511**. As shown in FIG. **6**A, a slit valve opening **515** is formed on the bottom wall **528** and is configured to allow a slit valve **507** to be disposed inside the inner volume **512** and to selectively seal the load lock opening **511**. In one embodiment, two slit valves **506**, **507** may be used to provide selective fluid communication between the inner volume **512** and two load lock chambers independently via the load lock opening **511**.

[0129] In one embodiment, the shelf cover **504** is disposed above the top plate **502** sealing the shelf opening **520**. The shelf cover **504** provides space in connection with the inner volume **512** to store a movable shelf **503** therein. The movable shelf **503** is configured to support one or more shutter disks thereon. The shutter disks may be used by processing chambers connected to the transfer chamber that connects to the vacuum extension assembly **500**. In one embodiment, the movable shelf **503** may comprise two opposing posts **521**, each having one or more supporting fingers **522** extending therefrom. The supporting fingers **522** are configured to support a shutter disk from the edge.

[0130] In one embodiment, the movable shelf **503** may be connected to an indexer **505**. The indexer **505** may be disposed above the shelf cover **504**. A shaft **532** extends from the indexer **505** through an aperture **557** in the shelf cover **504** and connects to the movable shelf **503**. The shaft **532** moves vertically providing vertical movement to the movable shelf **503**, so that the elevation of the movable shelf **503** may be selected.

[0131] In one embodiment, notches **533** may be formed on the bottom wall **528** and configured to accept independent supporting legs **509** therein. In one embodiment, windows **516**, **517** may be formed on sidewalls **531**, **534** of the body **501** and utilized for observing the interior of the vacuum extension assembly **500**. Transparent materials, such as quartz, may be used to seal the windows **516**, **517**.

[0132] FIG. **6**B schematically illustrates a sectional side view of the vacuum extension assembly **500** shown in FIG. **6**A. A transfer chamber **551**, partially shown, is connected to the vacuum extension assembly **500**. The transfer chamber **551** is in fluid communication with the inner volume **512** of the vacuum extension assembly **500** via the chamber opening **510** of the vacuum extension assembly **500** and an opening **554** of the transfer chamber **551**. Load locks chambers **555**, **556** are connected to the vacuum extension assembly **500** on a side opposing the transfer chamber **551**. The load lock chamber **555**, **556** are connected to the inner volume **512** via slit valve doors **525**, **526** respectively. Robot blades **552**, **553**, disposed in the transfer chamber **551**, are configured to access the load lock chambers **555**, **556** via the inner volume **512** of the vacuum extension assembly **500**.

[0133] As shown in FIG. **6**B, the movable shelf **503** is retracted to an upper portion of the inner volume **512**, thus providing a clear passage for the robot blades **552**, **553** extend past the movable shelf **503** to the load lock chambers **555**, **556**.

[0134] FIG. **6**C schematically illustrates a sectional side view of the vacuum extension assembly **500** with the movable shelf **503** lowered to a down position. The movable shelf **503** is positioned by the indexer **505** in a lower portion of the inner volume **512** such that shutter disks **523** may be picked up from and dropped onto the supporting fingers **522** by the robot blades **552**, **553**. The hand-off between the robot blades **552**, **553** and the movable shelf **503** may be facilitated by at least one of moving the movable shelf **503** or the robot blades **552**, **553** vertically.

[0135] The body **501**, top plate **502**, shelf cover **504**, and movable shelf **503** may be made from any suitable material. In one embodiment, the body **501**, top plate **502**, shelf cover **504**, and movable shelf **503** are made of cast aluminum.

[0136] It should be noted that position of indexer **505** may be positioned in a bottom of the vacuum extension assembly **500** while the vacuum pump **508** are mounted on top.

[0137] FIG. **7**A schematically illustrates an isometric view of the movable shelf **503** in accordance with one embodiment of the present invention. The movable shelf **503** comprises a bottom disk **580** and two posts **521** extended from the bottom disk **580**. The two posts **521** may be positioned on opposite sides of the bottom disk **580**. One or more supporting fingers **522** extend from each of the posts **521**. Each pair of supporting fingers **522** extending from opposite posts **521** is configured to support a disk near an edge of the disk. In one embodiment, vertical distance between neighboring support fingers **522** may be arranged so that a robot blade may pick up or drop off shutter disks from/to each pair of support fingers **522**. A bridge **581** may be formed between the posts **521**. The bridge **581** may be configured to couple with an indexer so that the movable shelf **503** may be translated.

[0138] FIG. **7**B schematically illustrates a supporting finger **522***a* in accordance with one embodiment of the present invention. The supporting finger **522***a* is configured to directly support a shutter disk near the edge.

[0139] FIG. **7**C schematically illustrates a supporting finger **522***b* in accordance with one embodiment of the present invention. The supporting finger **522** has two contact posts **585** disposed on a top surface. The contact posts **585** are configured to contact a shutter disk and provide point support to reduce particle contamination. In one embodiment, the contact posts **585**, including a substrate supporting roller, may be made from non-metallic material, such as silicon nitride (SiN).

[0140] FIG. **8**A schematically illustrates an isometric sectional view of a vacuum extension assembly **600** having a stationary shelf in accordance with one embodiment of the present invention. The vacuum extension assembly **600** is configured to connect to a transfer chamber, such as the transfer chamber **300** of FIG. **4**A, and to provide an interface between the transfer chamber and a load lock chamber and to provide fluid communication between the transfer chamber and a vacuum system.

[0141] The vacuum extension assembly **600** comprises a body **601** and a top plate **602** defining an inner volume **617** (marked in FIG. **8**B). A pressure modification port **607** may be formed on a bottom wall **606** of the body **601**. The pressure modification port **607** is configured to connect a vacuum system **612** to provide a low pressure environment to the inner volume **617** and volumes in fluid communication with the inner volume **617**. In one embodiment, a sensor **613** may be disposed on the vacuum system **612** outside the body **601** and configured to monitor status of the vacuum system **612**. In one embodiment, an opening **614** may be formed on a top wall of the body **601**. The opening **614** may be used to access the inner volume **617** during installation and/or maintenance of the vacuum system **612**. The top plate **602** is used to seal the opening **614**.

[0142] In one embodiment, a chamber opening **603** may be formed on a sidewall **615** of the vacuum extension assembly **600** which is configured to be coupled with a transfer chamber, such as the transfer chamber **300** of FIG. **4**A. The chamber opening **603** is configured to provide fluid communication with the transfer chamber and to provide passage for robot blades, typically disposed on a robot in the transfer chamber, to transfer substrates, and/or shutter disks. Therefore, width of the chamber opening **603** is generally slightly larger than a diameter of the largest substrate configured to be processed in a cluster tool. The height of the chamber opening **603** is selected to allow an appropriate range for robotic suitable for exchanging substrate and/or shutter disks between the shelf and the robot blades.

[0143] In one embodiment, a load lock opening **604** may be formed on a sidewall **605** opposite to the sidewall **615**. The load lock opening **604** is configured to provide selective communication between the inner volume **617** and one or more load lock chambers coupled to the side wall **605**. A slit valve opening **608** is formed through the bottom wall **606** and is configured to allow a slit valve **609** to be disposed inside the inner volume **617**. The slit valve **609** selectively seals the load lock opening **604**.

[0144] In one embodiment, a shutter disk shelf **616** is disposed within the inner volume **617** of the vacuum extension assembly **600**. The shutter disk shelf **616** is configured to support one or more shutter disks thereon. The shutter disks may be used by processing chambers connected to the vacuum extension assembly **600** via the transfer chamber. The shutter disk shelf **616** is positioned in a portion of the inner volume **617** so that the passage between the chamber opening **603** and the load lock opening **604** is maintained to allow the robot clear access through the vacuum extension assembly **600**. In one embodiment, as shown in FIG. **8**B, the shutter disk shelf **616** is positioned in a lower portion of the inner volume **617**, while the load lock opening **604** corresponding to an upper portion of the inner volume **617**. The height of the chamber opening **603** is large enough to accommodate sufficient vertical motion of the robot blades to allow access to both the load lock opening **603** and the shutter disk shelf **616**.

[0145] In one embodiment, the shutter disk shelf **616** may comprise two opposing posts **618**, each having one or more supporting fingers **619** extending therefrom. The supporting fingers **619** are configured to support a shutter disk near a periphery. Embodiments of the supporting fingers **619** may be similar to those shown in FIGS. 7B-C. In one embodiment, the fingers **619** may include a roller contact for supporting the shutter disk thereon.

[0146] In one embodiment, a window **611** may be formed through a sidewall **620** of the body **601** to allow the interior of the vacuum extension assembly **600** to be viewed. Transparent materials, such as quartz, may be used to seal the window **611**.

[0147] The body **601**, top plate **602**, and shutter disk shelf **616** may be made from any suitable material. In one embodiment, the body **601**, top plate **602**, and shutter disk shelf **616** are made of cast aluminum.

[0148] FIG. **8**B schematically illustrates a sectional side view of a mainframe having the vacuum extension assembly **600** of FIG. **8**A. A transfer chamber **650** is connected to the vacuum extension assembly **600**. An inner volume **654** of the transfer chamber **650** is in fluid communication with the inner volume **617** of the vacuum extension assembly **600** via the chamber opening **603** of the vacuum extension assembly **600** and an opening **655** of the transfer chamber **650**. A load lock chamber **660** is connected to the vacuum extension assembly **600** on a side opposing the transfer chamber **650**. The load lock chamber **660** may comprise a substrate support **661** configured to support one or more substrates. The load lock chamber **660** is selectively connected to the inner volume **617** via a slit valve door **610**. A central robot **651** is disposed in the inner volume **654** of the transfer chamber **650**. The central robot **651** comprises two robot blades **652**, **653**. The central robot **651** is configured with arrange of motion to allow the robot blades **652**,**653** to access the load lock chamber **660** via an upper portion of the inner volume **617** of the vacuum extension assembly **600**, and to the shutter disk shelf **616** disposed in the lower portion of the inner volume **617** of the vacuum extension assembly **600**.

[0149] As shown in FIG. **8**B, the robot blades **652**, **653** may be actuated over the shelf **616** on the way to the load lock chamber **660** to pick up substrates **622**. The slit valve door **610** is moved to an open position to allow the robot blades **652**, **653** to enter the load lock chamber **660**.

[0150] FIG. **8**C schematically illustrates a sectional side view of the mainframe of FIG. **8**B showing the central robot **651** positioning the robot blades **652**, **653** in a lowered position to access the shutter disks **621** disposed in the shutter disk shelf **616** within the vacuum extension assembly **600**.

[0151] FIG. **9** schematically illustrates a plan view of a cluster tool **200** in accordance with one embodiment of the present invention. FIG. **10** schematically illustrates a sectional side view of the cluster tool **200** of FIG. **9**. The cluster tool **200** comprises multiple processing chambers coupled a mainframe comprising two transfer chambers.

[0152] The cluster tool **200** comprises a front-end environment **202** in selective communication with a load lock chamber **204**. One or more pods **201** are coupled to the front-end environment **202**. The one or more pods **201** are configured to store substrates. A factory interface robot **203** is disposed in the front-end environment **202**. The factory interface robot **203** is configured to transfer substrates between the pods **201** and the load lock chamber **204**.

[0153] The load lock chamber **204** provides a vacuum interface between the front-end environment **202** and a first transfer chamber assembly **210**. An internal region of the first transfer chamber assembly **210** is typically maintained at a vacuum condition and provides an intermediate region in which to shuttle substrates from one chamber to another and/or to a load lock chamber.

[0154] In one embodiment, the first transfer chamber assembly **210** is divided into two parts. In one embodiment of the present invention, the first transfer chamber assembly **210** comprises a transfer chamber **208** and a vacuum extension chamber **207**. The transfer chamber **208** and the vacuum extension chamber **207** are coupled together and in fluid communication with one another. An inner volume of the first transfer chamber assembly **210** is typically maintained a low pressure or vacuum condition during process. The load lock chamber **204** may be connected to the front-end environment **202** and the vacuum extension chamber **207** via slit valves **205** and **206** respectively.

[0155] In one embodiment, the transfer chamber **208** may be a polygonal structure having a plurality of sidewalls, a bottom and a lid. The plurality sidewalls may have opening formed therethrough and are configured to connect with processing chambers, vacuum extension and/or pass through chambers. The transfer chamber **208** shown in FIG. **9** has a square or rectangular shape and is coupled to processing chambers **211**, **213**, a pass through chamber **231** and the vacuum extension chamber **207**. The transfer chamber **208** may be in selective communication with the processing chambers **211**, **213**, and the pass through chamber **231** via slit valves **216**, **218**, and **217** respectively.

[0156] In one embodiment, a central robot **209** may be mounted in the transfer chamber **208** at a robot port formed on the bottom of the transfer chamber **208**. The central robot **209** is disposed in an internal volume **220** of the transfer chamber **208** and is configured to shuttle substrates **214** among the processing chambers **211**, **213**, the pass through chamber **231**, and the load lock chamber **204**. In one embodiment, the central robot **209** may include two blades for holding substrates, each blade mounted on an independently controllable robot arm mounted on the same robot base. In another embodiment, the central robot **209** may have the capacity for vertically moving the blades.

[0157] The vacuum extension chamber **207** is configured to provide an interface to a vacuum system to the first transfer chamber assembly **210**. In one embodiment, the vacuum extension chamber **207** comprises a bottom, a lid and sidewalls. A pressure modification port may be formed on the bottom of the vacuum extension chamber **207** and is configured to adapt to a vacuuming pump system. Openings are formed on the sidewalls so that the vacuum extension chamber **207** is in fluid communication with the transfer chamber **208**, and in selective communication with the load lock chamber **204**.

[0158] In one embodiment, the cluster tool **200** may be configured to deposit a film on semiconductor substrates using physical vapor deposition (PVD) process. During conditioning operations, a dummy substrate or a shutter disk is disposed on the pedestal to protect the substrate support from any deposition.

[0159] In one embodiment of the present invention, the vacuum extension chamber **207** comprises a shutter disk shelf **222**, shown in FIG. **10**, configured to store one or more shutter disks **223**. Processing chambers directly or indirectly connected to the transfer chamber **208** may store their shutter disks in the shutter disk shelf **222** and use the central robot **209** to transfer the shuttle disks.

[0160] The cluster tool **200** further comprises a second transfer chamber assembly **230** connected to the first transfer chamber assembly **210** by the pass through chamber **231**. In one embodiment, the pass through chamber **231**, similar to a load lock chamber, is configured to provide an interface between two processing environments. In this case, the pass through chamber **231** provides a vacuum interface between the first transfer chamber assembly **210** and the second transfer chamber assembly **230**.

[0161] In one embodiment, the second transfer chamber assembly **230** is divided into two parts to minimize the footprint of the cluster tool **200**. In one embodiment of the present invention, the second transfer chamber assembly **230** comprises a transfer chamber **233** and a vacuum extension chamber **232** in fluid communication with one another. An inner volume of the second transfer chamber assembly **230** is typically maintained a low pressure or vacuum condition during process. The pass through chamber **231** may be connected to the transfer chamber **208** and the vacuum extension chamber **232** via slit valves **217** and **238** respectively so that the pressure within the transfer chamber **208** may be maintained at different vacuum levels.

[0162] In one embodiment, the transfer chamber **233** may be a polygonal structure having a plurality of sidewalls, a bottom and a lid. The plurality sidewalls may have opening formed therein and are configured to connect with processing chambers, vacuum extension and/or pass through chambers. The transfer chamber **233** shown in FIG. **9** has a square or rectangular shape and is coupled to processing chambers **235**, **236**, **237**, and the vacuum extension chamber **232**. The transfer chamber **233** may be in selective communication with the processing chambers **235**, **236**, via slit valves **241**, **240**, **239** respectively.

[0163] A central robot **234** is mounted in the transfer chamber **233** at a robot port formed on the bottom of the transfer chamber **233**. The central robot **234** is disposed in an internal volume **249** of the transfer chamber **233** and is configured to shuttle substrates **214** among the processing chambers **235**, **236**, **237**, and the pass through chamber **231**. In one embodiment, the central robot **234** may include two blades for holding substrates, each blade mounted on an independently controllable robot arm mounted on the same robot base. In another embodiment, the central robot **234** may have the capacity for moving the blades vertically.

[0164] In one embodiment, the vacuum extension chamber **232** is configured to provide an interface between a vacuum system and the second transfer chamber assembly **230**. In one embodiment, the vacuum extension chamber **232** comprises a bottom, a lid and sidewalls. A pressure modification port may be formed on the bottom of the vacuum extension chamber **232** and is configured to adapt to a vacuum system. Openings are formed through the sidewalls so that the vacuum extension chamber **232** is in fluid communication with the transfer chamber **233**, and in selective communication with the pass through chamber **231**.

[0165] In one embodiment of the present invention, the vacuum extension chamber **232** includes a shutter disk shelf

243, shown in FIG. **10**, configured to store one or more shutter disks **223**. Processing chambers directly or indirectly connected to the transfer chamber **233** may store their shutter disks in the shutter disk shelf **243** and use the central robot **234** to transfer the shuttle disks.

[0166] In one embodiment, the cluster tool **200** may be configured to perform a PVD process. The processing chamber **211** may be a pre-clean chamber configured to perform a cleaning process prior to a PVD process. The processing chambers **235**, **236**, **237** may be PVD chambers configured to deposition a thin film on a substrate using physical vapor deposition. The processing chamber **213** may be a de-gas chamber configured to degas and clean a substrate after a deposition process in a PVD chamber.

[0167] In one embodiment, the transfer chambers **208**, **233** may have a similar design as shown in FIGS. **4**A-**4**F. The transfer chambers **208**, **233** are configured to minimize foot print of the cluster tool **200** and are connected to a vacuum system through separated vacuum extensions.

[0168] The vacuum extension chambers **207**, **232** may have similar designs of the vacuum extension assemblies **500** and **600** shown in FIGS. **6**A-**6**C and FIGS. **8**A-**8**C.

[0169] As shown in FIG. **10**, the load lock chamber **204** comprises an upper load lock chamber **204***a* stacked over a lower load lock chamber **204***b*. The upper load lock chamber **204***a* and the lower load lock chamber **204***b* may be operated independently so that substrate transferring between the front-end environment **202** and the first transfer chamber assembly **210** can be conducted in both directions simultaneously.

[0170] The load lock chambers **204***a*, **204***b* provide a first vacuum interface between the front-end environment **202** and the first transfer chamber assembly **210**. In one embodiment, two load lock chambers **204***a*, **204***b* are provided to increase throughput by alternatively communicating with the first transfer chamber assembly **210** and the front-end environment **202**. While one load lock chamber **204***a* or **204***b* communicates with the first transfer chamber assembly **210**, a second load lock chamber **204***b* or **204***a* can communicate with the front-end environment **202**.

[0171] In one embodiment, the load lock chambers **204***a*, **204***b* are a batch type load lock chamber that can receive two or more substrates from the factory interface, retain the substrates while the chamber is sealed and then evacuated to a low enough vacuum level to transfer of the substrates to the first transfer chamber assembly **210**.

[0172] The internal volume of the first transfer chamber assembly **210** is defined by an internal volume **219** of the vacuum extension chamber **207** connected to an internal volume **220** of the transfer chamber **208**. An opening **228** is formed between the transfer chamber **208** and the vacuum extension chamber **207**. The opening **228** provides fluid communication between the vacuum extension chamber **207** and the transfer chamber **208**, and are large enough to allow the central robot **209** to shuttle substrates to and from the load lock chamber **204**.

[0173] A vacuum system **225** is coupled the vacuum extension chamber **207** and configured to provide a low pressure environment to both the internal volume **219** and the internal volume **220**. A robotic mechanism **226** is coupled to the transfer chamber **208**. The transfer chamber **208** and the vacuum extension chamber **207** are constructed to minimize the foot print of the cluster tool **200**.

[0174] In the one hand, the duel load lock chamber improves system throughput by allowing simultaneous two way substrate transportation. In the other hand, stacked load lock chambers require more vertical access space. To allow the robot, such as the central robot **209**, to access the stacked load lock chambers **204***a*, **204***b* and the shutter disk shelf **222**, the shutter disk shelf **222** in the vacuum extension chamber **207** is made vertically movable. An indexer **224** is coupled to the shutter disk shelf **222** and is configured to vertically move the shutter disk shelf **222** into a position that allows unobstructed movement of the robot through the vacuum extension chamber **207**. The shutter disk shelf **222** may be lowered to the lower portion of the internal volume **219** by the indexer **224** so that the central robot **209** interface with the shutter disk shelf **222** to pick up a shutter disk or drop a shutter disk to the shutter disk shelf **222**.

[0175] As shown in FIG. **10**, the pass through chamber **231** provides an interface between the first transfer chamber assembly **210** and the second transfer chamber assembly **230** allowing the first and second transfer chamber assemblies **210**, **230** to have different levels of vacuum. In one embodiment, the pass through chamber **231** may comprise a temperature controlled substrate supports **246**, **247** to prepare substrates for a subsequent processing step. In one embodiment, the substrate support **246** may be heated while the substrate support **247** may be cooled.

[0176] The internal volume of the second transfer chamber assembly **230** is defined by an internal volume **248** of the vacuum extension chamber **232** connected to an internal volume **249** of the transfer chamber **233**. An opening **244** is formed between the transfer chamber **233** and the vacuum extension chamber **232**. The opening **244** provides fluid communication between the vacuum extension chamber **232** and the transfer chamber **233**, and are large enough to allow the central robot **234** to shuttle substrates to and from the pass through chamber **231**.

[0177] A vacuum system **242** is coupled the vacuum extension and configured to provide a low pressure environment to both the internal volume **248** and the internal volume **249**. A robotic mechanism **245** is coupled to the transfer chamber **233**. The transfer chamber **233** and the vacuum extension chamber **232** are constructed to minimize the foot print of the cluster tool **200**. In embodiment wherein the transfer chambers remain at the same vacuum level, only one of the vacuum systems may optionally be utilized.

[0178] As shown in FIG. **10**, the shutter disk shelf **243** of the vacuum extension chamber **232** is stationary. The shutter disk shelf **243** is positioned on a lower portion of the internal volume **248** of the vacuum extension chamber **232** while the central robot **234** is configured to transfer substrates to and from the pass through chamber **231** through an upper portion of the internal volume **248**.

[0179] It should be noted that any processing chambers connected to a transfer chamber may be replaced by a pass through and/or extension chamber so that another transfer chamber may be added to a cluster tool.

[0180] As shown in FIG. **10**, the cluster tool **200** is supported by supporting legs **227**. The supporting legs **227** provide vertical and lateral support to the mainframe and chambers of the cluster tool **200**. Each of the supporting legs **227** may be vertically adjustable on site. The supporting legs **227** are coupled to sidewalls of the transfer chambers **208**, **233**, the vacuum extension chambers **207**, **232**, and/or the load lock chamber **204** and the pass through chamber **231** for lateral support to the cluster tool **200**.

[0181] In one embodiment, four pairs supporting legs **227** may be used to support the cluster tool **200**. One pair of supporting legs **227** are coupled to a backend (away from the front-end environment **202**) of each of the transfer chambers **208**, **233**. Notches may be formed on the backend of the transfer chamber **208**, **233** for providing lateral support to the supporting legs **227**. A pair of supporting legs **227** is coupled to near a joint region of the load lock chamber **204** and the vacuum extension chamber **207**. Another pair of supporting legs **227** is coupled to near a joint region of the pass through chamber **231** and the vacuum extension chamber **232**.

[0182] Independent supporting legs of the present invention not only greatly reduces the cost compared a supporting frame, but also provide great flexibility to the system. If desired, the cluster tool of the present invention may also be transported with the independent supporting legs assembled.

[0183] FIG. **11**A schematically illustrates an isometric view of the cluster tool **200** of FIG. **9** with transporting braces **260** configured to engage the supporting legs **227** with transporting tools, such as a fork lift, for transporting the cluster tool **200** in a whole or partially assembled. One or more transporting braces **260** may be coupled to a cluster tool **200** for transporting the cluster tool **200** fully or partially assembled. In one embodiment, each of the transporting braces **206** is coupled to a pair of the independent supporting legs **127**.

[0184] FIG. **11**B schematically illustrates the transporting brace **260** in accordance with one embodiment of the present invention. The transporting brace **260** has a elongated body **261** formed from a ridged material, such as steel, and aluminum. The body **261** may be a tube, for reduced weight, with a rectangular or squared shape. Two lifting openings **262** may be formed near two ends of the body **261**. The lifting opening **262** is configured to provide interface to a lifting tool, such as a fork lift. Distance between the two lifting openings **262** on the transporting brace **260** may be configured to adapt a lifting tool, for example, to adapt a distance between the forks of a fork lift. In one embodiment, an independent supporting leg **227** may be bolted to the transporting brace **260** through one or more coupling holes **263** formed on the body **261**. The coupling holes **263** may be elongated to provide tolerance on distance variations between a pair of independent supporting legs **227**.

[0185] Referring back to FIG. **11**A, one or more transporting braces **260** may be coupled to the independent supporting legs **227** of the cluster tool **200** at substantially similar elevation with the lifting openings **262** substantially aligned. A lifting tool may thread thought the lifting openings **262** of two or more transporting braces **260** to lift and transport the cluster tool **200**.

[0186] The transporting braces of the present invention provide an interface and robust structure to supporting assembly, such as the independent supporting legs, during transportation. The transport braces may be easily coupled to and removed from the cluster tool for transportation and processing. The transport braces allow the cluster tool to have a simple, non obstructive supporting assembly using independent supporting legs, as well as a reinforced structure for transportation if needed.

[0187] Even though, a PVD process is describe in accordance with the present application, the cluster tools of the present invention may be used for any suitable processes.

[0188] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

1. A mainframe for a cluster tool, comprising:

a transfer chamber having a substrate transferring robot disposed therein, wherein the substrate transferring robot is configured to shuttle substrates among one or more processing chambers directly or indirectly connected to the transfer chamber; and

a shutter disk shelf configured to store one or more shutter disks to be used by the one or more processing chambers, wherein the shutter disk shelf is accessible to the substrate transferring robot so that the substrate transferring robot can transfer the one or more shutter disks between the shutter disk shelf and the one or more processing chambers directly or indirectly connected to the transfer chamber.

2. The mainframe of claim **1**, wherein the substrate transferring robot is configured to shuttle substrates in a range of motion extending beyond the location of the shutter disk shelf.

3. The mainframe of claim **1**, further comprising an extension chamber connected to the transfer chamber, wherein the shutter disk shelf is disposed in the extension chamber.

4. The mainframe of claim **3**, further comprising one of a load lock chamber or a pass through chamber connected to the extension chamber, wherein the load lock chamber or the pass through chamber is configured to connect the transfer chamber with a front end environment, and an inner volume of the extension chamber provides a robot passage between the load lock chamber or the pass through chamber and the transfer chamber for the substrate transferring robot.

5. The mainframe of claim **4**, wherein the shutter disk shelf is positioned in the inner volume of the extension chamber away from the robot passage.

6. The mainframe of claim **4**, wherein the shutter disk shelf is movably disposed in the inner volume of the extension chamber.

7. The mainframe of claim **6**, further comprising an indexer coupled to the shutter disk shelf, wherein the indexer is configured to move the shutter disk shelf vertically within the inner volume of the extension chamber.

8. The mainframe of claim **3**, wherein the transfer chamber and the extension chamber are in fluid communication, and a vacuum pump is adapted to a pressure modification port formed on a bottom wall of the extension chamber and configured to provide a low pressure environment to the transfer chamber.

9. The mainframe of claim **1**, wherein the shutter disk shelf comprises:

a first post;

a second post disposed opposing the first post; and

one or more pairs supporting fingers extending from each of the first and second posts, wherein the one or more pairs of supporting fingers form one or more slots, and each slot is configured to support one shutter disk thereon.

10. The mainframe of claim **9**, wherein each of the supporting fingers comprises two contact balls configured to be in contact with a back side of a shutter disk.

11. A transfer chamber assembly for a cluster tool, comprising:

a main chamber having a central robot disposed therein, wherein the main chamber configured to connect to a plurality of chambers, the central robot is configured to shuttle one or more substrates among the plurality of chambers connected to the main chamber;

an extension chamber connected to the main chamber;

a shutter disk shelf disposed in the extension chamber, wherein the shutter disk shelf is configured to support one or more shutter disks therein, and the shutter disk shelf is accessible to the central robot.

12. The transfer chamber assembly of claim **11**, wherein main chamber and the extension chamber form a single vacuum enclosure.

13. The transfer chamber assembly of claim **12**, wherein the extension chamber has a low pressure port formed therein configured to connect to a vacuum system.

14. The transfer chamber assembly of claim **11**, wherein the shutter disk shelf is disposed in a first portion of an inner volume of the extension chamber, and a second portion of the inner volume of the extension chamber is configured to provide a passage for the central robot to access a load lock chamber or a pass through chamber connected to the extension chamber.

15. The transfer chamber assembly of claim **14**, wherein the shutter disk shelf is disposed in a lower portion of the inner volume.

16. The transfer chamber assembly of claim **14**, wherein the shutter disk shelf is movably disposed in the inner volume of the extension chamber.

17. The transfer chamber assembly of claim **16**, further comprising an indexer connected to the shutter disk shelf, wherein the indexer is configured to transfer the shutter disk shelf vertically in the extension chamber so that the shutter disk shelf is accessible to the central robot.

18. A cluster tool configured to process semiconductor substrates, comprising:

a first transfer chamber having a first central robot disposed therein;

a first extension chamber connected to the first transfer chamber, the first extension chamber having a first shutter disk shelf positioned therein, wherein the first shutter disk shelf is configured to support one or more shutter disks thereon, and the first shutter disk shelf is accessible by the first central robot;

one or more processing chambers connected to the first transfer chamber; and

a load lock chamber connected to the first extension chamber.

19. The cluster tool of claim **18**, further comprising:

a pass through chamber connected to the first transfer chamber;

a second transfer chamber having a second central robot disposed therein, wherein the second transfer chamber is connected with the pass through chamber; and

one or more processing chambers connected to the second transfer chamber.

20. The cluster tool of claim **19**, further comprising a second extension chamber disposed between the pass through chamber and the second transfer chamber, wherein the second extension chamber comprises a second shutter disk shelf disposed therein and accessible to the second central robot.

21. The cluster tool of claim **18**, wherein the first shutter disk shelf is movably disposed in the first extension chamber.

22. The cluster tool of claim **18**, further comprising a pumping system connected to the first extension chamber, wherein the pumping system is configured to maintain a low pressure environment in the first extension chamber and the first transfer chamber.

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