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(54) Title: BULK MATERIAL HANDLING METHODS, SYSTEMS, SUBSYSTEMS, AND APPARATUSES

(57) Abstract: A bulk material handling method includes: a) receiving and pneumatically conveying bulk material via pressurized dilute phase, dense phase, and/or hybrid dilute/dense phase, and/or vacuum drawn conveyance into bulk material containers (a112, c276); b) storing the bulk material in the containers (a112, c276); c) dispensing the bulk material from the containers (a112, c276) into a bulk material transporter (b100); d) transporting the transporter (b100) from the containers to a bulk material transmitting vessel (d240); and e) discharging the bulk material from the transporter (b100) into the transmitting vessel (d240), including releasing the bulk material from the transporter (b100) into the transmitting vessel (d240), and pneumatically transmitting the bulk material out of the transmitting vessel (d240) to downstream bulk material processing equipment. Discharging also may include rejecting the bulk material from the transporter (b100) to a waste container (W). A related system, subsystems, and apparatuses are also disclosed.



BULK MATERIAL HANDLING METHODS,
SYSTEMS, SUBSYSTEMS, AND APPARATUSES

Technical Field

5 [0001] This patent application discloses innovations to material handling and, more particularly, to bulk material handling including pneumatic receiving and conveying, storing, gravity dispensing, vehicular transporting, and pneumatic discharging of bulk materials.

Background

10 [0002] A conventional glass “batch house” includes a custom architectural installation specifically designed for glass manufacturing, and a glass batch house system supported and sheltered by the architectural installation. With reference to prior art FIGS. A through E, a conventional glass container batch house is illustrated and described as an example. Those of ordinary skill in the art would recognize that other glass batch houses, for example, for producing glass fibers, glass display screens, architectural glass, vehicle glass, or any other glass
15 products, share many aspects with a glass container batch house. The conventional custom glass batch house architectural installation includes a feedstock subsystem that includes a “batch house” building located outside of the factory building.

[0003] The batch house building towers over the factory building and is generally configured to receive and store feedstock or “glass batch” including raw materials, for example,
20 sand, soda ash, and limestone, and also including cullet in the form of recycled, scrap, or waste glass. The batch house is usually several stories tall, and includes a covered unloading platform and a pit to receive the glass batch from underneath railcars or trucks that arrive loaded with glass batch materials. The batch house also includes multi-story silos to store the glass batch, and glass batch elevators and glass batch conveyors to move the glass batch from the pit to tops
25 of the silos. The batch house further includes cullet pads at ground level to receive and store cullet, crushers to crush cullet to a size suitable for melting, and cullet elevators and conveyors to move crushed cullet to one of the silos in the batch house. The batch house additionally includes

batch mixers to mix the glass batch received from the silos, conveyors with scales to weigh and deliver each glass batch material from the silos to the mixers, mixer conveyors to move the glass batch from the mixers to the hot-end subsystem, and dust collectors to collect dust from the various equipment.

5 [0004] With reference to FIGS. B-E, the height of a conventional batch house architectural installation is about 95 feet (29 meters) above a forming floor level and about 18 feet (5.5 meters) below the forming floor level, the length of the batch house architectural installation is about 95 feet (29 meters), and the width of the batch house architectural installation is about 61 feet (18.5 meters).

10 [0005] Accordingly, the batch house requires a specialized, dedicated, and permanent architectural installation including a pit, and a two to three story building. The time to construct a new glass batch house of the conventional type is about one to two years. And a conventional batch house cannot be easily relocated from one plant to another. The batch house installation occupies a large footprint of about 5,800 square feet or about 540 square meters, and a large
15 volumetric envelope of about 655,000 cubic feet or about 18,550 cubic meters. Such a size for a conventional glass container batch house supports a production output of about 140 tons of glass per day. Accordingly, a capacity-adjusted size of the batch house can be characterized by the volumetric envelope of the batch house divided by the production output enabled by the batch house, which is about 133 cubic meters per each ton of glass produced per day. As used herein,
20 the term “about” means within plus or minus five percent.

Summary of the Disclosure

[0006] The present disclosure embodies a number of aspects that can be implemented separately from or in combination with each other.

25 [0007] In accordance with an aspect of the present disclosure, a bulk material handling system includes a bulk material storage and dispensing subsystem, a bulk material discharging subsystem, and a bulk material transport subsystem. The storage and dispensing system includes bulk material conduit to receive bulk material from outside the system and convey the bulk material under pressure, bulk material containers in downstream pneumatic communication with

the bulk material conduit to receive and store the bulk material, and bulk material dispensing equipment in communication with the bulk material containers to receive the bulk material from the bulk material containers and dispense the bulk material within the system. The discharging subsystem includes a bulk material transmitting vessel to discharge the bulk material out of the system, and a transporter handler. The transporter is configured to receive bulk material from the bulk material storage and dispensing subsystem, be transported between the bulk material storage and dispensing subsystem and the bulk material discharging subsystem, be lifted and conveyed by the transporter handler of the bulk material discharging subsystem over the bulk material transmitting vessel of the bulk material discharging subsystem, and release the bulk material received from the bulk material storage and dispensing subsystem into the bulk material transmitting vessel.

[0008] In accordance with another aspect of the present disclosure, a bulk material handling method includes receiving bulk material and pneumatically conveying the bulk material via at least one of pressurized dilute phase, pressurized dense phase, hybrid dilute/dense phase, or vacuum draw conveyance into bulk material containers. The method also includes storing the bulk material in the bulk material containers, dispensing the bulk material from the bulk material containers into a bulk material transporter, and transporting the bulk material transporter from the bulk material containers to a bulk material discharging system. The method further includes discharging the bulk material out of the bulk material transporter, including releasing the bulk material from the bulk material transporter into a bulk material transmitting vessel, and pneumatically transmitting the bulk material out of the bulk material transmitting vessel to downstream bulk material processing equipment.

Brief Description of the Drawings

[0009] FIG. A is a front perspective schematic view of a conventional glass factory and glass batch house for the factory, in accordance with the prior art, and drawn to scale.

[0010] FIG. B is another front perspective view of the factory and glass batch house of FIG. A.

[0011] FIG. C is a rear perspective schematic view of the factory and glass batch house of FIG. A.

[0012] FIG. D is an elevational schematic view of the factory and glass batch house of FIG. A.

5 [0013] FIG. E is a plan schematic view of the factory and glass batch house of FIG. A.

[0014] FIG. 1 is a front perspective schematic view of a glass factory and bulk material handling system for the factory, in accordance with an illustrative embodiment of the present disclosure, and drawn to scale.

[0015] FIG. 2 is another front perspective view of the factory and system of FIG. 1.

10 [0016] FIG. 3 is a rear perspective schematic view of the factory and system of FIG. 1.

[0017] FIG. 4 is an elevational schematic view of the factory and system of FIG. 1.

[0018] FIG. 5 is a plan schematic view of the factory and system of FIG. 1.

[0019] FIG. 6A is a perspective view of a bulk material handling system in accordance with another illustrative embodiment of the present disclosure, illustrating a building having a
15 roof, cladding, elevator, stairs, ladders, and platforms.

[0020] FIG. 6B is different perspective view of the system of FIG. 6A, illustrating the building with the roof, cladding, elevator, stairs, ladders, and platforms.

[0021] FIG. 7A is another perspective view of the system corresponding to FIG. 6A, without the roof, cladding, elevator, and ladders.

20 [0022] FIG. 7B is another perspective view of the system corresponding to FIG. 6B, without the roof, cladding, elevator, and ladders.

[0023] FIG. 8 is a top view of the system of FIG. 6A.

[0024] FIG. 9 is a bottom view of the system of FIG. 6A.

[0025] FIG. 10 is an upstream end view of the system of FIG. 6A.

[0026] FIG. 11 is a downstream end view of the system of FIG. 6A opposite that of FIG. 10.

[0027] FIG. 12 is a side view of the system of FIG. 6A.

5 [0028] FIG. 13 is another side view of the system of FIG. 6A opposite that of FIG. 12.

[0029] FIG. 14 is a perspective view of a modular wall of the system of FIG. 6A.

[0030] FIG. 15 is a perspective view of a dispenser modular frame of the system of FIG. 6A.

[0031] FIG. 16 is a perspective view of silo modular frame of the system of FIG. 6A.

10 [0032] FIG. 17A is a perspective view of a multi-purpose modular frame of the system of FIG. 6A.

[0033] FIG. 17B is a perspective view of another multi-purpose modular frame of the system of FIG. 6A.

[0034] FIG. 18 is a perspective view of a rack carrying additional multi-purpose modular
15 frames and related equipment of the system of FIG. 6A.

Detailed Description

[0035] In general, a new bulk material handling system is illustrated and described with reference to a glass feedstock handling system for a glass container factory as an example. Those of ordinary skill in the art would recognize that other glass factories, for example, for
20 producing glass fibers, glass display screens, architectural glass, vehicle glass, or any other glass products, share many aspects with a glass container factory. Accordingly, the presently disclosed and claimed subject matter is not necessarily limited to glass containers, glass container feedstock handling systems, and glass container factories and, instead, encompasses any glass products, glass product feedstock handling systems, and glass product factories.
25 Moreover, the presently disclosed and claimed subject matter is not necessarily limited to bulk

material handling for the glass industry and, instead, encompasses any products, bulk material handling systems, and factories in any industry in which bulk material handling is useful.

[0036] Although conventional glass batch houses and methods enable efficient production of high-quality products for large-scale production runs, the presently disclosed subject matter introduces a revolutionary bulk material handling system that is simpler than a conventional batch house, is modular and mobile, and is more compact and economical at least for smaller scale production runs or incremental additions to existing large-scale production runs. More specifically, in accordance with an aspect of the present disclosure, the system may include prefabricated modular equipment configurations that involve rapid construction of the system in about three to six months, simplify production capacity expansion in smaller increments and at lower capital cost than conventional glass batch houses, and render the system mobile and easily moved from one standard industrial location to another, completely unlike conventional glass batch houses that require dedicated, customized, permanent installations that take a much longer time to construct. In accordance with another aspect of the present disclosure, the bulk material handling system need not include a conventional batch house or any one or more of the following conventional batch house elements: basements or pits, for example, to receive glass batch from underneath railcars or trucks, or glass batch elevators, or glass batch mixers. Accordingly, a permanent site and facility in a heavy industrial zone need not be purchased; rather, an existing site and facility for the system can be temporarily leased in a light industrial zone, until it is desirable to relocate the system to another site and facility. In accordance with a further aspect of the present disclosure, the new bulk material handling system has a footprint and volumetric envelope that are significantly reduced compared to that of conventional glass batch houses, as described in further detail below.

[0037] More specifically, with reference to FIGS. 1-5, the new architectural installation is much smaller than a conventional batch house installation. For example, the bulk material handling building 16 occupies a smaller footprint of about 3,500 square feet or about 325 square meters. The height of the new architectural installation may be about 54 feet (16.5 meters) to 57 feet (17.4 meters) above floor level, the length of the new architectural installation may be about 78 feet (23.8 meters) to 81 feet (24.7 meters), and the width of the new architectural installation may be about 33 feet (10.1 meters) to 35 feet (10.7 meters). In another example, with reference

to FIGS. 6A and 7A, the bulk material handling building has a smaller volumetric envelope of about 189,000 cubic feet or about 5,350 cubic meters. Thus, the architectural installation of the new system occupies a footprint and volumetric envelope much smaller than that of conventional batch houses. As used herein, the term “about” means within plus or minus five percent.

5 [0038] The new bulk material handling system is sized to support production output of a glass manufacturing system or factory at about 110 TPD. Accordingly, a capacity-adjusted size of the presently disclosed bulk material handling system can be characterized by the volumetric envelope of the presently disclosed bulk material handling system divided by the glass production output supported by the system. For example, the bulk material handling building
10 size of about 5,350 cubic meters is divided by 110 TPD for a capacity-adjusted size of about 49 cubic meters per each ton of glass produced per day by a glass manufacturing system supported by the bulk material handling system.

[0039] The capacity-adjusted size of the bulk material handling building is less than 50 cubic meters per each ton of glass produced per day by the glass container factory supported by
15 the bulk material handling system, certainly less than 75 cubic meters per each ton of glass produced per day, and much less than the 125+ cubic meters per each ton of glass produced per day of the conventional factory. Accordingly, the capacity-adjusted size of the bulk material handling building is about 49 cubic meters per each ton of glass produced each day. Thus, the capacity-adjusted size of the presently disclosed bulk material handling building may be less
20 than half, or even less than a quarter, that of the conventional batch house. Therefore, and because the presently disclosed system is modular, the system is particularly amenable to being scaled up to support any desired output. For instance, the system can be replicated in multiples, for example, to accommodate expansion of a glass factory supported by the system.

[0040] Additionally, although shown as a separate architectural installation in the
25 drawing figures, at least a portion of the architectural installation of the bulk material handling system may be integrated with an architectural installation of hot and cold end systems of a glass container manufacturing plant. For example, a majors subsystem of the bulk material handling system and the enclosure and foundation portion of the bulk material handling building corresponding to the majors subsystem may be located outside of the architectural installation of

the hot and cold end subsystems, and the rest of the bulk material handling system may be located within the enclosure of the architectural installation of the hot and cold end subsystems with no increase – and perhaps some decrease – in footprint or volumetric envelope described above. In another example, a weatherproof majors subsystem may be located outside of the architectural installation of the hot and cold end subsystems on a suitable foundation, and access to the majors subsystem may be provided by an above ground enclosed tunnel or hallway traversable by automatically guided vehicles.

[0041] With specific reference now to FIGS. 1-3, 6A, and 6B, a new bulk material handling system 10' includes a new architectural installation 12' and new subsystems and equipment supported and sheltered by the installation 12'. The installation 12' includes a concrete foundation 14' having a floor which may include, for example, a four to six-inch-thick slab, and a bulk material handling building 16' on the foundation including walls 18' and a roof 20'. The installation 12 requires no basement and no pit below the floor, such that the concrete foundation has earthen material directly underneath, wherein the foundation slab establishes the floor. As used herein, the term "pit" includes an elevator pit, conveyor pit, loading pit, and the like, located below grade or below ground level and that may require excavation of earthen material to form. As used herein, the term "basement" includes the lowest habitable level of the bulk material handling building below a floor of the building and can include a first level or a below grade or below ground level portion that may require excavation of earthen material.

[0042] With reference to FIGS. 6A and 6B, the installation 12' also includes multiple habitable levels, including a base or first level 21, an intermediate or second level 22, an upper or third level 23, and an attic or fourth level 24. Also, as used herein, the term "habitable" means that there is standing room for an adult human in the particular space involved and there is some means of ingress/egress to/from the space while walking such as a doorway, stairway, and/or the like. The installation 12' further includes egress doors 26, egress platforms 27, stairs 28, ladders 30, and an elevator 32 to facilitate access to the egress platforms 27 and doors 26. The installation 12 additionally includes loading doors 34 and loading platforms 35 and one or more ramps 36. Notably, the building 16' is constructed of many modules, including modular walls used to construct a base frame for the first level, and modular frames for the second, third, and fourth levels, as will be discussed in detail below.

[0043] With reference to FIGS. 7A through 13 generally, a bulk material handling system 10 includes several subsystems that occupy a volumetric envelope much smaller than conventional batch houses such that the system 10 likewise requires a smaller volumetric envelope than conventional glass batch houses. The bulk material handling system 10 may be a glass bulk material handling system configured to receive and store glass feedstock or “glass batch.” The glass batch includes glassmaking raw materials, including glass feedstock “majors” and “minors” and also may include cullet in the form of recycled, scrap, or waste glass. The bulk material handling system receives glass batch bulk materials and combines them into doses and provides the doses to a downstream hot-end system of a glass factory adjacent to or part of the bulk material handling system.

[0044] The bulk material handling system 10 includes a new architectural installation 12 and new subsystems and equipment supported and sheltered by the installation 12. The installation 12 includes a concrete foundation 14 having a floor which may include, for example, a four to six-inch-thick slab, and a bulk material handling building 16 on the foundation including walls 18 and a roof 20. The system 10 is substantively the same as that previously described above with respect to FIGS. 1-5, with the exception that the system 10 may include fewer bulk handling storage containers. As will be described more specifically below with reference to the drawings, generally the system 10 may include only eight majors silos instead of 12 majors silos of the system 10' of FIGS. 1-5. Despite the reduction in such quantity of storage containers, the system 10 is still capable of supporting production output of a glass manufacturing system or factory at about 110 TPD.

[0045] The system 10 includes one or more of the following subsystems. A first bulk material, or majors, subsystem 38 is configured to receive, pneumatically convey, store, and gravity dispense majors bulk material. Glassmaking majors may include sand, soda, limestone, alumina, saltcake, and, in some cases, dust recovery material. Similarly, a second bulk material, or minors, subsystem 40 is configured to receive, pneumatically convey, and store minors bulk material from individual bulk material bags. Glassmaking minors may include selenium, cobalt oxide, and any other colorants, decolorants, fining agents, and/or other minors materials suitable for glassmaking. A bulk material discharging subsystem 42 is configured to receive bulk material from the majors and minors subsystems 38, 40 and transmit the bulk material to

downstream bulk material processing equipment, for example, a glass melting furnace separate from and downstream of the bulk material handling system 10. A bulk material transfer or transport subsystem 44 is configured to receive bulk material from the majors and minors subsystems 38, 40, and transport the bulk material within, to, and from, the majors and minors subsystems 38, 40, and to and from the discharge subsystem 42. A controls subsystem 46 is in communication with various equipment of one or more of the other subsystems 38, 40, 42, 44, and is configured to control various aspects of the system 10. Those of ordinary skill in the art would recognize that the system 10 can be supplied with utility or plant electrical power, and can include computers, sensors, actuators, electrical wiring, and the like to power and communicate different parts of the system 10 together. Likewise, the system 10 can be supplied with plant or compressor pneumatic power/pressure, and can include valves, lubricators, regulators, conduit, and other like pneumatic components to pressurize and communicate different parts of the system 10 together.

[0046] With reference to FIG. 6A and/or 7A, the system 10 may be pneumatically closed from pneumatic input or receiving conduit 39 of the majors subsystem 38 to pneumatic output or transmitting conduit 43 of the discharging subsystem 42. The pneumatic receiving conduit 39 may extend through one or more walls 18 or roof 20 of the building 16 for accessibility to bulk transporters, e.g., trucks or rail cars (not shown), that bring bulk materials and that may have pressurized vessels to assist with pneumatic receiving and conveying of bulk material. The receiving conduit 39 has any suitable couplings for coupling to bulk transporters in a pneumatically sealed manner, wherein the bulk transporters may have pumps, valves, and/or other equipment suitable to pressurize the receiving conduit to push bulk material into the majors subsystem 38 and/or the batch handling system 10 itself may include pumps, valves, pressurized plant air plumbing, and/or other equipment suitable to apply positive and/or negative (vacuum) pressure to the input conduit to push and/or pull bulk material into the majors and minors subsystems 38, 40.

[0047] With reference to FIGS. 6B and/or 7B, the transmitting conduit 43 may extend through one or more walls 18 or the roof 20 of the building 16 for transmission to downstream bulk material processing equipment, for instance, in a hot end subsystem of a glass manufacturing system (not shown). For example, the transmitting conduit 43 is pneumatically

sealingly coupled to a receiver hopper at a glass melter in the hot end subsystem (not shown). The conduit 43 may have any suitable couplings for coupling to the receiver hopper in a pneumatically sealed manner. Those of ordinary skill in the art would recognize that the bulk material handling system is pneumatically closed between the pneumatic receiving conduit and the pneumatic transmitting conduit. This is in contrast to conventional systems where bulk material is open to the surrounding environment. The phrase “pneumatically closed” means that the path, and the bulk materials following that path, from receiving conduit to transmitting conduit is/are enclosed, and not openly exposed to the surrounding environment, although not necessarily always sealed air-tight.

[0048] With reference now to FIG. 14, a representative modular wall 48 of the first level 21 of the building is constructed as a rectangular truss, having a longitudinal axis L and a vertical axis V, and including lower and upper beams 48a,b extending longitudinally and being vertically opposed from one another. The wall 48 also includes vertically extending end posts 48c and intermediate posts 48d longitudinally between the end posts 48c, and struts 48e extending obliquely between the beams 48a,b and connected to the posts 48c,d. The modular wall 48 may be preassembled at an equipment fabricator, shipped from the fabricator to a product manufacturer, and erected at the product manufacturer. The modular wall 48 may have exterior dimensions less than or equal to exterior dimensions of an intermodal freight container, more specifically, a height less than or equal to 9' 6" (2.896 m), a width less than or equal to 8' 6" (2.591 m), and a length less than or equal to 53' (16.154 m). With reference again to FIGS. 7B, the modular wall 48 may be used as a portion of a base frame establishing the habitable first level 21 of the system 1 and spanning the majors subsystem 38, the minors subsystem 40, and the discharging subsystem 42.

[0049] With reference now to FIG. 15, a representative horizontal or dispensing modular frame 50 is constructed as a rectangular box truss, having a longitudinal axis L₅₀, a transverse or lateral axis T₅₀, and a vertical axis V₅₀, including lower beams 50a extending longitudinally and being laterally opposed from one another, and including upper beams 50b extending longitudinally and being laterally opposed from one another. The frame 50 also includes posts 50c,d extending vertically between the lower and upper beams 50a,b and, more specifically, may include corner posts 50c extending vertically between ends of the lower and upper beams 50a,b,

and intermediate posts 50d extending vertically between intermediate portions of the lower and upper beams 50a,b between the ends thereof. The frame 50 also includes lower end cross-members 50e extending laterally between the lower beams 50a, and upper end cross-members 50f extending laterally between the upper beams 50b. Likewise, the frame 50 also may include lower intermediate cross-members 50g extending between portions of the lower beams 50a between the ends thereof, and upper intermediate cross-members 50h extending between portions of the upper beams 50b between the ends thereof. The frame 50 may also include one or more side struts 50i extending obliquely between the lower and upper beams 50a,b and end struts 50j extending between lower and upper end cross-members 50e,f opposite longitudinal ends of the frame 50. The modular frame 50 may have exterior dimensions less than or equal to exterior dimensions of an intermodal freight container, more specifically, a height less than or equal to 9' 6" (2.896 m), a width less than or equal to 8' 6" (2.591 m), and a length less than or equal to 40' (16.154 m).

[0050] With reference now to FIG. 16, a representative vertical or silo modular frame 52 is constructed as a rectangular box truss, having a longitudinal axis L_{52} , a transverse or lateral axis T_{52} , and a normal axis N , and including corner beams 52a extending longitudinally, and being laterally and normally opposed from one another, and end cross-members 52b and intermediate cross-members 52c extending laterally and normally between the beams 52a. The frame 52 also includes one or more longer struts 52d extending obliquely between the beams 52a and may be attached to the beams 52a. The frame 52 further includes one or more shorter struts 52e extending between the beams 52a and a corresponding cross-member 52c, and one or more intermediate struts 52f extending between the beams 52a and coupled thereto. Finally, the frame 52 also may include platform brackets 52g coupled to upper intermediate cross-members 52c and configured to support a platform (not shown) thereon to establish a habitable attic level of the system. The modular frame 52 may have exterior dimensions less than or equal to exterior dimensions of an intermodal freight container, more specifically, a height less than or equal to 9' 6" (2.896 m), a width less than or equal to 8' 6" (2.591 m), and a length less than or equal to 40' (12.192 m).

[0051] With reference to FIG. 7B, the majors subsystem 38 includes a dispensing level frame 51 constituted from two of the horizontal modular dispensing frames 50 of FIG. 15

situated side-by-side and carried on the base frame , and a storage container frame constituted from eight of the vertical modular storage container frames 52 of FIG. 16 situated in a 4 x 2 array carried on the dispensing level frame.

[0052] With reference to now FIG. 17A, a representative horizontal or multi-purpose modular frame 54 is constructed as a rectangular box truss, having a longitudinal axis L_{54} , a transverse or lateral axis T_{54} , and a vertical axis V_{54} , including lower beams 54a extending longitudinally and being laterally opposed from one another, and including upper beams 54b extending longitudinally and being laterally opposed from one another. The frame 54 also includes posts 54c,d extending vertically between the lower and upper beams 54a,b. The posts 54c may include corner posts 54c extending vertically between ends of the lower and upper beams 54a,b, and intermediate posts 54d extending vertically between intermediate portions of the lower and upper beams 54a,b between the ends thereof. The frame 54 also includes lower end cross-members 54e extending laterally between the lower beams 54a, and upper end cross-members 54f extending laterally between the upper beams 54b. Although not shown, the frame 54 also may include lower intermediate cross-members extending between intermediate portions of the lower beams 54a between the ends thereof. The frame 54 may also include one or more struts 54g,h extending obliquely between the lower and upper beams 54a,b, for example, side struts 54g extending between lower and upper beams 54a,b on opposite lateral sides of the frame 54 and may be coupled to the beams 54a,b and/or posts 54c,d, and/or may include end struts 54h extending between lower and upper end cross-members 54e,f on one or both longitudinal ends of the frame 54. With reference to FIG. 17B, another multi-purpose modular frame 54' may be arranged to add struts 54g,h such that the quantity and arrangement of struts 54g,h may be configured for particular application locations for example, where earthquake, high winds, and/or snow are prevalent. The modular frames 54, 54' may have exterior dimensions less than or equal to exterior dimensions of an intermodal freight container, more specifically, a height less than or equal to 9' 6" (2.896 m), a width less than or equal to 8' 6" (2.591 m), and a length less than or equal to 20' (6.096 m), such that two modules 54, 54' could be laid end to end and be shipped like a 40' intermodal freight container.

[0053] With reference now to FIG. 18, two or more multi-purpose modular frames 54'', 54''' or any of the other modular frames 50, 52, 54, 54' (FIGS. 15-17B) disclosed herein may

share common exterior dimensions such that the frames can be carried together on a common pallet, and can be easily aligned with one another to facilitate positioning and assembling them together on site. In fact, many of the modular frames may share identical exterior dimensions. More specifically, FIG. 18 illustrates modules 56 including the modular frames 54'', 54''' that
5 can be shipped on a standard seagoing flat rack 57 like a Mafi trailer or the like to constitute a rack and module assembly 58. On trucks, the modular frames 54'', 54''' (shipped as modules with equipment carried by the modular frames) are designed to be self-supporting and may be wrapped in plastic foil or sheet or truck tarpaulins (not shown) to seal against dust, dirt, and sea water/air, and bottoms and tops may be covered with planks or sheets (not shown) of wood,
10 metal, or plastic to protect the equipment in the modules 56. On ships, the modules 56 may be placed on the rack 57 and rolled onto a roll on / roll off ship at a departure seaport and, at an arrival sea port, the rack 57 is rolled off the ship and the modules 56 are placed on a truck. Accordingly, the modules 56 can be placed in a closed belly of the ship and not be exposed to sea water. The frames 54'', 54''' also may include a platform 54i carried on the lower beams
15 54a and the lower cross-members 54e to establish a floor. The platform 54i may be constructed from a single panel or multiple panels.

CHAPTER A – DOCKET 19650**BULK MATERIAL RECEIVING, CONVEYING, STORING, AND DISPENSING****Technical Field**

5 [0054] This patent application discloses innovations to material handling and, more particularly, to bulk material handling including receiving, conveying, storing, and dispensing of bulk materials.

Background

10 [0055] A conventional glass “batch house” includes a custom architectural installation specifically designed for glass manufacturing, and a glass batch handling system supported and sheltered by the architectural installation. The batch house is generally configured to receive and store glass feedstock, or “glass batch” materials, including glassmaking raw materials, for example, sand, soda ash, and limestone, and also including cullet in the form of recycled, scrap,
15 or waste glass. The conventional glass batch house requires a specialized, dedicated, and permanent architectural installation including a tall building and a covered receiving platform and pit to receive glass batch from underneath railcars or trucks that arrive loaded with glass batch materials. The batch house also includes multi-story silos to store the glass batch, and glass batch elevators and conveyors to move the glass batch from receiving systems at a bottom
20 of the pit to tops of the silos. The batch house further includes cullet pads at ground level to receive and store cullet, crushers to crush cullet to a size suitable for melting, and cullet elevators and conveyors to move crushed cullet to one of the silos in the batch house. The batch house additionally includes a mixer to mix the glass batch received from the silos, conveyors integrated with scales to weigh and deliver each glass batch material from the silos to the mixer, mixer
25 conveyors to move the glass batch from the mixers to the hot-end subsystem, and dust collectors to collect dust from the various equipment. The installation occupies a large footprint and a large volumetric envelope, takes about one to two years to construct, cannot be relocated from one location to another, and tends to be a dusty and dirty environment.

CHAPTER A – DOCKET 19650**Summary of the Disclosure**

[0056] The present disclosure embodies a number of aspects that can be implemented separately from or in combination with each other.

[0057] Embodiments of a bulk material storage module include a container module
5 frame, a bulk material container supported within the frame, the bulk material container having: an upper portion and a lower portion, an inlet located along the upper portion for receiving bulk material into the material container, an outlet located along the lower portion for discharging bulk material from the material container, and a vent to permit air exchange between an inside of the container and outside the container during receiving and/or discharging of bulk material from
10 the material container. The module further includes at least one utilities receiver configured to couple the module with at least one of: a control system, an electric utility, a pneumatic utility, or another bulk material storage module. The module is configured to be attached side-by-side with up to four other bulk material storage modules and corner-to-corner with up to four other bulk material storage modules, all of the modules having identical frames and bulk material
15 containers.

[0058] Embodiments of a bulk material dispensing module include: a dispensing module frame having a longitudinal axis, the frame further comprising a plurality of transverse frame members spaced along the longitudinal axis, wherein a dispensing cell is defined between each pair of transverse frame members; at least one bulk material dispenser supported within the
20 frame, each bulk material dispenser being supported in a different dispensing cell and comprising: an inlet accessible through a first side of the frame and configured to be coupled with and receive material from a bulk material container, an outlet accessible through an opposite side of the frame and configured to be coupled with and discharge material to a transport bin, and a conveyor configured to move bulk material from the inlet to the outlet when
25 the inlet is coupled with the bulk material container. The module further includes a controller carried by the frame for each bulk material dispenser. The module is configured to be attached side-by-side with one or more other bulk material dispensing modules, each of the modules having identical frames, dispenser inlets, and dispenser outlets, and the storage module has external dimensions less than or equal to an intermodal freight container.

CHAPTER A – DOCKET 19650

[0059] Embodiments of a bulk material handling method include conveying bulk material directly from a mobile bulk material container into a stationary bulk material container at a glass manufacturing facility via dense phase pneumatic conveying.

[0060] Embodiments of a bulk material dispenser include a dispenser inlet configured for coupling with and receiving bulk material from an outlet of a bulk material container, a dispenser outlet configured for coupling with and discharging the bulk material into a transport bin, a conveyor that moves bulk material received at the inlet side toward the outlet, and a filter assembly configured to filter solids from air displaced from the transport bin during dispenser operation.

[0061] Embodiments of a docking assembly for use in a bulk material dispensing system include an inlet configured for coupling with and receiving bulk material from a bulk material dosing assembly, and an outlet configured for coupling with and discharging the bulk material into a transport bin. The outlet is moveable toward and away from the inlet and, thereby, respectively away from and toward the transport bin.

[0062] Embodiments of a bulk material handling method include: coupling an outlet of a bulk material dispenser with a transport bin to form a closure at an inlet of the transport bin and place an inside of the transport bin in communication with the dispenser; receiving bulk material in the dispenser from a bulk material container; forming a reduced pressure region in an internal volume of the dispenser; and dispensing the bulk material from the dispenser and into the transport bin through the reduced pressure region.

Brief Description of the Drawings

[0063] FIG. 1A is a perspective view of a bulk material handling system in accordance with an illustrative embodiment of the present disclosure, illustrating a building having a roof, cladding, elevator, stairs, ladders, and platforms.

[0064] FIG. 1B is another perspective view of the system corresponding to FIG. 1A, without the roof, cladding, elevator, and ladders.

[0065] FIG. 2A is a different perspective view of the system of FIG. 1A, illustrating the building with the roof, cladding, elevator, stairs, ladders, and platforms.

[0066] FIG. 2B is another perspective view of the system corresponding to FIG. 2A, without the roof, cladding, elevator, and ladders.

CHAPTER A – DOCKET 19650

- [0067] FIG. 3 is a top view of the system of FIG. 1A.
- [0068] FIG. 4 is a bottom view of the system of FIG. 1A.
- [0069] FIG. 5 is an end view of the system of FIG. 1A.
- [0070] FIG. 6 is another end view of the system of FIG. 1A opposite that of FIG. 5.
- 5 [0071] FIG. 7 is a side view of the system of FIG. 1A.
- [0072] FIG. 8 is another side view of the system of FIG. 1A opposite that of FIG. 7.
- [0073] FIG. 9 is a perspective view of a modular frame of the system of FIG. 1A.
- [0074] FIG. 10 is a perspective view of another modular frame of the system of FIG. 1A.
- [0075] FIG. 11 is a perspective view of another modular frame of the system of FIG. 1A.
- 10 [0076] FIG. 12 is a perspective view of a bulk material storage module as part of a rack and module assembly.
- [0077] FIG. 13 is a perspective view of an illustrative modular bulk material storage and dispensing system.
- [0078] FIG. 14 is a partially exploded isometric view of the system of FIG. 13.
- 15 [0079] FIG. 15 is a further exploded isometric view of the system of FIG. 13.
- [0080] FIG. 16 is an isometric view of an array of another modular bulk material storage and dispensing system.
- [0081] FIG. 17 is a perspective view of a bulk material storage module of the system of FIG. 13 in a shipping orientation as viewed from a top end of the module.
- 20 [0082] FIG. 18 is a perspective elevation view of a bulk material storage container of the module of FIG. 17.
- [0083] FIG. 19 is a top perspective view of an array of storage container modules of the system of FIG. 13 with a top portion of the module frames omitted.
- [0084] FIG. 20A is the installation of FIG. 1A illustrated with a mobile bulk material
25 container arrived at the installation to convey bulk material to the stationary bulk material containers of the installation with elements of a pneumatic conveying system additionally illustrated.
- [0085] FIG. 20B is an elevation view of the inlet conduits of FIG. 20A, further
30 illustrating high-pressure lines and pulse-pressure lines for use in dense phase conveying of bulk material.

CHAPTER A – DOCKET 19650

[0086] FIG. 20C is an isometric view of a pneumatic panel configured to provide elements of the dense phase conveying system.

[0087] FIG. 20D is a schematic representation of a mobile bulk material storage container coupled with the pneumatic dense phase conveying system.

5 [0088] FIG. 21 is a schematic depiction of a conduit system with incoming bulk material routed to one of three storage containers of one branch of the conduit system.

[0089] FIG. 22 is a schematic depiction of the conduit system of FIG. 21 with the incoming bulk material re-routed to a different one of the three storage containers.

10 [0090] FIG. 23 is a schematic depiction of the conduit system of FIG. 21 with the incoming bulk material re-routed to a third one of the three storage containers.

[0091] FIG. 24 is a top perspective view of a bulk material dispensing module of the system of FIG 13.

[0092] FIG. 25 is a bottom perspective view of the bulk material dispensing module of the system of FIG 13.

15 [0093] FIG. 26 is a perspective view of a bulk material dispenser of the module of FIGS. 24 and 25.

[0094] FIG. 27 is another perspective view of the bulk material dispenser of FIG. 26.

[0095] FIG. 28 is a perspective view of the bulk material dispenser of FIGS. 24-27 coupled with a transport bin.

20 [0096] FIG. 29 is a top perspective view of the transport bin of FIG. 28 uncoupled from the bulk material dispenser.

[0097] FIG. 30 is a perspective view of a docking assembly of the bulk material dispenser of FIG. 28 coupled with the transport bin.

25 [0098] FIG. 31 is a schematic cross-sectional view of a screw conveyor of the bulk material dispenser of FIGS. 26-28.

[0099] FIG. 32 is an isometric view of a docking assembly.

[00100] FIG. 33 is an isometric cross-sectional view of a docking assembly of the bulk material dispenser of FIGS. 26-28.

30 [00101] FIG. 34 is a schematic cross-sectional view of a portion of a docking assembly in a retracted condition over a transport bin.

CHAPTER A – DOCKET 19650

[00102] FIG. 34 is a schematic cross-sectional view of a portion of a docking assembly in an extended condition and coupled with a transport bin.

Detailed Description

5 [00103] In general, a new bulk material handling system is illustrated and described with reference to a glass feedstock handling system for a glass container factory as an example. Those of ordinary skill in the art would recognize that other glass factories, for example, for producing glass fibers, glass display screens, architectural glass, vehicle glass, or any other glass products, share many aspects with a glass container factory. Accordingly, the presently
10 disclosed and claimed subject matter is not necessarily limited to glass containers, glass container feedstock handling systems, and glass container factories and, instead, encompasses any glass products, glass product feedstock handling systems, and glass product factories. Moreover, the presently disclosed and claimed subject matter is not necessarily limited to bulk material handling for the glass industry and, instead, encompasses any products, bulk material
15 handling systems, and factories in any industry in which bulk material handling is useful.

[00104] Although conventional glass batch houses and methods enable efficient production of high-quality products for large-scale production runs, the presently disclosed subject matter facilitates implementation of a revolutionary bulk material handling system that is simpler than a conventional batch house, is modular and mobile, and is more compact and
20 economical at least for smaller scale production runs or incremental additions to existing large-scale production runs. More specifically, in accordance with an aspect of the present disclosure, a new bulk material handling system may include prefabricated modular equipment configurations to facilitate rapid and mobile production capacity expansion in smaller increments and at lower capital cost than conventional glass batch houses, and also may include techniques
25 for handling bulk material in a dust-free or reduced dust manner. Further, the new system may omit one or more conventional glass batch house subsystems or aspects thereof, as described in further detail below.

[00105] With specific reference now to FIGS. 1A through 8, a new bulk material handling system 10 includes a new architectural installation 12 and new subsystems and equipment
30 supported and sheltered by the installation 12. The installation 12 includes a concrete foundation 14 having a floor which may include, for example, a four to six-inch-thick slab, and a bulk

CHAPTER A – DOCKET 19650

material handling building 16 on the foundation including walls 18 and a roof 20. The installation 12 requires no basement and no pit below the floor, such that the concrete foundation has earthen material directly underneath, wherein the foundation slab establishes the floor. As used herein, the term “pit” includes an elevator pit, conveyor pit, loading pit, and the like, located below grade or below ground level and that may require excavation of earthen material. As used herein, the term “basement” includes the lowest habitable level of the bulk material handling building below a floor of the building and can include a first level or a below grade or below ground level portion that may require excavation of earthen material.

[00106] The installation 12 also includes multiple habitable levels, including a base or first level 21, an intermediate or second level 22, an upper or third level 23, and an attic or fourth level 24. Also, as used herein, the term “habitable” means that there is standing room for an adult human in the particular space involved and there is some means of ingress/egress to/from the space while walking such as a doorway, stairway, and/or the like. The installation 12 further includes egress doors 26, egress platforms 27, stairs 28, ladders 30, and an elevator 32 to facilitate access to the egress platforms 27 and doors 26. The installation 12 additionally includes loading doors 34, loading platforms, and one or more ramps. Notably, the building 16 is constructed of many modules, including modular walls used to construct a base frame for the first level, and modular frames for the second, third, and fourth levels, as will be discussed in detail below.

[00107] With continued reference to FIGS. 1A through 8, the bulk material handling system 10 includes several subsystems that occupy a volumetric envelope much smaller than conventional batch houses such that the system 10 likewise requires a smaller volumetric envelope than conventional glass batch houses. The bulk material handling system 10 may be a glass bulk material handling system configured to receive and store glass feedstock or “glass batch.” The glass batch includes glassmaking raw materials, including glass feedstock “majors” and “minors” and also may include cullet in the form of recycled, scrap, or waste glass. The bulk material handling system receives glass batch bulk materials and combines them into doses and provides the doses to a downstream hot-end system of a glass factory adjacent to or part of the bulk material handling system.

[00108] The bulk material handling system 10 includes one or more of the following subsystems. A first bulk material, or majors, subsystem 38 is configured to receive,

CHAPTER A – DOCKET 19650

pneumatically convey, store, and gravity dispense majors bulk material. Glassmaking majors may include sand, soda, limestone, alumina, saltcake, and, in some cases, dust recovery material. Similarly, a second bulk material, or minors, subsystem 40 is configured to receive, pneumatically convey, and store minors bulk material from individual bulk material bags.

5 Glassmaking minors may include selenium, cobalt oxide, and any other colorants, decolorants, fining agents, and/or other minors materials suitable for glassmaking. A bulk material discharging subsystem 54 is configured to receive bulk material from the majors and minors subsystems 38, 40 and transmit the bulk material to downstream bulk material processing equipment, for example, a glass melting furnace separate from and downstream of the bulk material handling system 10. A bulk material transfer or transport subsystem 44 is configured to receive bulk material from the majors and minors subsystems 38, 40, and transport the bulk material within, to, and from, the majors and minors subsystems 38, 40, and to and from the discharge subsystem 42. A controls subsystem 46 is in communication with various equipment of one or more of the other subsystems 38, 40, 42, 44, and is configured to control various aspects of the system 10. Those of ordinary skill in the art would recognize that the system 10 can be supplied with utility or plant electrical power, and can include computers, sensors, actuators, electrical wiring, and the like to power and communicate different parts of the system 10 together. Likewise, the system 10 can be supplied with plant or compressor pneumatic power/pressure, and can include valves, lubricators, regulators, conduit, and other like pneumatic components to pressurize and communicate different parts of the system 10 together.

[00109] The system 10 may be pneumatically closed from pneumatic input or receiving conduit 39 of the majors subsystem 38 to pneumatic output or transmitting conduit 43 of the discharging subsystem 54. The pneumatic receiving conduit 39 may extend through one or more walls of the building for accessibility to bulk transporters, e.g., trucks or rail cars, that bring bulk materials and that may have pressurized vessels to assist with pneumatic receiving and conveying of bulk material. The receiving conduit 39 has any suitable couplings for coupling to bulk transporters in a pneumatically sealed manner, wherein the bulk transporters may have pumps, valves, and/or other equipment suitable to pressurize the receiving conduit to push bulk material into the majors subsystem 38 and/or the batch handling system 10 itself may include pumps, valves, pressurized plant air plumbing, and/or other equipment suitable to apply positive

CHAPTER A – DOCKET 19650

and/or negative (vacuum) pressure to the input conduit to push and/or pull bulk material into the majors and minors subsystems 38, 40.

[00110] The transmitting conduit 43 may extend through one or more walls or the roof of the building for transmission to downstream bulk material processing equipment, for instance, in a hot end subsystem of a glass manufacturing system (not shown). For example, the transmitting conduit 43 is pneumatically sealingly coupled to a receiver hopper at a glass melter in the hot end subsystem. The conduit 43 may have any suitable couplings for coupling to the receiver hopper in a pneumatically sealed manner. Those of ordinary skill in the art would recognize that the bulk material handling system is pneumatically closed between the pneumatic receiving conduit and the pneumatic transmitting conduit. This is in contrast to conventional systems where bulk material is open to the surrounding environment. The phrase “pneumatically closed” means that the path, and the bulk materials following that path, from receiving conduit to transmitting conduit is/are enclosed, and not openly exposed to the surrounding environment, although not necessarily always sealed air-tight.

[00111] With reference to FIG. 9, a representative modular wall 48 of the first level 21 of the building is constructed as a rectangular truss, having a longitudinal axis L and a vertical axis V, and including lower and upper beams 48a,b extending longitudinally and being vertically opposed from one another. The wall 48 also includes vertically extending end posts 48c and intermediate posts 48d longitudinally between the end posts 48c, and struts 48e extending obliquely between the beams and connected to the posts 48c,d. The modular wall 48 is preassembled at an equipment fabricator, shipped from the fabricator to a product manufacturer, and is erected at the product manufacturer. The modular wall has exterior dimensions less than or equal to exterior dimensions of an intermodal freight container, more specifically, a height less than or equal to 9' 6" (2.896 m), a width less than or equal to 8' 6" (2.591 m), and a length less than or equal to 53' (16.154 m). As best illustrated in FIGS. 2B, 7 and 8, the modular wall 48 may be used as a portion of a base frame establishing the habitable first level of the system and spanning the majors subsystem, the minors subsystem, and the discharging subsystem. In the majors subsystem, the system also includes a dispensing level frame constituted from two of the horizontal modular dispensing frames 50 of FIG. 10 situated side-by-side and carried on the base frame, and a storage container frame constituted from eight of the vertical modular container frames 52 of FIG. 11 situated in a 4 x 2 array carried on the dispensing level frame.

CHAPTER A – DOCKET 19650

[00112] With reference to FIG. 10, a representative horizontal or dispensing module frame 50 is constructed as a rectangular box truss, having a longitudinal axis L_{50} , a transverse or lateral axis T_{50} , and a vertical axis V_{50} , including lower beams 50a extending longitudinally and being laterally opposed from one another, and including upper beams 50b extending longitudinally and being laterally opposed from one another. The frame 50 also includes posts 50c,d extending vertically between the lower and upper beams 50a,b and, more specifically, may include corner posts 50c extending vertically between ends of the lower and upper beams 50a,b, and intermediate posts 50d extending vertically between intermediate portions of the lower and upper beams 50a,b between the ends thereof. The frame 50 also includes lower end cross-members 50e extending laterally between the lower beams 50a, and upper end cross-members 50f extending laterally between the upper beams 50b. Likewise, the frame 50 also may include lower intermediate cross-members 50g extending between portions of the lower beams 50a between the ends thereof, and upper intermediate cross-members 50h extending between portions of the upper beams 50b between the ends thereof. The frame 50 may also include one or more side struts 50i extending obliquely between the lower and upper beams 50a,b and end struts 50j extending between lower and upper end cross-members 50e,f opposite longitudinal ends of the frame 50.

[00113] With reference to FIG. 11, a representative vertical or container modular frame 52 is constructed as a rectangular box truss, having a longitudinal axis L_{52} , a transverse or lateral axis T_{52} , and a normal axis N , and including corner beams 52a extending longitudinally, and being laterally and normally opposed from one another, and end cross-members 52b and intermediate cross-members 52c extending laterally and normally between the beams 52a. The frame 52 also includes one or more longer struts 52d extending obliquely between the beams 52a and may be attached to the beams 52a. The frame 52 further includes one or more shorter struts 52e extending between the beams 52a and a corresponding cross-member 52c, and one or more intermediate struts 52f extending between the beams 52a and coupled thereto. Finally, the frame 52 also may include platform brackets 52g coupled to upper intermediate cross-members 52c and configured to support a platform (not shown) thereon to establish a habitable attic level of the system.

[00114] With reference to FIG. 12, the modular storage container frame 52 can be shipped with or without the associated storage container equipment on a standard seagoing flat rack

CHAPTER A – DOCKET 19650

like a Mafi trailer or the like to constitute a rack and module assembly 58. On trucks, the modular frame 52 (shipped as part of a module with equipment carried by the modular frame) is designed to be self-supporting and may be wrapped in plastic foil or sheet or truck tarpaulins (not shown) to seal against dust, dirt, and sea water/air, and bottoms and tops may be covered with planks or sheets (not shown) of wood, metal, or plastic to protect the equipment in the module. On ships, the module frame 52 and equipment may be placed on the rack 57 and rolled onto a roll on / roll off ship at a departure seaport and, at an arrival seaport, the rack 57 is rolled off the ship and the module is placed on a truck. Accordingly, the module can be placed in a closed belly of the ship and not be exposed to sea water.

[00115] The same can be said for the dispensing modular frame 50 of FIG. 10, which in some cases can be stacked in pairs one over the other with overall external dimensions equal to or less than those of an intermodal freight container and supported on a standard seagoing flat rack 57 like a Mafi trailer or the like to constitute a rack and module assembly 58. In fact, the different modular frames 50, 52 may share one or more common exterior dimensions such as dimensions along their respective transverse axes T_{50} , T_{52} and be easily aligned with one another to facilitate positioning and assembling them together on site.

[00116] With reference again to FIGS. 1A-8, the majors system 38 is configured to receive, pneumatically convey, store, and gravity dispense majors bulk material. Glassmaking majors may include sand, soda, limestone, alumina, saltcake, and, in some cases, dust recovery material. In general, the majors system 38 is the tallest of the subsystems and is supported over a portion of the transport subsystem 44 and thus has its bottom aligned with the bottom of the second level 22 of the system 10 and extends upward to the attic level 24.

[00117] With reference to FIGS. 13-16, the majors system 38 includes a bulk material storage and dispensing system 100 including an array 200 of bulk material storage container modules 110 atop an array 300 of bulk material dispensing modules 120. The majors system 38 also includes a pneumatic bulk material receiving and conveyance system 130 including the above-mentioned receiving conduit 39 coupled with a conduit system 132 carried by the storage container array 200. The storage and dispensing system 100 is both intramodular and intermodular, meaning that each of the different types of modules 110, 120 are modular amongst their own kind and are additionally modular with one another.

CHAPTER A – DOCKET 19650

[00118] In the illustrated example, each storage container module 110 includes an individual bulk material storage container 112 carried by a corresponding storage container frame 52, and each dispensing module 120 includes the dispensing module frame 50 with a plurality of dispensing cells 122 defined between dispensing frame crossmembers 50h, 50g. The dispensing modules 120 are configured to carry a bulk material dispenser 124 in each cell 122. The intramodularity of the modules 110, 120 is by virtue of the respective frames 52, 50 being identical among their own kind. The intermodularity of the modules 110, 120 is by virtue of certain dimensions of the frames 50, 52 being the same. In this example, the frame 52 of each storage container module 110 has the same transverse dimension as the frame 50 of each dispensing module 120, and the longitudinal dimension of each dispensing cell 122 is the same as the width or normal dimension of each storage container module frame 52.

[00119] Accordingly, each dispensing module 120 can support an $1 \times n$ array 200 of storage container modules 110, where n is the number of dispensing cells 122. Here, each dispensing module 120 includes four dispensing cells 122, which is the maximum number possible when the module 120 has a longitudinal dimension equal to or less than that of an intermodal freight container and when each container module 110 has a width equal to or less than the height of an intermodal freight container. The same dispenser module 120 can alternatively carry a smaller number of storage container modules 110 with the capacity to add more at a later date. The dispensing module array 300 in this case is a 1×2 array, with each module 120 including four dispensing cells, and the storage container array 200 is a 2×4 array.

[00120] FIG. 16 illustrates another modularity feature of the of the modules 110, 120 in the form of a storage and dispensing module 100' which is itself modular. The system 10 of FIGS. 1A-8 includes two of the modules 100' of FIG. 16 with the capability to add one or more additional dispensing modules 120, storage modules 110, or storage and dispensing modules 100'.

[00121] With reference to FIGS. 17-18, each bulk material storage module 110 may include the container module frame 52, the bulk material storage container 112 supported within the frame, a platform 114, a utilities receiver 116, and a portion of the conduit system 132. In this example, the bulk material storage container 112 is a silo having a first or upper portion 118, a second or lower portion 126, an inlet 128 located along the upper portion for receiving bulk

CHAPTER A – DOCKET 19650

material into the material container, and an outlet 134 located along the lower portion for discharging bulk material from the material container.

[00122] The inlet 128 receives bulk material from the conduit system 132, and each module 110 includes at least a downpipe or vertical inlet conduit section 136 of the conduit system 132 coupled with the inlet 128 and a horizontal connector conduit 138 of the conduit system configured to be coupled with another portion of the conduit system carried by an adjacent module. Each module 110 includes conduit supports 140 at the top of the frame 52 for supporting the horizontal connector 138 of FIG. 18 as well as other horizontal connectors 138' (FIG. 17) of the conduit system 132 that are merely routed through the module framework to interconnect surrounding modules.

[00123] The silo 112 is configured for gravity discharge of the bulk material from the outlet 134, which is at the bottom of a spout 142 connected to a lower conical part of the lower portion 126 of the silo. The illustrated silo 112 has a shut-off valve 144 in the form of a transverse plate that can be manually or actuator-driven across the outlet 134 to close it for maintenance of the attached dispensing system, for example.

[00124] The platform 114 at least partially surrounds the upper portion 118 of the bulk material container 112 and is level with the top of the silo in this example, thus forming a habitable maintenance space between the top of the silo and the top of the frame 52. The top of the silo 112 includes an access hatch 146, a filter assembly 148, a fill-level sensor 150, a pressure sensor 152, a high-pressure relief valve 154, and/or other components. The filter assembly 148 is passive and contains a filter element to remove solids from the air in the silo 112 displaced by incoming bulk material before venting the air to the atmosphere. The filter assembly 148 may double as a vent to permit air exchange between the inside of the container 112 and outside the container during receiving and/or discharging of bulk material. The fill-level sensor 150 may be radar-based and thus detect the real-time amount of bulk material in the silo as well as the instant rate of filling or discharging. Other types of fill-level sensors such as lidar or load cells can be employed. Each of the sensors, gauges, and/or valves of the silo 112 may be in communication with a system controller (e.g., of the controls subsystem 46) configured to receive information about the storage module 112 and/or to control those connected components in response to the received information or to other received system information.

CHAPTER A – DOCKET 19650

[00125] The utilities receiver 116 in this case is a junction box for connecting electric power to the module to power sensors, gauges, and other equipment and for placing the above-platform components to controllers located elsewhere in the overall system 10.

[00126] As noted above, the storage container module 110 is intramodular, each having
5 the same external dimensions and being configured to be attached side-by-side with up to four other bulk material storage modules and corner-to-corner with up to four other bulk material storage modules. Each module 110 is also sized to fit atop an individual dispensing cell 122 of an underlying dispensing module 120. When arranged together in the array 200 of the previous figures, the platforms 114 of each module 110 together form a continuous floor or bottom of the
10 maintenance space or attic, where a person is able to access all of the components on top of each silo and the associated pneumatic conduit system 132 all in one space without the need to climb up and down ladders along the side of each individual silo to do so.

[00127] FIG. 19 is a top perspective view of the storage container array 200 with portions of the module frames 52 omitted for a full view of the conduit system 132. The conduit system
15 132 includes all of the vertical downpipes 136 that lead to each silo inlet 128, all of the horizontal connector conduit sections 138, vertical feed pipes or up-pipes 158A-D, three-way junctions 160 interconnecting some of the horizontal connectors 138, and valves 162 for regulating the flow of bulk material through the conduit system 132.

[00128] For purposes of illustration of one particular embodiment, the silos 112 of the
20 illustrated array 200 are labelled A-D, indicating four different types of bulk material intended to be received by, stored in, and discharged from each silo 112. In embodiments in which the system 10 is a glass feedstock handling system, three of the silos (A) may contain sand, two of the silos (B) may contain limestone, two of the silos (C) may contain soda ash, and one of the silos (D) may contain alumina. One vertical feed pipe 158A-D is dedicated to each different
25 material type, and each of these feed pipes 158A-D is at an inlet end of the conduit system 132. Each of the feed pipes 158A-D is coupled with a dedicated segment of the pneumatic receiving conduit 39 leading outside the installation 12, and represents a branch of the conduit system 132. The feed pipes 158A-D are located along a side of the array 200 closest to the exterior wall of the installation 12 through which the segments of receiving conduit 39 extend.

[00129] Branches leading to a single silo 112, such as branch 158D in this case, do not
30 include a three-way junction 160 or valve 162 because the branch exclusively feeds that one silo.

CHAPTER A – DOCKET 19650

Branches leading to more than one silo include a number of junctions 160 equal to one less than the number of silos being fed by that branch and a number of valves 162 equal to $(X-1)$ multiplied by 2, where X is the number of silos being fed by that branch. In this example, the 158A branch feeds three silos and thus has two junctions 160 and $(3-1) \times (2) = 4$ valves 162. The 158B-C branches feed two silos each and thus have one junction 160 each and $(2-1) \times (2) = 2$ valves each.

[00130] With continued reference to FIG. 19 and additional reference to FIG. 20A, which illustrates the installation 12 of FIG. 1A with a bulk material transport vehicle 164 delivering bulk material to the majors system, the conduit system 132 including the three-way junctions 160 and valves 162 is operable as part of the receiving and pneumatic conveyance system 130 to provide a bulk material handling method that includes conveying bulk material from a mobile bulk material container 166 into a stationary bulk material container 112 at a glass manufacturing facility. For simplicity in illustration, only a single silo 112 of one bulk material storage module 110 of the array is illustrated schematically inside the installation 12 in FIG. 20A. As shown in FIG. 20A, in addition to the conduit system 132 carried by the silo array 200, the bulk material receiving and pneumatic conveyance system 130 may additionally include one or more pneumatic bulk material inlet conduits 39 extending through a wall of the installation 12, a plurality of couplings 168 configured to couple a feed conduit 170 of the mobile bulk material container 166 with the conduit system 132 via the inlet conduits 39, a receiving terminal 172, valves 174 operable to open and close to connect and disconnect each coupling 168 with the respective inlet conduit 39, a dense phase pneumatic panel 175, a controller 176, indicators 178 to communicate to a user the proper coupling 168 to use, and utility lines 180 coupling the terminal 172 and/or the controller 176 with the valves 174. In FIG. 20A, the pneumatic panel 175 and controller 176 are illustrated schematically because they may be located remotely—i.e., somewhere else in the installation 12.

[00131] In this example, the mobile bulk material container 166 is part of a transport truck 164 that is able to pull-up next to the installation without the limitations of rail cars, although rail cars may still be used. The system 130 is designed to pneumatically convey bulk majors materials from the mobile container 166 to one or more silos 112 of the array 200. Conventionally, it has not been possible to use pneumatic conveying to fill glass majors containers directly because conventional pneumatic conveying is dilute phase conveying in

CHAPTER A – DOCKET 19650

which air pressure at the inlet side of the system blows the bulk material through conduits as fast as the bulk material can be added to the flow of air in the conduits. While this is not problematic with other silo-containing facilities, it is problematic with abrasive glass feedstock materials such as sand and limestone. Conventional dilute phase pneumatic conveying of such abrasive materials quickly wears down the inner wall of the conduit—particularly at 90-degree or other sharp turns of a conduit system.

[00132] The pneumatic receiving and conveying system described here uses dense phase pneumatic conveying to address the conduit wear problem. In dense phase conveying, a series of spaced-apart slugs or packets of the bulk material are conveyed through the conduit system 132.

Dense phase conveying operates at a low air velocity in comparison to dilute phase conveying, which keeps the dense slugs of material together while being conveyed. The slower conveyance speed relative to dilute phase conveying significantly reduces conduit wear with abrasive bulk materials. The dense phase system requires an unconventionally high pressure to move the material through the conduit system. Dense phase conveying may for example required inlet pressure on the order of 20-30 psi compared to the relatively low pressure of 10-15 psi required for dilute phase conveying. Dense phase conveying can be somewhat more expensive than dilute phase conveying due to the lower feed rates and more complex equipment. But in the case of abrasive glass feedstock materials, the additional costs may be at least partly offset by the ability to eliminate subterranean material pits and bulk material elevators from conventional majors feedstock systems. Another benefit of pneumatic conveyance is the ability to operate a closed pneumatic system throughout the installation and, thereby, an essentially dust-free batch house, which is entirely unknown to the glass industry and some other industries that rely on bulk material handling systems.

[00133] Mobile bulk material containers such as pneumatic trailers typically used to deliver and unload bulk materials are generally incapable of sustaining the higher hopper and conveyance line pressures required for dense phase conveying, particularly in the United States. While other industries may employ dense phase conveying of particulate materials within manufacturing or processing facilities, pneumatic unloading from a delivery trailer or railcar is typically via dilute phase only. Then, a specialized dense phase system is provided and used only within the manufacturing or processing facility for intra-plant conveyance. Disclosed herein is a pneumatic unloading system in which the bulk material is unloaded directly from a pneumatic

CHAPTER A – DOCKET 19650

trailer or other mobile bulk material storage container and into the silos or other stationary bulk material storage containers via dense phase conveying. Here, the mobile hoppers and conveying lines leading from the mobile delivery vehicle are pressurized at the higher pressure required for dense phase conveying. It has been found during development of this system that fleets of delivery vehicles and pneumatic unloading trailers must be retrofitted, as bulk material delivery companies have balked at requests for high-pressure capable delivery containers.

[00134] FIGS. 20B-20D illustrate portions of the pneumatic system 130 of FIG. 20A in greater detail in order to further explain dense phase conveying and how it is accomplished. FIG. 20B illustrates the pneumatic inlet conduits 39, couplings 168, and valves 174 of the pneumatic system 130 of FIG. 20A. In addition, FIG. 20B illustrates high-pressure lines 171 and pulse-pressure lines 173 of the system 130. FIG. 20B is also schematically labelled to indicate which branch 158A-D of the conduit system 132 each inlet conduit 39 may be coupled with where the illustrative array 200 of FIG. 19 is employed. In this example, only two of the four inlet conduits 39 have one of the pulse-pressure lines 173 associated therewith. The number of high-pressure lines 171 is equal to the number of pulse-pressure lines 173, and a high-pressure coupling 177 is provided at the end of each high-pressure line.

[00135] The two branches 158A, 158B of the conduit system 132 with associated pulse-pressure lines 173 employ dense phase pneumatic conveying, while the other two branches 158C, 158D employ dilute phase conveying. Where the system 10 is a glass feedstock handling system, the most abrasive feedstock materials—e.g., sand and limestone—may be conveyed using the dense phase branches 158A, 158B. Each dense phase branch may have a dedicated high-pressure line 171 as illustrated. In this case, one high-pressure line 171 is associated with branch 158A, while the other high-pressure line 171' is associated with 158B. Likewise, each dense phase branch 158A, 158B may have a dedicated pulse-pressure line 173, 173'. Each pulse-pressure line is coupled with the respective inlet conduit 39 near the valve 174 that provides or blocks bulk material conveying into the conduit system 132.

[00136] Each high-pressure coupling 177 is adapted to be coupled with the mobile bulk material container 166 such as that of FIG. 20A via a second conduit between the coupling 177 and the container 166. The high-pressure line 171 provides the pressure to push the bulk material into the conduit system 132 in dense slugs or segments.

CHAPTER A – DOCKET 19650

[00137] FIG. 20C illustrates the pneumatic panel 175 of FIG. 20A in further detail. The panel 175 includes a pneumatic manifold 179 with one air inlet 181 and three air outlets 183, 185, 187. The panel 175 can be located remotely, away from the conduit system 132 and silo array 200, for example. In one embodiment, the pneumatic panel is located in a module of the minors subsystem 40 (FIG. 1B), which may be a more centralized location of the installation 12 than the bulk material receiving area. Additionally, the minors subsystem 40 may also employ pneumatic conveying systems, and locating majors and minors control panel together within the installation can centralize control and maintenance of the two pneumatic conveying systems.

[00138] The air inlet 181 is coupled with an air compressor or other pressure source, such as a standard manufacturing plant air pressure system. A first outlet 183 is coupled with one of the high-pressure lines 171 of FIG. 20B. The associated high-pressure line 171 may be maintained at 20-30 psi from the first outlet 183 and pressurizes the mobile bulk material container when coupled therewith. Various pneumatic components between the inlet 181 and first outlet may include a 2-way magnetic valve 183a, pressure regulator 183b, check valve 183c, pressure sensor/gauge 183d, and safety valve 184e. The magnetic or solenoid valve 183a may be controlled remotely via a controller or control system and is one of the valves that may be opened once the associated high-pressure line 171 is coupled with the delivery vehicle 164 or other mobile bulk material storage container 166. Other types of remotely controllable valves may be employed, and the panel 175 may include additional components between the inlet 181 and first outlet 183.

[00139] The second outlet 185 of the manifold 179 is coupled with one of the pulse-pressure lines 173 of FIG. 20B. The associated pulse-pressure line 173 has a non-uniform pressure during conveying with periodic high-pressure pulses and an otherwise low or zero baseline pressure between pulses. Various pneumatic components between the inlet 181 and second outlet 185 may include a pressure regulator 185a, a 2-way magnetic valve 185b, a volume regulator 185c, and a check valve 185d. Pressure pulses can be generated via a time-dependent or otherwise controllable valve of the panel 175, such as the magnetic valve 185b, which can be controlled remotely via a controller or control system. The valve 185b is closed for a period of time to allow pressure to build and then opens to discharge the built-up pressure before closing again to build pressure for the next pulse. The valve 185b can be electronically controlled and electrically operated, or it may be similar to a pressure relief valve that

CHAPTER A – DOCKET 19650

mechanically opens at a threshold pressure and closes again when the pressure drops. There may be other suitable techniques for generating pressure pulses at the second outlet 185 and in the pulse-pressure lines 173.

[00140] The effect of pressure pulses in the pulse pressure lines 173 is the injection of periodic air pockets into the stream of bulk material being conveyed into the conduit system 132 with dense slugs of bulk material between successive air pockets. Those air pockets between slugs of bulk material are compressed during conveyance, effectively keeping the entire length of conduit periodically pressurized rather than just being pressurized at the inlet.

[00141] The third outlet 187 is coupled with a dense phase boost line 189 (FIG. 20D). The boost line is optional but useful in dense phase conveying where a portion of the conveyance is vertical, since some of the conveying energy is lost to potential energy in the higher regions of the system. When employed, such boost lines 189 may be coupled with the conduit system 132 at one or more different heights to inject additional air pockets into the stream of bulk material and/or repressurize already existing air pockets. Various pneumatic components between the inlet 181 and third outlet 187 may include a 2-way magnetic or other remotely controllable valve 187a, a pressure regulator 187a, and/or other components. A controller or control system can remotely operate the valve 187a and/or synchronize its operation with the pressure pulses in the associated pulse-pressure line 173.

[00142] The pneumatic panel 175 may of course include other common pneumatic components such as pressure regulators, shut-off valves, flow restrictors, and/or sensors. Each branch 158A-D in which dense phase conveying is desired may have a dedicated pneumatic panel.

[00143] FIG. 20D is a schematic representation of a mobile bulk material container 166 coupled with the pneumatic receiving and conveying system 130 to convey bulk material into a bulk material silo or stationary storage container 112 via dense phase conveying. The mobile storage container 166 is coupled with the pneumatic inlet conduit 39 via a bulk material feed conduit 170 and coupling 168. The mobile storage container 166 is pressurized by the high-pressure line 171, to which it is coupled via coupling 177. The high-pressure line 171 is pressurized from the pneumatic panel 175. The pulse-pressure line 173, powered by the pneumatic panel 175, is coupled with the bulk material inlet conduit 39 downstream of the valve 174. And a boost pressure line 189 powered by the pneumatic panel is coupled with the conduit

CHAPTER A – DOCKET 19650

system 132 at multiple points along the conduit between the inlet conduit 39 and the storage container 112 into which the bulk material is being conveyed.

[00144] A bulk material handling method may include one or more of the following steps in various operable orders. In one aspect, the system 130 employs non-human verification that the bulk material from the mobile storage or transport container 166 is of the type intended to be stored in the stationary container 112 with which the mobile container is coupled. In one example, non-human verification includes receipt at the receiving terminal 172 of information pertinent to the type of material contained in the mobile container 166 before conveying begins. For instance, a 2D data matrix, QR code, bar code, or other encoded machine-readable image can be included on a bill of lading or other shipping document in the transport vehicle 164 operator's possession upon delivery. The terminal 172 may include a camera or other type of scanner configured to recognize the image on the shipping document and match the image with a material type from a data table in computer memory, for example. In other examples, the delivery vehicle 164 may be equipped with an RFID tag or other wireless communicator indicative of the type of bulk material contained in the mobile container, and the receiving terminal is an RFID reader or wireless receiver that does not require human-user interaction.

[00145] In one manner of operating the pneumatic receiving and conveyance system, the driver/operator of the transport vehicle 164 arrives at the installation 12 with the mobile container 166 filled with a particular type of bulk material. The driver/operator may be unaware of the type of bulk material being delivered. On arrival, the driver/operator presents a shipping document to a vision system of the receiving terminal 172, which reads a graphic image and thereby determines the type of material in the mobile container 166 and actuates the appropriate indicator 178 to inform the driver/operator which of the multiple couplings 168 along the outside of the installation 12 is the proper coupling to receive the type of material in the mobile container 166. In FIG. 20A, the indicators 178 are visual indicators and the leftmost indicator in the figure is shown illuminated. Auditory indicators can be used in addition to or instead of visual indicators. When the driver/operator couples the feed conduit 170 to the indicated coupling 168, the system detects the coupling (e.g., via microswitch, capacitive sensing, proximity switch, etc.) and may provide another indicator prompting the driver/operator to approach the receiving terminal, where they are instructed to again present the shipping document to the receiving terminal 172 to verify that the proper coupling 168 has been engaged by the feed conduit 170.

CHAPTER A – DOCKET 19650

The system 130 may for example employ a mechanical microswitch, a capacitive sensor, a proximity switch, or other type of sensor at each coupling to detect which coupling has been engaged with the feed conduit. If the proper coupling 168 has been engaged, the system 130 checks to determine whether the appropriate high-pressure line 171 has been coupled with the mobile storage container 166. If not, the driver/operator is provided another indicator to do so. Once the feed conduit 170 is coupled with the proper inlet conduit 39 and with the proper high-pressure line 171, the corresponding valve 174 is opened and the pneumatic conveying is permitted to begin.

[00146] The determinations made by the system 130 based on information received at the receiving terminal 172 can be made locally by a controller at the terminal or remotely by a different system controller, such as a controller 176 of the controls subsystem 46. Likewise, operation of the valves 174 may be under the control of a terminal controller or another system controller.

[00147] In another aspect, the system 130 is capable of selecting which silo 112 of the array 200 the incoming bulk material should be routed to and is further capable of operating the valves 162 of the conduit system 132 to direct the bulk material to the desired silo. In one embodiment, the controller 176 determines which one of multiple silos containing the same bulk material the incoming bulk material should be routed to based on information received from the fill-level sensors. For example, the controller 176 may have information from the various fill-level sensors 150 of the array 200 allowing it to determine which of the silos 112 containing bulk material A is at the lowest level and which of the same silos is at the highest level. The controller 176 may then control the valves 162 to initially route incoming bulk material to the silo containing the least amount of bulk material A. In other embodiments, the controller 176 may operate to initially top-off the silo 112 having the greatest amount of bulk material contained therein when conveying begins.

[00148] In either case, the system 130 may also be configured to reroute incoming bulk material to a different silo containing the same type of bulk material during conveyance without interrupting the conveying. An example is illustrated schematically in FIGS. 21-23, where three of the silos 112 are intended to contain bulk material A and are labelled A1-A3. Here, a mobile bulk material container 166 has arrived for delivery of bulk material, and information has been received at the receiving terminal 172 that the type of bulk material is bulk material A. The

CHAPTER A – DOCKET 19650

controller 176 receives that information and, in response, determines which of silos A1-A3 has the least amount of material inside, based on information received from the fill-level sensors on each silo. In this case, silo A3 contains the least amount of bulk material, and the controller opens the valves 162 leading from branch feed pipe 158A to the downpipe 136 of silo A3 while
5 closing the valves leading to the downpipes of silos A1 and A2 so that the incoming material is initially routed to silo A3, as indicated in FIG. 21.

[00149] Once the fill-level sensor of silo A3 indicates that a threshold level of bulk material is contained in silo A3, the controller reroutes the incoming material to one of the other two silos A1-A2 based on which of the silos presently contains the least amount of material. In
10 the example of FIG. 22, the incoming material is rerouted to silo A2. This involves first opening the valve 162 leading to the downpipe 136 of silo A2, and then closing the valve leading to silo A3 while leaving the other two valves in the same position. This order of valve operation helps prevent unwanted pressure build-up in the conduit system 132.

[00150] Once the fill-level sensor of silo A2 indicates that a threshold level of bulk
15 material is contained in silo A2, the controller reroutes the incoming material to silo A1 if there is still bulk material remaining to be conveyed from the mobile container 166 and if silo A1 is not already at the threshold level indicating it is full. In any case, conveying is halted if all silos containing the same type of material are full. In FIG. 23, the incoming material is rerouted from silo A2 to silo A1, which involves first opening the valve 162 leading to the downpipe 136 of
20 silo A1, and then closing the valve leading to silos A2 and A3.

[00151] This order of silo filling is merely illustrative, and other valve control schemes can be used. For example, the fill-level of each of a plurality of silos containing the same bulk material type can be monitored during conveying from the mobile bulk material container and the valves of the system 132 can be controlled to more evenly distribute the incoming bulk
25 material.

[00152] With reference now to FIGS. 13-16 and FIGS. 24-34, various components of an illustrative bulk material dispensing module 120 are described in further detail. FIGS. 24 and 25 respectively illustrate top and bottom perspective views of a dispensing module 120 of the dispensing module array 300 of FIGS. 13-15 and of the storage and dispensing module 100' of
30 FIG. 16. Each dispensing module 120 includes the dispensing module frame 50 of FIG. 10 and one or more bulk material dispensers 124. Dispensing cells 122 are defined between successive

CHAPTER A – DOCKET 19650

transverse cross-members 50h, which are spaced apart by the width of the silo modules 110 which they support. In this example, a bulk material dispenser 124 is supported by the frame 50 in each of the four dispensing cells 122. One end of each dispenser 124 is supported in its respective cell 122 by upper and lower intermediate cross-members 50g,h, and an opposite end of each dispenser is supported by an additional transverse member 182 having its ends affixed to the upper beams 50b of the frame 50. Each dispensing cell 122 also includes one or more microcontrollers 184 on one vertical side (e.g., the back side) of the frame 50 and a pressure valve 186 on the opposite vertical side (e.g., the front side) of the frame.

[00153] With continued reference to FIGS. 24 and 25, each material dispenser 124 includes an inlet 188 accessible through a first or top side of the frame 50 and configured to be coupled with and receive material from the bulk material container 112 of an overlying storage container module 110. An outlet 190 of each dispenser 124 is accessible through an opposite second or bottom side of the frame 50 and configured to be coupled with and discharge bulk material to a transport bin (not shown in FIGS. 24-25). Each bulk material dispenser 124 also includes a conveyor 192 configured to move bulk material from the inlet 188 to the outlet 190 when the inlet is coupled with the overlying bulk material container. The conveyor 192 in this case is a screw conveyor comprising a screw with one or more screw flights housed in a housing 194 and rotated within the housing by a motor 196 or other actuator under the control of the associated microcontroller(s) 184.

[00154] Each bulk material dispenser 124 includes a dosing assembly 198 that provides the dispenser inlet 188 and includes the conveyor 192, as well as a docking assembly 202 that provides the dispenser outlet 190. The docking assembly 202 is arranged beneath the dosing assembly 198 to receive bulk material therefrom. Each bulk material dispenser 124 also includes at least a portion of a filter assembly 204 configured to remove solids from air inside the dispenser during dispenser operation. Each dispensing module 120 may include only a portion of the filter assembly 204 as part of the stand-alone module 120 due to the height of certain components of the filter assembly causing it to extend above the frame 50 when fully assembled. The illustrated dispensing module 120 thus includes only a lower portion 206 of the filter assembly 204 when the module is built remotely to be shipped to the installation site.

[00155] With reference now to FIGS. 26-34, an illustrative bulk material dispenser 124 is described as fully assembled with the overlying bulk material storage container 112 and

CHAPTER A – DOCKET 19650

dockable with an underlying transport bin 208. The illustrated bulk material dispenser 124 includes the dosing assembly 198 as an upper portion, the docking assembly 202 as a lower portion, and the filter assembly 204 configured to filter solids from air displaced from the transport bin 208 (FIGS. 28-30) during dispenser operation. The dispenser inlet 188 is carried by an inlet portion 210 of the dosing assembly 198 and is coupled with the outlet of the associated bulk material container 112 to receive bulk material therefrom. The inlet portion 210 feeds the conveyor 192 and, in this example, includes a hopper 212 coupled with the conveyor 192 at a lower end of the hopper and a connector tube 214 coupling the hopper 212 with the outlet of the overlying storage container 112. The conveyor 192 moves bulk material received from the storage container 112 from the inlet portion 210 to the outlet 190.

[00156] The dispenser outlet 190 is carried by the docking assembly 202 and is coupled with the transport bin 208 during dispenser operation to discharge the bulk material into the transport bin. The dispenser outlet 190 is provided by a lower plate 216 of the docking assembly 202 in this example. The lower plate 216 and outlet 190 are moveable toward and away from the dosing assembly 198 to couple with and decouple from the transport bin 208. The docking assembly 202 has an inlet 218 coupled with an outlet 220 of the conveyor 192 and includes one or more actuators 222 that move the dispenser outlet 190 with respect to the docking assembly inlet 218. In this example, the actuators 222 are pneumatic actuators and, more particularly, are lost-motion actuators configured to limit an amount of force applied to the transport bin 208 during docking and dosing. The docking assembly 202 and its operation will be described further below.

[00157] With reference to FIGS. 26-28 and 30, the filter assembly 204 includes a filter inlet 224, a filter outlet 226, a turbine 228, a housing 230 with an internal filter element, an air pressure accumulator tank 232, and a solids outlet 234. The filter inlet 224 is in fluidic communication with the dispenser outlet 190 via a conduit 236 extending between a vacuum port 238 and the filter inlet. More particularly, the filter inlet 224 is in fluidic communication with an internal volume 240 of the docking assembly 202 so that, when coupled with the transport bin 208 with the turbine 228 operating, an internal pressure of the internal volume 240 of the docking assembly 202 is less than the surrounding atmospheric pressure. This low-pressure region 240 within the docking assembly 202 ensures that no dust or other solids in the air displaced from the transport bin 208 during bulk material dispensing escapes from the system.

CHAPTER A – DOCKET 19650

[00158] With reference to FIGS. 26, 30 and 32, an adjustable vent 242 is provided, as part of the docking assembly 202 in this case, to permit atmospheric air to enter the internal volume 240 of the docking assembly during turbine 228 operation and prevent the internal pressure from dropping too low and causing the turbine to be overworked. The illustrated vent 242 includes an annular adjuster 244 with apertures 246 formed therethrough. The adjuster 244 is located atop the lower plate 216, which has corresponding apertures formed therethrough. The adjuster 244 can be rotated about a vertical axis between a fully open position, in which the apertures 246 of the adjuster are aligned with the apertures of the lower plate 216, and a fully closed position, in which all apertures are closed-off. Adjustment of the vent 242 between these two extremes results in adjustment of the pressure differential between the internal volume 240 and the surrounding atmosphere. In particular, a more open vent 242 results in a higher internal pressure (and a lower pressure differential with the atmosphere), while a more closed vent results in a lower internal pressure (and a higher pressure differential with the atmosphere. This adjustment can be fine-tuned by starting with a fully open vent 242 and gradually closing it off until the pressure is sufficiently low in the internal volume 240 to prevent dust and other solids from escaping during dispensing.

[00159] The filter assembly housing 230 and its internal filter element are arranged between the filter inlet 224 and outlet 226. In this example, the outlet 224 is provided by the turbine assembly 228, which has an internal impeller operable to force air from the filter inlet 224, through the filter element, and out of the filter outlet 226. Dust and other solids filtered from the displaced transport bin air are routed to the conveyor 192 via gravity through the solids outlet 234 of the filter assembly 204. To accommodate this capture and rerouting of filtered particulates, the accumulator tank 232 is pulsed or discharged after dosing so that the solids fall to the conveyor 192. The accumulator tank 232 is charged via a system pressure source between pulse cycles. The filter pulse cycle is effected via the pressure valve 186 of the corresponding dispensing cell 122.

[00160] With reference to the schematically depicted conveyor 192 of FIG. 31, where the conveyor 192 is a screw conveyor, an internal screw 248 may include a first screw flight 250 at one end of the screw that moves the bulk material in a first direction from the inlet 188 toward the conveyor outlet 220, and a second reverse screw flight 252 at an opposite end of the screw that moves the solids recovered from the filter assembly 204 from the solids outlet 234 in an

CHAPTER A – DOCKET 19650

opposite second direction toward the conveyor outlet 220 while the screw 248 is being turned in only one rotational direction about its axis.

[00161] With reference now to FIGS. 32-33 the docking assembly 202 is further described. The illustrated docking assembly 202 includes a receiving portion 254 that includes the docking assembly inlet 218, a docking portion 256 that includes the dispenser outlet 190, and one or more actuators 222 that moving the docking portion with respect to the receiving portion. The docking portion comprises the above-described lower plate 216, which provides the dispenser outlet 190 and mates with the transport bin 208. The actuators 222 may be lost-motion actuators as noted above to limit the amount of force applied to the transport bin 208 during docking and dosing. Here, the actuators 222 are pneumatic cylinders, but other actuators and actuator mechanisms are contemplated (e.g., solenoid, servo-powered gear train, etc.).

[00162] As best illustrated in the schematic depiction of FIGS. 34-35, the illustrated docking assembly 202 includes a collapsible sleeve 258 extending between the receiving portion 254 and docking portion 256. The collapsible sleeve 258 delimits the internal volume 240 of the docking assembly 202. The collapsible sleeve 258 can be a telescopic sleeve with nesting segments, a corrugated polymer sleeve, a fabric sleeve, or similar. The internal volume 240 of the docking assembly 202 thus changes with relative movement of the receiving portion 254 and docking portion 256.

[00163] The receiving portion 254 of the docking assembly 202 includes a coupling sleeve 260 having a first end 262 attached to the dosing assembly 198 and a second end 264 extending into the internal volume 240 of the docking assembly 202, as best illustrated in the cross-sectional view of FIG. 33. The first end 262 of the coupling sleeve 260 provides the docking assembly inlet 218. The coupling sleeve 260 further includes an inner sleeve 266 and an outer sleeve 268, both of which extend from the first end 262 and downward into the internal volume 240 of the docking assembly 202. The vacuum port 238 extends through the outer sleeve and fluidly connects the filter inlet to the internal volume 240 of the docking assembly 202 via an annular gap between the inner and outer sleeves 266, 268. The top end of the inner sleeve 266 is funnel-shaped and receives the bulk material from the conveyor 192. The bulk material thus travels through the center of the docking assembly 202 from the dosing assembly 198 to the transport bin 208. The inner sleeve 266 extends downward past the end of the outer sleeve and

CHAPTER A – DOCKET 19650

isolates the discharged bulk material from the outer sleeve 268 so that bulk material from the conveyor outlet 220 is not inadvertently drawn into the conduit 236 of the filter assembly.

[00164] In addition to the lower plate 216 and adjustable vent 242, the docking portion 256 of the docking assembly 202 also includes an upwardly extending sleeve 270 to which the lower end of the collapsible sleeve 258 is affixed. All of the sleeves 258, 266, 268, 270 are concentric. When the docking portion 256 is retracted toward the receiving portion 254, the inner sleeve 266 and outer sleeve 268 of the coupling sleeve are nested within the sleeve 270 of the docking portion 256 and the collapsible sleeve 258 is collapsed. When the docking portion 256 is extended away from the receiving portion 254, the inner sleeve 266 and outer sleeve 268 of the coupling sleeve are withdrawn from the sleeve 270 of the docking portion 256 and surrounded by the extended collapsible sleeve 258.

[00165] The above-described dispensing equipment enables bulk material dispensing methods, including methods of docking a transport bin with the dispensing equipment and methods of metering doses of bulk material from the bulk material silos at least as follows.

[00166] An illustrative bulk material handling method may include a coupling or docking step, a receiving step, formation of a reduced pressure region, and a dispensing step. In the coupling or docking step, the outlet of the bulk material dispenser 124 is coupled with a transport bin 208 to form a closure at an inlet of the transport bin and place an inside of the transport bin in communication with the dispenser. The dispenser 124 and transport bin 208 are illustrated in the docked or coupled condition in FIGS. 28 and 30, and the inlet of an illustrative transport bin 208 is illustrated in FIG. 29 before docking. In this example, the coupling includes interfacial contact between the lower plate of the docking assembly and a lip surrounding the inlet of the transport bin. Other types of coupling are contemplated, such as positive engagement of protrusions and corresponding recesses, or positive engagement of a latch or other reversible attachment.

[00167] The receiving step in this case includes receiving bulk material in the dispenser 124 from the overlying bulk material container 112. Receiving of the bulk material in the dispenser occurs via gravity feed whenever the conveyer is actively moving bulk material toward the conveyor outlet. Formation of the reduced pressure region occurs in the internal volume 240 of the dispenser 124 when the turbine of the filter assembly is activated. Dispensing of the bulk material occurs via operation of the conveyor, which drops the bulk material from the conveyor outlet, through the reduced pressure region of the internal volume 240, and into the transport bin.

CHAPTER A – DOCKET 19650

[00168] In one illustrative and more detailed example of the method, the transport bin 208 is placed beneath the docking assembly with the docking assembly in a retracted condition in which the actuators are in a retracted position and the collapsible sleeve is collapsed. With the docking assembly in this state, the dosing assembly and its conveyor are idle and not moving or
5 actively receiving any bulk material, although the conveyor may be entirely full of bulk material from a previous dosing cycle. In addition, the filter assembly and its turbine are idle when the docking assembly is in the retracted condition.

[00169] With the inlet of the transport bin aligned beneath the docking portion of the docking assembly, the actuators of the docking assembly are extended and move the docking
10 portion and the dispenser outlet toward the transport bin as the collapsible sleeve extends. When the docking portion contacts the transport bin and a minimal force is applied, the downward motion of the docking portion is halted by virtue of the lost-motion actuators, and the docked or coupled condition of FIGS. 28 and 30 is achieved.

[00170] After the docking assembly and transport bin are coupled together, the turbine of
15 the filter assembly is activated. This reduces the pressure within the internal volume of the docking assembly and, thereby, within the transport bin. With this internal pressure sufficiently reduced, the conveyor of the dosing assembly is activated and begins moving the bulk material received from the overlying silo toward the conveyor outlet, where it is dropped through the concentric sleeves of the docking assembly and into the transport bin. The bulk material
20 discharged from the conveyor is continuously replenished via gravity feed from the overlying silo.

[00171] When the desired dose of bulk material is dispensed into the transport bin, the conveyor is deactivated, thereby halting bulk material dispensing. The filter assembly may continue to operate for several seconds after dispensing is halted to remove as much solid
25 material from the air inside the transport bin as possible. The filter assembly is then deactivated, and the filter element may be pulsed to dislodge the filtrate from the filter element to be dropped into the conveyor for dispensing during the next dosing cycle. Next, the actuators of the docking assembly are retracted, and the docking portion of the docking assembly is moved back toward the receiving portion to the retracted position. The transport bin can then be transported to
30 another part of the majors or minors section of the installation.

CHAPTER A – DOCKET 19650

[00172] In various embodiments, the dispensing step includes at least two sequential stages, a later one of the stages being slower than an earlier one of the stages. For example, the conveyor may operate with at least two rotational speeds, including a high speed and a low speed. When the conveyor is initially activated after docking, it may operate at the high speed and then change to the low speed at some threshold amount of the full dose of bulk material. In one particular example, the screw of a screw conveyor rotates at a high rotational speed until 85-95% of the desired dose of bulk material is dispensed, after which the rotational speed of the screw is slowed to a slow speed. The associated “coarse” and “fine” dispensing combines the speed of the high speed dispensing with the accuracy of low speed dispensing, which is most important as the amount of material dispensed into the transport bin approaches the total desired amount.

[00173] In various embodiments, the filter assembly may also operate with at least two sequential stages, a later one of the stages being more powerful than an earlier one of the stages. For example, the turbine of the filter assembly may operate with at least two rotational speeds, including a high speed and a low speed. When the turbine is initially activated after docking, it may operate at the low speed to achieved just enough of a reduced pressure region within the docking assembly as is necessary to prevent dust from escaping the coupled system. Then, the turbine may change to the high speed after dosing is completed and the conveyor is deactivated. The high-speed operation draws a much higher volume of atmospheric air through the vent of the docking assembly and causes turbulent flow within the space over the dispensed material in the transport bin to help draw as much of the solids-laden air from the transport bin as possible before halting the vacuum filtration and undocking from the transport bin.

[00174] The docking assembly may also cooperate with the transport bin to further reduce the amount of dust and other solids that escape the system during docking and undocking. In one non-limiting example, and with reference to FIG. 29, the transport bin 208 may be equipped with a closure 272 that is changeable between a closed condition and an open condition. In the example of FIG. 29, the closure 272 includes a pair of doors, one of which is in the closed condition (i.e., the left door in the figure) and one of which is in the open condition (i.e., the right door in the figure). Levers 274 are affixed to hinges of the doors and extend above the inlet of the bin when the docking assembly is in the retracted condition. The doors of the closure 272 are biased toward the closed condition so that they are closed when the transport bin is undocked. As

CHAPTER A – DOCKET 19650

best shown in the schematic views of FIGS. 34 and 35, when the docking assembly is changed from the retracted condition of FIG. 34 to the extended condition of FIG. 35, the lower plate of the docking assembly contacts the levers 274, which rotates the doors of the closure to their open condition as the transport bin is docked. Likewise, after bulk material dispensing is completed
5 and the docking assembly is changed back to the retracted condition of FIG. 34, the doors of the closure are moved back to the closed condition by virtue of their bias toward that condition.

CHAPTER A – DOCKET 19650

Example claims for Chapter A (Docket 19650) include the following:

1.

A bulk material storage module, comprising:

a container module frame;

a bulk material container supported within the frame, the bulk material container having an upper portion and a lower portion;

an inlet located along the upper portion for receiving bulk material into the material container,

an outlet located along the lower portion for discharging bulk material from the material container, and

a vent to permit air exchange between an inside of the container and outside the container during receiving and/or discharging of bulk material from the material container; and

at least one utilities receiver configured to couple the module with at least one of: a control system, an electric utility, a pneumatic utility, or another bulk material storage module,

wherein the module is configured to be attached side-by-side with up to four other bulk material storage modules and corner-to-corner with up to four other bulk material storage modules, all of the modules having identical frames and bulk material containers.

2.

The storage module of claim 1, wherein the bulk material container is a silo comprising an inlet conduit section at the inlet and a spout comprising the outlet,

the storage module having external dimensions less than or equal to an intermodal freight container.

3.

The storage module of claim 1, further comprising a platform at least partially surrounding the upper portion of the bulk material container, wherein a top end of the material container is located between the platform and a top of the frame.

CHAPTER A – DOCKET 19650

4.

A storage module array comprising a plurality of the storage modules of claim 3 arranged side-by-side with the top and a bottom of each frame lying in common respective planes and the platform of each module lying in a common plane,

5 whereby a habitable space is formed between the platforms and the tops of the frames, the platforms together forming a floor of the habitable space.

5.

10 The storage module array of claim 4, further comprising at least a portion of a branched conduit system in communication with the inlet of each storage container of each module of the array, the conduit system being configured to interconnect a mobile bulk material container with a selected storage container of the array and to change which storage container of the array is interconnected with the mobile bulk material container during conveyance of bulk material from the mobile container to the array.

15

6.

A bulk material dispensing module, comprising:

20 a dispensing module frame having a longitudinal axis, the frame further comprising a plurality of transverse frame members spaced along the longitudinal axis, wherein a dispensing cell is defined between each pair of transverse frame members;

 at least one bulk material dispenser supported within the frame, each bulk material dispenser being supported in a different dispensing cell and comprising

 an inlet accessible through a first side of the frame and configured to be coupled with and receive material from a bulk material container,

25 an outlet accessible through an opposite side of the frame and configured to be coupled with and discharge material to a transport bin, and

 a conveyor configured to move bulk material from the inlet to the outlet when the inlet is coupled with the bulk material container; and

 a controller carried by the frame for each bulk material dispenser,

CHAPTER A – DOCKET 19650

wherein the module is configured to be attached side-by-side with one or more other bulk material dispensing modules, each of the modules having identical frames, dispenser inlets, and dispenser outlets, and

5 wherein the storage module has external dimensions less than or equal to an intermodal freight container.

7.

The dispensing module of claim 6, wherein each bulk material dispenser comprises:

a dosing assembly comprising the inlet of the dispenser; and

10 a docking assembly comprising the outlet of the dispenser and arranged to receive bulk material from the dosing assembly.

8.

15 The dispensing module of claim 6, wherein each bulk material dispenser comprises at least a portion of a filter assembly configured to remove solids from air inside the dispenser during dispenser operation.

9.

20 A dispensing module array comprising a plurality of the dispensing modules of claim 6 arranged side-by-side with the top and a bottom of each frame lying in common respective planes.

10.

25 A bulk material storage and dispensing system comprising the storage module array of claim 4 arranged atop the dispensing module array of claim 9,

wherein each storage module is aligned with a different one of the dispensing cells, and the inlet of each dispenser is coupled with the outlet of one of the bulk storage containers.

11.

CHAPTER A – DOCKET 19650

A glass manufacturing facility comprising a ground level floor and no basement, a main frame on the floor, and the system of claim 10 supported from below by the main frame such that a habitable space is defined between the floor and the system.

5

12.

A bulk material handling method, comprising:

conveying bulk material directly from a mobile bulk material container into a stationary bulk material container at a glass manufacturing facility via dense phase pneumatic conveying.

10

13.

The method of claim 12, further comprising, before the conveying step, non-human verification that the bulk material is of a type intended to be stored in the stationary container.

14.

15

The method of claim 12, wherein the stationary container is one of a plurality of stationary bulk material containers at the facility, each stationary container being configured to receive and store a different type of bulk material,

a plurality of couplings being located at the facility for coupling a feed conduit of the mobile bulk material container to a conduit system, and

20

wherein the conduit system interconnects each stationary bulk material container with a single one of the couplings so that each coupling conveys only one of the different types of bulk material.

15.

25

The method of claim 14, further comprising:

receiving information indicating the type of bulk material in the mobile bulk material container;

providing an indicator identifying the proper one of the plurality of couplings to connect the feed conduit to, based on the received information;

30

connecting the feed conduit to the proper coupling;

CHAPTER A – DOCKET 19650

receiving information to verify that the feed conduit is connected to the proper coupling;
and
performing the conveying only after the two receiving steps.

5

16.

The method of claim 12, wherein the stationary container is one of a plurality of stationary bulk material containers at the facility that contain the same type of bulk material, the method further comprising, during conveying, rerouting the bulk material to a different one of the stationary containers containing the same type of bulk material.

10

17.

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The method of claim 12, wherein the stationary container is one of a plurality of stationary bulk material containers at the facility that contain the same type of bulk material, the method further comprising routing the bulk material to said one stationary container based on an amount of bulk material contained in said one stationary container relative to the other stationary containers when the conveying step begins.

18.

20

The method of claim 17, wherein the bulk material is routed to the stationary container of the plurality of stationary containers containing the least amount of bulk material.

19.

25

The method of claim 17, further comprising rerouting the bulk material to a different one of the plurality of stationary containers after said one stationary container is filled to a threshold level.

20.

30

A bulk material dispenser, comprising:
a dispenser inlet configured for coupling with and receiving bulk material from an outlet of a bulk material container;
a dispenser outlet configured for coupling with and discharging the bulk material into a transport bin;

CHAPTER A – DOCKET 19650

a conveyor that moves bulk material received at the inlet side toward the outlet; and
a filter assembly configured to filter solids from air displaced from the transport bin during dispenser operation.

5

21.

The dispenser of claim 20, further comprising:

a dosing assembly comprising the dispenser inlet and the conveyor; and

10

a docking assembly comprising the dispenser outlet, wherein the dispenser outlet is moveable toward and away from the dosing assembly to couple with and decouple from the transport bin.

22.

15

The dispenser of claim 21, wherein the docking assembly comprises an inlet coupled with an outlet of the dosing assembly and an actuator that moves the dispensing outlet with respect to the docking assembly inlet.

23.

20

The dispenser of claim 21, wherein an inlet of the filter assembly is coupled with an internal volume of the docking assembly so that an internal pressure of said volume is less than atmospheric pressure when the dispenser is coupled with the transport bin.

24.

25

The dispenser of claim 23, further comprising an adjustable vent that permits air flow into said volume, wherein adjustment of the vent changes said pressure.

25.

30

The dispenser of claim 20, wherein the filter assembly comprises:

a filter inlet in fluidic communication with the dispenser outlet;

a filter outlet;

a filter element between the filter inlet and filter outlet;

CHAPTER A – DOCKET 19650

a turbine arranged to force air from the filter inlet, through the filter element, and toward the filter outlet; and

a solids outlet coupled with the conveyor,

wherein the solids filtered from the air in the filter assembly are routed to the conveyor

5 for movement toward the dispenser outlet.

26.

The dispenser of claim 25, wherein the conveyor is a screw conveyor comprising a screw having a first flight that moves bulk material in a first direction from the dispenser inlet toward the dispenser outlet and second flight that moves filtered solids in an opposite second direction from the solids outlet toward the dispenser outlet.

27.

A docking assembly for use in a bulk material dispensing system, comprising:

15 an inlet configured for coupling with and receiving bulk material from a bulk material dosing assembly; and

an outlet configured for coupling with and discharging the bulk material into a transport bin, wherein the outlet is moveable toward and away from the inlet and, thereby, respectively away from and toward the transport bin.

20

28.

The docking assembly of claim 27, further comprising:

a receiving portion comprising the inlet;

a docking portion comprising the outlet; and

25 an actuator that moves the docking portion relative to the receiving portion.

29.

The docking assembly of claim 28, wherein the actuator is a lost-motion actuator that limits an amount force applied to the transport bin by the docking portion.

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30.

CHAPTER A – DOCKET 19650

The docking assembly of claim 28, further comprising a collapsible sleeve extending between the receiving portion and docking portion and defining an internal volume of the docking assembly that changes with relative movement of the receiving portion and docking portion.

5 31.

The docking assembly of claim 30, further comprising a vacuum port in fluidic communication with the internal volume of the collapsible sleeve to reduce an internal pressure of the internal volume when the docking portion is in contact with the transport bin and a negative pressure is applied at the vacuum port.

10 32.

The docking assembly of claim 31, further comprising a vent that is operable to adjust the magnitude of the internal pressure for a given applied negative pressure.

15 33.

The docking assembly of claim 31, wherein the receiving portion further comprises a coupling sleeve comprising the vacuum port,

a first end of the coupling sleeve being configured for attachment to the dosing assembly,
and

20 a second end of the coupling sleeve extending into said internal volume.

34.

The docking assembly of claim 33, wherein the coupling sleeve comprises an inner sleeve and an outer sleeve, the vacuum port being located on the outer sleeve and the inner
25 sleeve being arranged to isolate the bulk material from the outer sleeve.

35.

A bulk material handling method, comprising:

coupling an outlet of a bulk material dispenser with a transport bin to form a closure at an
30 inlet of the transport bin and place an inside of the transport bin in communication with the dispenser;

CHAPTER A – DOCKET 19650

receiving bulk material in the dispenser from a bulk material container;
forming a reduced pressure region in an internal volume of the dispenser; and
dispensing the bulk material from the dispenser and into the transport bin through the
reduced pressure region.

5

36.

The method of claim 35, wherein the dispensing step includes at least two sequential
stages, a later one of the stages being slower than an earlier one of the stages.

37.

10

The method of claim 35, wherein the reduced pressure region is provided by a filter
assembly such that air displaced from the transport bin during the dispensing is received in the
filter assembly, the method further comprising filtering solids from the air received in the filter
assembly.

15

38.

The method of claim 37, further comprising routing said solids to a conveyor of the
material dispenser.

39.

20

The method of claim 38, wherein the conveyor moves the bulk material received from the
bulk material storage container in a first direction and solids received from the filter assembly in
an opposite second direction.

CHAPTER B – DOCKET 19651**BULK MATERIAL RETRIEVAL AND TRANSPORT SYSTEM AND METHODS****Technical Field**

5 [00175] This patent application discloses innovations to bulk material handling and, more particularly, to systems and methods of retrieving and transporting bulk materials.

Background

10 [00176] A conventional glass “batch house” includes a custom architectural installation specifically designed for glass manufacturing, and a glass batch handling system supported and sheltered by the architectural installation. The batch house is generally configured to receive and store glass feedstock, or “glass batch” materials, including glassmaking raw materials, for example, sand, soda ash, and limestone, and also including cullet in the form of recycled, scrap, or waste glass. The conventional glass batch house requires a specialized, dedicated, and
15 permanent architectural installation including a tall building and a covered receiving platform and pit to receive glass batch from underneath railcars or trucks that arrive loaded with glass batch materials. The batch house also includes multi-story silos to store the glass batch, and glass batch elevators and conveyors to move the glass batch from receiving systems at a bottom of the pit to tops of the silos. The batch house further includes cullet pads at ground level to
20 receive and store cullet, crushers to crush cullet to a size suitable for melting, and cullet elevators and conveyors to move crushed cullet to one of the silos in the batch house. The batch house additionally includes a mixer to mix the glass batch received from the silos, conveyors integrated with scales to weigh and deliver each glass batch material from the silos to the mixer, mixer conveyors to move the glass batch from the mixers to the hot-end subsystem, and dust collectors
25 to collect dust from the various equipment. The installation occupies a large footprint and a large volumetric envelope, takes about one to two years to construct, cannot be relocated from one location to another, and tends to be a dusty and dirty environment.

Summary of the Disclosure

30 [00177] The present disclosure embodies a number of aspects that can be implemented separately from or in combination with each other.

CHAPTER B – DOCKET 19651

[00178] Embodiments of a bulk material transporter include a hollow transport bin having an inlet and an outlet, an inlet closure having an open position for receiving bulk material and a closed position for blocking the inlet while not actively receiving bulk material, an outlet closure having an open position for discharging bulk material from the bin and a closed position blocking the outlet while not actively discharging bulk material, and a cradle that supports the bin in an upright orientation during receiving of bulk material through the inlet and discharging of bulk material through the outlet. The outlet is located at a tapered bottom portion of the bin, and the cradle supports the bin along a perimeter of the bin.

[00179] Embodiments of a bulk material transport unit include a table, a scale supported by the table, and a transport bin supported by the scale. The table, scale, and transport bin are together moveable among a plurality of locations along a floor, and the scale is in communication with a controller configured to receive information pertinent to an amount of bulk material contained by the transport bin.

[00180] Embodiments of a material handling method include coupling a transport bin with a bulk material container, forming a reduced pressure region at least at an inlet of the transport bin, and dispensing bulk material from the bulk material container and into the transport bin through the reduced pressure region.

[00181] Embodiments of a material handling method include measuring an amount of glass feedstock dispensed from a bulk material storage container using a mobile scale.

Brief Description of the Drawings

[00182] FIG. 1A is a perspective view of a bulk material handling system in accordance with an illustrative embodiment of the present disclosure, illustrating a building having a roof, cladding, elevator, stairs, ladders, and platforms.

[00183] FIG. 1B is another perspective view of the system corresponding to FIG. 1A, without the roof, cladding, elevator, and ladders.

[00184] FIG. 2A is a different perspective view of the system of FIG. 1A, illustrating the building with the roof, cladding, elevator, stairs, ladders, and platforms.

[00185] FIG. 2B is another perspective view of the system corresponding to FIG. 2A, without the roof, cladding, elevator, and ladders.

[00186] FIG. 3 is a top view of the system of FIG. 1A.

CHAPTER B – DOCKET 19651

- [00187] FIG. 4 is a bottom view of the system of FIG. 1A.
- [00188] FIG. 5 is an end view of the system of FIG. 1A.
- [00189] FIG. 6 is another end view of the system of FIG. 1A opposite that of FIG. 5.
- [00190] FIG. 7 is a side view of the system of FIG. 1A.
- 5 [00191] FIG. 8 is another side view of the system of FIG. 1A opposite that of FIG. 7.
- [00192] FIG. 9 is a perspective view of a modular frame of the system of FIG. 1A.
- [00193] FIG. 10 is a perspective view of various modules of the system of FIG. 1A.
- [00194] FIG. 11 is another perspective view of various modules of the system of FIG. 1A opposite that of FIG. 10.
- 10 [00195] FIG. 12 is another perspective view of various modules of the system of FIG. 1A.
- [00196] FIG. 13 is another perspective view of various modules of the system of FIG. 1A opposite that of FIG. 12.
- [00197] FIG. 14 is an isometric view of an illustrative bulk material transport unit.
- [00198] FIG. 15 is an isometric view of the transport unit of FIG. 14 illustrating its
- 15 separable components.
- [00199] FIG. 16 is an isometric top view of a vehicle of the transport unit of FIG. 14.
- [00200] FIG. 17 is an isometric bottom view of the vehicle of FIG. 16.
- [00201] FIG. 18 is a plan view of the transport unit of FIG. 14 at a first bulk material dispenser.
- 20 [00202] FIG. 19 is a plan view of the transport unit of FIG. 14 at a second bulk material dispenser.
- [00203] FIG. 20 is a plan view of the transport unit of FIG. 14 at a third bulk material dispenser.
- [00204] FIG. 21 is an isometric view of a bulk material transporter of the transport unit of
- 25 FIG. 14.
- [00205] FIG. 22 is a perspective view of an inlet of the transporter of FIG. 21.
- [00206] FIG. 23 is a perspective view of an outlet of the transporter of FIG. 21.
- [00207] FIG. 24 is a schematic representation of a docking assembly uncoupled from a transport bin inlet.
- 30 [00208] FIG. 25 is a schematic representation of the docking assembly of FIG. 24 coupled with the transport bin inlet.

CHAPTER B – DOCKET 19651

[00209] FIG. 26 is a perspective view of a weighing platform of the transport unit of FIG. 14.

[00210] FIG. 27 is a perspective view of a charging interface of the platform of FIG. 26.

[00211] FIG. 28 is a perspective view of an uncoupled inlet of the transport unit of FIG. 14.

[00212] FIG. 29 is a perspective view of a coupled inlet of the transport unit of FIG. 14.

[00213] FIG. 30 is a perspective view of the transport unit of FIG. 14 coupled with a bulk material dispenser.

[00214] FIG. 31 is a schematic plan view of a transport unit at a first bulk material dispenser.

[00215] FIG. 32 is a schematic plan view of a transport unit at a second bulk material dispenser.

[00216] FIG. 33 is a schematic plan view of a transport unit at a third bulk material dispenser.

Detailed Description

[00217] In general, a new bulk material handling system is illustrated and described with reference to a glass feedstock handling system for a glass container factory as an example. Those of ordinary skill in the art would recognize that other glass factories, for example, for producing glass fibers, glass display screens, architectural glass, vehicle glass, or any other glass products, share many aspects with a glass container factory. Accordingly, the presently disclosed and claimed subject matter is not necessarily limited to glass containers, glass container feedstock handling systems, and glass container factories and, instead, encompasses any glass products, glass product feedstock handling systems, and glass product factories. Moreover, the presently disclosed and claimed subject matter is not necessarily limited to bulk material handling for the glass industry and, instead, encompasses any products, bulk material handling systems, and factories in any industry in which bulk material handling is useful.

[00218] Although conventional glass batch houses and methods enable efficient production of high-quality products for large-scale production runs, the presently disclosed subject matter facilitates implementation of a revolutionary bulk material handling system that is simpler than a conventional batch house, is modular and mobile, and is more compact and

CHAPTER B – DOCKET 19651

economical at least for smaller scale production runs or incremental additions to existing large-scale production runs. More specifically, in accordance with an aspect of the present disclosure, a new bulk material handling system may include prefabricated modular equipment configurations to facilitate rapid and mobile production capacity expansion in smaller increments and at lower capital cost than conventional glass batch houses, and also may include techniques for handling bulk material in a dust-free or reduced dust manner. Further, the new system may omit one or more conventional glass batch house subsystems or aspects thereof, as described in further detail below.

[00219] With specific reference now to FIGS. 1A through 8, a new bulk material handling system 10 includes a new architectural installation 12 and new subsystems and equipment supported and sheltered by the installation 12. The installation 12 includes a concrete foundation 14 having a floor which may include, for example, a four to six-inch-thick slab, and a bulk material handling building 16 on the foundation including walls 18 and a roof 20. The installation 12 requires no basement and no pit below the floor, such that the concrete foundation has earthen material directly underneath, wherein the foundation slab establishes the floor. As used herein, the term “pit” includes an elevator pit, conveyor pit, loading pit, and the like, located below grade or below ground level and that may require excavation of earthen material. As used herein, the term “basement” includes the lowest habitable level of the bulk material handling building below a floor of the building and can include a first level or a below grade or below ground level portion that may require excavation of earthen material.

[00220] The installation 12 also includes multiple habitable levels, including a base or first level 21, an intermediate or second level 22, an upper or third level 23, and an attic or fourth level 24. Also, as used herein, the term “habitable” means that there is standing room for an adult human in the particular space involved and there is some means of ingress/egress to/from the space while walking such as a doorway, stairway, and/or the like. The installation 12 further includes egress doors 26, egress platforms 27, stairs 28, ladders 30, and an elevator 32 to facilitate access to the egress platforms 27 and doors 26. The installation 12 additionally includes loading doors 34, loading platforms, and one or more ramps. Notably, the building 16 is constructed of many modules, including modular walls used to construct a base frame for the first level, and modular frames for the second, third, and fourth levels, as will be discussed in detail below.

CHAPTER B – DOCKET 19651

[00221] With continued reference to FIGS. 1A through 8, the bulk material handling system 10 includes several subsystems that occupy a volumetric envelope much smaller than conventional batch houses such that the system 10 likewise requires a smaller volumetric envelope than conventional glass batch houses. The bulk material handling system 10 may be a glass bulk material handling system configured to receive and store glass feedstock or “glass batch.” The glass batch includes glassmaking raw materials, including glass feedstock “majors” and “minors” and also may include cullet in the form of recycled, scrap, or waste glass. The bulk material handling system receives glass batch bulk materials and combines them into doses and provides the doses to a downstream hot-end system of a glass factory adjacent to or part of the bulk material handling system.

[00222] The bulk material handling system 10 includes one or more of the following subsystems. A first bulk material, or majors, subsystem 38 is configured to receive, pneumatically convey, store, and gravity dispense majors bulk material. Glassmaking majors may include sand, soda, limestone, alumina, saltcake, and, in some cases, dust recovery material. Similarly, a second bulk material, or minors, subsystem 40 is configured to receive, pneumatically convey, and store minors bulk material from individual bulk material bags. Glassmaking minors may include selenium, cobalt oxide, and any other colorants, decolorants, fining agents, and/or other minors materials suitable for glassmaking. A bulk material discharging subsystem 54 is configured to receive bulk material from the majors and minors subsystems 38, 40 and transmit the bulk material to downstream bulk material processing equipment, for example, a glass melting furnace separate from and downstream of the bulk material handling system 10. A bulk material transfer or transport subsystem 44 is configured to receive bulk material from the majors and minors subsystems 38, 40, and transport the bulk material within, to, and from, the majors and minors subsystems 38, 40, and to and from the discharge subsystem 42. A controls subsystem 46 is in communication with various equipment of one or more of the other subsystems 38, 40, 42, 44, and is configured to control various aspects of the system 10. Those of ordinary skill in the art would recognize that the system 10 can be supplied with utility or plant electrical power, and can include computers, sensors, actuators, electrical wiring, and the like to power and communicate different parts of the system 10 together. Likewise, the system 10 can be supplied with plant or compressor pneumatic

CHAPTER B – DOCKET 19651

power/pressure, and can include valves, lubricators, regulators, conduit, and other like pneumatic components to pressurize and communicate different parts of the system 10 together.

[00223] The system 10 may be pneumatically closed from pneumatic input or receiving conduit 39 of the majors subsystem 38 to pneumatic output or transmitting conduit 43 of the discharging subsystem 54. The pneumatic receiving conduit 39 may extend through one or more walls of the building for accessibility to bulk transporters, e.g., trucks or rail cars, that bring bulk materials and that may have pressurized vessels to assist with pneumatic receiving and conveying of bulk material. The receiving conduit 39 has any suitable couplings for coupling to bulk transporters in a pneumatically sealed manner, wherein the bulk transporters may have pumps, valves, and/or other equipment suitable to pressurize the receiving conduit to push bulk material into the majors subsystem 38 and/or the batch handling system 10 itself may include pumps, valves, pressurized plant air plumbing, and/or other equipment suitable to apply positive and/or negative (vacuum) pressure to the input conduit to push and/or pull bulk material into the majors and minors subsystems 38, 40.

[00224] The transmitting conduit 43 may extend through one or more walls or the roof of the building for transmission to downstream bulk material processing equipment, for instance, in a hot end subsystem of a glass manufacturing system (not shown). For example, the transmitting conduit 43 is pneumatically sealingly coupled to a receiver hopper at a glass melter in the hot end subsystem. The conduit 43 may have any suitable couplings for coupling to the receiver hopper in a pneumatically sealed manner. Those of ordinary skill in the art would recognize that the bulk material handling system is pneumatically closed between the pneumatic receiving conduit and the pneumatic transmitting conduit. This is in contrast to conventional systems where bulk material is open to the surrounding environment. The phrase “pneumatically closed” means that the path, and the bulk materials following that path, from receiving conduit to transmitting conduit is/are enclosed, and not openly exposed to the surrounding environment, although not necessarily always sealed air-tight.

[00225] With reference to FIG. 9, a representative modular wall 48 of the first level 21 of the building is constructed as a rectangular truss, having a longitudinal axis L and a vertical axis V, and including lower and upper beams 48a,b extending longitudinally and being vertically opposed from one another. The wall 48 also includes vertically extending end posts 48c and intermediate posts 48d longitudinally between the end posts 48c, and struts 48e extending

CHAPTER B – DOCKET 19651

obliquely between the beams and connected to the posts 48c,d. The modular wall 48 is preassembled at an equipment fabricator, shipped from the fabricator to a product manufacturer, and is erected at the product manufacturer. The modular wall has exterior dimensions less than or equal to exterior dimensions of an intermodal freight container, more specifically, a height
5 less than or equal to 9' 6" (2.896 m), a width less than or equal to 8' 6" (2.591 m), and a length less than or equal to 53' (16.154 m). As best illustrated in FIGS. 2B, 7, 8, and 10-13, the modular wall 48 may be used as a portion of a base frame establishing the habitable first level of the system and spanning the majors subsystem, the minors subsystem, and the discharging subsystem. In the majors subsystem, the system also includes a dispensing level frame
10 constituted from two of the horizontal modular dispensing frames 50 of FIG. 10 situated side-by-side and carried on the base frame, and a storage container frame constituted from eight of the vertical modular container frames 52 of FIG. 11 situated in a 4 x 2 array carried on the dispensing level frame.

[00226] With reference to FIGS. 10-13, select modules of the installation 12 are shown to
15 generally illustrate relevant portions of the overall system 10 with which the bulk material transport system 44 interacts. A primary component of the bulk material transport system 44 is a mobile bulk material transport unit 100, which is able to move among different locations of the installation 12. As discussed further below, the transport unit 100 is also separable into certain components or groups of components. As illustrated in FIGS. ##-13, the system 44 may include
20 more than one transport unit 100 or parts of transport units. The main operating envelope of the transport system 44 is on the first level 21 of the building. Each transport unit 100 of the system 44 is configured to be moved among various locations along the floor of the first level 21 of the building, including a plurality of locations beneath bulk material dispensing modules 200 and dispensers 210 of the majors subsystem 38, a plurality of locations beneath bulk material
25 dispensing modules 300 and dispensers 310 of the minors subsystem 38, and at least one location of a handling module 400 and handling station 410, where the transport unit 100 may be separated into individual components for its transported contents to be discharged into a transmission vessel 500 of the discharging subsystem 54 for subsequent processing at a melting furnace, for example, or into a reject material vessel. Although the transport units 100 may not
30 physically interact with the controls subsystem 46, components of each transport unit 100 may be in real-time communication with a control module of the controls subsystem 46, and the bulk

CHAPTER B – DOCKET 19651

material transport system 44 may be considered to comprise certain elements of the control module and controls subsystem.

[00227] FIGS. 14 and 15 are isometric views of an illustrative bulk material transport unit 100, which includes a bulk material transport assembly 102 supported by a vehicle 104. The transport assembly 102 and vehicle 104 are configured to move together along the floor of the installation 12 among a plurality of locations, but they are also separable from one another such that the vehicle 104 can move the transport assembly 102 to one location, detach itself from the transport assembly, and move itself to a different location, such as to the location of a different transport assembly 102 of the system 44 to temporarily become part of a different transport unit 100.

[00228] The transport assembly 102 includes a transporter 106 supported by a weighing platform 108, which includes a table 110 and a scale 112. The scale 112 is supported by the table 110, and the transporter 106 is supported by the scale 112 when part of the transport assembly 102. The transporter 106 and vehicle platform 108 are configured to move together along the floor of the installation 12 among a plurality of locations when supported by a vehicle 104, but they are also separable from one another such that the transporter 104 can be detached from the platform 108 at one location and the platform 108 can be moved by the vehicle 104 or other means to a different location.

[00229] Each transport unit 100 thus includes multiple distinct components 104, 106, 108 that are configured to move to various locations together and that are separable from each other such that they can all be at different locations at one time. The system 44 may therefore include different numbers of vehicles 104, transporters 106, and platforms 108 used in different combinations to form transport assemblies 102 and/or transport units 100. In some embodiments, the system 44 includes only one vehicle 104 and a plurality of transport assemblies 102, or a higher number of transporters 106 and weighing platforms 108 than vehicles 104.

[00230] With reference to FIGS. 16 and 17, the vehicle 104 may be an automated guided vehicle (AGV), including a body 114, a drive/steer system 116, a platform 118, a power source charging system 120, and a guidance system (not shown). The body 114 is the main structure of the AGV 104 to which the drive/steer system 116 and platform 118 are affixed and which protects many of the electric and electronic components therebeneath. The drive/steer system 116 propels the vehicle 104 along the ground via one or more motorized drive wheels and rotates

CHAPTER B – DOCKET 19651

the drive wheel or a non-drive wheel about a vertical axis to steer the vehicle. The drive/steer system 116 may include independent drive and steering components as well. The guidance system uses the drive/steer system to guide the AGV 104 along a desired path. Various guidance systems can be used, such as a sensor system that detects an electric or magnetic field produced by components along the ground and drives and steers the AGV to follow the field, or the AGV may be programmed with several distinct coordinate locations along the ground—such as fixed docking locations where bulk materials may be dispensed—and receive wirelessly communicated instructions from the controls subsystem 46 relating to the next destination of the vehicle 104.

[00231] The illustrated drive/steer system 116 provides zero-turning radius movement, meaning that the vehicle 104 can make 90-degree turns by stopping movement in one direction, steering the drive wheel(s) 90 degrees about a vertical axis, then powering the drive wheel(s) again to move in a new perpendicular direction. In some embodiments, the larger system 10 may be strategically laid out to minimize the number of turns the vehicle must make while retrieving and transporting bulk materials from different locations. The plan views of FIGS. 18-20 illustrate an example. In FIG. 18, the transport unit 100 is at a first location beneath a dispenser 210 of a dispenser array, in which the dispensers are spaced at regular intervals. After receiving bulk material from the dispenser at the first location, the AGV 104 moves the transport assembly to a second location to dock with a different dispenser of the array (FIG. 19) to receive another bulk material, and then moves in a perpendicular direction to a third location to dock with another dispenser of the array (FIG. 20) to receive another bulk material. In this manner, wasted turning movements are eliminated. As shown in FIG. 11, for example, the handling station 410 of the handling module 400 may be aligned with one row of the array of dispensers 210 to achieve further straight-line movement. And while the dispensers 310 of the minors subsystem are not perfectly in-line with the dispensers 210 of the majors subsystem, they can be nearly aligned and/or aligned with each other in a perpendicular direction. The vehicle 104 can thus be moved along the floor of the installation in the manner of chess pieces on a chess board, with faces of the AGV 104 always facing in the same direction.

[00232] Returning now to FIGS. 16-17, the illustrated platform 118 is vertically movable with respect to the body 114 of the AGV 104 such that the AGV can maneuver beneath the transport assembly 102 and extend the platform upward from a retracted position to lift the

CHAPTER B – DOCKET 19651

transport assembly 102 off of the ground for relocation as a complete transport unit 100. As illustrated in FIG. 16, the platform 118 may include one or more locators 122 that mate with complimentary locators along a bottom side of the table 110 of the weighing platform 108. The mating locators 122 ensure that the transport assembly 102 is in a known position with respect to the underlying vehicle 104, which is the part of the unit 100 being guided. Alternatively, the transport assembly may be equipped to change its own height to lower itself onto the vehicle 104 and/or lift itself from the vehicle when necessary to respectively be moved or stay in place.

[00233] The power source charging system 120 is a wireless battery charger, such as an inductive charger. A mating part of the charging system may be located at any one or more of the various locations to which the transport unit 100 normally travels. In one embodiment, the mating part of the charging system is located along the floor at the transport handling station 410. Other charging arrangements may be employed.

[00234] While AGVs offers a great degree of flexibility as vehicles 104 of the transport system 44, an AGV is not required. Any sort of vehicle capable of moving the transport assembly 102 from location-to-location may be used, whether a forklift, a pallet jack, a hand cart, or an overhead lift.

[00235] Turning now to FIGS. 21-23, the bulk material transporter 106 includes a hollow transport bin 124 supported by a frame-like cradle 125 and having an inlet 126 at a first or top end 128, and an outlet 130 at a second or bottom end 132. The illustrated transport bin 124 is formed as a wall 134 that at least partially defines the hollow interior of the bin and an exoskeleton 136 that extends along an exterior of the wall 134 and interconnects the inlet 126 and outlet 130 of the bin. A central portion 138 of the wall 134 is cylindrical, a lower portion 140 of the wall is generally conical, tapering down toward the outlet 130, and an upper portion 142 of the wall has a concave exterior or frustoconical shape and carries the inlet 126. The upper portion 142 may be separable from the remainder of the wall 134 in the form of a removable lid.

[00236] At least a portion of the wall 134 of the bin 124 may be formed from a polymer-based material. Polymer-based materials can offer a significant weight savings over metal, and in some cases can be more wear resistant. The polymer-based material may also be a pliable material. Here, “pliable” means the material is elastically deformable in a flexural mode and will return to its original shape after deformation. The pliable material is preferably an elastomeric material, such as a vulcanized rubber material or a polyurethane rubber. Given the heavy loads of

CHAPTER B – DOCKET 19651

bulk material to be carried by the bin 124, it may have a substantial wall thickness on the order of 15-25 mm. Using polymeric materials for batch containers with such heavy bulk materials (e.g., sand, limestone, etc.) is unconventional. However, it has been found that use of a pliable wall material facilitates discharge of the bulk material from the bin after all bulk materials have
5 been received by the bin. In particular, the pliable wall 134 can be purposefully and locally deformed to break-up the very dense conglomeration of particulate bulk material in the bin during discharge from the outlet. A traditional metal bin can of course not be elastically deformed—meaning that, if the heavy load of particulate bulk material is compacted too much to drain from the bin via gravity feed, the only way to break the compacted material away from the
10 wall is scraping along the inside of the bin wall.

[00237] Use of a pliable material in wall of the transport bin 124 is made possible in part by the exoskeleton 136. The exoskeleton 136 is formed from a rigid, non-pliable material such as a metallic material (e.g., steel) or a highly reinforced polymer composite (e.g., a fiberglass or carbon fiber composite). In the illustrated example, the exoskeleton 136 includes circumferential
15 bands 144 along the central portion and lower end of the bin wall and longitudinal ribs 146 interconnecting all of the circumferential bands. The portion of the exoskeleton 136 along the lid or upper portion 142 of the bin wall has an annular portion 148 at the outer edge, a standing portion 150 surrounding the inlet 126, and radial ribs 152 interconnecting those portions in alignment with the longitudinal ribs 146 of the central and lower portions. The exoskeleton 136
20 also provides locations for attachment of the transport bin 124 to the cradle 125.

[00238] The cradle 125 is frame-like in construction and may be constructed from tubular steel members or the like. The cradle 125 includes a bottom 153 having a polygonal (e.g., rectangular) perimeter formed from multiple bottom frame members 154 arranged end-to-end. The illustrated cradle bottom 153 additionally includes angled reinforcing members 156
25 interconnecting adjacent bottom frame members 154. The cradle 125 further includes upright members 158 extending from corners of the bottom 153 to a free end 160. Engagement features 162 are provided at the ends 160 of the uprights 158. In this example, the engagement features 162 are in the form of hooks or downward facing cut-outs and can be used by other machinery of the larger system 10 to lift the transporter 106, such as a handler or elevator of the handling
30 module 400. Other engagement features are possible, including but not limited to pins or posts, pin-receiving apertures, latches, pulleys, etc. Finally, the illustrated cradle 125 includes radial

CHAPTER B – DOCKET 19651

braces 164 extending from each upright to interconnect the cradle with the transport bin 124 via the top circumferential band 144 and the bin wall 134. Additional bracing 166 is provided between the cradle 125 and the exoskeleton 136 near the outlet 130 of the transporter 106.

[00239] Notably the cradle 125 is constructed such that it fully supports the weight of the transport bin 124 only along the perimeter of the bin, and the upper end of the cradle is open—i.e., there are no cross-members boxing off the ends 160 of the uprights 158 as with a traditional support frame. The illustrated construction permits the inlet 126 to be located above the cradle 125 so that the cradle does not interfere with dosing or docking equipment, yet still provides structure for lifting the transporter 106 when not receiving bulk material from a material dispenser. As shown in FIG. 23, a central portion of the bottom 152 of the cradle is also open and accessible for being coupled with a different receiving vessel in a relatively dust-free manner when discharging the contents of the bin 124.

[00240] The transporter 106 includes an inlet closure 168 at the inlet 126 and an outlet closure 170 at the outlet 130. Each closure 168, 170 has an open position and a closed position. When the inlet closure 168 is in the open position, the hollow inner volume of the bin 124 can be accessed through the inlet 126, and bulk material can be received into the bin from above. When the inlet closure 168 is in the closed position, access to the inner volume of the bin 124 is blocked by the closure. In the illustrated example, the inlet closure 168 comprises a pair of doors 172. For purposes of illustration, one door 172 is illustrated in the closed position (horizontal and partially spanning the inlet 126), and the other door is illustrated in the open position (vertical and extending downward toward the internal volume of the bin). The doors or other closure elements are biased toward the closed position (e.g., via a spring) or otherwise are normally kept in the closed condition until some action is taken to open the inlet 126. In this example, each door 172 is hinged and pivots about an axis near an edge of the inlet 126 against a bias. The closure 168 includes levers 174 fixed to the hinge pins of each door 172 that operate to open the respective door when pressed downward from above.

[00241] A schematic representation of the operation of the illustrated inlet closure 168 is provided in FIGS. 24 and 25. An illustrative docking assembly 212 has an upper portion 214 coupled with a stationary bulk material dispenser and a lower portion 216 that moves under the power of actuators 218. When uncoupled, such as before or after dispenser operation as in FIG. 24, the closure 168 is in the closed position. During docking and before dispensing, downward

CHAPTER B – DOCKET 19651

movement of the lower portion 216 of the docking assembly 212 contacts the levers 174 of the closure 168. Continued downward motion of the docking assembly opens the closure 168 as in FIG. 25, and the closure remains in the open position as long as the transporter 106 is docked. When the docking assembly 212 moves away from the transporter, the closure returns to the closed position of FIG. 24. This is but one example of an inlet closure 168. Other types of doors or other physical barriers that can be opened, moved aside, or can otherwise be made to closably permit access to the internal volume of the bin 124 can be employed.

[00242] When the outlet closure 170 is in the closed position, as in FIG. 23, access to the inner volume of the bin 124 is blocked by the closure, and any bulk material contained in the bin is not permitted to escape the bin under the influence of gravity. When the outlet closure is in the open position, the inner volume of the bin is connected with the space below the bin, and any bulk material contained in the bin are permitted to escape through the outlet 130. As with the inlet closure 168, the outlet closure 170 is biased toward or otherwise normally kept in the closed position until some action is taken to open the outlet 130. In the illustrated example, the outlet closure 170 is a hinged plate slightly recessed in the outlet 130. The hinge pins of the plate lie along a pivot axis extending through the center of the round plate. One side of the hinge pins is operatively coupled with a mechanical transmission 176.

[00243] The transmission 176 is carried by the cradle 125 and includes a rotational input 178, a gearbox 180, and a linkage 182. The rotational input 178 is a friction wheel or gear that is accessible from below and/or from the transmission side of the cradle 125 and is configured to rotate about a horizontal axis. The gearbox 180 transmits rotation of the input 178 to the linkage 182 and changes the axis of rotation by about 90 degrees (e.g., via bevel gears or a worm gear). The rotating linkage 182 causes the closure to pivot about its axis to change the closure between the open and closed positions, depending on the direction of rotation of the rotational input. Where the rotational input 178 is a friction wheel, a mating friction wheel of another portion of the overall system can be pressed on the wheel and rotated in one direction to open the closure 170, to thereby discharge the contents of the bin 124 into an underlying receiving vessel, and in the opposite direction to close the closure to prepare the bin to be refilled. This is of course only one example of a suitable closure, as nearly any movable barrier can serve the same purpose of opening and closing the outlet 130 of the transporter 106.

CHAPTER B – DOCKET 19651

[00244] With reference to FIG. 26, the weighing platform 108 is essentially a mobile scale, including a table 110 and a scale 112 that are attached together for movement together from location to location by the vehicle 104. This mobile scale is new to the bulk material handling industry, and particularly to glass feedstock handling. Conventionally, bulk material dispensing from enormous silos into an open-top vessel supported by a platform built-in to the floor with stationary load cells used to weigh out the discharged material. The presently disclosed transport system 44 and transport units 100 go against convention and provide an essentially dust-free environment in which a more accurate mobile scale can effectively operate and communicate with dosing equipment for high precision measurement and dispensing of bulk materials.

[00245] The table 110 includes a deck 184 with an upward facing surface that is flat or otherwise shaped to properly support the scale 112 from below. The illustrated table 110 also includes legs 186 extending downward from the deck 184 and an upwardly extending lip 188 along opposite edges of the deck 184. The illustrated table 110 carries a wireless charging receiver 190 coupled with the battery of the scale 112 and configured to link to a wireless charging transmitter. In one embodiment, the system 10 includes a wireless charging transmitter at a particular location where the transport unit is often parked, such as at the above-described handling module 400 of the system. FIG. 27 depicts the transport unit parked at one such location.

[00246] The legs 186 of the table 110 or assembly 102 are spaced to accommodate the AGV 104 or other lifting vehicle moving beneath the deck 184 from outside the perimeter of the deck. In this case, the legs 186 are spaced apart by slightly more than the width of the system AGV 104 so that the AGV can move beneath the deck from an external location, lift the transport assembly 102 or weighing platform 108 to relocate it, lower the transport assembly or platform 108 at the new location, and move out from beneath the deck 184 in the same or opposite direction.

[00247] The scale 112 is a high-capacity industrial scale, may have a capacity of approximately 2000 lbs., and may be in wireless communication with a controller 190 that monitors the weight on the scale 112 in real-time. The controller 190 may be in communication with or a part of the controls subsystem 46, which is capable of controlling bulk material dispensing equipment, such as the above-mentioned dispensers 210 based on the information

CHAPTER B – DOCKET 19651

communicated from the scale 112. The controller 190 may also be capable of taring the scale 112 once the transport assembly 102 is docked with a dispenser assembly.

[00248] In some embodiments, the controls subsystem 46 monitors the amount of bulk material dispensed into the transport bin 124 in real-time and compares that amount to a desired amount. When the amount dispensed approaches the desired amount and is within about 10% of the desired amount, the controls subsystem can change a dispensing rate to a slower rate for the final amount of bulk material and thereby achieve relatively precise dispensing. Real-world results of +/-0.1% or lower have been achieved with this system. Various arrangements of communication with the scale, both wired and wireless, and associated control of bulk material dispensing are possible. The transport assembly 102 includes a transporter 106 supported by a weighing platform 108, which includes a table 110 and a scale 112.

[00249] The above-described bulk material transport system 44, transport assembly 102, and transport unit 100 are useful in a bulk material handling method. With reference to FIGS. 28-30, the method may include coupling the transport bin 124 with a bulk material container (not shown) via a bulk material dispenser 210, forming a reduced pressure region at least at the inlet 126 of the transport bin, and dispensing bulk material from the bulk material container and into the transport bin through the reduced pressure region. FIG. 28 illustrates the inlet 126 of a bulk material transporter 106 and transport bin 124 before coupling or docking. FIGS. 29-30 illustrates the transporter 106 docked or otherwise coupled with the bulk material dispenser 210. Here, the transport bin 124 is coupled with the dispenser 210 when the lower portion 216 of the docking assembly 212 of the dispenser moves downward and makes interfacial contact with the perimeter of the inlet 126. Other manners of coupling are possible, including overlapping or interlocked couplings. In the illustrated example, the coupling step also opens the inlet closure 168 as described above.

[00250] After coupling, the reduced pressure region is formed at the coupled inlet 126 by pulling a vacuum on the combined hollow volume of the transport bin 124 and the docking assembly 212. In this example, a vacuum or negative pressure (-P) is applied via a vacuum port and conduit 220 in communication with the internal volume of the docking assembly. The resulting low pressure region within the docking assembly 212 and transport bin 124 ensures that the dust- or solids-laden air displaced from the transport bin 124 during dispensing does not escape the coupled system. The scale 112 is then tared (i.e., set to zero), and dispensing begins

CHAPTER B – DOCKET 19651

via a bulk material conveyor atop the docking assembly 212 or other means. As the dispensed amount, according to the scale 212, approaches the desired amount, dispensing may be slowed as described above and finally halted when the desired amount is obtained. The docking assembly 212 may then uncouple from the transport bin 124, which causes the inlet closure 168 to return to the closed position. If the vehicle 104 that brought the transport assembly 102 to the dispenser 210 has since departed, it or another vehicle can then return to lift the transport assembly and relocate it to another bulk material dispenser or to the handling module 400 for further processing.

[00251] The above-described system can strategically result in a layered or stratified configuration of different types of bulk materials in the transport bin 124 as follows. With reference to FIGS. 31-33, an illustrative bulk material handling method may include first locating the bulk material transport unit 100 at a first bulk material dispenser 210 of the system 10 (FIG. 31), coupling the transport bin with the dispenser 210 and receiving a first type of bulk material in the transport bin, uncoupling the transport bin from the first dispenser 210, relocating the transport unit 100 or the associated transport bin to a second bulk material dispenser 310 (FIG. 32), coupling the transport bin with the second dispenser 310 and receiving a second type of bulk material in the transport bin, uncoupling the transport bin from the second dispenser 310, relocating the transport unit 100 or the associated transport bin to a third bulk material dispenser 210' (FIG. 33), and coupling the transport bin with the third dispenser 210' and receiving a third type of bulk material in the transport bin.

[00252] The result is a layered or stratified configuration of at least three different types of bulk material in the transport bin. While this may no be surprising on its own, the order in which the different bulk materials are dispensed can be made advantageous in some instances. In the illustrated example, the first and third dispensers 210, 210' are in the majors subsystem 38, and the second dispenser 310 is in the minors subsystem 40. The amount of material dispensed at the minors subsystem may be significantly less than at the dispensers of the majors subsystem. Indeed, in embodiments where the bulk material handling system is a glass feedstock handling system, the amount of minors feedstock added to the transport bin in a typical batch is too low to be accurately weighed using the same scale 112 as that used with the majors feedstock, and the minors feedstock materials must therefore be weighed separately from the majors feedstock before dispensing instead of during dispensing.

CHAPTER B – DOCKET 19651

[00253] Interposing the relatively small layer of minors feedstock between relatively large layers of majors feedstock helps ensure the accuracy of the batch mixture upon discharge from the transport bin. In other words, such a layered structure of bulk materials keeps the small amount of minors feedstock away from the walls of the bin so that all of it is discharged with the full mixture. If, for example, the minors feedstock is added to the transport bin last, the small amount that may stick to the walls of the transport bin could be a significant percentage of the total amount of minors feedstock required in the batch.

[00254] It is noted that the illustrated number and arrangement of modules of the above-described system 10 is merely illustrative. For example, the illustrated bulk material dispensing modules 200 which form a 2 x 4 array of bulk material dispensers 210 can be expanded to a 3 x 4 array or a 4 x 4 array by adding additional modules 200. Or the installation 12 can be constructed with only one dispensing module 200 and a 1 x 4 array of dispensers 210. The same can be said for the minors-side modules 300 and dispensers 310. The added storage and dispensing capacity may also require expansion of the transport system 44 via additional transporter units 100, transporter assemblies 102, or vehicles 104. It is contemplated that a single AGV or other lift and transport vehicle 104 can offer sufficient capacity in an installation sized as that in the figures by moving multiple transport assemblies 102 from place to place. In another example of modularity, the majors and minors array may be expanded to provided bulk material batches that feed two different hot-side facilities with their own melting furnaces and post-melt shaping capabilities. In that case, additional handling modules 400 may be easily added to the discharging subsystem, including an additional transmission vessel 500, for example. Or an additional handling module and/or transmission vessel may be added to feed two separate hot-side facilities, even without expansion of the majors and minors relative capacities—for example, two different melt furnaces processing two very different glass formulations may be fed from the same transport subsystem via separate transmission vessels. The modular construction of the installation provides this and other types of flexibility without a total redesign of the facility.

CHAPTER B – DOCKET 19651**Example claims for Chapter B (Docket 19651) include the following:**

1.

A bulk material transporter, comprising:

a hollow transport bin having an inlet and an outlet, the outlet being located at a tapered

5 bottom portion of the bin;

an inlet closure having an open position for receiving bulk material and a closed position for blocking the inlet while not actively receiving bulk material;

an outlet closure having an open position for discharging bulk material from the bin and a closed position blocking the outlet while not actively discharging bulk material; and

10 a cradle that supports the bin in an upright orientation during receiving of bulk material through the inlet and discharging of bulk material through the outlet, wherein the cradle supports the bin along a perimeter of the bin.

2.

15 The transporter of claim 1, wherein the cradle supports the bin only along said perimeter.

3.

The transporter of claim 1, wherein at least a portion of a wall of the transfer bin is formed from a pliable material.

20

4.

The transporter of claim 3, further comprising a rigid exoskeleton extending along an exterior of the bin to maintain a shape of the pliable material when the bin contains bulk material and to attach the bin to the cradle.

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5.

The transporter of claim 1, wherein a wall of the transfer bin comprises a polymer.

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CHAPTER B – DOCKET 19651

6.

The transporter of claim 1, wherein the cradle includes structural uprights spaced about the bin and interconnected by bottom members, and wherein upper ends of the structural uprights are not interconnected by cross-members.

5

7.

The transporter of claim 6, wherein each structural upright is affixed to the bin by a radial member.

10

8.

The transporter of claim 1, further comprising a transmission affixed to the cradle and configured to operate the outlet closure when actuated.

9.

15

The transporter of claim 1, further comprising engagement features by which the transporter can be vertically raised and lowered.

10.

A bulk material transport unit, comprising:

20

a table;

a scale supported by the table; and

a transport bin supported by the scale,

wherein the table, scale, and transport bin are together moveable among a plurality of locations along a floor, and

25

wherein the scale is in communication with a controller configured to receive information pertinent to an amount of bulk material contained by the transport bin.

11.

The transport unit of claim 10, further comprising locators to align the table with a vehicle configured to lift the table and scale for movement among said locations.

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CHAPTER B – DOCKET 19651

12.

The assembly of claim 10, further comprising an automated guided vehicle (AGV) configured to move the table, scale, and transport bin together among said locations.

13.

The assembly of claim 10, wherein the table has downwardly extending legs spaced from each other to accommodate a lifting vehicle between said legs and beneath a deck of the table.

14.

The assembly of claim 10, wherein the table and scale are attached together to move together among said locations without the transport bin.

15.

The assembly of claim 10, further comprising a wireless charging interface for charging a power source of the scale while the table and scale are stationary at one of said locations.

16.

The assembly of claim 10, wherein the transport bin is removable from the scale to accommodate discharging of bulk material from the transport bin at one of said locations and to accommodate transport of the platform and scale to a different one of said locations.

17.

A material handling method, comprising:
coupling a transport bin with a bulk material container;
forming a reduced pressure region at least at an inlet of the transport bin; and
dispensing bulk material from the bulk material container and into the transport bin through the reduced pressure region.

CHAPTER B – DOCKET 19651

18.

The method of claim 17, wherein the inlet of the transport bin is closed before coupling, the method further comprising opening the inlet during coupling and maintaining the inlet in an open condition during dispensing.

5

19.

The method of claim 17, further comprising:

measuring in real-time an amount of bulk material dispensed into the bin after coupling;

and

10

halting the dispensing when said amount reaches a desired amount.

20.

The method of claim 17, wherein the bulk material container is a first bulk material container and the bulk material is a first type of bulk material, the method further comprising:

15

decoupling the transport bin from the bulk material container;

transporting the transport bin to a second bulk material container;

coupling the transport bin with the second bulk material container; and

dispensing a second type of bulk material from the second bulk material container into the transport bin to form a layer of the second bulk material over the first type of bulk material.

20

21.

The method of claim 20, further comprising:

decoupling the transport bin from the second bulk material container;

transporting the transport bin to a third bulk material container;

25

coupling the transport bin with the third bulk material container; and

dispensing a third type of bulk material from the third bulk material container into the transport bin to form a layer of the third type of bulk material over the first types of bulk materials,

wherein an amount of the second type of bulk material dispensed into the transport bin is less than amounts of the first and third types of bulk materials dispensed into the transport bin.

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CHAPTER B – DOCKET 19651

22.

The method of claim 21, wherein the first and third types of bulk materials are majors glass feedstock materials and the second type of bulk material is minors glass feedstock material.

5

23.

The method of claim 17, wherein the transport bin is supported on a scale, and the scale is supported on a table during dispensing, the method further comprising:

using a vehicle to transport the table, scale, and transport bin to the bulk material container before coupling; and

10

using the same vehicle to transport a different table, scale, and transport bin to a different bulk material container for dispensing of a different bulk material into the different transport bin.

24.

A material handling method comprising measuring an amount of glass feedstock dispensed from a bulk material storage container using a mobile scale.

15

25.

The method of claim 24, further comprising dispensing the glass feedstock into a transport bin supported by the scale.

20

26.

The method of claim 25, further comprising coupling the transport bin with a bulk material dispenser coupled with the storage container before dispensing, and taring the scale after coupling.

25

27.

The method of claim 26, wherein the transport bin and scale are supported by a table during the docking, dispensing, and measuring.

CHAPTER C – DOCKET 19652**BULK MATERIAL RECEIVING, CONVEYING, STORING, AND DISPENSING****Technical Field**

[00255] This patent application discloses innovations to material handling and, more
5 particularly, to bulk material handling including receiving, conveying, storing, and dispensing of bulk materials.

Background

[00256] A conventional glass “batch house” includes a custom architectural installation specifically designed for glass manufacturing, and a glass batch handling system supported and
10 sheltered by the architectural installation. The batch house is generally configured to receive and store glass feedstock, or “glass batch” materials, including glassmaking raw materials, for example, sand, soda ash, and limestone, and also including cullet in the form of recycled, scrap, or waste glass. The conventional glass batch house requires a specialized, dedicated, and permanent architectural installation including a tall building and a covered unloading platform
15 and pit to receive glass batch from underneath railcars or trucks that arrive loaded with glass batch materials. The batch house also includes multi-story silos to store the glass batch, and glass batch elevators and conveyors to move the glass batch from unloading systems at a bottom of the pit to tops of the silos. The batch house further includes cullet pads at ground level to receive and store cullet, crushers to crush cullet to a size suitable for melting, and cullet elevators
20 and conveyors to move crushed cullet to one of the silos in the batch house. The batch house additionally includes a mixer to mix the glass batch received from the silos, conveyors integrated with scales to weigh and deliver each glass batch material from the silos to the mixer, mixer conveyors to move the glass batch from the mixers to the hot-end subsystem, and dust collectors to collect dust from the various equipment. The installation occupies a large footprint and a
25 large volumetric envelope, takes about one to two years to construct, cannot be relocated from one location to another, and tends to be a dusty and dirty environment.

CHAPTER C – DOCKET 19652**Summary of the Disclosure**

[00257] The present disclosure embodies a number of aspects that can be implemented separately from or in combination with each other.

[00258] According to one aspect of the disclosure, a bulk material handling method
5 includes receiving bulk material on a first level of a system at receiving stations equipped with dust control filtration equipment, pneumatically conveying the bulk material up to a third level into bulk material storage hoppers, storing the bulk material, dispensing the stored bulk material to a bulk material transporter on the first level, including dosing the stored bulk material to an interior of a bulk material dosing hopper to create a bulk material dose, docking the dosing
10 hopper with the transporter via a docking apparatus, and releasing the dose into the interior of the transporter, through a reduced pressure region in an internal volume of the docking apparatus. Other disclosed aspects include a related system, subsystems, and apparatuses.

Brief Description of the Drawings

[00259] FIG. 1A is a perspective view of a bulk material handling system in accordance
15 with an illustrative embodiment of the present disclosure, illustrating a building having a roof, cladding, elevator, stairs, ladders, and platforms.

[00260] FIG. 1B is another perspective view of the system corresponding to FIG. 1A, without the roof, cladding, elevator, and ladders.

[00261] FIG. 2A is a different perspective view of the system of FIG. 1A, illustrating the
20 building with the roof, cladding, elevator, stairs, ladders, and platforms.

[00262] FIG. 2B is another perspective view of the system corresponding to FIG. 2A, without the roof, cladding, elevator, and ladders.

[00263] FIG. 3 is a top view of the system of FIG. 1A.

[00264] FIG. 4 is a bottom view of the system of FIG. 1A.

25 [00265] FIG. 5 is an upstream end view of the system of FIG. 1A.

CHAPTER C – DOCKET 19652

[00266] FIG. 6 is a downstream end view of the system of FIG. 1A opposite that of FIG. 5.

[00267] FIG. 7 is a side view of the system of FIG. 1A.

[00268] FIG. 8 is another side view of the system of FIG. 1A opposite that of FIG. 7.

5 [00269] FIG. 9A is a perspective view of a modular frame of the system of FIG. 1A.

[00270] FIG. 9B is a perspective view of another modular frame of the system of FIG. 1A.

[00271] FIG. 10 is a perspective view of a rack carrying additional modular frames, and equipment carried by the modular frames, of the system of FIG. 1A.

[00272] FIG. 11A is an enlarged, fragmentary, perspective view of a large container receiving module of the system of FIG. 1.

[00273] FIG. 11B is an exploded view of a large container and a large container pallet to carry the large container and including a frame and a chain cradle suspended by the frame.

[00274] FIG. 11C is an enlarged, fragmentary, side view of a nearly empty large container carried in the chain cradle of FIG. 11B.

15 [00275] FIG. 11D is an enlarged, fragmentary, lower perspective view of a lower end of the large container of FIG. 11C fed through an iris valve of the large container pallet of FIG. 11B.

[00276] FIG. 11E is an enlarged, fragmentary, upper perspective view of a receiving station of the large container receiving module of FIG. 11A.

20 [00277] FIG. 11F is an enlarged fragmentary, lower perspective view of the iris valve and container lower end of FIG. 11D and of the receiving station of FIG. 11E with the container lower end clamped to the receiving station.

[00278] FIG. 12A is an enlarged perspective view of a small container receiving module of the system of FIG. 1A.

CHAPTER C – DOCKET 19652

[00279] FIG. 12B is an enlarged perspective view of a small container receiving station of the module of FIG. 12A showing a platform in a lifted position.

[00280] FIG. 12C is an enlarged perspective view of a small container receiving station of the module of FIG. 12A showing the platform in a lifted and rotated position.

5 [00281] FIG. 13 is an enlarged perspective view of a small container filtration module of the system of FIG. 1A.

[00282] FIG. 14 is an enlarged, fragmentary, perspective view of a portion of a minors subsystem of the system of FIG. 1A.

10 [00283] FIG. 15 is another enlarged, fragmentary, perspective view of a portion of a minors subsystem of the system of FIG. 1A.

[00284] FIG. 16A is an enlarged perspective view of bulk material storage modules including a circular array of storage hoppers, and dispensing filters.

[00285] FIG. 16B is another enlarged perspective view of the bulk material storage modules including the circular array of storage hoppers.

15 [00286] FIG. 16C is a further enlarged, fragmentary, perspective view of the bulk material storage modules including the circular array of storage hoppers.

[00287] FIG. 16D is an enlarged perspective view of the dispensing filters of FIG. 16A.

[00288] FIG. 16E is an enlarged top view of the bulk material storage modules including the circular array of storage hoppers.

20 [00289] FIG. 16F is an enlarged bottom view of the bulk material storage modules including the circular array of storage hoppers.

[00290] FIG. 17A is an enlarged perspective view of bulk material dispensing modules of the system of FIG. 1A.

CHAPTER C – DOCKET 19652

[00291] FIG. 17B is another enlarged perspective view of the bulk material dispensing modules of the system of FIG. 1A.

[00292] FIG. 17C is a further enlarged, fragmentary, perspective view of a dosing apparatus of the bulk material dispensing modules of FIGS. 17A-B.

5 [00293] FIG. 17D is an enlarged, fragmentary, upper perspective view of the dosing apparatus of FIG. 17C.

[00294] FIG. 17E is an enlarged perspective view of a rotary bucket scale of the dosing apparatus of FIG. 17C.

10 [00295] FIG. 17F is an enlarged, fragmentary, perspective view of the dosing apparatus of FIG. 17C.

[00296] FIG. 18A is an enlarged, fragmentary, lower perspective view of a docking apparatus of the bulk material dispensing modules of FIGS. 17A-F.

[00297] FIG. 18B is a perspective view of the docking apparatus of FIG. 18A coupled with a transporter.

15 [00298] FIG. 18C is an isometric view of the docking apparatus of FIG. 18A.

[00299] FIG. 18D is an isometric cross-sectional view of the docking apparatus shown in FIG. 18C.

[00300] FIG. 18E is a schematic cross-sectional view of a portion of a docking apparatus in a retracted condition over a transport bin.

20 [00301] FIG. 18F is a schematic cross-sectional view of a portion of a docking apparatus in an extended condition and coupled with a transport bin.

[00302] FIG. 19 is an enlarged side view of the storage modules of FIGS. 16A-E carried on the dispensing modules of FIGS. 17A-F.

CHAPTER C – DOCKET 19652**Detailed Description**

[00303] In general, a new bulk material handling system is illustrated and described with reference to a glass feedstock handling system for a glass container factory as an example. Those of ordinary skill in the art would recognize that other glass factories, for example, for
5 producing glass fibers, glass display screens, architectural glass, vehicle glass, or any other glass products, share many aspects with a glass container factory. Accordingly, the presently disclosed and claimed subject matter is not necessarily limited to glass containers, glass container feedstock handling systems, and glass container factories and, instead, encompasses any glass products, glass product feedstock handling systems, and glass product factories.
10 Moreover, the presently disclosed and claimed subject matter is not necessarily limited to bulk material handling for the glass industry and, instead, encompasses any products, bulk material handling systems, and factories in any industry in which bulk material handling is useful.

[00304] Although conventional glass batch houses and methods enable efficient production of high-quality products for large-scale production runs, the presently disclosed
15 subject matter facilitates implementation of a revolutionary bulk material handling system that is simpler than a conventional batch house, is modular and mobile, and is more compact and economical at least for smaller scale production runs or incremental additions to existing large-scale production runs. More specifically, in accordance with an aspect of the present disclosure, a new bulk material system may include prefabricated modular equipment configurations to
20 facilitate rapid and mobile production capacity expansion in smaller increments and at lower capital cost than conventional glass batch houses, and also may include techniques for handling bulk material in a dust-free or reduced dust manner. Further, the new system may omit one or more conventional glass batch house subsystems or aspects thereof, as described in further detail below.

25 [00305] With specific reference now to FIGS. 1A and 2A, a new bulk material handling system 10 includes a new architectural installation 12 and new subsystems and equipment supported and sheltered by the installation 12. The installation 12 includes a concrete foundation 14 having a floor which may include, for example, a four to six-inch-thick slab, and a bulk material handling building 16 on the foundation including walls 18 and a roof 20. The

CHAPTER C – DOCKET 19652

installation 12 requires no basement and no pit below the floor, such that the concrete foundation has earthen material directly underneath, wherein the foundation slab establishes the floor. As used herein, the term “pit” includes an elevator pit, conveyor pit, loading pit, and the like, located below grade or below ground level and that may require excavation of earthen material.

5 As used herein, the term “basement” includes the lowest habitable level of the bulk material handling building below a floor of the building and can include a first level or a below grade or below ground level portion that may require excavation of earthen material.

[00306] The installation 12 also includes multiple habitable levels, including a base or first level 21, an intermediate or second level 22, an upper or third level 23, and an attic or fourth level 24. Also, as used herein, the term “habitable” means that there is standing room for an adult human in the particular space involved and there is some means of ingress/egress to/from the space while walking such as a doorway, stairway, and/or the like. The installation 12 further includes egress doors 26, egress platforms 27, stairs 28, ladders 30, and an elevator 32 to facilitate access to the egress platforms 27 and doors 26. The installation 12 additionally includes loading doors 34 and loading platforms 35 and one or more ramps 36. Notably, the building 16 is constructed of many modules, including modular walls used to construct a base frame for the first level, and modular frames (not shown) for the second, third, and fourth levels, as will be discussed in detail below.

[00307] With reference now to FIGS. 2A through 8, the bulk material handling system 10 includes several subsystems that occupy a volumetric envelope much smaller than conventional batch houses such that the system 10 likewise requires a smaller volumetric envelope than conventional glass batch houses. The bulk material handling system 10 may be a glass bulk material handling system configured to receive and store glass feedstock or “glass batch.” The glass batch includes glassmaking raw materials, including glass feedstock “majors” and “minors” and also may include cullet in the form of recycled, scrap, or waste glass. The bulk material handling system receives glass batch bulk materials and combines them into doses and provides the doses to a downstream hot-end system of a glass factory adjacent to or part of the bulk material handling system.

CHAPTER C – DOCKET 19652

[00308] The bulk material handling system 10 includes one or more of the following subsystems. A first bulk material, or majors, subsystem 38 is configured to receive, pneumatically convey, store, and gravity dispense majors bulk material. Glassmaking majors may include sand, soda, limestone, alumina, saltcake, and, in some cases, dust recovery material.

5 Similarly, a second bulk material, or minors, subsystem 40 is configured to receive, pneumatically convey, and store minors bulk material from individual bulk material bags. Glassmaking minors may include selenium, cobalt oxide, magnesium, potassium, sulfur, chromium, iron, copper, tin, bismuth, carbon, and/or the like, and/or any other colorants, decolorants, fining agents, and/or other minors materials suitable for glassmaking. A bulk

10 material discharging subsystem 54 is configured to receive bulk material from the majors and minors subsystems 38, 40 and transmit the bulk material to downstream bulk material processing equipment, for example, a glass melting furnace (not shown) separate from and downstream of the bulk material handling system 10. A bulk material transfer or transport subsystem 44 is configured to receive bulk material from the majors and minors subsystems 38, 40, and transport

15 the bulk material within, to, and from, the majors and minors subsystems 38, 40, and to and from the discharge subsystem 42.

[00309] A controls subsystem 46 is in communication with various equipment of one or more of the other subsystems 38, 40, 42, 44, and is configured to control various aspects of the system 10. Those of ordinary skill in the art would recognize that the system 10 can be supplied

20 with utility or plant electrical power, and can include computers, sensors, actuators, electrical wiring, and the like to power and communicate different parts of the system 10 together. Likewise, the system 10 can be supplied with plant or compressor pneumatic power/pressure, and can include valves, lubricators, regulators, conduit, and other like pneumatic components to pressurize and communicate different parts of the system 10 together.

25 [00310] The system 10 may be pneumatically closed, from pneumatic input or receiving conduit 39 (FIG. 1A) of the majors subsystem 38 to pneumatic output or transmitting conduit 43 (FIG. 2A) of the discharging subsystem 54. The pneumatic receiving conduit 39 may extend through one or more walls of the building for accessibility to bulk transporters, e.g., trucks or rail cars, that bring bulk materials and that may have pressurized vessels to assist with pneumatic

30 receiving and conveying of bulk material. The receiving conduit 39 has any suitable couplings

CHAPTER C – DOCKET 19652

for coupling to bulk transporters in a pneumatically sealed manner, wherein the bulk transporters may have pumps, valves, and/or other equipment suitable to pressurize the receiving conduit to push bulk material into the majors subsystem 38, and/or the batch handling system 10 itself may include pumps, valves, pressurized plant air plumbing, and/or other equipment suitable to apply
5 positive and/or negative (vacuum) pressure to the input conduit to push and/or pull bulk material into the majors and minors subsystems 38, 40. Similarly, the transmitting conduit 43 may extend through one or more walls or the roof of the building for transmission to downstream bulk material processing equipment, for instance, in a hot end subsystem of a glass manufacturing system (not shown). For example, the transmitting conduit 43 is pneumatically sealingly
10 coupled to a receiver hopper at a glass melter in the hot end subsystem. The conduit 43 may have any suitable couplings for coupling to the receiver hopper in a pneumatically sealed manner. Therefore, those of ordinary skill in the art would recognize that the bulk material handling system is pneumatically closed between the pneumatic receiving conduit and the pneumatic transmitting conduit. This is in contrast to conventional systems where bulk material
15 is open to the surrounding environment. The phrase “pneumatically closed” means that the path, and the bulk materials following that path, from receiving conduit to transmitting conduit is/are enclosed, and not openly exposed to the surrounding environment, although not necessarily always sealed air-tight.

[00311] With reference now to FIG. 9A, a representative horizontal or multi-purpose
20 modular frame 54 is constructed as a rectangular box truss, having a longitudinal axis L, a transverse or lateral axis T, and a vertical axis V, including lower beams 54a extending longitudinally and being laterally opposed from one another, and including upper beams 54b extending longitudinally and being laterally opposed from one another. The frame 54 also includes posts 54c,d extending vertically between the lower and upper beams 54a,b. The posts
25 54c may include corner posts 54c extending vertically between ends of the lower and upper beams 54a,b, and intermediate posts 54d extending vertically between intermediate portions of the lower and upper beams 54a,b between the ends thereof. The frame 54 also includes lower end cross-members 54e extending laterally between the lower beams 54a, and upper end cross-members 54f extending laterally between the upper beams 54b. Although not shown, the frame
30 54 also may include lower intermediate cross-members extending between intermediate portions of the lower beams 54a between the ends thereof. The frame 54 may also include one or more

CHAPTER C – DOCKET 19652

struts 54g,h extending obliquely between the lower and upper beams 54a,b, for example, side struts 54g extending between lower and upper beams 54a,b on opposite lateral sides of the frame 54 and may be coupled to the beams 54a,b and/or posts 54c,d, and/or may include end struts 54h extending between lower and upper end cross-members 54e,f on one or both longitudinal ends of the frame 54. With reference to FIG. 9B, another multi-purpose modular frame 54' may be arranged to add struts 54g,h such that the quantity and arrangement of struts 54g,h may be configured for particular application locations for example, where earthquake, high winds, and/or snow are prevalent.

[00312] With reference now to FIG. 10, any two of several multi-purpose modular frames 54'', 54''' and the other modular frames 54, 54' (FIGS. 9A-B) disclosed herein may share common exterior dimensions such that at least two of the frames 54, 54', 54'', 54''' can be carried together on a common pallet, and can be easily aligned with one another to facilitate positioning and assembling them together on site. In fact, many of the modular frames 54, 54', 54'', 54''' may share identical exterior dimensions and may be intramodular and intermodular, such that each of the different types of modular frames 54, 54', 54'', 54''' are modular amongst their own kind and are additionally modular across different kinds. The intramodularity of the modular frames 54, 54', 54'', 54''' is by virtue of dimensions of respective frames being identical among their own kind. The intermodularity of the modular frames 54, 54', 54'', 54''' is by virtue of certain dimensions of the frames being the same. For example, some frames may have identical height and width, but different lengths.

[00313] FIG. 10 illustrates modules 56 including the modular frames 54'', 54''' that can be shipped on a standard seagoing flat rack 57 like a Mafi trailer or the like to constitute a rack and module assembly 58. On trucks, the modular frames 54'', 54''' (shipped as modules with equipment carried by the modular frames) are designed to be self-supporting and may be wrapped in plastic foil or sheet or truck tarpaulins (not shown) to seal against dust, dirt, and sea water/air, and bottoms and tops may be covered with planks or sheets (not shown) of wood, metal, or plastic to protect the equipment in the modules 56. On ships, the modules 56 may be placed on the rack 57 and rolled onto a roll on / roll off ship at a departure seaport and, at an arrival sea port, the rack 57 is rolled off the ship and the modules 56 are placed on a truck. Accordingly, the modules 56 can be placed in a closed belly of the ship and not be exposed to

CHAPTER C – DOCKET 19652

sea water. The frames 54'', 54''' also may include one or more platforms 54i carried on the lower beams 54a and the lower cross-members 54e to establish a floor. The platform may be constructed from a single panel or multiple panels.

[00314] With reference again to FIGS. 7 and 8, the minors system 40 is provided for
5 handling glass feedstock minors. In general, the minors system 40 occupies portions of the first three levels 21, 22, 23 of the system 10, including a base or first minors level 101 having minors receiving equipment 104, an upper or third minors level 103 having minors storing equipment 106, and an intermediate or second minors level 102 having minors dispensing equipment 108, as will be discussed in further detail below. All three levels are habitable and accessible via
10 doors, and via stairs or ladders where applicable.

[00315] With reference specifically to FIG. 8, the minors receiving equipment 104 includes a large container receiving module 110, a small container receiving module 112, a small container filtration module 114, a vestibule module 116, and an auxiliary module 118. The large container receiving module 110 is provided for receiving larger quantities of the minors, for
15 example, carbon, saltcake, filter dust, iron chromite, and/or tube scale, via flexible intermediate bulk containers or “big bags” that may range in size from 28” x 28” x 12” to 51” x 51” x 71” (filled dimensions) and may contain up to 4000lbs of material, for example. The small container receiving module 112 is provided for receiving smaller quantities of the minors, for example, selenium and cobalt oxide, via bulk totes or “small bags” that may range in size from 6” x 4” to
20 18” to 13” and may contain up to 25 kg (55 lbs) of material, for example. The small container filtration module 114 is provided for filtering air displaced when small containers are unloaded and small minors are received, as will be discussed in greater detail below. The vestibule module 116 is provided to accommodate arrival and receiving of small minors to the small container receiving module 112, and includes a frame 54 equipped with doorways, and is also
25 equipped with a human access door (not shown) and a pallet access door (not shown), and is coupled to a human access staired platform at the human access door and a pallet access platform at the pallet access door.

[00316] With reference now to FIG. 11A, the large container receiving module 110 includes one of the modular frames 54, and one or more large container receiving stations 120

CHAPTER C – DOCKET 19652

carried by the modular frame 54. The large container receiving module 110 is internally modular such that it may be modifiable to include less than three instances of the receiving station 120. The particular large container receiving equipment described below is illustrative and those of ordinary skill in the art would recognize that other large container receiving equipment could be used, such that the large container receiving module 110 may take many different forms in deployment with other aspects of the minors system.

[00317] With continued reference to FIG. 11A, a representative large container receiving station 120 includes one or more large container frames 122 configured to support large containers thereon, large container hoppers 124, large container pneumatic bulk material conduits 126 in communication with the hoppers 124, and large container pneumatic vents 128 in communication with the hoppers 124. The frames 122 are supported on, and may be fastened or otherwise coupled to, the lateral cross-members of the modular frame 54. The frames 122 may be pallet frames that include an open front 130, corner posts 132, lower lateral beams 134 connecting front and rear posts 132, and rear lower, intermediate and upper cross-members 136a,b,c connecting rear posts 132, and may have top guide rails 138 connecting respective front and rear posts 132.

[00318] With reference to FIGS. 11B and 11C, the bulk containers may be carried in a pallet 140, more specifically, by a chain cradle 142 that may be cone-shaped and coupled to the pallet 140 to form a big bag bulk container into a cone to facilitate emptying of the big bag. The pallet 140 includes base rails 144 extending from front to rear, vertical posts 146 extending upwardly from ends of the base rails 144 at corners of the pallet 140, an upper rim 148 connecting upper ends of the posts 146, cradle rails 150 connecting the posts 146 proximate to but vertically spaced downwardly from the upper rim 148 and coupled to an upper end of the chain cradle 142 that is suspended therefrom, and a platform 152 connecting the posts 146 proximate to but vertically spaced above the base rails 144 and establishing an outlet 154 and supporting an iris valve 156 at the outlet 154, as better shown in FIG. 11D.

[00319] With reference to FIG. 11E, each hopper 124 may have a body 158 that may be coupled to support posts 160 that support the hopper 124 in a position spaced above the module platform and that, in turn, are supported on, and may be fastened or otherwise coupled to, the

CHAPTER C – DOCKET 19652

module frame platform and/or to lateral cross-members of the module frame 54 and/or to braces extending longitudinally therebetween. Also, the hopper 124 may have an upper portion 162 that may coupled to support brackets 164 that, in turn, may be coupled to the upper and intermediate rear cross members 136b,c of the frame 122. The hopper 124 includes an outlet 166 at a lower
5 portion of the hopper 124 that is in fluid communication with the pneumatic bulk material conduit 126 and the pneumatic vent 128. The hopper 124 also includes an inlet 168 at the upper portion of the hopper 124.

[00320] With reference now to FIG. 11F, the upper portion of the hopper 124 at the hopper inlet 168 may be equipped with a container coupling 170 that may include a ring 172
10 having an aperture 174 into which a circumferential edge of a container opening is inserted and fed through a gap 176 between the ring 172 and the hopper body 158 and clamped thereto by ergonomic spring-loaded over-center clamps 178 on either lateral side of the hopper 124. Clamping a container in this manner reduces exposure of dust to the atmosphere.

[00321] With reference again to FIG. 11E, the pneumatic bulk material conduit 126 is in
15 fluid communication with the outlet 166 of the hopper 124 and may be coupled thereto in any suitable manner. Likewise, the pneumatic vent 128 includes a vent conduit 180 in fluid communication with the outlet of the hopper 124 and may be coupled thereto in any suitable manner, and a vent valve 182 (e.g., manual) coupled to the vent conduit 180 and a vent filter 184 coupled to the vent valve 182. The vent valve 182 and the vent filter 184 may be coupled to a
20 side rail of the frame 122.

[00322] In operation, and with general reference to FIG. 11A-F, a bulk container is unloaded from a truck by a forklift onto the pallet 140 (see FIG. 11B) and, after retractable doors of the module are opened, the forklift places the pallet 140 on the pallet frame 122 (see FIG. 11A). Then the open end or nozzle of the bulk container is fed through the gap 176 under the
25 ring 172 of the coupling 170 and over a seal on the hopper upper portion 162 and then the clamps 178 can be pulled down until they are firmly latched in place to seal the open end of the bulk container to the hopper 124. Thereafter, the iris valve 156 can be actuated and upstream tie straps on the container can be undone to release bulk material from the container into the hopper 124 in a dust-free manner. Before initiating bulk material conveying, a system and/or module

CHAPTER C – DOCKET 19652

controller can run any suitable checks, such as verifying that a destination storage hopper is not already full or too full to accept a full container load or the like, or verifying that other equipment is in good working order, or the like. Once such checks are complete, an operator can initiate pneumatic conveying from the station 120 in any suitable manner, so that bulk material is pneumatically conveyed to the bulk material storage module, which applies vacuum to the hopper 124 to pull the bulk materials to the storage module, as will be further described herein below after a discussion of the storing equipment 106.

[00323] With reference again to FIGS. 1A and 8, the large container receiving module 110 may be built and shipped with preinstalled equipment, e.g., pneumatic conduit and equipment, electrical wires/cable, control panels, and the like. And the module exterior may be equipped with one or more overhead rollaway doors 34 along an outside of the frame 54, for instance, three rollaway doors 34, each corresponding to an individual bay of the frame 54 and workstation of the module 110. Also, an exterior end of the module 110 may be equipped with a human access door 26, doorway 26a, and a human access platform 27 accessible via stairs 28.

[00324] With reference now to FIG. 12A, the small container receiving module 112 includes one of the modular frames 54, and at least one small container receiving station 186 carried by the modular frame 54. The receiving module 112 is internally modular such it may be expandable to include additional instances of the receiving station 186. The particular small container receiving equipment described below is illustrative and those of ordinary skill in the art would recognize that other small container receiving equipment could be used, such that the small container receiving module 112 may take many different forms in deployment with other aspects of the minors system.

[00325] With continued reference to FIGS. 12A and 12B, the station 186 includes a small container hopper 188 to receive and hold bulk material, a small container receiver 190 above the small container hopper 188 to communicate bulk material therethrough to the small container hopper 188, and a small container inverter 192 configured to dump contents of a small container or bulk tote into the small container receiver 190. The station 186 also includes receiving filter conduit 194 in fluid communication with an interior of the small container receiver 190, and a small container pneumatic bulk material conduit 196 in communication with the small container

CHAPTER C – DOCKET 19652

hopper 188. The hopper 188, the receiver 190, and the inverter 192 may be supported on a frame 198 having beams 200 on which the receiver 190 is carried and from which the hopper 124 is suspended and posts 202 supporting the beams 200. In turn, the posts 202 are supported on, and may be fastened or otherwise coupled to, platform panels of the modular frame 54 and/or to underlying lateral cross-members and/or braces. Each receiver 190 may have a front panel 204 having inlets 206 that may be equipped with a container coupling 208 that may seal to a small container 231, and a rear panel 210 with integral gloves 212 to allow an operator to open a bulk material tote once loaded into the receiver 190. As such, the receivers 190 are termed “glove boxes”. The hopper 188 may have an upper inlet 214 coupled to the receiver 190, and an outlet 216 in fluid communication with the bulk material conduit 196. The station 186 also may include a pneumatic vent 218 in fluid communication with an interior of the receiver 190 and hopper 188, and that may include a vent conduit 220 coupled to an upper portion of the receiver 190, a vent valve 222 (e.g., manual) coupled to the vent conduit and a vent filter 224 coupled to the vent valve 222. The station 186 also may include a conduit 226 coupled to the receiver 190 and in fluid communication with the interior thereof, and a tubefoil waste bin coupled to the end of the conduit 226 for receiving waste tubefoil from the unloading and receiving process.

[00326] With reference to FIGS. 12B and 12C, the inverter 192 may be an ergonomic lift and rotate inverter with a container platform 230, an elevator 232 with an actuator 234 (e.g. motor) and screw 236 threaded to the platform 230 to lift the platform 230, and a rotator 238 with an actuator 240 (e.g. motor), drive shaft 242 coupled to the actuator 234, and rotator arms 244 coupled to the drive shaft 242 and to the platform 230 to rotate the platform 230 after the platform 230 has been lifted so as to engage a bulk tote to the inlet 206 of the receiver 190.

[00327] In operation, a container may be clamped to the platform 230 with a clamp 246, for example, a tension belt, ratchet strap, or the like. Then, as shown in FIG. 12B, the elevator 232 may be actuated to lift the platform 230 and the container 231, and then, as shown in FIG. 12C, the rotator 238 may be actuated to rotate the platform 230 and the container 231 to facilitate insertion of the container 231 through the inlet 206 of the receiver 190. The receiver inlet 206 may be lined with an endless tubefoil (not shown) to promote a dustless or reduced dust environment. In some instances, a bulk material bag within the bulk tote may be removed from the container 231 and released into glove box interior of the receiver 190. The container 231 is

CHAPTER C – DOCKET 19652

then removed, and a closure (not shown) is attached to the inlet 206 of the receiver 190 to seal all materials inside the receiver 190. Then the material bag is sliced open and material is dumped into the hopper 124. Before initiating bulk material conveying, a system and/or module controller can run any suitable checks, such as verifying that a destination storage hopper is not
5 already full or too full to accept a full container load or the like, or verifying that other equipment is in good working order, or the like. Once such checks are complete, an operator can initiate pneumatic conveying from the station 186 in any suitable manner, so that bulk material is pneumatically conveyed to the bulk material storage module, which applies vacuum to the hopper 188 to pull the bulk materials to the storage module, as will be further described herein
10 below after a discussion of the storing equipment 106.

[00328] With reference now to FIG. 13, the filtration module 114 includes one of the modular frames 54, and at least one small container receiving filtration apparatus 248 carried by the modular frame 54. The filtration module 114 may be internally modular such that it may be expansible to include additional instances of the filtration apparatus 248. The particular filtration
15 equipment described below is illustrative and those of ordinary skill in the art would recognize that other filtration equipment could be used, such that the filtration module 114 may take many different forms in deployment with other aspects of the minors system.

[00329] The apparatus 248 includes a receiving filter 250 including a filter housing 252 and an inlet 254 that may be a spout or funnel-shaped, is coupled to a lower end of the housing
20 252, and is configured for fluid communication with the receiving filter conduit 194 of the small container receiving module 112 and includes a filter element (not separately shown). The apparatus 248 also includes a filter rotor 256 that may be located at an upper end of the filter housing 252 and has a rotor housing 258 in operative fluid communication with the interior of the filter housing 252, and a rotor motor 260 coupled to the filter rotor 256 to rotate a rotor
25 element like a fan, impeller, or the like (not separately shown) to pneumatically pull air and dust through the filter 250. The apparatus 248 also may include a filter pulser 262 pneumatically coupled through the filter housing 252 and actuated periodically to pneumatically pulse the filter element to release accumulated solids that may fall back down into the receiver 190 and the hopper 188 for use. The filtration apparatus 248 also may include a secondary filter 264
30 including a secondary filter housing 266 in downstream fluid communication with the rotor

CHAPTER C – DOCKET 19652

housing 258 and having an upper inlet 268 and a lower outlet 270, and a secondary filter element (not separately shown) carried in the housing 266. The secondary filter 264 may have a relatively finer filter element compared to that of the upstream filter 250 and may be configured for periodic replacement, in contrast to the upstream filter element which may not require replacement.

[00330] With reference to FIGS. 11A and 14, the large container bulk material conduit 126 may be routed from each large container receiving station 120 longitudinally along the lower rear portion of the module 110 and into and through a lower rear corner of the adjacent vestibule module 116, into, along, and up one end of the small container receiving module 112, and then into, and up one end of the filtration module 114, and then into and up one end of the auxiliary module 118 and out one side of the auxiliary module 118, and finally routed in one or both of the storage modules 272 to corresponding storage hoppers. Likewise, with reference to FIGS. 12A and 15, the small container bulk material conduit 196 may be routed from each small container receiving station 186 up and longitudinally along an upper rear portion of the module 112 and into and up one end of the adjacent filtration module 114, and then into and up one end of the auxiliary module 118 and out one side of the auxiliary module 118, and finally routed in one or both of the storage modules 272 to corresponding storage hoppers therein. Similarly, the receiving filtration conduit 194 may be routed up through a roof of the receiving module 112 and through a floor of the filtration module 114. In one example, selenium and cobalt oxide from the small container receiving module 112 and carbon from the large container receiving module 110 are routed to one storage module, and filter dust and saltcake from the large container receiving module 110 are routed to the other storage module, with a spare or optional other material loadable to the other storage module.

[00331] With reference generally now to FIGS. 16A-C, the minors storing equipment 106 includes a bulk material storage module 272 that includes one of the modular frames 54, and a bulk material storage apparatus 274 carried by the frame 54. The particular storage equipment described below is illustrative and those of ordinary skill in the art would recognize that other storage equipment could be used, such that the storage module may take many different forms in deployment with other aspects of the minors system.

CHAPTER C – DOCKET 19652

[00332] The apparatus 274 includes one or more storage tanks or hoppers 276, and one or more corresponding pneumatic separators 278 that each may be carried by a corresponding one of the hoppers 276 and in fluid communication with an interior thereof to pull vacuum through the pneumatic bulk material conduit 126, 196 so as to draw bulk material from the receiver
5 hoppers 124, 188, through the conduit 126, 196, into the separator 278, and down into the storage hoppers 276. More specifically, the hoppers 276 include bulk material inlets 277, and the pneumatic separators 278 include housings 280 with bulk material outlets 282 in communication with the inlets 277. The separators 278 also have bulk material inlets 284 between the lower and upper ends of the separators 278 in communication with respective
10 pneumatic bulk material conduits 126, 196, and vacuum generators 286 in upstream fluid communication with interiors of the housings 280 at upper ends of the separators 278 and in downstream fluid communication with pressurized air lines 288 (FIG. 16C).

[00333] In operation, once an operator has carried out an unloading and receiving process described above for a particular receiver hopper 124, 188 and then initiated pneumatic
15 conveying, for example, by pressing a button or taking some other action to open a pressurized air valve in a respective air line 288 corresponding to the particular receiver hopper 124, 188, pressurized air is supplied through the respective air line 288 and into the vacuum generator 286 for one of the storage hoppers 276 corresponding to the receiving station. The vacuum generator 286 thus pulls vacuum through a portion of the separator 278 that corresponds to the particular
20 storage hopper 276 and through the corresponding bulk material conduit 126, 196 all the way back to the particular receiver hopper 124, 188 to draw bulk material into an air stream in the separator 278 and falls by gravity down into the storage hopper 276.

[00334] With continued reference to FIGS. 16A-F, the bulk material storage module 272 includes a dispensing filter apparatus 290 that is common to the plurality of storage hoppers 276
25 of the bulk material storage module 272. The apparatus 290 includes a dispensing filter 292 including a filter housing 294 and an inlet 296 that may be a spout or funnel-shaped, is coupled to a lower end of the filter housing 294, and is configured for fluid communication with the dispensing equipment as will be described in detail below and includes a filter element (not separately shown). The apparatus 290 also includes a filter rotor 298 that may be located at an
30 upper end of the filter housing 294 and has a rotor housing 300 in operative fluid communication

CHAPTER C – DOCKET 19652

with the interior of the filter housing 294, and a rotor motor 302 coupled to the filter rotor 298 to rotate a rotor element like a fan, impeller, or the like (not separately shown) to pneumatically pull air and dust through the filter 292. The apparatus 290 also may include a filter pulser 304 pneumatically coupled through the filter housing 294 and actuated periodically to pneumatically pulse the filter element to release accumulated solids that may fall back down into the dispensing equipment for use. The filter apparatus 290 also may include a secondary filter 306 including a secondary filter housing 308 in downstream fluid communication with the rotor housing 300 and having an upper inlet 310 and a lower outlet 312, and a secondary filter element (not separately shown) carried in the housing 308. The secondary filter 306 may have a relatively finer filter element compared to that of the upstream filter and may be configured for periodic replacement, in contrast to the upstream filter element which may not require replacement.

[00335] In general, and with reference again to FIG. 16A, various utilities are carried by the storage modules 272 and may include vents, filters, pressure relief valves, pneumatic conduit, electrical cabling, control modules, level gauges, and the like. In a specific example, the hoppers may include material level sensors 314, e.g., a BINDICATOR type of level sensor, or any other type of material level sensor suitable for particulate matter. In another example, the hoppers 276 may include vents 316 coupled thereto and in fluid communication with interiors thereof. Although not separately shown in the drawings, one or more of the hoppers 276 further may include an integrated vibratory bin activator to prevent caking and bridging therein. The hoppers 276 may have a volumetric capacity of 0.5 to 2.5 cubic meters, including all ranges, subranges, values, and endpoints of that range.

[00336] In a single module, the hoppers 276 are arranged in a partial array, or an array that is semicircular or semi-hexagonal, including three hoppers 276 and a single dispensing filter apparatus 290. In two side-by-side modules, the hoppers 276 are arranged in a complete array, or an array that is circular or hexagonal, including six hoppers 276 and two dispensing filter apparatuses 290. Accordingly, a second of the two modules 272 includes a second bulk material storage apparatus and a second one of each apparatus, component, utility, and interconnections therebetween, already described above with reference to one of the modules 272. The storage modules 272 may be internally modular such that they may be modifiable to include more or fewer instances of the hoppers 276 and/or filter apparatuses 290.

CHAPTER C – DOCKET 19652

[00337] With general reference to FIGS. 17A-B, the minors dispensing equipment 108 includes a bulk material dispensing module 318 includes one of the modular frames 54, and a bulk material dispensing apparatus 320 carried by the frame 54 and including a dosing apparatus 322 that creates doses of desired amounts of bulk material from the storage hoppers, and a docking apparatus 324 to dock the dosing apparatus with a portion of the bulk material transport system 44 as will be discussed in further detail below. The particular dispensing equipment described below is illustrative and those of ordinary skill in the art would recognize that other dispensing equipment could be used, such that the dispensing module may take many different forms in deployment with other aspects of the minors system.

[00338] With reference to FIGS. 17C and 17D, the dosing apparatus 322 includes a doser feeding apparatus 326 including a plurality of feeder bins 328 below and operatively aligned with the plurality of storage hoppers 276 and including bin bodies 330 with bin interiors (not separately shown) and having bin body inlets 332 to receive bulk material from the plurality of storage hoppers 276 and bin body outlets 334. The apparatus 326 also may include inlet conduits 336 coupled to upper ends of the bin bodies 330, mounting adapters 338 having outlet conduits 340 in fluid communication with the inlet conduits 336, and funnel shaped adapters or spouts 342 having lower ends coupled to the mounting adapters 338 and upper flanges that couple to corresponding lower flanges of the storage hoppers 276. The spouts 342 may carry agitators or stirrers 344 to promote movement of bulk material. The doser feeding apparatus 326 also includes a plurality of dosing feeders 346 in communication with the bin interiors of the bin bodies 330 and having feeder outlets 348. The dosing feeders 346 may include motor actuated augers, or any bulk material fine feeding devices suitable for dosing material like glassmaking minors. One or more of the feeder bins 328 may be equipped with agitators or stirrers 350 to promote movement of bulk material and material sensors 352 to sense presence and/or amount of bulk material. Those of ordinary skill in the art would recognize that the dosing apparatus 322 may include one or more controllers (not shown) that may be used to receive input signals from various devices of the dosing apparatus 322 e.g. material sensors 352, process the inputs in any suitable manner, and transmit output signals to various devices of the dosing apparatus e.g. the stirrers 344 and the feeders 346.

CHAPTER C – DOCKET 19652

[00339] With reference to FIG. 17C, the dosing apparatus 322 further includes a bulk material doser 354 common to the pluralities of storage hoppers 276 and feeder bins 328 and including a dosing hopper 356 having a dosing hopper interior (not separately shown), a dosing scale 358 adjacent to the hopper 356, and, with reference also to FIG. 17D, a dosing container 360 that may be cantilevered from the dosing scale 358 and positioned in the dosing hopper interior of the dosing hopper 356. The feeder outlets 348 of the plurality of dosing feeders 346 extend into the dosing hopper 356 interior a distance sufficient to feed bulk material into the dosing container 360. The dosing scale 358 may be a rotary bucket type scale capable of rotating or inverting the dosing container 360 so that the dosing container 360 can dump bulk material into the bottom of the dosing hopper 356. The scale may have up to +/- 2g accuracy and the dosing container 360 may have a volumetric capacity of up to 25 liters. The scale 358 may be enclosed for negative airflow for dust reduction.

[00340] With continued reference to FIG. 17C, the doser 344 may be carried on a platform 362, which, in turn may be carried on a frame 364, which, in turn, may be carried by any suitable portion(s) of the module frame 54. The platform 362 may be supported on the frame 364 by a plurality of vibration isolating mounts 366, for example, located at corners of the platform 362 and the frame 364. The frame 364 may include side and upper walls 368 to enclose or cover portions of the dispensing apparatus 320 as a dust control measure. As can be seen in FIG. 17F, the dosing hopper 356 also includes a funnel shaped lower end or spout 370 having an inlet in communication with the dosing hopper interior and, with reference to FIG. 18A, having an outlet 371 for dispensing bulk material to the docking apparatus 324 wherein a dispensing valve 388 may be coupled to and between the spout 370 and the docking apparatus 324 and in communication therewith. The dispensing valve 388 may be actuated to open, close, or otherwise regulate flow between the spout 370 and the docking apparatus 324.

[00341] With reference again to FIGS. 17D, the dispensing apparatus 320 includes dispensing filtration conduit 372, including a dispensing filtration extension conduit 374 having a downstream end configured for fluid communication with the inlet of the dispensing filter 292 of the storage apparatus 274, and an upstream end. The dispensing filtration conduit 372 also includes a junction 376 that may be conical or funnel-shaped having a downstream end in fluid communication with the upstream end of the extension conduit 374, an upstream end, and a

CHAPTER C – DOCKET 19652

branch conduit 378. The filtration conduit 372 further includes a docking filtration conduit 380 having an upstream end in fluid communication with a corresponding portion of the docking apparatus 324 and a downstream end. The filtration conduit 380 also include a docking filtration valve 382 having an upstream end in fluid communication with the downstream end of the docking filtration conduit 372 and a downstream end in fluid communication with the branch conduit 378 of the junction 376 to regulate flow through the docking filtration conduit 380. The filtration conduit 372 additionally includes a dosing vent conduit 384 (FIG. 17C) having an upstream end in fluid communication with the interior of the dosing hopper 356 and a downstream end, and a dispensing filtration valve 386 (FIG. 17C) in fluid communication between the downstream end of the dosing vent conduit 384 and the upstream end of the junction to regulate flow through the dispensing filtration conduit 372. Accordingly, with reference to FIGS. 16C and 17C, the bulk material dispensing apparatus 320 also includes the dispensing filter apparatus 290 that is common not only to the plurality of storage hoppers 276 of the bulk material storage module 272 and apparatus 274 above the dispensing module 318, but is also common to the plurality of feeder bins 328 as well as to the dosing apparatus 322 and to the docking apparatus 324.

[00342] With reference now to FIGS. 18A-B, the docking apparatus 324 is illustrated as being located beneath and coupled to an outlet 371 of the dosing hopper spout 370 to receive bulk material therefrom. The illustrated docking apparatus 324 includes a receiving portion 400 that includes a docking apparatus inlet 402, a docking portion 404 below the receiving portion 400 and that includes a dispenser outlet 406, a collapsible sleeve 408 extending between the receiving portion 400 and docking portion 404 and at least partially establishing an internal volume 409 of the docking apparatus 324 in communication with the inlet 402 and the outlet 404. The docking apparatus 324 also includes one or more actuators 410 that move the docking portion 404 with respect to the receiving portion 400.

[00343] With reference now to FIGS. 18C-D, the receiving portion 400 of the docking apparatus 324 includes a coupling sleeve 412 having a first end 414 configured to be attached to the dosing hopper spout 370 (FIG. 18A) and a second end 416 extending into the internal volume 409 (FIG. 18D) of the docking apparatus 324. The first end 414 of the coupling sleeve 412 provides the docking apparatus inlet 402. The coupling sleeve 412 further includes an inner

CHAPTER C – DOCKET 19652

sleeve 418 (FIG. 18D) and an outer sleeve 420, both of which extend from the first end 414 and downward into the internal volume 409 of the docking apparatus 324. A vacuum port 422 extends through the outer sleeve 420 and fluidly connects the dispensing filter inlet to the internal volume 409 of the docking apparatus 324 via an annular gap between the inner and outer sleeves 418, 420 as best shown in FIG. 18D. The top end of the inner sleeve 418 may be funnel-shaped and receives the bulk material from the dosing hopper 356. The bulk material thus travels through the center of the docking apparatus 324 from the dosing hopper 356 to a transporter 500. The transporter 500 may include a transport bin having an upper inlet to receive bulk material, a lower outlet to release the bulk material, a wall between the inlet and the outlet to retain the bulk material, and any suitable inlet and outlet closures. Any transport bin suitable for use with bulk material handling may be used. The inner sleeve 418 extends downward past the end of the outer sleeve 420 and isolates the discharged bulk material from the outer sleeve 420 so that bulk material from the dosing hopper 356 is not inadvertently drawn into the docking vent conduit 380 (FIG. 18B) and up into the dispensing filter.

[00344] With reference to FIG. 18D, the docking portion 404 includes a lower plate 424, which provides the dispenser outlet 406 and mates with the transporter, and an adjustable vent 426 to permit atmospheric air to enter the internal volume 409 of the docking apparatus 324 during operation of the dispensing filter and prevent internal pressure from dropping too low and causing the dispensing filter to be overworked. The illustrated vent 426 includes an annular adjuster 428 with apertures 430 formed therethrough. The adjuster 428 is located atop the lower plate 424, which has corresponding apertures 432 formed therethrough. The adjuster 428 can be rotated about a vertical axis between a fully open position, in which the apertures 430 of the adjuster 428 are aligned with the apertures 432 of the lower plate 424, and a fully closed position, in which all apertures 430, 432 are closed-off. Adjustment of the vent 426 between these two extremes results in adjustment of the pressure differential between the internal volume 409 and the surrounding atmosphere. In particular, a more open vent 426 results in a higher internal pressure (and a lower pressure differential with the atmosphere), while a more closed vent results in a lower internal pressure (and a higher pressure differential with the atmosphere). This adjustment can be fine-tuned by starting with a fully open vent 426 and gradually closing it off until the pressure is sufficiently low in the internal volume 409 to prevent dust and other solids from escaping during dispensing. This low-pressure region 409 within the docking

CHAPTER C – DOCKET 19652

apparatus 324 ensures that little to no dust or other solids in the air displaced from the transporter 500 during bulk material dispensing escapes from the coupled portions of the system.

[00345] With continued reference to FIG. 18D, in addition to the lower plate 424 and adjustable vent 426, the docking portion 404 of the docking apparatus 324 also includes an upwardly extending sleeve 434 to which the lower end of the collapsible sleeve 408 is affixed. All of the sleeves 408, 418, 420, 434 are concentric. When the docking portion 404 is retracted toward the receiving portion 400, the inner sleeve 418 and outer sleeve 420 of the coupling sleeve 412 are nested within the sleeve 434 of the docking portion 404 and the collapsible sleeve 408 is collapsed. When the docking portion 404 is extended away from the receiving portion 400, the inner sleeve 418 and outer sleeve 420 of the coupling sleeve 412 are withdrawn from the sleeve 434 of the docking portion 404 and surrounded by the extended collapsible sleeve 408.

[00346] With reference to FIG. 18C, the collapsible sleeve 408 can be a telescopic sleeve with nesting segments, a corrugated polymer sleeve, a fabric sleeve, or similar. The internal volume 409 of the docking apparatus 324 thus changes with relative movement of the receiving portion 400 and docking portion 404. The actuators 408 may be lost-motion actuators to limit an amount of force applied to the transporter during docking and dosing. Here, the actuators 408 are pneumatic cylinders, but other actuators and actuator mechanisms are contemplated (e.g., solenoid, servo-powered gear train, etc.).

[00347] The above-described dispensing equipment enables bulk material dispensing methods, including methods of docking a transport bin with the dispensing equipment and methods of metering doses of bulk material from the bulk material storage hoppers at least as follows.

[00348] With general reference to FIGS. 16A-18D, an illustrative bulk material handling method may include a coupling or docking step, a receiving step, formation of a reduced pressure region, and a dispensing step. In the coupling or docking step, the outlet 406 of the docking apparatus 324 of the dispensing apparatus 320 is coupled with a transporter 500 to form a closure at an inlet of the transporter and place an inside of the transporter 500 in communication with the docking apparatus 324 and the storage hopper 276. The dispenser 124 and transporter 500 are illustrated in the docked or coupled condition in FIG. 18B covering an

CHAPTER C – DOCKET 19652

inlet of the transporter 500. In this example, the coupling includes interfacial contact between the lower plate 424 of the docking apparatus 324 and a lip surrounding the inlet of the transporter 500. Other types of coupling are contemplated, such as positive engagement of protrusions and corresponding recesses, or positive engagement of a latch or other reversible attachment.

5 [00349] The receiving step includes receiving bulk material in the dosing apparatus 322 from the overlying bulk material storage hopper. Receiving of the bulk material in the dosing apparatus 322 occurs via gravity feed whenever a dosing feeder is actively moving bulk material toward the feeder outlet. Formation of the reduced pressure region occurs in the internal volume 408 of the dispenser 324 when the dispensing filter is activated. Dispensing of the bulk material
10 occurs via operation of the doser 354, which drops the bulk material from the dosing container 360 through the dosing hopper outlet 371, through the reduced pressure region of the internal volume 409, and into the transporter 500.

[00350] In one illustrative and more detailed example of the method, the transporter 500 is placed beneath the docking apparatus 324 with the docking apparatus 324 in a retracted
15 condition in which the actuators 410 are in a retracted position and the collapsible sleeve 408 is collapsed. With the docking apparatus 324 in this state, the dosing apparatus 322 and its dosing feeders are idle and not moving or actively feeding any bulk material, although the feeders may be entirely full of bulk material from a previous dosing cycle. In addition, the dispensing filter is idle when the docking apparatus 324 is in the retracted condition.

20 [00351] With the inlet of the transporter 500 aligned beneath the docking portion 404 of the docking apparatus 324, the actuators 410 of the docking apparatus 324 are extended and move the docking portion 404 and the dispenser outlet 406 toward the transporter 500 as the collapsible sleeve 408 extends. When the docking portion 404 contacts the transporter 500 and a minimal force is applied, the downward motion of the docking portion 404 is halted by virtue of
25 the lost-motion actuators 410, and the docked or coupled condition of FIG. 18B is achieved.

[00352] After the docking apparatus 324 and transporter 500 are coupled together, the dispensing filter is activated. This reduces the pressure within the internal volume 409 of the docking apparatus 324 and, thereby, within the transporter 500. With this internal pressure sufficiently reduced, the dosing feeder 346 of the doser 354 is activated and begins moving the

CHAPTER C – DOCKET 19652

bulk material received from the overlying storage hopper 276 toward the feeder outlet 348, where it is dropped into the dosing container 360. One or more other dosing feeders 346 of the doser 354 may be activated to move bulk material received from one or more other corresponding overlying storage hoppers 276 toward the feeder outlets, where it is dropped into
5 the dosing container 260 along with bulk material received from other feeders 346. Once a desired dose of the bulk materials has been achieved and verified by weighing with the scale 358, the feeder(s) 346 are deactivated, the scale 358 is activated to rotate or invert the dosage container 360 and dump the bulk material dose down through the hopper outlet, and the dispensing valve 388 may be opened to allow the bulk material dose to fall through the
10 concentric sleeves of the docking apparatus 324 and into the transporter 500. Thereafter, the dispensing valve 388 may be closed. The bulk material discharged from the feeders 346 may be continuously replenished via gravity feed from the overlying storage hopper 276.

[00353] The dispensing filter 292 may continue to operate for several seconds after dispensing is halted to remove as much solid material from the air inside the transporter 500 as
15 possible. The dispensing filter 292 is then deactivated, and the dispensing filter 292 may be pulsed to dislodge filtrate from the dispensing filter 292 to be dropped back down into and through the storage hopper 272 and into the transporter 500. Next, the actuators of the docking apparatus 324 are retracted, and the docking portion of the docking apparatus 324 is moved back toward the receiving portion to the retracted position. The transporter 500 can then be
20 transported to another part of the majors 38 or minors 40 section of the system 10.

[00354] In various embodiments, the dispensing filter 292 may also operate with at least two sequential stages, a later one of the stages being more powerful than an earlier one of the stages. For example, the dispensing filter 292 may operate with at least two rotational speeds, including a high speed and a low speed. When the dispensing filter 292 is initially activated after
25 docking, it may operate at the low speed to achieve just enough of a reduced pressure region within the docking apparatus 324 as is necessary to prevent dust from escaping the coupled system. Then, the dispensing filter 292 may change to the high speed after dosing and dispensing is completed. The high-speed operation draws a much higher volume of atmospheric air through the vent of the docking apparatus 324 and causes turbulent flow within the space over the
30 dispensed material in the transporter 500 to help draw as much of the solids-laden air from the

CHAPTER C – DOCKET 19652

transporter as possible before halting the vacuum filtration and undocking from the transporter 500.

[00355] The docking apparatus 324 may also cooperate with the transporter 500 to further reduce the amount of dust and other solids that escape the system during docking and undocking.

5 In one non-limiting example, and with reference to FIG. 18E, the transporter 500 may be equipped with a closure 502 that is changeable between a closed condition and an open condition. In the example of FIG. 18E, the closure 502 includes a pair of doors 504 and levers 506 affixed to hinges of the doors 504 and extend above the inlet of the transporter 500 when the docking apparatus 324 is in the retracted condition. The doors 504 of the closure 502 are biased
10 toward the closed condition so that they are closed when the transporter 500 is undocked. As best shown in the schematic views of FIGS. 18E and 18F, when the docking apparatus 324 is changed from the retracted condition of FIG. 18E to the extended condition of FIG. 18F, the lower plate 424 of the docking apparatus 324 contacts the levers 506, which rotates the doors 504 of the closure 502 to their open condition as the transporter 500 is docked. Likewise, after bulk material
15 dispensing is completed and the docking apparatus 324 is changed back to the retracted condition of FIG. 34, the doors 504 of the closure 502 are moved back to the closed condition by virtue of their bias toward that condition.

[00356] In one dispensing module 318, the feeder bins 328 and dosing feeders 346 are arranged in a partial array, or an array that is semicircular or semi-hexagonal, including three
20 feeder bins 328 and three dosing feeders 346 and one doser 354. In two side-by-side modules, the feeder bins 328 and dosing feeders 346 are arranged in a complete array, or an array that is circular or hexagonal, including six feeder bins 328 and six dosing feeders 346 and two dosers 354. Accordingly, a second of the two modules 318 includes a second bulk material dispensing apparatus and a second one of each apparatus, component, utility, and interconnections
25 therebetween, already described above with reference to one of the modules. The dispensing modules 318 may be internally modular such that they may be modifiable to include more or fewer instances of the feeding apparatuses 326 and/or dosers 354.

[00357] With reference now to FIG. 19, multiple storage and dispensing modules 272, 318 are coupled together including the storage hoppers 276, and the feeder bins 328 and the dosing

CHAPTER C – DOCKET 19652

feeders 346 being arranged in a complete array, or an array that is circular or hexagonal, including six storage hoppers 276, feeder bins 328, and dosing feeders 346, and two filters 292 and dosers 354.

CHAPTER C – DOCKET 19652**Example claims for Chapter C (Docket 19652) include the following:**

1.

A bulk material handling system, comprising:

a bulk material storage apparatus including

5 a plurality of storage hoppers; and

a dispensing filter common to the plurality of storage hoppers and including a dispensing filter housing, a dispensing filter rotor in fluid communication with the dispensing filter housing, and a dispensing filter motor coupled to the dispensing filter rotor.

2.

The system of claim 1, further comprising:

a bulk material storage module including:

a modular frame; and

wherein the bulk material storage apparatus is coupled to the modular frame.

3.

The system of claim 2, wherein the modular frame is constructed as a rectangular box truss, having a longitudinal axis, a lateral axis, and a vertical axis, and including

20 lower beams extending longitudinally, and being laterally opposed from one another,

upper beams extending longitudinally, and being laterally opposed from one another,

posts extending vertically between the lower and upper beams,

upper cross-members extending laterally between the upper beams, and

25 lower cross-members extending laterally between the lower beams,

wherein the plurality of storage hoppers are coupled to at least one of the lower beams or cross-members, and the common dispensing filter is coupled to at least one of the lower beams or cross-members.

4.

The system of claim 3, wherein the modular frame also includes

CHAPTER C – DOCKET 19652

one or more struts extending obliquely between the lower and upper beams, and
 a platform carried on at least some of the lower cross-members to establish a
 floor.

5

5.

The system of claim 2, wherein the modular frame has exterior dimensions less than or
 equal to exterior dimensions of an intermodal freight container.

6.

10

The system of claim 1, further comprising:

a bulk material dispensing apparatus including

a dosing apparatus including

a doser feeding apparatus including

a plurality of feeder bins below the plurality of storage hoppers and

15

including bin bodies with bin interiors and having bin body inlets to receive bulk material from
 the plurality of storage hoppers, and

a plurality of dosing feeders in communication with the bin

interiors of the bin bodies of the plurality of bins and having feeder outlets.

20

7.

The system of claim 6, wherein the dosing apparatus further includes

a bulk material doser common to the pluralities of storage hoppers and
 feeder bins and including

a dosing hopper having a dosing hopper interior,

25

a dosing container positioned in the dosing hopper interior of the
 dosing hopper, wherein the feeder outlets of the plurality of dosing feeders extend into the dosing
 hopper interior to feed the bulk material into the dosing container,

a dosing scale coupled to the dosing container, and

a spout having an inlet in communication with the dosing hopper

30

interior and having an outlet.

CHAPTER C – DOCKET 19652

8.

The system of claim 7, wherein the dosing apparatus additionally includes
a dispensing filtration duct in fluid communication with the dosing hopper
interior of the dosing hopper and in fluid communication with the filter housing of the common
5 dispensing filter.

9.

The system of claim 7, wherein the bulk material dispensing apparatus also includes
a docking apparatus including
10 a collapsible conduit having a conduit interior to receive the bulk material
from the dosing container of the bulk material doser, and
a docking filtration duct in fluid communication with the conduit interior
of the collapsible conduit and in fluid communication with the filter housing of the dosing filter
of the bulk material storage apparatus.

15

10.

The system of claim 9, further comprising:
a second bulk material storage apparatus including
a second plurality of storage hoppers; and
20 a second dispensing filter common to the second plurality of storage hoppers and
including a second dispensing filter housing, a second dispensing filter rotor in fluid
communication with the dispensing filter housing, and a second dispensing filter motor coupled
to the dispensing filter rotor.

25

11.

The system of claim 10, further comprising:
a second bulk material dispensing apparatus including
a second dosing apparatus including
a second doser feeding apparatus including

CHAPTER C – DOCKET 19652

a second plurality of feeder bins below the second plurality of storage hoppers and including second bin bodies with second bin interiors and having second bin body inlets to receive bulk material from the second plurality of storage hoppers, and

5 a second plurality of dosing feeders in communication with the second bin interiors of the second bin bodies of the second plurality of bins and having second feeder outlets.

12.

The system of claim 11, wherein the second dosing apparatus further includes

10 a second bulk material doser common to the second pluralities of storage hoppers and feeder bins and including

a second dosing hopper having a second dosing hopper interior,

a second dosing container positioned in the second dosing hopper interior of the second dosing hopper, wherein the second feeder outlets of the second plurality of dosing feeders extend into the second dosing hopper interior to feed the bulk material into the
15 second dosing container,

a second dosing scale coupled to the second dosing container, and

a second spout having a second inlet in communication with the second dosing hopper interior and having a second outlet.

20

13.

The system of claim 11, wherein the second bulk material dispensing apparatus also includes

a second docking apparatus, including

25 a second collapsible conduit having a second interior, and

a second docking filtration duct in fluid communication with the second interior of the second collapsible conduit and in fluid communication with the second filter housing of the second filter of the second bulk material storage module.

30

14.

CHAPTER C – DOCKET 19652

The system of claim 13, wherein the plurality of storage hoppers of the bulk material storage apparatus is in a first storage hopper partial array and the second plurality of storage hoppers of the second bulk material storage apparatus is in a second storage hopper partial array, which together with the first storage hopper partial array, establishes a complete storage hopper array, and wherein the plurality of dosing hoppers of the dosing apparatus is in a first dosing hopper partial array and the second plurality of dosing hoppers of the second dosing apparatus is in a second dosing hopper partial array, which together with the first dosing hopper partial container array, establishes a complete dosing hopper array.

15.

The system of claim 14, wherein the partial arrays are semi-circular and the complete arrays are circular.

16.

The system of claim 15, wherein the bulk material storage apparatus also includes a set of utilities coupled to the storage hoppers and including at least one of a filter, a pressure relief valve, a pneumatic conduit, or a level gauge, and the second bulk material storage apparatus also includes a second set of utilities coupled to the second vessel inlets of the second vessels of the second storage hoppers and including at least one of a second filter, a second pressure relief valve, a second pneumatic conduit, or a second level gauge.

17.

The system of claim 1, further comprising:

a plurality of bulk tote unloaders pneumatically coupled to corresponding storage hoppers of the plurality of storage hoppers; and

a plurality of bulk container unloaders pneumatically coupled to corresponding storage hoppers of the plurality of storage hoppers.

CHAPTER C – DOCKET 19652

18.

A bulk material handling system, comprising:

a dosing apparatus including

a doser feeding apparatus including

5 a plurality of feeder bins including bin bodies with bin interiors and having inlets and outlets, and

a plurality of dosing feeders in communication with the outlets of the bin bodies of the plurality of feed bins and having feeder outlets; and

10 a bulk material doser common to the pluralities of feeder bins and dosing feeders and including

a dosing hopper having a dosing hopper interior,

a dosing container positioned in the dosing hopper interior of the dosing hopper, wherein the feeder outlets of the plurality of dosing feeders extend into the dosing hopper interior to feed bulk material into the dosing container,

15 a dosing scale coupled to the dosing container, and

a spout having an inlet in communication with the dosing hopper interior and having an outlet.

19.

20 The system of claim 18, further comprising:

a bulk material dispensing module including:

a modular frame, and

wherein the dosing apparatus is carried by the modular frame.

20.

25 The system of claim 19, wherein the modular frame is constructed as a rectangular box truss, having a longitudinal axis, a lateral axis, and a vertical axis, and including

lower beams extending longitudinally, and being laterally opposed from one another,

30 upper beams extending longitudinally, and being laterally opposed from one another,

posts extending vertically between the lower and upper beams,

CHAPTER C – DOCKET 19652

upper cross-members extending laterally between the upper beams, and
lower cross-members extending laterally between the lower beams, and
wherein the plurality of feeder bins are coupled to at least one of the lower beams or
cross-members.

5

21.

The system of claim 18, wherein the bulk material doser additionally includes
a dispensing filtration duct in fluid communication with the dosing hopper
interior of the dosing hopper and in fluid communication with a common dispensing filter.

10

22.

The system of claim 21, wherein the bulk material dispensing apparatus also includes
a docking apparatus including
a collapsible conduit having a conduit interior to receive the bulk material
from the dosing container of the bulk material doser, and
a docking filtration duct in fluid communication with the conduit interior
of the collapsible conduit and in fluid communication with the common dispensing filter.

15

23.

The system of claim 22, wherein the bulk material dispensing apparatus further includes
a dispensing filtration valve to regulate flow through the dispensing filtration
duct, and
a docking filtration valve to regulate flow through the docking filtration duct.

20

25

24.

The system of claim 18, further comprising:
a second dosing apparatus including
a second doser feeding apparatus including
a second plurality of feeder bins including second bin bodies with second
bin interiors and having second bin body inlets to receive bulk material, and

30

CHAPTER C – DOCKET 19652

a second plurality of dosing feeders in communication with the second bin interiors of the second bin bodies of the second plurality of bins and having second feeder outlets.

5

25.

The system of claim 24, wherein the second dosing apparatus further includes

a second bulk material doser common to the second pluralities of feeder bins and dosing feeders and including

a second dosing hopper having a second dosing hopper interior,

10

a second dosing container positioned in the second dosing hopper interior of the second dosing hopper, wherein the second feeder outlets of the second plurality of dosing feeders extend into the second dosing hopper interior to feed the bulk material into the second dosing container,

a second dosing scale coupled to the second dosing container, and

15

a second spout having a second inlet in communication with the second dosing hopper interior and having a second outlet.

26.

The system of claim 25, wherein the second bulk material dispensing apparatus also includes

20

a second docking apparatus, including

a second collapsible conduit having a second interior, and

a second docking filtration duct in fluid communication with the second interior of the second collapsible conduit and in fluid communication with the second filter housing of the second filter of the second bulk material storage module.

25

CHAPTER C – DOCKET 19652

27.

A bulk material handling system, comprising:

a dosing apparatus including

a bulk material doser including

a dosing hopper having a dosing hopper interior,

a dosing container positioned in the dosing hopper interior of the dosing hopper,

a dosing scale coupled to the dosing container,

a spout having an inlet in communication with the dosing hopper interior to receive bulk material from the dosing container, and having an outlet,

a dispensing filtration duct in fluid communication with the dosing hopper interior of the dosing hopper and in fluid communication with a common dispensing filter; and

a docking apparatus including

a collapsible conduit having a conduit interior to receive the bulk material from the outlet of the spout of the bulk material doser of the dosing apparatus, and

a docking filtration duct in fluid communication with the conduit interior of the collapsible conduit and in fluid communication with the common dispensing filter.

28.

The system of claim 27, further comprising:

a dispensing filtration valve to regulate flow through the dispensing filtration duct, and

a docking filtration valve to regulate flow through the docking filtration duct.

29.

The system of claim 28, further comprising:

a dispensing filtration duct in communication with the dosing and docking filtration ducts downstream of the dosing and docking filtration valves.

CHAPTER C – DOCKET 19652

30.

A modular bulk material handling system, comprising:

a plurality of modular frames constructed as rectangular box trusses, each having a longitudinal axis, a lateral axis, and a vertical axis, and including lower beams extending longitudinally and being laterally opposed from one another, upper beams extending
5 longitudinally and being laterally opposed from one another, posts extending vertically between the lower and upper beams, upper cross-members extending laterally between the upper beams, and lower cross-members extending laterally between the lower beams;

a large container receiving module including a first one of the plurality of modular
10 frames, and a large container receiving station carried by the first one of the plurality of modular frames and including a large container hopper, a large container frame configured to support a large container thereon, and a large container pneumatic bulk material conduit in communication with a lower portion of the large container hopper; and

a small container receiving module including a second one of the plurality of modular
15 frames, and a small container receiving station carried by the second one of the plurality of modular frames and including a small container hopper, a small container receiver above the small container hopper and configured to communicate bulk material therethrough to the small container hopper, a small container inverter configured to dump contents of a small container into the small container receiver, a receiving filter conduit in fluid communication with an
20 interior of the small container receiver, and a small container pneumatic bulk material conduit in communication with a lower portion of the small container hopper.

31.

The system of claim 30, further comprising:

a bulk material storage module including a third one of the plurality of modular frames,
25 and a bulk material storage hopper carried by the third one of the plurality of modular frames and including an inlet and an outlet, and a dispensing filter carried by the frame and including a filter housing, a rotor in fluid communication with the filter housing, and a rotor motor coupled to the rotor.

CHAPTER C – DOCKET 19652

32.

The system of claim 31, further comprising:

a bulk material dispensing module including a fourth one of the plurality of modular frames, and a bulk material dispensing apparatus carried by the fourth one of the plurality of modular frames and including a bulk material doser including a dosing hopper having a dosing hopper interior, a dosing container positioned in the dosing hopper interior of the dosing hopper, a dosing scale coupled to the dosing container, a spout having an inlet in communication with the dosing hopper interior to receive the bulk material from the dosing container, and having an outlet, and a dispensing filtration duct in fluid communication with the dosing hopper interior of the dosing hopper and in fluid communication with the dispensing filter of the bulk material storage module.

33.

The system of claim 32, further comprising:

a receiving filtration module including a fifth one of the plurality of modular frames, and small container receiving filtration equipment carried by the fifth one of the plurality of modular frames and including a receiving filter housing configured for fluid communication with the receiving filter conduit of the small container receiving module.

34.

The system of claim 33, further comprising:

a vestibule module including a sixth one of the plurality of modular frames, and one or more bulk material receiving doorways.

35.

The system of claim 34, further comprising:

an auxiliary module including a seventh one of the plurality of modular frames, and configured to be located above the filtration module.

CHAPTER C – DOCKET 19652

36.

The system of claim 32, wherein the large container receiving module includes a plurality of the large container receiving station, the small container receiving module includes a plurality of the small container receiving station, the bulk material storage module includes a plurality of the bulk material hopper, and the bulk material dispensing module includes a plurality of the bulk material hopper, the bulk material bin, and the bulk material conveyor.

37.

The system of claim 32, wherein the large container receiving module and the small container receiving module are on a first level of the system, the bulk material dispensing module is on a second level of the system above the first level, and the bulk material storage module is on a third level of the system above the second level.

38.

The system of claim 30, wherein each modular frame has exterior dimensions less than or equal to exterior dimensions of an intermodal freight container.

39.

The system of claim 30, wherein each modular frame also includes one or more struts extending obliquely between the lower and upper beams.

40.

The system of claim 30, wherein each modular frame also includes a platform carried on the lower beams and the lower cross-members to establish a floor.

41.

A bulk material handling method, comprising:

receiving bulk material from bulk material containers on a first level of a bulk material handling system at receiving stations having pneumatically closed receivers in fluid communication with dust control filtration equipment;

CHAPTER C – DOCKET 19652

pneumatically conveying the bulk material up to a third level of the bulk material handling system into bulk material storage hoppers;

storing the bulk material in the storage hoppers; and

5 dispensing the bulk material from the storage hoppers on the third level of the system to a bulk material transporter on the first level of the system, including

dosing the bulk material from the storage hoppers to an interior of a bulk material dosing hopper to create a bulk material dose,

10 docking an outlet of the dosing hopper with an inlet of the transporter with a docking apparatus to place an interior of the transporter in selective communication with the interior of the dosing hopper, and

releasing the bulk material dose from the interior of the dosing hopper to the interior of the transporter, through a reduced pressure region in an internal volume of the docking apparatus.

15 42.

The method of claim 41, wherein the reduced pressure region is provided by a dispensing filter apparatus having a conduit in fluid communication with the internal volume of the docking apparatus, such that air displaced from the transporter during the releasing is received in the filtration apparatus, the method further comprising filtering solids from air received in the
20 filtration apparatus.

43.

The method of claim 42, further comprising routing the filtered solids back to the dosing hopper.

25

44.

The method of claim 42, further comprising pulling vacuum from the interior of the dosing hopper into the filtration apparatus.

CHAPTER D – DOCKET 19653
BULK MATERIAL DISCHARGING

Technical Field

5 [00358] This patent application discloses innovations to material handling and, more particularly, to bulk material discharging including loading, conveying, gravity releasing, rejecting, and pneumatically transmitting bulk material.

Background

10 [00359] A conventional glass “batch house” includes a custom architectural installation specifically designed for glass manufacturing, and a glass batch handling system supported and sheltered by the architectural installation. The batch house is generally configured to receive and store glass feedstock, or “glass batch” materials, including glassmaking raw materials, for example, sand, soda ash, and limestone, and also including cullet in the form of recycled, scrap,
15 or waste glass. The conventional glass batch house requires a specialized, dedicated, and permanent architectural installation including a tall building and a covered unloading platform and pit to receive glass batch from underneath railcars or trucks that arrive loaded with glass batch materials. The batch house also includes multi-story silos to store the glass batch, and glass batch elevators and conveyors to move the glass batch from unloading systems at a bottom
20 of the pit to tops of the silos. The batch house further includes cullet pads at ground level to receive and store cullet, crushers to crush cullet to a size suitable for melting, and cullet elevators and conveyors to move crushed cullet to one of the silos in the batch house. The batch house additionally includes a mixer to mix the glass batch received from the silos, conveyors integrated with scales to weigh and deliver each glass batch material from the silos to the mixer, mixer
25 conveyors to move the glass batch from the mixers to the hot-end subsystem, and dust collectors to collect dust from the various equipment. The installation occupies a large footprint and a large volumetric envelope, takes about one to two years to construct, cannot be relocated from one location to another, and tends to be a dusty and dirty environment.

CHAPTER D – DOCKET 19653**Summary of the Disclosure**

[00360] The present disclosure embodies a number of aspects that can be implemented separately from or in combination with each other.

[00361] Embodiments of a bulk material discharging system includes a transmission station including a transmitting vessel having a transmitting vessel inlet configured to receive bulk material from an outlet of a bulk material transporter, and a transmitting vessel outlet to transmit bulk material therefrom. The system also includes a transporter handling station located operatively upstream of the transmission station and including at least a portion of a transporter handler including at least one carriage with transporter couplings configured to engage corresponding carriage couplings of the bulk material transporter and configured to convey the bulk material transporter over the transmitting vessel.

[00362] Embodiments of a bulk material transmission station includes a transmitting vessel having a vessel inlet configured to receive bulk material from an outlet of a bulk material transporter, a vessel outlet to transmit bulk material therefrom, a vessel inlet closure, and a vessel outlet closure. The station also includes a station outlet conduit in downstream fluid communication with the vessel outlet to receive bulk material from the vessel outlet, a station outlet pressurization conduit in fluid communication with the station outlet conduit to pressurize the station outlet conduit for pneumatic transmission of the bulk material through the station outlet conduit, and a station outlet pressurization valve to regulate opening of the station outlet pressurization conduit.

[00363] Embodiments of a bulk material transporter handler includes an elevator including vertical guides, an elevator carriage guided by the vertical guides and having a first set of transporter couplings, and one or more elevator actuators operatively coupled to the elevator carriage to raise and lower the elevator carriage along the vertical guides. The handler also includes a conveyor carriage operatively coupled with the elevator, and including horizontal guides, a conveyor carriage guided by the horizontal guides and having a second set of transporter couplings, and one or more conveyor actuators operatively coupled to the conveyor carriage to advance and retract the conveyor carriage along the horizontal guides.

[00364] Embodiments of a bulk material rejection station includes a rejection hopper including a rejection inlet to receive bulk material therein, and a rejection outlet to transmit bulk material therefrom, and an auger including an auger inlet in downstream communication with the

CHAPTER D – DOCKET 19653

rejection hopper outlet. The station also includes a recirculation conduit including a recirculation inlet in fluid communication with the auger at a location upstream of the auger outlet, and a recirculation outlet in fluid communication with an upper portion of an interior of the rejection hopper.

5

Brief Description of the Drawings

[00365] FIG. 1A is a perspective view of a bulk material handling system in accordance with another illustrative embodiment of the present disclosure, illustrating a building having a roof, cladding, elevator, stairs, ladders, and platforms.

10 [00366] FIG. 1B is another perspective view of the system corresponding to FIG. 1A, without the roof, cladding, elevator, and ladders.

[00367] FIG. 2A is a different perspective view of the system of FIG. 1A, illustrating the building with the roof, cladding, elevator, stairs, ladders, and platforms.

15 [00368] FIG. 2B is another perspective view of the system corresponding to FIG. 2A, without the roof, cladding, elevator, and ladders.

[00369] FIG. 3 is a top view of the system of FIG. 1A.

[00370] FIG. 4 is a bottom view of the system of FIG. 1A.

[00371] FIG. 5 is a side view of the system of FIG. 1A.

[00372] FIG. 6 is an upstream end view of the system of FIG. 1A.

20 [00373] FIG. 7 is another side view of the system of FIG. 1A opposite that of FIG. 5.

[00374] FIG. 8 is a downstream end view of the system of FIG. 1A opposite that of FIG. 6.

[00375] FIG. 9A is a perspective view of a bulk material transport assembly including a bulk material transporter and a vehicle.

25 [00376] FIG. 9B is a perspective view of assembly and vehicle of FIG. 9A, illustrating the vehicle moving relative to the transport assembly.

[00377] FIG. 10A is an enlarged perspective view of the transporter of FIG. 9A.

[00378] FIG. 10B is an enlarged, fragmentary, perspective view of an inlet end of the transporter of FIG. 9A.

30 [00379] FIG. 10C is an enlarged, fragmentary, perspective view of an outlet end of the transporter of FIG. 9A.

CHAPTER D – DOCKET 19653

[00380] FIG. 11A is an enlarged perspective view of a downstream corner portion of the system of FIG. 1A, illustrating a bulk material discharging subsystem.

[00381] FIG. 11B is an enlarged fragmentary perspective view of the downstream corner portion shown in FIG. 11A.

5 [00382] FIG. 11C is another enlarged fragmentary perspective view, from a different angle, of the bulk material discharging subsystem of FIG. 11A.

[00383] FIG. 12 is an enlarged fragmentary perspective view of a portion of a handling station of the bulk material discharging subsystem of FIG. 11A, showing chargers for an AGV and a weigh scale carried by the AGV.

10 [00384] FIG. 13A is a perspective view of a transporter handler coupled to a modular frame.

[00385] FIG. 13B is a perspective view of a transporter handler of the bulk material discharging subsystem of FIG. 11A, illustrating a conveyor and an elevator having an elevator carriage carrying a bulk material transporter.

15 [00386] FIG. 14A is an enlarged fragmentary perspective view of the transporter handler of FIG. 13, illustrating the elevator carriage without the transporter.

[00387] FIG. 14B is an enlarged fragmentary perspective view of the elevator carriage illustrated in FIG. 14A.

[00388] FIG. 14C is an enlarged fragmentary perspective view of the elevator carriage and
20 the transporter illustrated in FIG. 13.

[00389] FIG. 15A is an enlarged fragmentary lower perspective view of a portion of the conveyor illustrated in FIG. 13, illustrating a conveyor carriage.

[00390] FIG. 15B is a further enlarged perspective view of the conveyor carriage of FIG. 15A.

25 [00391] FIG. 15C is a fragmentary perspective view of a stabilizer coupling and a suspension coupling coupled to a corresponding portion of a bulk material transporter.

[00392] FIG. 15D is a fragmentary perspective end view of the conveyor carriage carrying a transporter, illustrating transporter couplings.

[00393] FIG. 15E is another fragmentary perspective view of the conveyor carriage and
30 transporter of FIG. 15D, illustrating transporter couplings.

CHAPTER D – DOCKET 19653

[00394] FIG. 16 is a perspective view of a transporter handler module including the modular frame carrying the transporter handler illustrated in FIG. 13B.

[00395] FIG. 17A is an enlarged perspective view of a transmitting vessel and related equipment of the bulk material discharging system of FIGS. 11A and 11B.

5 [00396] FIG. 17B is a fragmentary perspective view of a portion of the transmitting vessel and related equipment of FIG. 19A, and illustrating a pneumatic supply line and equipment in communication therewith.

[00397] FIG. 18A is a fragmentary upper perspective view of a transporter closure actuator.

10 [00398] FIG. 18B is another fragmentary upper perspective view of the transporter closure actuator of FIG. 18A.

[00399] FIG. 18C is a fragmentary perspective view, from another angle, of the transporter closure actuator of FIG. 18A.

[00400] FIG. 18D is a fragmentary lower perspective view of the transporter closure
15 actuator of FIG. 18A, illustrating the actuator in a disengaged state.

[00401] FIG. 18E is a fragmentary lower perspective view of the transporter closure actuator of FIG. 18A, illustrating the actuator in an engaged state.

[00402] FIG. 19A is an enlarged perspective view of a transporter massager of the bulk material discharging system of FIG. 11A.

20 [00403] FIG. 19B is a fragmentary perspective view of a transmission station of the bulk material discharging system of FIG. 11A, illustrating the transporter massager of FIG. 19A adjacent to the transporter of FIG. 11A.

[00404] FIG. 20A is an enlarged fragmentary perspective view of a portion of a rejecting station of the bulk material discharging system of FIG. 11A.

25 [00405] FIG. 20B is a further enlarged fragmentary perspective view of the rejection station shown in FIG. 20A.

[00406] FIG. 20C is an enlarged fragmentary perspective view of the rejection station shown in FIG. 20A, illustrating transporter docking equipment and a transporter closure actuator.

[00407] FIG. 20D is an enlarged fragmentary perspective view, taken from another angle,
30 of the transporter docking equipment and transporter closure actuator shown in FIG. 20C.

CHAPTER D – DOCKET 19653**Detailed Description**

[00408] In general, a new bulk material handling system is illustrated and described with reference to a glass feedstock handling system for a glass container factory as an example. Those of ordinary skill in the art would recognize that other glass factories, for example, for
5 producing glass fibers, glass display screens, architectural glass, vehicle glass, or any other glass products, share many aspects with a glass container factory. Accordingly, the presently disclosed and claimed subject matter is not limited to glass containers, glass container feedstock handling systems, and glass container factories and, instead, encompasses any glass products, glass product feedstock handling systems, and glass product factories. Moreover, the presently
10 disclosed and claimed subject matter is not limited to bulk material handling for the glass industry and, instead, encompasses any products, bulk material handling systems, and factories in any industry in which bulk material handling is useful.

[00409] Although conventional glass batch houses and methods enable efficient production of high-quality products for large-scale production runs, the presently disclosed
15 subject matter facilitates implementation of a revolutionary bulk material handling system that is simpler than a conventional batch house, is modular and mobile, and is more compact and economical at least for smaller scale production runs or incremental additions to existing large-scale production runs. More specifically, in accordance with an aspect of the present disclosure, a new bulk material handling system may include prefabricated modular equipment
20 configurations to facilitate rapid and mobile production capacity expansion in smaller increments and at lower capital cost than conventional glass batch houses, and also may include techniques for handling bulk material in a dust-free or reduced dust manner. Further, the new system may omit one or more conventional glass batch house subsystems or aspects thereof, as described in further detail below.

25 [00410] With specific reference now to FIGS. 1A through 8, a new bulk material handling system 10 includes a new architectural installation 12 and new subsystems and equipment supported and sheltered by the installation 12. The installation 12 includes a concrete foundation 14 having a floor which may include, for example, a four to six-inch-thick slab, and a bulk material handling building 16 on the foundation including walls 18 and a roof 20. The
30 installation 12 requires no basement and no pit below the floor, such that the concrete foundation has earthen material directly underneath, wherein the foundation slab establishes the floor. As

CHAPTER D – DOCKET 19653

used herein, the term “pit” includes an elevator pit, conveyor pit, loading pit, and the like, located below grade or below ground level and that may require excavation of earthen material to form. As used herein, the term “basement” includes the lowest habitable level of the bulk material handling building below a floor of the building and can include a first level or a below
5 grade or below ground level portion that may require excavation of earthen material.

[00411] The installation 12 also includes multiple habitable levels, including a base or first level 21, an intermediate or second level 22, an upper or third level 23, and an attic or fourth level 24. Also, as used herein, the term “habitable” means that there is standing room for an adult human in the particular space involved and there is some means of ingress/egress to/from
10 the space while walking such as a doorway, stairway, and/or the like. The installation 12 further includes egress doors 26, egress platforms 27, stairs 28, ladders 30, and an elevator 32 to facilitate access to the egress platforms 27 and doors 26. The installation 12 additionally includes loading doors 34 and loading platforms 35 and one or more ramps 36. Notably, the building 16 is constructed of many modules, including modular walls used to construct a base
15 frame for the first level, and modular frames for the second, third, and fourth levels, as will be discussed in detail below.

[00412] With continued reference to FIGS. 1A through 8, the bulk material handling system 10 includes several subsystems that occupy a volumetric envelope much smaller than conventional batch houses such that the system 10 likewise requires a smaller volumetric
20 envelope than conventional glass batch houses. The bulk material handling system 10 may be a glass bulk material handling system configured to receive and store glass feedstock or “glass batch.” The glass batch includes glassmaking raw materials, including glass feedstock “majors” and “minors” and also may include cullet in the form of recycled, scrap, or waste glass. The bulk material handling system receives glass batch bulk materials and combines them into doses
25 and provides the doses to a downstream hot-end system of a glass factory adjacent to or part of the bulk material handling system.

[00413] The bulk material handling system 10 includes one or more of the following subsystems. A first bulk material, or majors, subsystem 38 is configured to receive, pneumatically convey, store, and gravity dispense majors bulk material. Glassmaking majors
30 may include sand, soda, limestone, alumina, saltcake, and, in some cases, dust recovery material. Similarly, a second bulk material, or minors, subsystem 40 is configured to receive,

CHAPTER D – DOCKET 19653

pneumatically convey, and store minors bulk material from individual bulk material bags. Glassmaking minors may include selenium, cobalt oxide, and any other colorants, decolorants, fining agents, and/or other minors materials suitable for glassmaking. A bulk material discharge subsystem 42 is configured to receive bulk material from the majors and minors subsystems 38, 40 and transmit the bulk material to downstream bulk material processing equipment, for example, a glass melting furnace separate from and downstream of the bulk material handling system 10. A bulk material transfer or transport subsystem 44 is configured to receive bulk material from the majors and minors subsystems 38, 40, and transport the bulk material within, to, and from, the majors and minors subsystems 38, 40, and to and from the discharge subsystem 42. A controls subsystem 46 is in communication with various equipment of one or more of the other subsystems 38, 40, 42, 44, and is configured to control various aspects of the system 10. Those of ordinary skill in the art would recognize that the system 10 can be supplied with utility or plant electrical power, and can include computers, sensors, actuators, electrical wiring, and the like to power and communicate different parts of the system 10 together. Likewise, the system 10 can be supplied with plant or compressor pneumatic power/pressure, and can include valves, lubricators, regulators, conduit, and other like pneumatic components to pressurize and communicate different parts of the system 10 together.

[00414] The system 10 may be pneumatically closed from pneumatic input or receiving conduit 39 of the majors subsystem 38 to pneumatic output or transmitting conduit 43 of the discharging subsystem 42. The pneumatic receiving conduit 39 may extend through one or more walls of the building for accessibility to bulk transporters, e.g., trucks or rail cars, that bring bulk materials and that may have pressurized vessels to assist with pneumatic receiving and conveying of bulk material. The receiving conduit 39 has any suitable couplings for coupling to bulk transporters in a pneumatically sealed manner, wherein the bulk transporters may have pumps, valves, and/or other equipment suitable to pressurize the receiving conduit to push bulk material into the majors subsystem 38 and/or the batch handling system 10 itself may include pumps, valves, pressurized plant air plumbing, and/or other equipment suitable to apply positive and/or negative (vacuum) pressure to the input conduit to push and/or pull bulk material into the majors and minors subsystems 38, 40.

[00415] The transmitting conduit 43 may extend through one or more walls or the roof of the building for transmission to downstream bulk material processing equipment, for instance, in

CHAPTER D – DOCKET 19653

a hot end subsystem of a glass manufacturing system (not shown). For example, the transmitting conduit 43 is pneumatically sealingly coupled to a receiver hopper at a glass melter in the hot end subsystem. The conduit 43 may have any suitable couplings for coupling to the receiver hopper in a pneumatically sealed manner. Those of ordinary skill in the art would recognize that the bulk material handling system is pneumatically closed between the pneumatic receiving conduit and the pneumatic transmitting conduit. This is in contrast to conventional systems where bulk material is open to the surrounding environment. The phrase “pneumatically closed” means that the path, and the bulk materials following that path, from receiving conduit to transmitting conduit is/are enclosed, and not openly exposed to the surrounding environment, although not necessarily always sealed air-tight.

[00416] FIGS. 9A and 9B are isometric views of an illustrative bulk material transport assembly 50 and vehicle 52 to carry the assembly 50 of the transport subsystem 44. The transport assembly 50 and vehicle 52 are configured to move together along the floor of the installation among a plurality of locations, but they are also separable from one another such that the vehicle 52 can move the transport assembly 50 to one location, detach itself from the transport assembly 50, and move itself to a different location, such as to the location of a different transport assembly 50 of the system to temporarily become part of a different transport apparatus.

[00417] The transport assembly 50 includes a transporter 54 supported by a weighing platform 56, which includes a table 58 and a scale 60. The scale 60 is supported by the table 58, and the transporter 54 is supported by the scale 60 when part of the transport assembly 50. The transporter 54 and vehicle platform 56 are configured to move together along the floor of the installation among a plurality of locations when supported by a vehicle 52, but they are also separable from one another such that the transporter 54 can be detached from the platform 56 at one location and the platform 56 can be moved by the vehicle 52 or other means to a different location.

[00418] The vehicle 52 may be an automated guided vehicle (AGV) that may have a platform that is vertically movable such that the AGV can maneuver beneath the transport assembly 52 and extend the platform upward from a retracted position to lift the transport assembly 52 off of the ground for relocation as a complete transport unit. The AGV may include one or more locators that mate with complimentary locators along a bottom side of the table 58

CHAPTER D – DOCKET 19653

of the weighing platform 56. The AGV may have a power source charging system including a wireless battery charger, such as an inductive charger.

[00419] With reference to FIGS. 10A-C, The bulk material transporter 54 may include a hollow transport bin 62 supported by a frame-like cradle 64 and having an inlet 66 at a first or top end, and an outlet 68 at a second or bottom end. The illustrated transport bin 62 is formed as a wall 70 that at least partially defines the hollow interior of the bin and an exoskeleton 72 that extends along an exterior of the wall 70 and interconnects the inlet 66 and outlet 68 of the bin. A central portion 74 of the wall 70 is cylindrical, a lower portion 74a of the wall is generally conical, tapering down toward the outlet 68, and an upper portion 74b of the wall 70 has a concave exterior or frustoconical shape and carries the inlet 66.

[00420] At least a portion of the wall 70 of the bin 62 is formed from a pliable material. Here, “pliable” means the material is elastically deformable in a flexural mode and will return to its original shape after deformation. The pliable material is preferably an elastomeric material, such as a vulcanized rubber material or a polyurethane rubber. Given the heavy loads of bulk material to be carried by the bin 62, it may have a substantial wall thickness on the order of 10-20mm. Using polymeric materials for batch containers with such heavy bulk materials (e.g., sand, limestone, etc.) is unconventional. However, it has been found that use of a pliable wall material facilitates discharge of the bulk material from the bin after all bulk materials have been received by the bin. In particular, the pliable wall 70 can be purposefully and locally deformed to break-up the very dense conglomeration of particulate bulk material in the bin during discharge from the outlet. A traditional metal bin can of course not be elastically deformed—meaning that, if the heavy load of particulate bulk material is compacted too much to drain from the bin via gravity feed, the only way to break the compacted material away from the wall is scraping along the inside of the bin wall. Use of a pliable material in wall of the transport bin 62 is made possible in part by the exoskeleton 72. The exoskeleton 72 is formed from a rigid, non-pliable material such as a metallic material (e.g., steel) or a highly reinforced polymer composite (e.g., a fiberglass or carbon fiber composite).

[00421] The cradle 64 is frame-like in construction and may be constructed from tubular steel members or the like. The cradle 64 includes a bottom 80 having a polygonal (e.g., rectangular) perimeter formed from multiple bottom frame members 82 arranged end-to-end. The cradle 64 further includes upright members 81 extending from corners of the bottom 80 to a

CHAPTER D – DOCKET 19653

free end 81a. The free end 81a may have obliquely angled surfaces 81b for engaging cradle engagement features of a transporter handler described hereinafter. Carriage engagement features 81c are provided at the ends 81a of the uprights 81. In this example, the engagement features 81c are in the form of hooks or downward facing cut-outs and can be used by other machinery of the larger system 10 to lift the transporter 54, such as a transporter handler e.g., elevator and/or conveyor of the discharging module. Other engagement features are possible, including but not limited to pins or posts, pin-receiving apertures, latches, pulleys, etc. Finally, the illustrated cradle 64 includes radial braces 82 extending from each upright 81 to interconnect the cradle 64 with the transport bin 62. Additional bracing may be provided between the cradle 64 and the exoskeleton 72 near the outlet 66 of the transporter 54.

[00422] Notably the cradle 64 is constructed such that it fully supports the weight of the transport bin 62 only along the perimeter of the bin, and the upper end of the cradle is open—i.e., there are no cross-members boxing off the ends 81a of the uprights 81 as with a traditional support frame. The illustrated construction permits the inlet 66 to be located above the cradle 64 so that the cradle does not interfere with dosing or docking equipment, yet still provides structure for lifting the transporter 54 when not receiving bulk material from a material dispenser. As shown in FIG. 10C, a central portion of the bottom 80 of the cradle 64 is also open and accessible for being coupled with a different receiving vessel in a relatively dust-free manner when discharging the contents of the bin 62.

[00423] The transporter 54 includes an inlet closure 84 at the inlet 66 and an outlet closure 86 at the outlet 130. Each closure 84, 86 has an open position and a closed position. When the inlet closure 84 is in the open position, the hollow inner volume of the bin 62 can be accessed through the inlet 66, and bulk material can be received into the bin from above. When the inlet closure 84 is in the closed position, access to the inner volume of the bin 62 is blocked by the closure. In the illustrated example, the inlet closure 84 comprises doors 84a. For purposes of illustration, one door 84a is illustrated in the closed position (horizontal and partially spanning the inlet 66), and the other door is illustrated in the open position (vertical and extending downward toward the internal volume of the bin). The doors 84a or other closure elements are biased toward the closed position (e.g., via a spring) or otherwise are normally kept in the closed condition until some action is taken to open the inlet 66. In this example, each door 84a is hinged and pivots about an axis near an edge of the inlet 66 against a bias. The closure 84 includes

CHAPTER D – DOCKET 19653

levers 84b fixed to the hinge pins of each door 84a that operate to open the respective door when pressed downward from above.

[00424] When the outlet closure 86 is in the closed position, as in FIG. 10C, access to the inner volume of the bin 62 is blocked by the closure, and any bulk material contained in the bin is not permitted to escape the bin under the influence of gravity. When the outlet closure 86 is in the open position, the inner volume of the bin 62 is connected with the space below the bin 62, and any bulk material contained in the bin 62 are permitted to escape through the outlet 66. As with the inlet closure 84, the outlet closure 86 may be biased toward or otherwise normally kept in the closed position until some action is taken to open the outlet 66. In the illustrated example, the outlet closure 86 is a hinged plate slightly recessed in the outlet 66. The hinge pins of the plate lie along a pivot axis extending through the center of the round plate. One side of the hinge pins is operatively coupled with a mechanical transmission 88.

[00425] The transmission 88 is carried by the cradle 64 and includes a driven wheel or rotational input 90, a gearbox 92, and a linkage 94. The rotational input 90 may be a friction wheel or gear that is accessible from below and/or from the transmission side of the cradle 64 and is configured to rotate about a horizontal axis. The gearbox 92 transmits rotation of the input 90 to the linkage 94 and changes the axis of rotation by about 90 degrees (e.g., via bevel gears or a worm gear). The rotating linkage 94 causes the closure to pivot about its axis to change the closure between the open and closed positions, depending on the direction of rotation of the rotational input. Where the rotational input 90 is a friction wheel, a mating friction wheel of another portion of the overall system can be pressed on the wheel and rotated in one direction to open the closure 86, to thereby discharge the contents of the bin 62 into an underlying receiving vessel, and in the opposite direction to close the closure to prepare the bin to be refilled. This is of course only one example of a suitable closure, as nearly any movable barrier can serve the same purpose of opening and closing the outlet 66 of the transporter 54.

[00426] With reference now to FIG. 11A, the bulk material discharging system 42 occupies the first two levels 21, 22 of the system 10, including a first discharging level 101 and a second discharging level 102 that are habitable. The discharging system 42 includes a transmission station 104 to transmit bulk material out of the system 10, a transporter handling station 106 to load and unload the transporter 54 (FIGS. 10A-C) and move the transporter 54 to the transmission station 104 and being located operatively upstream of the transmission station

CHAPTER D – DOCKET 19653

104. The system 42 also may include a rejection station 108 to reject bulk material from the system 10 and may be located between the handling station 106 and the transmission station 104. As will be discussed in further detail below, the discharging system 42 also includes a modular frame 109 to carry portions of the transport handling station 106. Although not shown, those of
5 ordinary skill in the art would recognize, that the subsystem 42 may include any suitable controllers, sensors, actuators, electrical wiring, and the like that may be used to carry out automatic operation of the subsystem 42.

[00427] With reference now to FIGS. 11B and 11C, the handling station 106 may be located at an upstream end of the discharging system 42 and is configured to receive the
10 transporter 54, raise the transporter 54, convey the transporter 54 toward the transmission station 104, receive the transporter 54 en route back from the transmission station 104, and lower the transporter 54 back to the first discharging level 101 for unloading of the transporter 54 out of the transmission station 104 by, for example, an AGV. The handling station 106 includes at least a portion of a transporter handler 110 that raises and lowers the transporter 54 and conveys the
15 transporter 54 back and forth. The transporter handler 110 includes an elevator 112 located at the transporter handling station 106 and a conveyor 114 that cooperates with the elevator 112 and extends between the loading area and transmission station 104, with an upstream end at the transporter handling station 106 and a downstream end at the transmission station 104 and an intermediate portion at the rejection station 108. The elevator 112 raises and lowers the
20 transporter 54 between the lower and upper levels of the discharging system 42, and the conveyor 114 conveys the transporter 54 back and forth to and from the transmission station 104 and to and from the rejection station 108 at the second discharging level 102 of the discharging system 42. The transporter handler 110 includes a vertical elevator axis E along which the elevator 112 operates, a horizontal conveyor axis C along which the conveyor 114 travels
25 downstream and upstream, and a lateral or width axis W. As will be discussed in detail below, the elevator 112 and conveyor 114 cooperate to exchange the transporter 54 between the elevator 112 and the conveyor 114.

[00428] With reference to FIG. 12, while the bulk material transport assembly 50 is located in the transporter handling station 106, the AGV 52 may be charged and/or the weigh
30 scale may be charged. For example, the handling station 106 may include an AGV charger 116 that may be floor-mounted and located in a position that corresponds to an on-board AGV

CHAPTER D – DOCKET 19653

charger when the AGV 52 is in a transporter unloading/loading position. In another example, the transporter handling station 106 may include a scale charger 118 located in a position that corresponds to an on-board scale charger when the AGV is in the transporter unloading/loading position. The scale charger 118 may be mounted to a bracket coupled to a corresponding structural member of the rejection station 108 or to any other suitable nearby structure. Those of ordinary skill in the art would recognize that the chargers 116, 118 may be supplied with electrical power via wires or cables coupled to any suitable power source and in any suitable manner.

[00429] With reference now to FIGS. 13A, the transporter handler 110 may be coupled to a modular frame 109. The modular frame 109 is constructed as a rectangular box truss, having a longitudinal axis L, a transverse or lateral axis T, and a vertical axis V, and including lower beams 109a extending longitudinally, and being laterally opposed from one another, and upper beams 109b extending longitudinally, and being laterally opposed from one another. The frame 109 also includes posts 109c,d extending vertically between the lower and upper beams 109a,b. The posts 109c,d may include corner posts 109c extending vertically between ends of the lower and upper beams 109a,b, and intermediate posts 109d extending vertically between intermediate portions of the lower and upper beams 109a,b between the ends thereof. The frame 109 also includes lower end cross-members 109e extending laterally between the lower beams 109a, and upper end cross-members 109f extending laterally between the upper beams 109b. Although not shown, the frame 109 also may include lower intermediate cross-members extending between intermediate portions of the lower beams 109a between the ends thereof. The frame 109 may also include one or more struts 109g,h extending obliquely between the lower and upper beams 109a,b, for example, side struts 109g extending between lower and upper beams 109a,b on opposite lateral sides of the frame 109 and may be coupled to the beams 109a,b and/or posts 109c,d, and/or may include end struts 109h extending between lower and upper end cross-members 109e,f on one or both longitudinal ends of the frame 109. Moreover, the frame 109 further may include one or more braces 109i extending longitudinally between respective portions of one or more of the side struts 109g and respective portions of one or more of the posts 109c,d. The braces 109i may provide additional structure to carry portions of the elevator and the conveyor. More specifically, the elevator guides and the conveyor guides may be fastened or otherwise coupled to the braces 109i.

CHAPTER D – DOCKET 19653

[00430] The modular frame 109 may share identical exterior dimensions with other modular frames of the system 10 and may be intramodular and intermodular, such that each of different types of modular frames of the system 10 are modular amongst their own kind and are additionally modular across different kinds. The intramodularity of the modular frames is by virtue of dimensions of respective frames being identical among their own kind. The intermodularity of the modular frames is by virtue of certain dimensions of the frames being the same. For example, some frames may have identical height and width, but different lengths. Such modularity facilitates scalability of the system 10 or portions thereof. Additionally, any given modular frame can be lengthened, for example, to add stations and corresponding equipment within each modular frame, or can be shortened, for instance, to omit stations and corresponding equipment.

[00431] With reference to FIG. 13B, the elevator 112 includes vertical guides 120, an elevator carriage 122 guided by the vertical guides 120, and one or more elevator actuators 124 operatively coupled to the elevator carriage 122 to raise and lower the elevator carriage 122 along the vertical guides 120. The elevator actuators 124 may include a set of hydraulic cylinders having cylinder housings 126 coupled to the vertical guides 120 and pistons 128 coupled to the elevator carriage 122.

[00432] With reference to FIG. 14A, the vertical guides 120 include beams 130 and wear rails 132 carried on the beams 130. The beams 130 may be C-shaped as shown, or I-shaped, or of any other suitable transverse cross-sectional shape and may have base walls 134 and flanges 136 that establish channels between the flanges 136. The channels may accommodate the hydraulic cylinders therein. The wearable rails may be composed of a wear-resistant polymeric material of any suitable type. Lower ends of the beams 130 may be coupled to feet 138 (FIG. 13B) that, in turn, are coupled to the foundation by fastening, staking, or in any other suitable manner. Upper ends of the beams 130 may be coupled to the interior portions of one or more of the lower and upper beams 109a,b (FIG. 13A) of the modular frame 109 by fastening, welding, or in any other suitable manner. The elevator 112 may include hydraulic power supplies to power the cylinders and, although not shown, may include suitable fluid hoses, fittings, and the like coupled between the power supplies and the cylinders.

[00433] With reference to FIG. 14A, the elevator carriage 122 includes a frame 140 including upper and lower sets of roller arms 142 at opposite lateral sides and configured to

CHAPTER D – DOCKET 19653

extend over upstream and downstream sides of the vertical guides 120 and carry upstream and downstream rollers 144a to engage corresponding wear rails 132 on the upstream and downstream sides of the vertical guides 120 and outboard facing rollers 144b to engage corresponding wear rails 132 on inboard facing surfaces of the vertical guides 120. The frame 140 also includes a lower transporter restraint rail 146 extending between lower sets of roller arms 142 on either side of the frame. The frame 140 further includes side walls 148 extending between and coupling together upper and lower sets of roller arms 142 on either side of the frame 140. The frame 140 additionally includes cradle arms 150 coupled to upper ends of the side walls 148 and connected together at an upstream end by an upper transporter restraint rail 152.

[00434] With reference now to FIG. 14B, the cradle arms 150 carry transporter couplings 154 configured to engage the corresponding carriage couplings of the bulk material transporter 54. The transporter couplings 154 are arranged proximate upstream and downstream ends of the cradle arms 150. The transporter couplings 154 include a first set of actuatable pins 156 that are actuatable into and out of engagement with the first set of hooks of the transporter 54. FIG. 14C, illustrates an example of engagement between one of the pins 156 and one of the transporter hooks 81c. As shown in FIG. 14B, the pins 156 may be actuated by pneumatic or hydraulic cylinders 158 having cylinder housings 158a coupled to the cradle arms 150 and pistons 158b extending out of the cylinder housings 158a in an outboard direction along the width axis, brackets 162 coupled to the pistons 158b and to the pins 156 and pin guide 162 coupled to outboard sides of the cradle arms 150. In other embodiments, the pins 162 may be actuated by electromechanical devices, for example, solenoids or the like. The elevator carriage 122 also may include one or more transporter sensors 164 that may be coupled to one or both cradle arms 150 by a bracket or in any suitable manner.

[00435] With reference to FIGS. 15A-B, the conveyor 114 is operatively coupled with the elevator 112, and includes horizontal guides 166, and a conveyor carriage 168 guided by the horizontal guides 166 and including a frame 170, and a conveyor actuator 172 operatively coupled to the frame 170 and to the horizontal guides 166 to advance and retract the conveyor carriage 168 along the horizontal guides 166, and a second set of transporter couplings 174. The conveyor 114 also may include one or more conveyor carriage sensors 176 that may be carried

CHAPTER D – DOCKET 19653

by the horizontal guides 166 in any suitable manner, and/or one or more transporter sensors 178 that may be carried by the frame 170 of the conveyor carriage 168 in any suitable manner.

[00436] The horizontal guides 166 may be coupled to the modular frame 109 (FIG. 13A) and, more particularly, may be coupled to the modular frame 109 by brackets 180 extending
5 laterally between the horizontal guides 166 and the modular frame 109 and coupled to interior portions of the upper beams of the modular frame 109. The horizontal guides 166 include beams 182 and wear rails (not shown) carried on the beams 182. The beams 182 may be C-shaped as shown, or I-shaped, or of any other suitable transverse cross-sectional shape and may have base walls 184 and flanges 186 that establish channels between the flanges 186, and vertically
10 extending flanges 188.

[00437] With reference to FIG. 15B, the frame 170 generally includes a base 190, and cradle arms 192 depending downwardly at upstream and downstream portions of the base 190 on opposite lateral sides of the base 190 and configured to extend over corresponding portions of the transporter 54. More specifically, the base 190 may include side rails 194 that may be
15 laterally spaced apart, and longitudinally extending, cross-members 196 extending laterally between the side rails 194. The base 190 may be a weldment constructed of various plates and tubing, or may be constructed in any other fashion suitable for lifting a bulk material transporter.

[00438] The conveyor actuator 172 may include a motor 198 carried by the frame 170, one or more suspension drive rollers 200 rotatably coupled to the frame 170 about a horizontal
20 axis and operatively coupled to the motor 198, a transmission 202 coupled to the motor 198 and coupled to the driver roller(s) 200 via a drive shaft 204 and a belt 206 or a chain, or the like coupled to the drive shaft 204 and to the transmission 202. The suspension drive rollers 200 cooperate with corresponding portions of the horizontal guides 166, for example, lower horizontal flanges of the beams 182 inside the channels of the beams 182. Similarly, the
25 conveyor carriage 168 may include suspension guide rollers 208 that may be rotatable about a forward or downstream horizontal axis and coupled proximate a downstream end of the frame 170. For example, two laterally opposed passive rollers 208 may be provided at a front or downstream end of the frame 170, and two laterally opposed drive rollers 200 may be provided at a rear or downstream end of the frame 170 although the passive and drive rollers 208,200
30 could be swapped between front and rear, or all the rollers could be drive rollers. Additionally, the conveyor carriage 168 may include lateral stabilization guide rollers 210 that may be

CHAPTER D – DOCKET 19653

rotatable about vertical axes and coupled to the frame 170 at sides of the frame 170 to cooperate with corresponding portions of the horizontal guides 166, for example, the vertical flanges 188 of the beams 182.

[00439] The transporter couplings may include suspension couplings 212 and also may
5 include stabilization couplings 214. The suspension couplings 212 are configured to suspend the transporter 54 from the frame 170 of the conveyor carriage 168, and may include, for example, a second set of actuatable pins 216 carried by the conveyor carriage frame 170 and actuatable along a longitudinal axis. The suspension couplings 212 are arranged proximate upstream and downstream ends of the cradle arms 192. The actuatable pins 216 are actuatable into and out of
10 engagement with the second set of hooks of the transporter 54. The stabilization couplings 214 are configured to stabilize the transporter 54 when the suspension couplings 212 are coupled to the transporter 54, and may include, for instance, one or more stabilizer pads 218 carried by the conveyor carriage frame 170 and actuatable along an oblique axis. More specifically, the stabilization couplings 214 may include four transporter stabilizers, one proximate each inside
15 corner of the conveyor carriage frame 170, and configured to be actuatable into and out of engagement with obliquely angled surfaces of the carriage couplings of the transporter 54. FIG. 15C, illustrates an example of engagement between one of the pins 216 and one of the transporter hooks. As shown in FIGS. 15D and 15E, the pins 216 may be actuated by pneumatic or hydraulic cylinders 220 having cylinder housings 220a coupled to the cradle arms 192 and
20 pistons 220b extending out of the cylinder housings 220a in a longitudinal direction along the horizontal conveyor axis C, brackets 222 coupled to the pistons 220b and to the pins 216 and pin guides 224 coupled to outboard sides of the cradle arms 192. In other embodiments, the pins 216 may be actuated by electromechanical devices, for example, solenoids or the like, or by any other suitable actuators. The stabilizer pads 218 may be actuated by pneumatic or hydraulic cylinders
25 220 having cylinder housings 220a coupled to the cradle arms 192 and pistons 220b extending out of the cylinder housings 220a in an oblique direction relative to the longitudinal and lateral axes of the conveyor 114.

[00440] With reference now to FIG. 16, a transporter handler module or the transporter handler 110 includes the modular frame 109, and the transporter handler 110 including the
30 vertical and horizontal guides 120, 166, the elevator carriage 122, the conveyor carriage 168, the elevator actuators 124, the conveyor actuator (not shown), all carried within the modular frame

CHAPTER D – DOCKET 19653

109 during shipment to an application site. For this purpose, the modular frame 109 additionally may include any suitable bracketry, couplings (e.g. fasteners or straps), and the like to secure the various portions of the transporter handler 110 to the frame 109. For example, the modular frame 109 may include elevator guide brackets 226 coupled to the modular frame 109 and to the
5 elevator guides 120, and elevator actuator brackets 228 coupled to the modular frame 109 and to the actuators 124. The modular frame 109 may have exterior dimensions less than or equal to exterior dimensions of an intermodal freight container, more specifically, a height less than or equal to 9' 6" (2.896 m), a width less than or equal to 8' 6" (2.591 m), and a length less than or equal to 20' (6.096 m).

10 [00441] With reference again to FIG. 11B, the bulk material transmission station 104 generally includes a transmitting vessel 230 to receive, hold, and release bulk material, an inlet dock 232 in communication with a vessel inlet 242 to facilitate communication with the bulk material transporter 54, and pneumatic transmission conduit 234 to receive bulk material from the transmitting vessel 230 and facilitate transmission of the bulk material out of the system.

15 With reference to FIG. 18A, the transmission station 104 also may include a transporter closure driver 236 to facilitate release of bulk material out of the transporter 54 and into the transmitting vessel 230, and, with reference to FIG. 19B, a transporter massaging apparatus 238 that massages sidewalls of the transporter to coax bulk material out of the transporter.

[00442] With reference now to FIG. 17A, the transmitting vessel 230 may include a body
20 240 having the vessel inlet 242 configured to receive bulk material from an outlet of the transporter 54 and a vessel outlet 244 to transmit bulk material out of the transmitting vessel 230. The body 240 may have a cylindrical upper portion 246 with a domed upper end 247 that may have the vessel inlet 242, and a lower hopper portion 248 that may have the vessel outlet 244. The lower hopper portion 248 may be a fluidization cone to assist with movement and
25 transmission of bulk material. The transmitting vessel 230 may be suspended by a frame 250 on the foundation 14, or may be suspended in any other manner. The transmitting vessel 230 may include a vessel inlet valve or closure 252 to selectively seal the vessel inlet 242, and a vessel outlet valve or closure 254 to selectively seal the vessel outlet 244. The closures 252, 254 may include actuators 256, which may be electrically, pneumatically, or hydraulically powered to
30 move one or more valves or other valve or closure elements. The transmitting vessel 230 may be pressurizable and the vessel inlet 242 sealingly closeable such that the transmitting vessel 230

CHAPTER D – DOCKET 19653

may be used to assist with pressurized pneumatic transmission of bulk material out of the system. Accordingly, the transmitting vessel 230 may have an interior that is volumetrically larger than that of the transporter 54 so as to define a sealable pressurizable headspace.

[00443] With continued reference to FIG. 17A, the pneumatic transmission conduit 234 includes a station outlet conduit 258 in downstream fluid communication with the vessel outlet 244 to receive bulk material from the vessel outlet 244, and a station outlet pressurization conduit 260 in fluid communication with the station outlet conduit 258 to pressurize the station outlet conduit 258 for pneumatic transmission of the bulk material through the station outlet conduit 258, and a station outlet pressurization closure or valve 262 that may be upstream of the vessel outlet 244 to open, close, or otherwise regulate flow through, the station outlet pressurization conduit 260. The pneumatic transmission conduit 234 further includes a vessel vent conduit 264 in fluid communication between an interior of the station outlet conduit 258 and an upper portion of an interior of the transmitting vessel 230, and a vessel vent conduit closure or valve 266 to close, open, and otherwise regulate flow through, the vessel vent conduit 264. The pneumatic transmission conduit 234 additionally includes a vessel pressurization conduit 268 in fluid communication with the upper portion of the interior of the transmitting vessel 230, and a vessel pressurization conduit closure valve 270 to open, close, and otherwise regulate flow through, the vessel pressurization conduit 268. The transmission station 104 is operated to transmit bulk material according to the following sequencing: a) pressurizing, wherein the inlet closure 252 is closed, the vent conduit valve is closed, and the vessel pressurization conduit valve 270 is opened; b) transmitting, wherein the station outlet pressurization valve 262 is opened to transmit bulk material out of the station outlet conduit 258; and venting, wherein the vessel pressurization conduit valve 270 is closed, the vessel outlet closure 254 is closed, the vent conduit valve is opened.

[00444] With reference now to FIG. 17B, the station outlet pressurization conduit 260 may be coupled to a pressurized airline, which may be powered by a plant-wide compressor, a local system compressor, or by any other suitable apparatus (not shown). The conduit 260 may include a pressure and flow regulator 272 as well as one or more pressure gauges 274 for monitoring pressure as the conveying pressure is regulated to ensure the bulk material does not clog the transmission line. The station outlet pressurization valve 262 is downstream of the regulator 272. A fluidization control panel 276 is coupled with the outlet pressurization conduit

CHAPTER D – DOCKET 19653

260 downstream from the pressurization valve 262. An air inlet 278 of the panel is pressurized by the same source as the station outlet pressurization conduit 260. A fluidization control valve 280 opens and closes, depending on whether the transmitting vessel requires fluidization. A pressure sensor 282 is in communication with a controller that monitors pressure at the panel 276. A manifold 284 provides air to pneumatically controlled valves of the panel 276. Based on monitored pressure in the pressurization conduit 260, which will rise and fall based on whether or not downstream bulk material begins to obstruct the transmission conduit 234, the control panel 276 operates to periodically pressurize the fluidization portion of the transmitting vessel 230 to break up the material near the outlet 244 and keep the bulk material moving through the transmission conduit. The resulting bulk material flow in the transmission conduit is in a state between dense phase conveying and dilute phase conveying. It is higher pressure and lower velocity than dilute phase conveying, but the velocity is maintained sufficiently high to prevent the bulk material in the transmission conduit from being packed together as dense slugs of material, thus striking a balance between reducing wear in the transmission conduit (via lower velocity) and the complexity of a true dense phase conveying system in which boost pressure points are often needed along the full-length of the transmission conduit.

[00445] With reference now to FIG. 18A, the transmission station inlet dock 232 is shown in communication with the vessel inlet 242 and includes a fixed portion 300 fixed to the transmitting vessel 230 at the vessel inlet 242 thereof, and a movable portion 302 movable away from the transmitting vessel 230 and configured to dock with the outlet of the bulk material transporter 54. The movable portion 302 includes an inlet flange 304 configured to be engageable with the outlet of the bulk material transporter 54, a collapsible conduit 306 extending between the inlet flange 304 and the fixed portion 300, and at least one actuator 308 to move the movable portion 302. When the transporter 54 is in a position suitable to release bulk material into the transmitting vessel 230, the actuator 308 may be activated to move the inlet flange 304 against the outlet of the transporter 54 and then the transporter outlet valve may be opened.

[00446] With reference to FIGS. 18A and 18B, the transporter closure driver 236 is configured to drive the transmission 88 at the outlet of the transporter 54 from a closed state to an open state to release bulk material from the transporter 54 into the transmitting vessel 230. The closure driver 236 includes a drive wheel 310, and a motor 312 coupled to the drive wheel

CHAPTER D – DOCKET 19653

310 to rotate the drive wheel 310. With additional reference to FIG. 18C, a motor carrier 314 carries the motor 312 and is translatable, and a motor carrier actuator 316 is coupled to the motor carrier 314 and is configured to translate the motor carrier 314, the motor 312, and the drive wheel 310 into and out of engagement with the driven closure 236 of the transporter 54, as depicted in FIGS. 18D and 18E.

[00447] With reference now to FIGS. 19A and 19B, the transporter massaging apparatus 238 may be coupled to the modular frame 109 (FIG. 13A) and may include upper and lower mounting rails 318 on either side of the conveyor axis that may be coupled to the modular frame 109, and massager mounts 320 coupled between the upper and lower mounting rails 318 on either side of the conveyor axis. The apparatus includes massagers 322 that may be pivotably mounted to the mounts and having massaging ends 324 that may carry rollers 326, actuator ends 328, and pivots 330 pivotably mounted to horizontal portions of the massager mounts 320. The transporter massaging apparatus 238 also includes actuators 332 to move the massagers 322 into and out of engagement with the sidewalls of the transporter 54 and in massaging engagement with the transporter sidewalls to coax bulk material out of the transporter 54 during releasing of bulk material therefrom into the transmitting vessel 230. More specifically, the massagers 322 may engage and massage sidewalls of the conical lower portion of the transporter 54. In operation, the massagers 322 may deflect the sidewalls of the transporter 54, for instance, three to four inches, or any other suitable displacement.

[00448] With reference now to FIGS. 20A and 20B, the rejection station 108 rejects bulk material from the system 10 and includes a rejection hopper 334 having a rejection inlet 336 to receive bulk material therein and a rejection outlet 338 to transmit bulk material therefrom, an auger 340 having an auger inlet 342 in communication with the rejection hopper outlet to receive bulk material therefrom and an auger outlet 344 that may be equipped with an outlet valve 344a, and a recirculation conduit 346 having a recirculation inlet 348 in fluid communication with the auger at a location upstream of the auger outlet and also having a recirculation outlet 350 in fluid communication with an upper portion of an interior of the rejection hopper 334. A rejection station outlet 338 may be positioned below the auger outlet 44. With reference now to FIGS. 20C and 20D, the rejection station 108 also may include the inlet dock 232 and the transporter closure driver 236 previously described with respect to the transmission station. Moreover, and with additional reference again to FIG. 4, the rejection station 108 also may include a waste

CHAPTER D – DOCKET 19653

disposal vessel W located outside of the building 16 in which the rejection hopper 334 is located and having an inlet to receive bulk material from the outlet 344 of the auger 340. Incorporation of the rejection hopper 334 promotes good uptime and usage of the discharging subsystem, because it allows the transporter 540 to be quickly emptied to clear the transporter 540 from
5 blocking or slowing down access to the transmission station 104.

CHAPTER D – DOCKET 19653

Example claims for Chapter D (Docket 19653) include the following:

1.

A bulk material discharging system, comprising:

a transmission station including

5 a transmitting vessel having

a transmitting vessel inlet configured to receive bulk material from an outlet of a bulk material transporter, and

a transmitting vessel outlet to transmit bulk material therefrom; and

10 a transporter handling station located operatively upstream of the transmission station and including

at least a portion of a transporter handler including

at least one carriage with transporter couplings configured to engage corresponding carriage couplings of the bulk material transporter and configured to convey the bulk material transporter over the transmitting vessel.

15

2.

The system of claim 1, wherein the transporter handler also includes an elevator at the transporter handling station and including vertical guides, an elevator carriage guided by the vertical guides, and one or more elevator actuators operatively coupled to the elevator carriage to
20 raise and lower the elevator carriage along the vertical guides, and wherein the transporter handler further includes a conveyor extending between the handling and transmission stations and including horizontal guides, a conveyor carriage guided by the horizontal guides, and one or more conveyor actuators operatively coupled to the conveyor carriage to advance and retract the conveyor carriage along the horizontal guides.

25

3.

The system of claim 2, wherein the one or more elevator actuators include at least one set of hydraulic cylinders having cylinder housings coupled to the vertical guides and pistons coupled to the elevator carriage.

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CHAPTER D – DOCKET 19653

4.

The system of claim 2, wherein the conveyor carriage includes a frame, at least one drive roller carried by the frame and configured to engage the horizontal guides, and the one or more conveyor actuators includes at least one motor coupled to the at least one drive roller.

5

5.

The system of claim 4, wherein the conveyor carriage also includes at least one transporter stabilizer that is configured to stabilize the bulk material transporter.

10

6.

The system of claim 1, wherein the carriage couplings of the bulk material transporter include a first and second set of hooks, and the transporter couplings of the transporter handler include a first set of actuatable pins carried by the elevator carriage that are actuatable into and out of engagement with the first set of hooks of the transporter and a second set of actuatable pins carried by the conveyor carriage that are actuatable into and out of engagement with the second set of hooks of the transporter.

15

7.

The system of claim 6, wherein the transporter couplings of the transporter handler include actuatable transporter stabilizers carried by the conveyor carriage and configured to be actuatable into and out of engagement with obliquely angled surfaces of the carriage couplings of the transporter.

20

8.

The system of claim 1, wherein the transporter handling station also includes an AGV charger.

25

9.

The system of claim 1, wherein the transporter handling station also includes a weigh scale charger.

30

CHAPTER D – DOCKET 19653

10.

The system of claim 1, wherein the transmission station also includes a closure driver configured to drive a driven closure at the outlet of the transporter from a closed state to an open state to release bulk material from the transporter into the transmitting vessel.

5

11.

The system of claim 10, wherein the closure driver includes a drive wheel, a motor coupled to the drive wheel to rotate the drive wheel, a motor carrier carrying the motor and being translatable, and a motor carrier actuator coupled to the motor carrier and configured to translate the motor carrier, the motor, and the drive wheel into and out of engagement with the driven closure of the transporter.

10

12.

The system of claim 1, wherein the transmitting vessel is pressurizable and the inlet is sealably closeable and the transmitting vessel has an interior that is volumetrically larger than that of the transporter so as to define a sealable pressurizable headspace.

15

13.

An architectural installation, comprising:

a foundation including a slab; and

the system of claim 1 carried on the foundation slab,

no pit or basement beneath at least that portion of the slab that carries the system.

20

14.

The system of claim 1, wherein the transmission station further includes

an inlet dock in communication with the transmitting vessel inlet including

a fixed portion fixed to the transmitting vessel,

a movable portion movable away from the transmitting vessel and configured to dock with the outlet of the transporter and including a flange configured to engage the transporter and a conduit extending between the flange and the fixed portion, and

25

30

at least one actuator to move the movable portion,

CHAPTER D – DOCKET 19653

a vessel inlet closure,

a vessel outlet closure,

a station outlet conduit in downstream fluid communication with the transmitting vessel outlet to receive bulk material from the transmitting vessel outlet,

5 a station outlet pressurization conduit in fluid communication with the station outlet conduit to pressurize the station outlet conduit for pneumatic transmission of the bulk material through the station outlet conduit,

a station outlet pressurization valve to regulate opening of the station outlet pressurization conduit,

10 a vessel vent conduit in fluid communication between an interior of the outlet conduit and an upper portion of an interior of the transmitting vessel,

a vessel vent conduit closure to close and open the vessel vent conduit, and

a vessel pressurization conduit in fluid communication with the upper portion of the interior of the transmitting vessel, and

15 a vessel pressurization valve to regulate opening of the vessel pressurization conduit.

15.

The system of claim 14, wherein the transmission station is operated to transmit bulk material according to the following sequencing:

20 pressurizing, wherein the inlet closure is closed, the vent conduit valve is closed, and the hopper pressurization valve is opened,

transmitting, wherein the outlet pressurization valve is opened to transmit bulk material out of the outlet conduit,

25 venting, wherein the hopper pressurization valve is closed, the outlet closure is closed, the vent conduit valve is opened.

16.

The system of claim 1, further comprising:

30 a modular frame constructed as a rectangular box truss, having a longitudinal axis, a lateral axis, and a vertical axis, and including lower beams extending longitudinally and being laterally opposed from one another, upper beams extending longitudinally and being laterally

CHAPTER D – DOCKET 19653

opposed from one another, posts extending vertically between the lower and upper beams, upper cross-members extending laterally between the upper beams, and lower cross-members extending laterally between the lower beams;

wherein the transporter handler includes an elevator having vertical guides coupled to interior portions of one or more of the lower and upper beams, and

wherein the transporter handler includes a conveyor having horizontal guides coupled to interior portions of the upper beams.

17.

The system of claim 16, wherein the modular frame also includes one or more struts extending obliquely between the lower and upper beams.

18.

The system of claim 1, further comprising:

a rejection station including

a rejection hopper having a rejection inlet to receive bulk material therein and a rejection outlet to transmit bulk material therefrom,

an auger having an auger inlet in communication with the rejection hopper outlet to receive bulk material therefrom and an auger outlet, and

a recirculation conduit having a recirculation inlet in fluid communication with the auger at a location upstream of the auger outlet and also having a recirculation outlet in fluid communication with an upper portion of an interior of the rejection hopper.

19.

The system of claim 18, wherein the rejection station also includes a disposal vessel located outside of a building in which the rejection hopper is located and having an inlet to receive bulk material from the outlet of the auger.

20.

The system of claim 18, wherein the rejection station is located between the transmission station and the transporter handling station.

CHAPTER D – DOCKET 19653

21.

A bulk material transmission station, comprising:

a transmitting vessel having

a vessel inlet configured to receive bulk material from an outlet of a bulk material

5 transporter,

a vessel outlet to transmit bulk material therefrom,

a vessel inlet closure,

a vessel outlet closure;

10 a station outlet conduit in downstream fluid communication with the vessel outlet to receive bulk material from the vessel outlet;

a station outlet pressurization conduit in fluid communication with the station outlet conduit to pressurize the station outlet conduit for pneumatic transmission of the bulk material through the station outlet conduit; and

15 a station outlet pressurization valve to regulate opening of the station outlet pressurization conduit.

22.

The system of claim 21, wherein the transmission station further comprises:

an inlet dock in communication with the vessel inlet and including

20 a fixed portion fixed to the transmitting vessel, and

a movable portion movable away from the transmitting vessel and configured to dock with the outlet of the bulk material transporter and having

a flange configured to be engageable with the outlet of the bulk material transporter,

25 a conduit extending between the flange and the fixed portion, and at least one actuator to move the movable portion.

23.

The system of claim 21, wherein the transmission station further comprises:

30 a vessel vent conduit in fluid communication between an interior of the station outlet conduit and an upper portion of an interior of the transmitting vessel;

CHAPTER D – DOCKET 19653

a vessel vent conduit valve to close and open the vessel vent conduit;
a vessel pressurization conduit in fluid communication with the upper portion of the interior of the transmitting vessel; and
a vessel pressurization conduit valve to regulate opening of the vessel pressurization
5 conduit.

24.

The system of claim 23, wherein the transmission station is operated to transmit bulk material according to the following sequencing:

- 10 pressurizing, wherein the inlet closure is closed, the vent conduit valve is closed, and the hopper pressurization valve is opened,
transmitting, wherein the outlet pressurization valve is opened to transmit bulk material out of the outlet conduit,
venting, wherein the hopper pressurization valve is closed, the outlet closure is closed,
15 the vent conduit valve is opened.

25.

A bulk material transporter handler, comprising:
an elevator including

- 20 vertical guides,
an elevator carriage guided by the vertical guides and having a first set of transporter couplings, and
one or more elevator actuators operatively coupled to the elevator carriage to raise and lower the elevator carriage along the vertical guides; and
25 a conveyor carriage operatively coupled with the elevator, and including
horizontal guides,
a conveyor carriage guided by the horizontal guides and having a second set of transporter couplings, and
one or more conveyor actuators operatively coupled to the conveyor carriage to
30 advance and retract the conveyor carriage along the horizontal guides.

CHAPTER D – DOCKET 19653

26.

The transporter handler of claim 25, wherein the one or more elevator actuators include at least one set of hydraulic cylinders having cylinder housings coupled to the vertical guides and pistons coupled to the elevator carriage.

5

27.

The transporter handler of claim 25, wherein the conveyor carriage includes a frame, at least one drive roller carried by the frame, and the one or more conveyor actuators includes at least one motor coupled to the at least one drive roller.

10

28.

The transporter handler of claim 27, wherein the conveyor carriage also includes at least one transporter stabilizer that is configured to stabilize the transporter.

15

29.

The transporter handler of claim 28, wherein the at least one transporter stabilizer includes four transporter stabilizers, one at each inside corner of the conveyor carriage.

20

30.

The transporter handler of claim 25, wherein the first set of transporter couplings of the transporter handler include a first set of actuatable pins carried by the elevator carriage that are actuatable along a lateral axis, and the second set of transporter couplings includes a second set of actuatable pins carried by the conveyor carriage that are actuatable along a longitudinal axis.

25

31.

A transporter handler module, comprising:

a modular frame constructed as a rectangular box truss, having a longitudinal axis, a lateral axis, and a vertical axis, and including lower beams extending longitudinally and being laterally opposed from one another, upper beams extending longitudinally and being laterally opposed from one another, posts extending vertically between the lower and upper beams, upper

30

CHAPTER D – DOCKET 19653

cross-members extending laterally between the upper beams, and lower cross-members extending laterally between the lower beams; and

the transporter handler of claim 23 wherein the vertical guides are coupled to interior portions of one or more of the lower and upper beams, and the horizontal guides are coupled to interior portions of the upper beams.

32.

The module of claim 31, wherein the modular frame also includes one or more struts extending obliquely between the lower and upper beams.

33.

The module of claim 31, wherein the vertical and horizontal guides, the elevator carriage, the conveyor carriage, and the one or more elevator actuators and the one or more conveyor actuators are all carried within the modular truss frame during shipment to an application site, and wherein the modular frame has exterior dimensions less than or equal to exterior dimensions of an intermodal freight container.

34.

A bulk material rejection station, comprising:

a rejection hopper including

a rejection inlet to receive bulk material therein, and

a rejection outlet to transmit bulk material therefrom;

an auger including an auger inlet in downstream communication with the rejection hopper outlet; and

a recirculation conduit including

a recirculation inlet in fluid communication with the auger at a location upstream of the auger outlet, and

a recirculation outlet in fluid communication with an upper portion of an interior of the rejection hopper.

CHAPTER D – DOCKET 19653

35.

The station of claim 34, further comprising:

an inlet dock in communication with the rejection inlet including a fixed portion fixed to the rejection hopper, a movable portion movable away from the rejection hopper and including a flange and a conduit extending between the flange and the fixed portion, and at least one actuator to move the movable portion.

36.

The station of claim 34, further comprising:

a closure driver including a drive wheel, a motor coupled to the drive wheel to rotate the drive wheel, a motor carrier carrying the motor and being translatable, and a motor carrier actuator coupled to the motor carrier to translate the motor carrier, the motor, and the drive wheel.

[00449] With reference in general to all drawings of the drawing figures, one of ordinary skill in the art would recognize that the above-described systems, subsystems, apparatuses, and components, enable various bulk material handling methods, at least as follows. A bulk material handling method includes receiving bulk material and pneumatically conveying the bulk material via at least one of pressurized dilute phase, pressurized dense phase, hybrid dilute/dense phase, or vacuum draw conveyance into bulk material containers, and storing the bulk material in the bulk material containers. The method also includes dispensing the bulk material from the bulk material containers into a bulk material transporter, and transporting the bulk material transporter from the bulk material containers to a bulk material discharging system. The method further includes discharging the bulk material out of the bulk material transporter, including releasing the bulk material from the bulk material transporter into a bulk material transmitting vessel, and pneumatically transmitting the bulk material out of the bulk material transmitting vessel to downstream bulk material processing equipment.

[00450] As used in herein, the terminology “for example,” “e.g.,” for instance,” “like,” “such as,” “comprising,” “having,” “including,” and the like, when used with a listing of one or more elements, is to be construed as open-ended, meaning that the listing does not exclude additional elements. Also, as used herein, the term “may” is an expedient merely to indicate optionality, for instance, of a disclosed embodiment, element, feature, or the like, and should not be construed as rendering indefinite any disclosure herein. Moreover, directional words such as front, rear, top, bottom, upper, lower, radial, circumferential, axial, lateral, longitudinal, vertical, horizontal, transverse, and/or the like are employed by way of example and not necessarily limitation.

[00451] Finally, the subject matter of this application is presently disclosed in conjunction with several explicit illustrative embodiments and modifications to those embodiments, using various terms. All terms used herein are intended to be merely descriptive, rather than necessarily limiting, and are to be interpreted and construed in accordance with their ordinary and customary meaning in the art, unless used in a context that requires a different interpretation. And for the sake of expedience, each explicit illustrative embodiment and modification is hereby incorporated by reference into one or more of the other explicit illustrative embodiments and modifications. As such, many other embodiments, modifications, and equivalents thereto, either exist now or are yet to be discovered and, thus, it is neither intended nor possible to presently

describe all such subject matter, which will readily be suggested to persons of ordinary skill in the art in view of the present disclosure. Rather, the present disclosure is intended to embrace all such embodiments and modifications of the subject matter of this application, and equivalents thereto, as fall within the broad scope of the accompanying claims.

Claims

1.

A bulk material handling system, comprising:

a bulk material storage and dispensing subsystem including

5 bulk material conduit to receive bulk material from outside the system and convey the bulk material under pressure,

 bulk material containers in downstream pneumatic communication with the bulk material conduit to receive and store the bulk material, and

 bulk material dispensing equipment in communication with the bulk material
10 containers to receive the bulk material from the bulk material containers and dispense the bulk material within the system;

 a bulk material discharging subsystem including

 a bulk material transmitting vessel to discharge the bulk material out of the system, and

15 a transporter handler; and

 a bulk material transport subsystem including

 a bulk material transporter configured to
 receive bulk material from the bulk material storage and dispensing
 subsystem,

20 be transported between the bulk material storage and dispensing subsystem and the bulk material discharging subsystem,

 be lifted and conveyed by the transporter handler of the bulk material discharging subsystem over the bulk material transmitting vessel of the bulk material discharging subsystem, and

25 release the bulk material received from the bulk material storage and dispensing subsystem into the bulk material transmitting vessel.

2.

 The system of claim 1, wherein the system occupies a volumetric envelope of less than
30 7,500 cubic meters and produces about 110 tons of glass per day, for a capacity adjusted size of less than 70 cubic meters per each ton of glass produced per day.

3.

The system of claim 1, wherein the system occupies a volumetric envelope of less than 6,000 cubic meters and produces about 110 tons of glass per day, for a capacity adjusted size of less than 55 cubic meters per each ton of glass produced per day.

5

4.

The system of claim 1, wherein the system occupies a volumetric envelope of about 5,350 cubic meters and produces about 110 tons of glass per day, for a capacity adjusted size of less than 50 cubic meters per each ton of glass produced per day.

10

5.

The system of claim 1, wherein the bulk material transport subsystem also includes a table having a platform and legs depending from the platform to support the platform,

15

a weigh scale configured to be carried on the platform of the table, and the transporter configured to be carried on the weigh scale.

6.

The system of claim 5, wherein the bulk material transporter includes

20

a transport bin, and a cradle to carry the bulk material transport bin.

7.

The system of claim 5, wherein the bulk material transport subsystem further includes

25

an automatically guided vehicle separate from the table and configured to

be traversable between the legs of the table and under the platform of the

table,

be raisable from a lowered position to a raised position to lift the table, the

scale, and the bulk material transporter, and

30

move the table, the scale, and the bulk material transporter between the bulk material storage and dispensing subsystem and the bulk material discharging subsystem.

8.

The system of claim 7, wherein the discharging subsystem includes at least one of a charger for the automatically guided vehicle or a charger for the weigh scale.

9.

The system of claim 1, wherein the bulk material storage and dispensing subsystem includes

a majors subsystem including

a plurality of majors containers to store majors bulk material, and

majors dispensing equipment in communication with the majors containers, and

a minors subsystem including

a plurality of minors containers to store minors bulk material, and

minors dispensing equipment in communication with the minors containers.

10.

The system of claim 9, wherein

the majors subsystem also includes

a majors dispensing module including a majors dispensing frame carrying the majors dispensing equipment, and

a plurality of majors container modules including majors container frames carried on the majors dispensing frame and carrying the majors containers;

the minors subsystem also includes

a minors dispensing module including a minors dispensing frame carrying the minors dispensing equipment, and

a minors containing module including a minors containing frame carried by the minors dispensing frame and carrying the plurality of minors containers.

11.

The system of claim 10, wherein the minors subsystem also includes

a large container unloading module including

a large container unloading frame, and

a large container unloading station carried by the large container unloading frame, and

a small container unloading module including

a small container unloading frame, and

5 a small container unloading station carried by the small container unloading frame.

12.

The system of claim 11, wherein the minors subsystem further includes

10 a small container unloading filtration module including

a small container unloading filtration frame carried on the small container unloading frame, and

a small container unloading filter in fluid communication with the small container unloading station and carried by the small container unloading filtration frame.

15

13.

The system of claim 12, wherein the minors subsystem additionally includes

a minors vestibule module including a minors vestibule frame coupled to, and positioned between, the large and small container unloading frames, and

20 a minors auxiliary module including a minors auxiliary frame carried at a second level of the system on the small container unloading filtration frame.

14.

The system of claim 10, wherein the bulk material discharging subsystem also includes

25 a bin handling module including a bin handling frame carrying portions of the bin handler.

15.

The system of claim 14, further comprising:

30 a first level base frame, wherein the majors and minors dispensing frames, and the bin handling frame, are configured to be carried on the first level base frame.

16.

The system of claim 15, further comprising:

a controls subsystem including

5 at least one controls module including at least one controls frame configured to be
carried at a second level of the system on the first level base frame, and
controls equipment carried by the at least one controls frame.

17.

10 The system of claim 16, wherein the at least one controls module also includes an
exterior access doorway, and an interior doorway between the at least one controls module and
the minors dispensing module.

18.

15 The system of claim 15, wherein the minors dispensing module includes an exterior
access doorway, and the minors containing module includes an exterior access doorway.

19.

20 The system of claim 15, wherein the majors container modules include an attic level, and
at least one of the majors container modules includes an exterior access doorway at the attic
level.

20.

The system of claim 10, wherein

25 the majors subsystem also includes

majors pneumatic inlet conduit in pneumatic communication with the majors
containers, and

majors pneumatic power supply equipment in fluid communication with the
system pneumatic inlet conduit,

30 the minors subsystem also includes

bulk material container unloading equipment, and

minors pneumatic inlet conduit in pneumatic communication with the bulk material container unloading equipment and with the minors containers, and

the bulk material discharging subsystem also includes

system pneumatic outlet conduit in pneumatic communication with the bulk material transmitting vessel, and

discharging pneumatic power supply equipment in fluid communication with the system pneumatic outlet conduit,

wherein the majors inlet conduit, the majors containers, the majors dispensing equipment, the minors unloading equipment, the minors inlet conduit, the minors containers, the minors dispensing equipment, the bulk material transport bin, and the bulk material transmitting vessel are closeable such that the system is pneumatically closed from the majors pneumatic inlet conduit and the minors unloading equipment to the system pneumatic outlet conduit.

21.

A method of constructing the bulk material handling system of claim 10, comprising: pre-assembling the modules of the system of claim 10 at an equipment fabricator; shipping the modules of the pre-assembled system from the fabricator to a product manufacturer like intermodal freight containers; and erecting the pre-assembled system from the modules at the product manufacturer.

22.

A bulk material handling method, comprising: receiving bulk material and pneumatically conveying the bulk material via at least one of pressurized dilute phase, pressurized dense phase, hybrid dilute/dense phase, or vacuum draw conveyance into bulk material containers; storing the bulk material in the bulk material containers; dispensing the bulk material from the bulk material containers into a bulk material transporter; transporting the bulk material transporter from the bulk material containers to a bulk material discharging system; and discharging the bulk material out of the bulk material transporter, including

releasing the bulk material from the bulk material transporter into a bulk material transmitting vessel, and

pneumatically transmitting the bulk material out of the bulk material transmitting vessel to downstream bulk material processing equipment.

5

23.

The method of claim 22, wherein the discharging also includes:

rejecting the bulk material from the bulk material transporter to a waste container.

10

24.

The method of claim 22, wherein the entire method is carried out in a volumetric envelope of less than 7,500 cubic meters and produces about 110 tons of glass per day, for a capacity adjusted size of less than 70 cubic meters per each ton of glass produced per day.

15

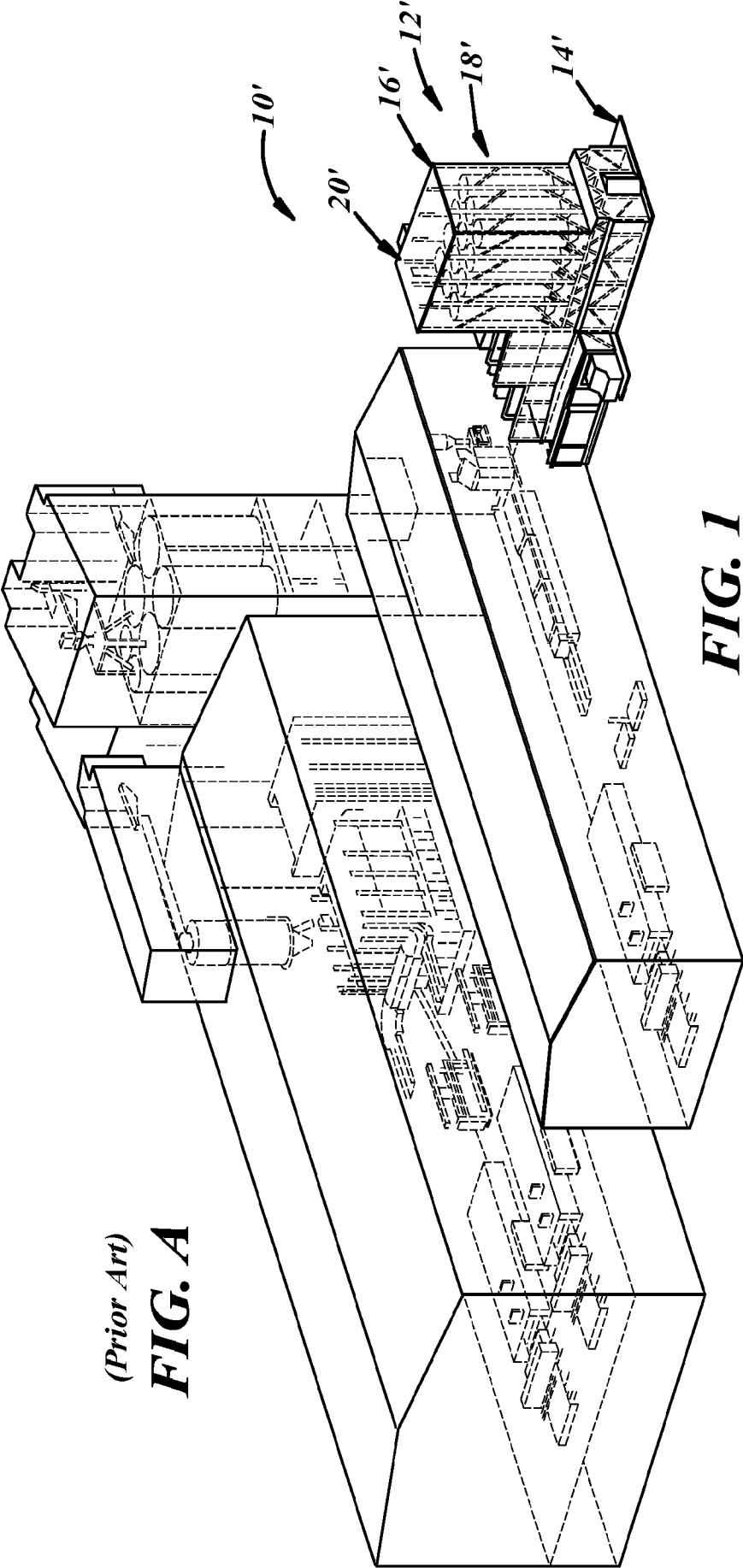
25.

The method of claim 22, wherein the entire method is carried out in a volumetric envelope of less than 6,000 cubic meters and produces about 110 tons of glass per day, for a capacity adjusted size of less than 55 cubic meters per each ton of glass produced per day.

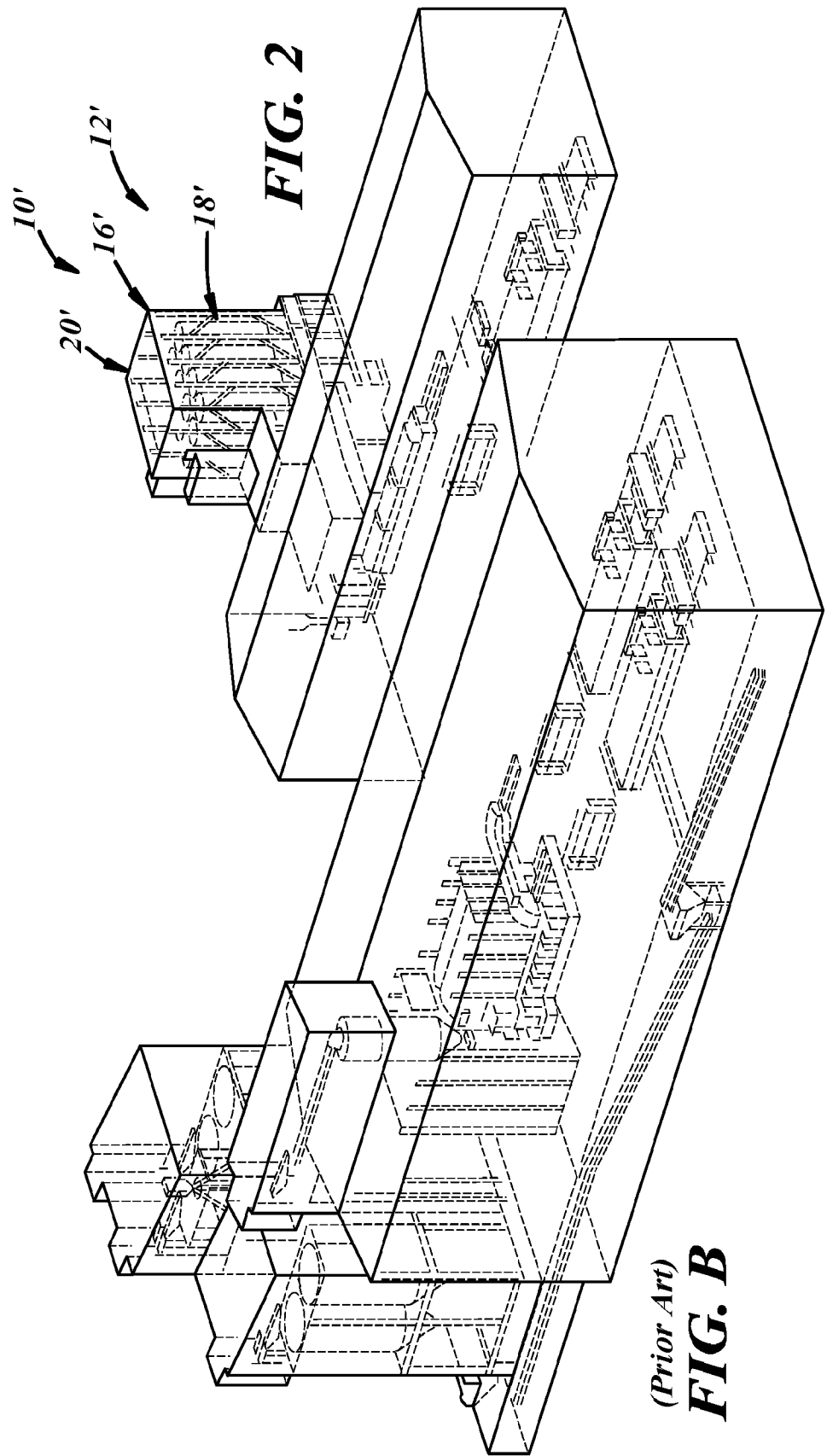
20

26.

The method of claim 22, wherein the entire method is carried out in a volumetric envelope of about 5,350 cubic meters and produces about 110 tons of glass per day, for a capacity adjusted size of less than 50 cubic meters per each ton of glass produced per day.



(Prior Art)
FIG. A



(Prior Art)
FIG. C

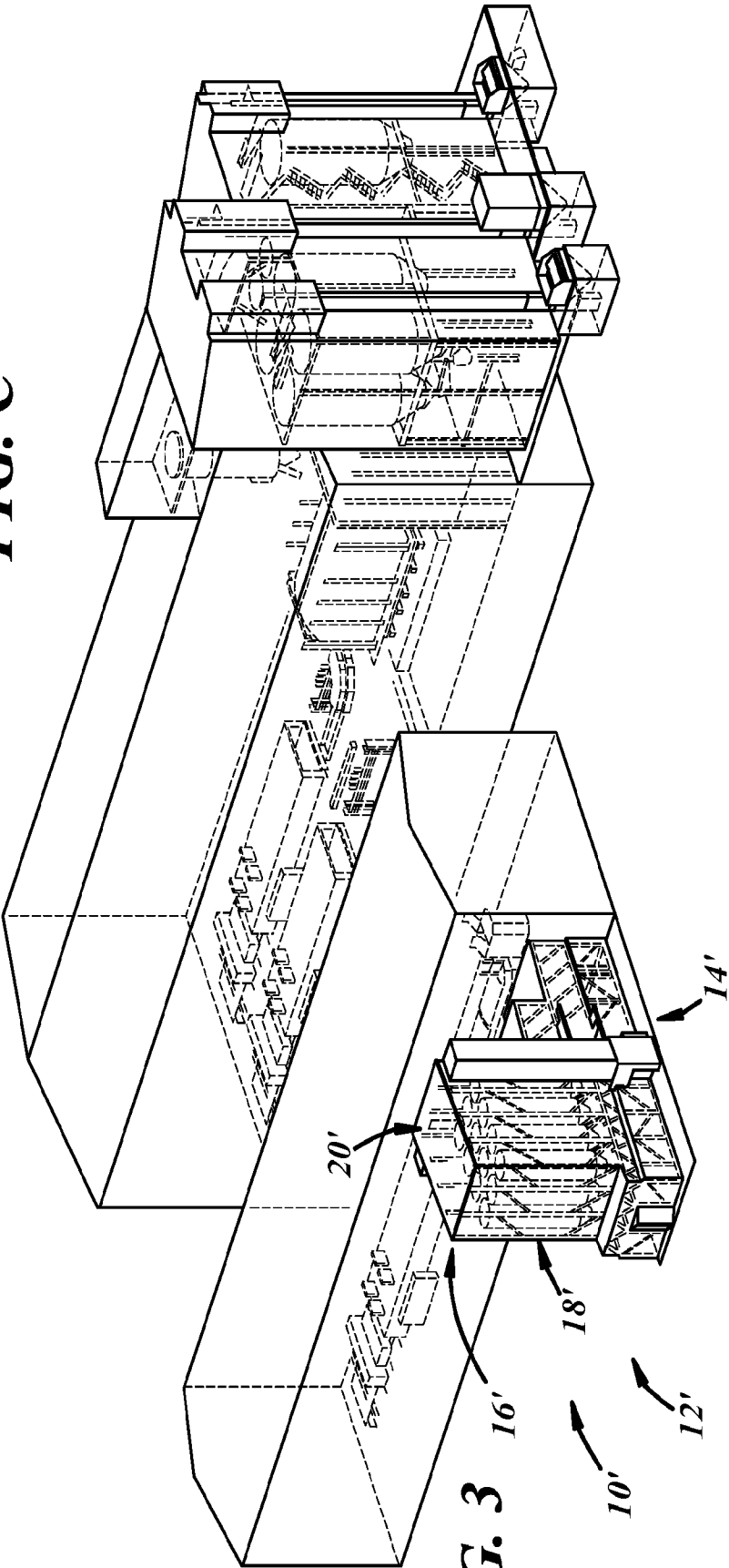


FIG. 3

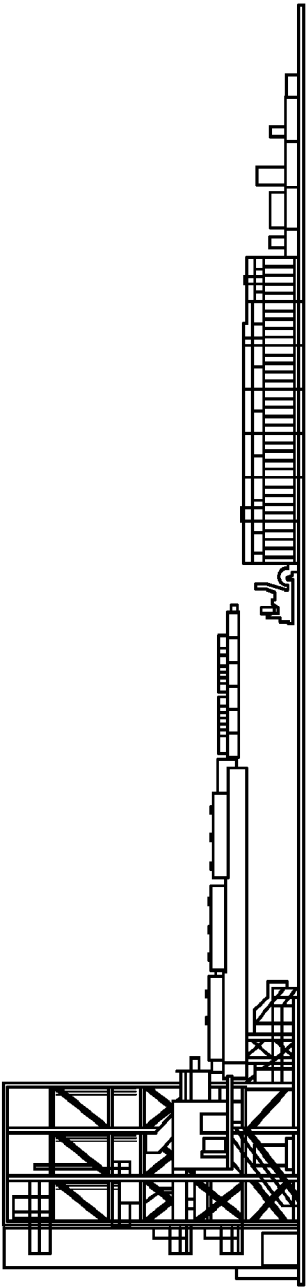
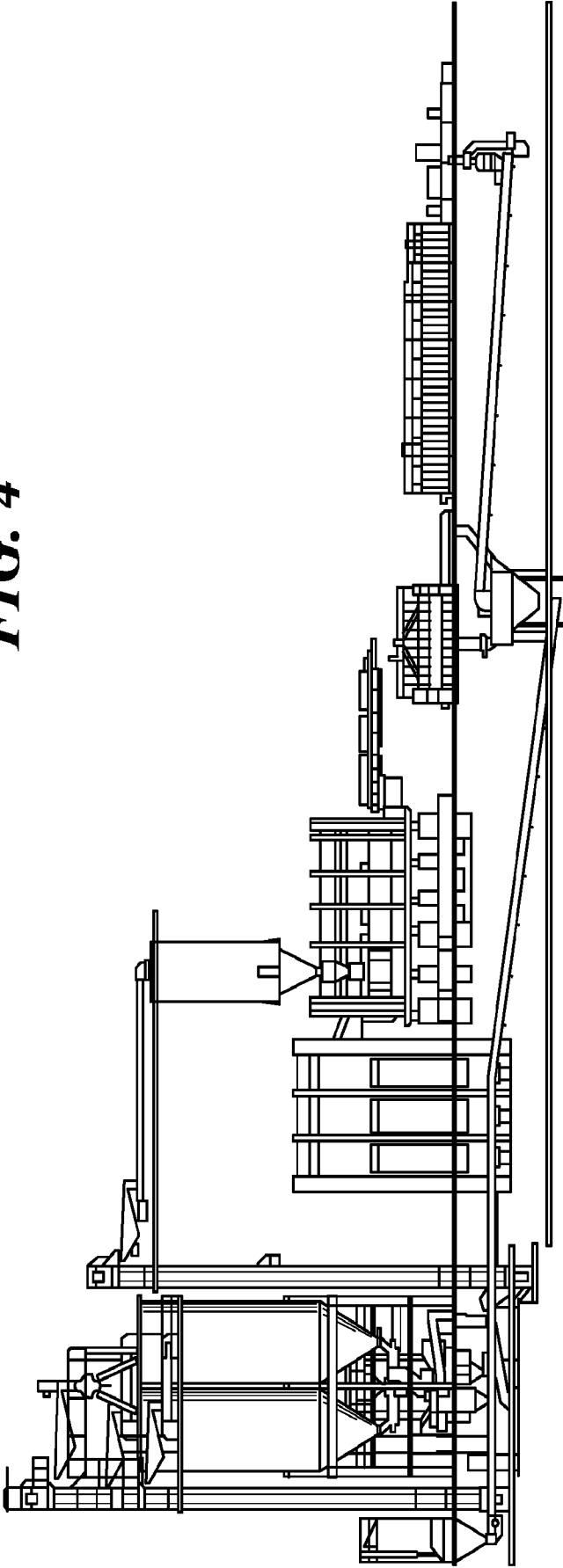


FIG. 4



(Prior Art)
FIG. D

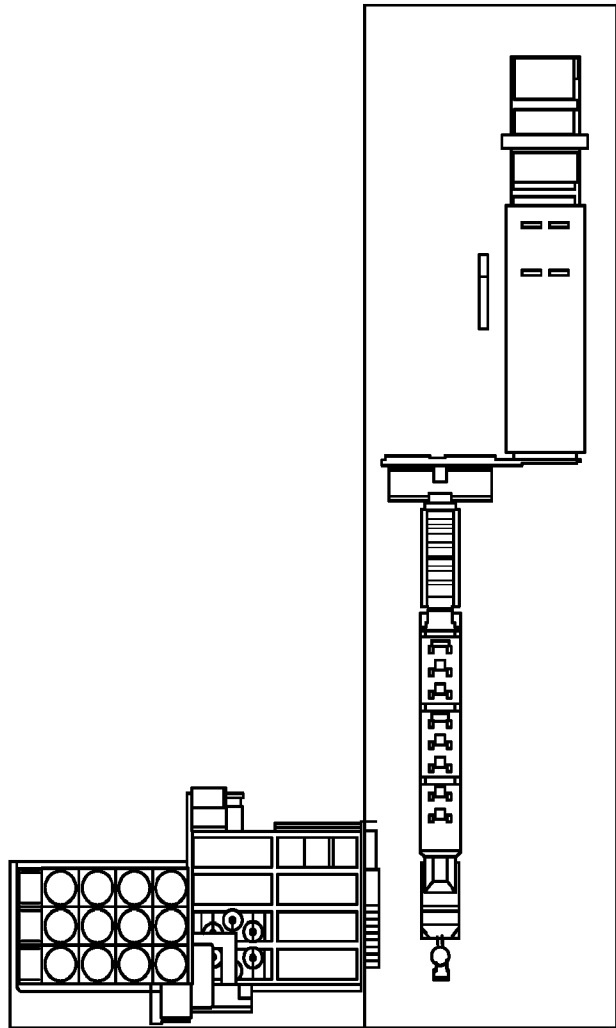
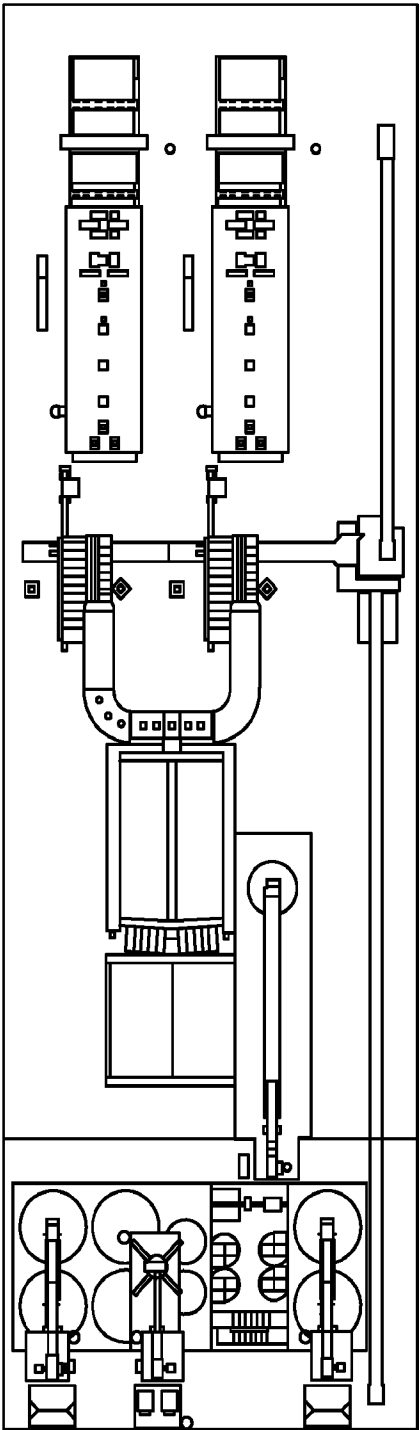
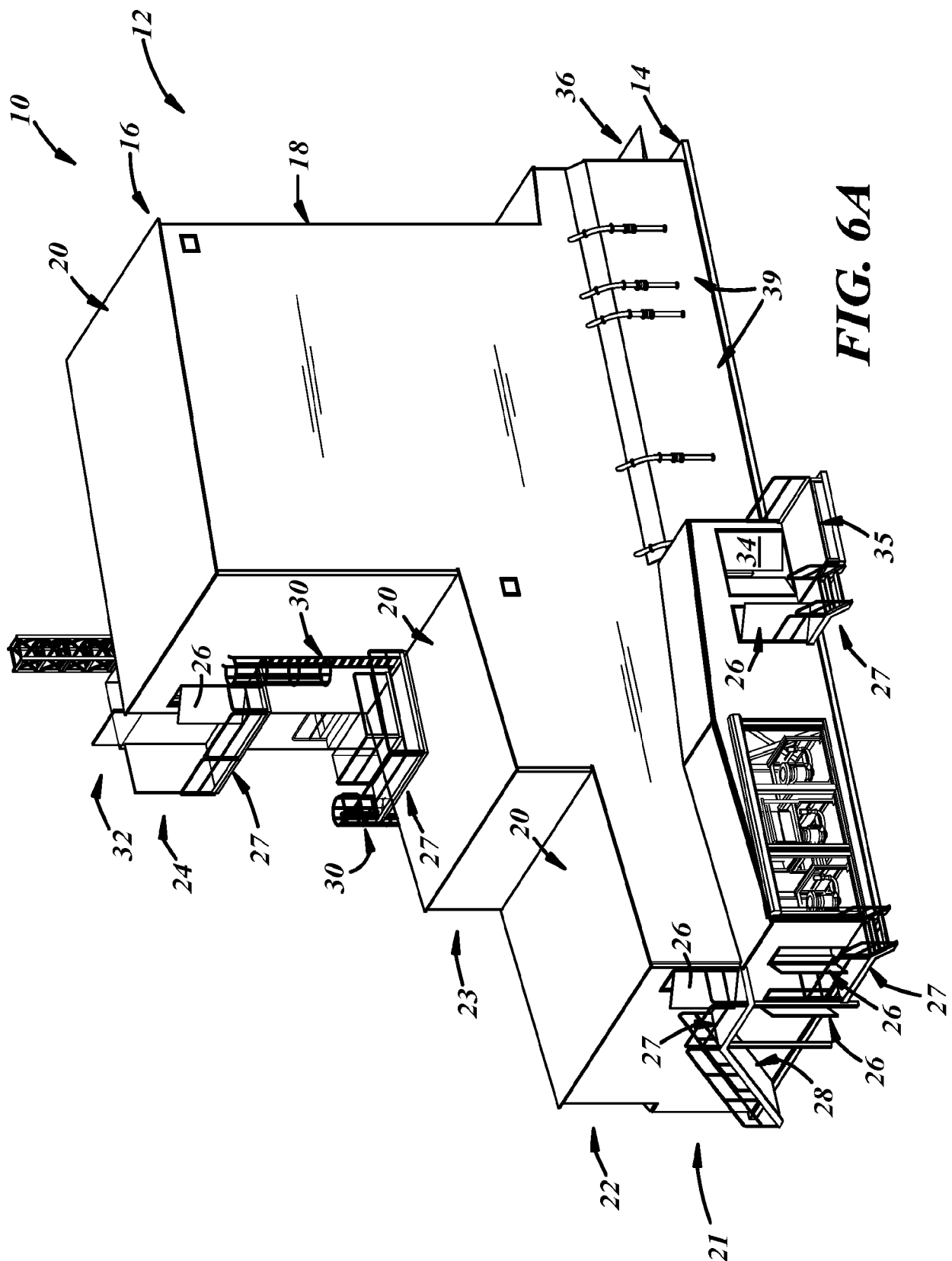


FIG. 5



(Prior Art)

FIG. E



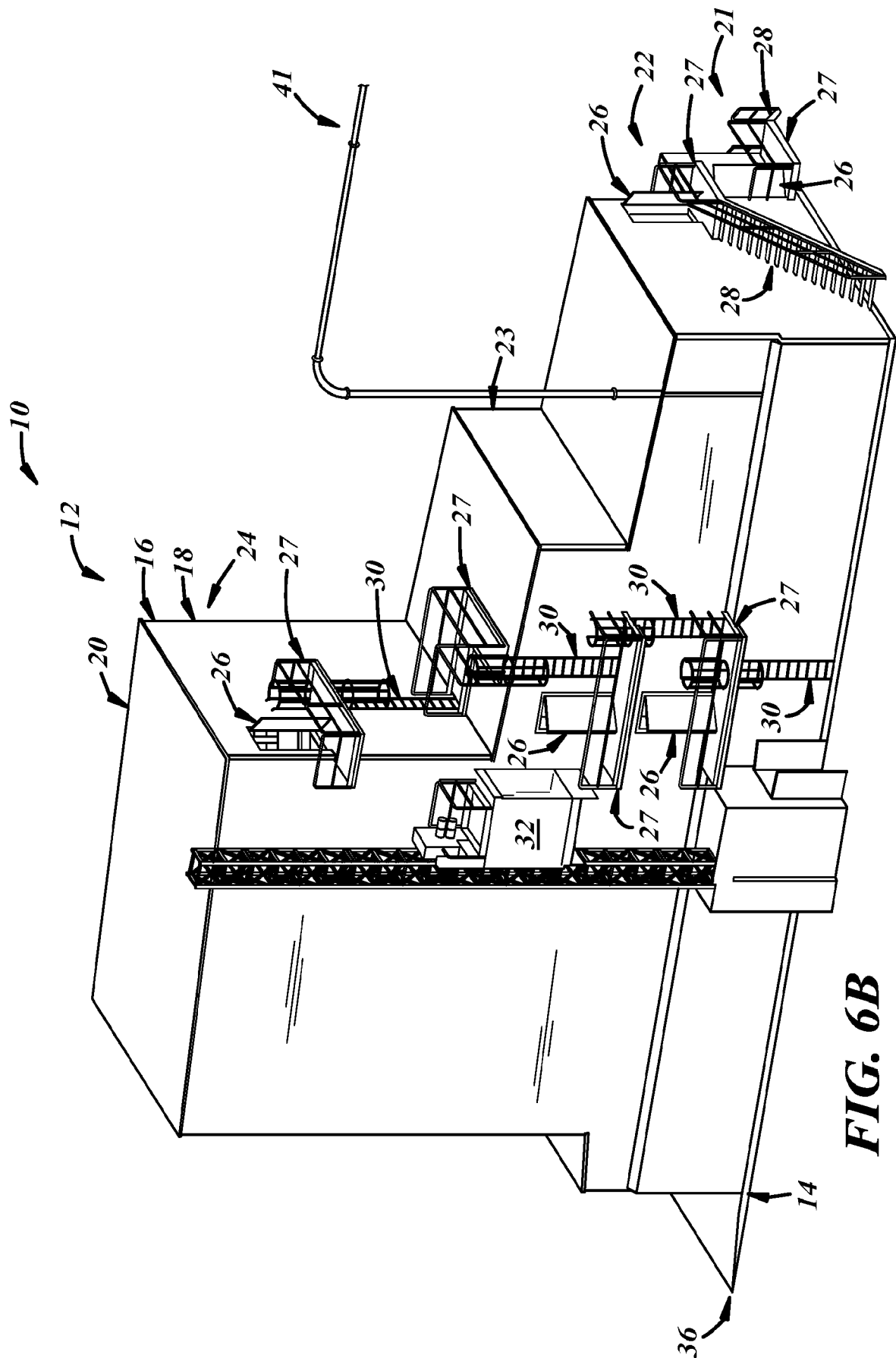


FIG. 6B

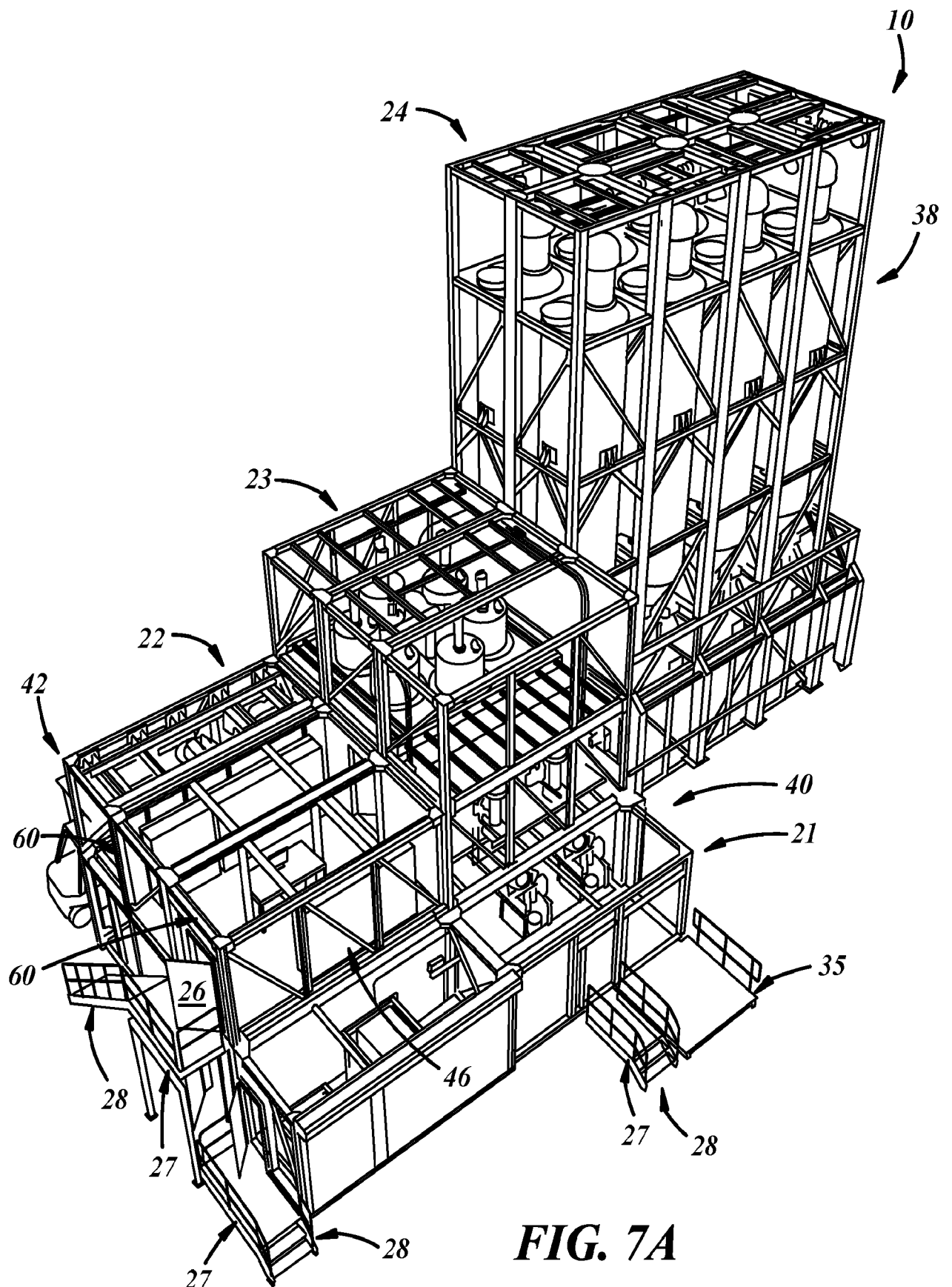


FIG. 7A

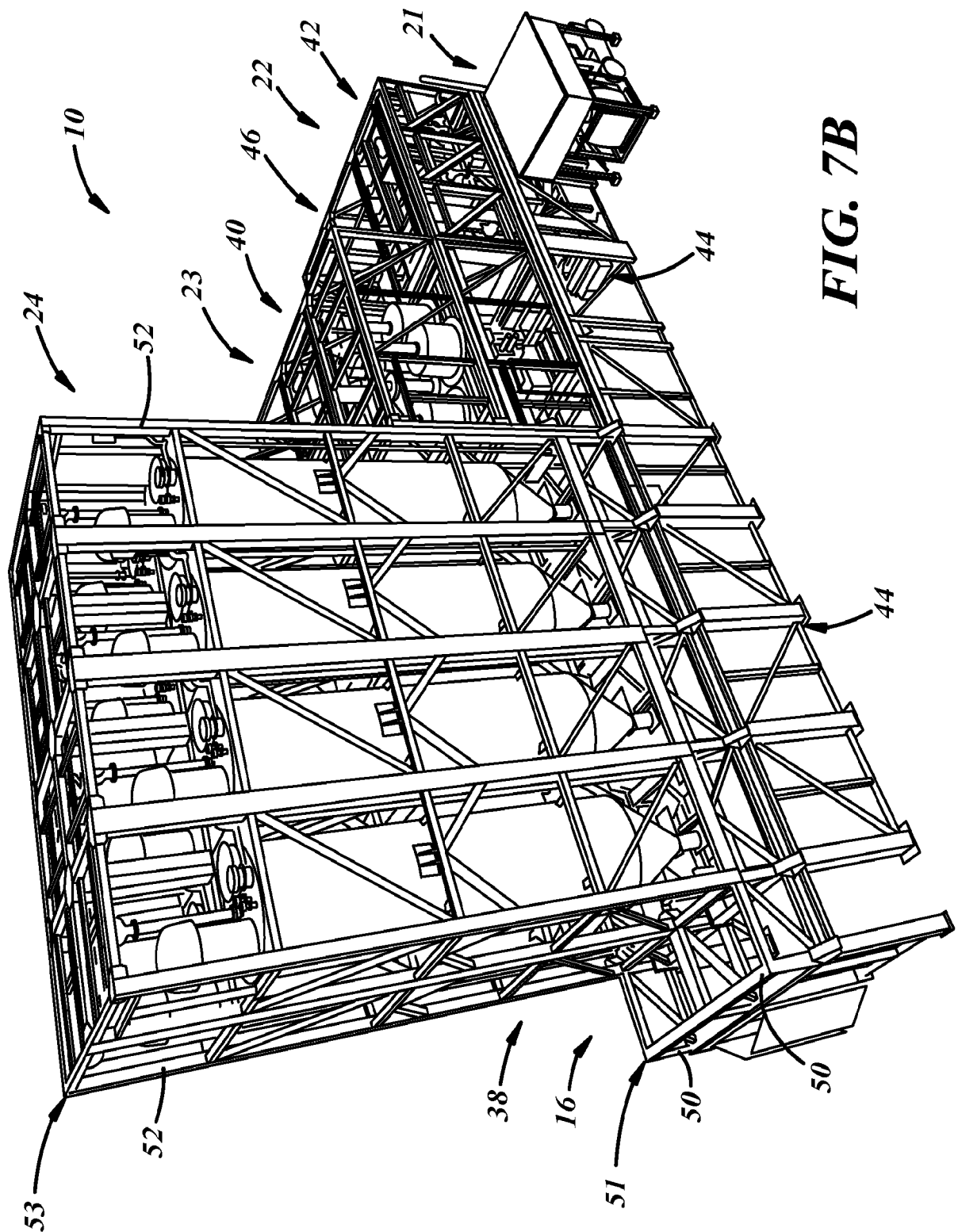


FIG. 7B

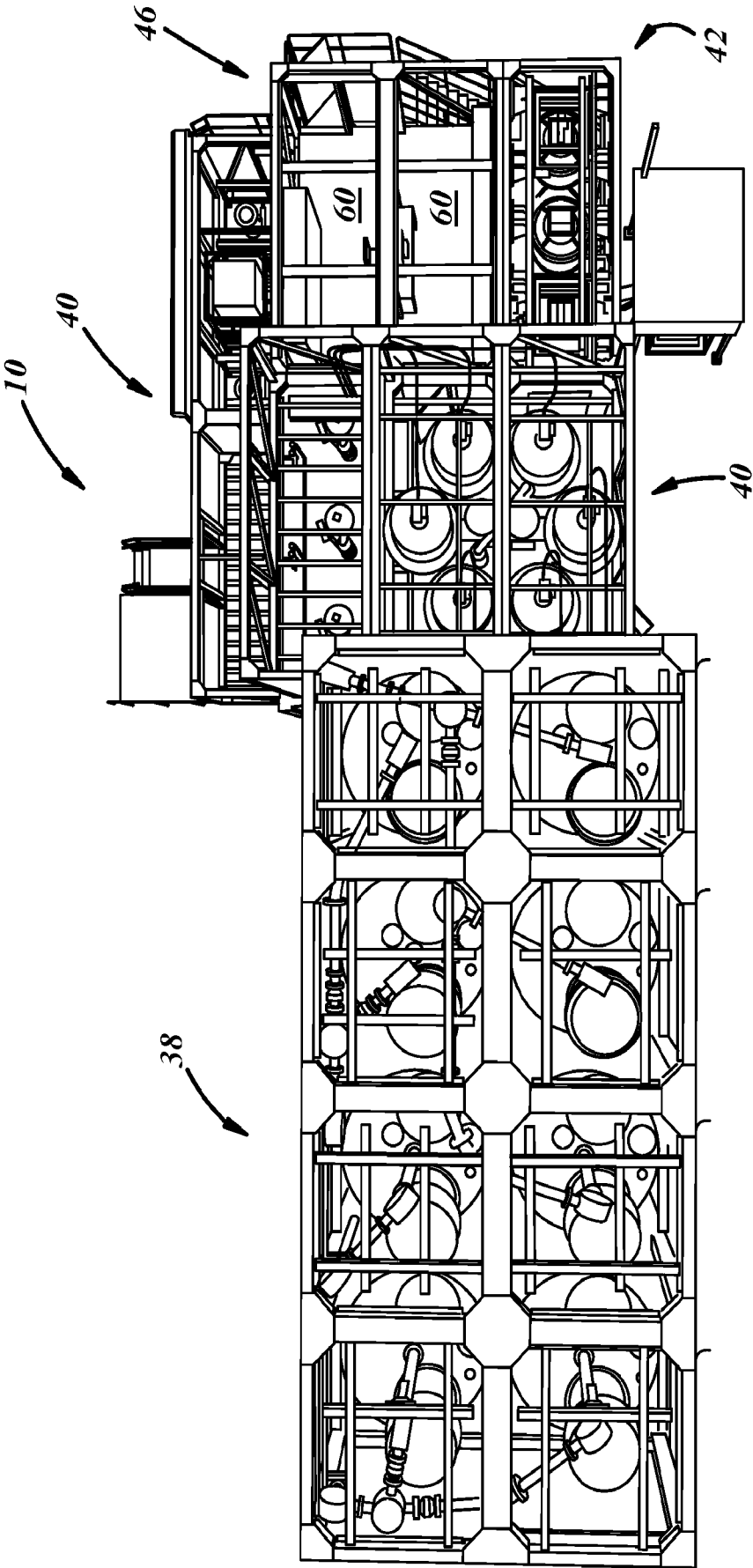


FIG. 8

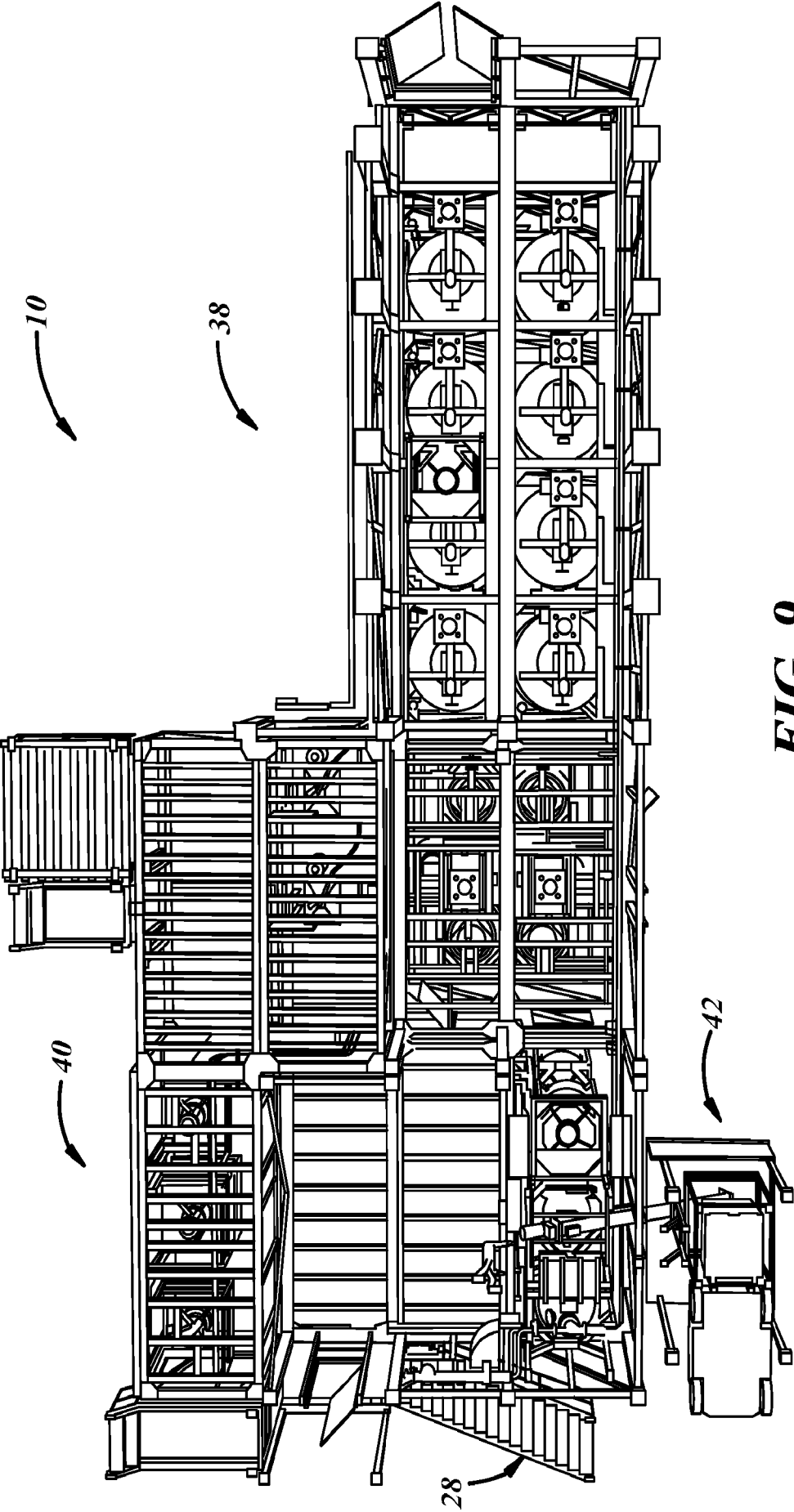


FIG. 9

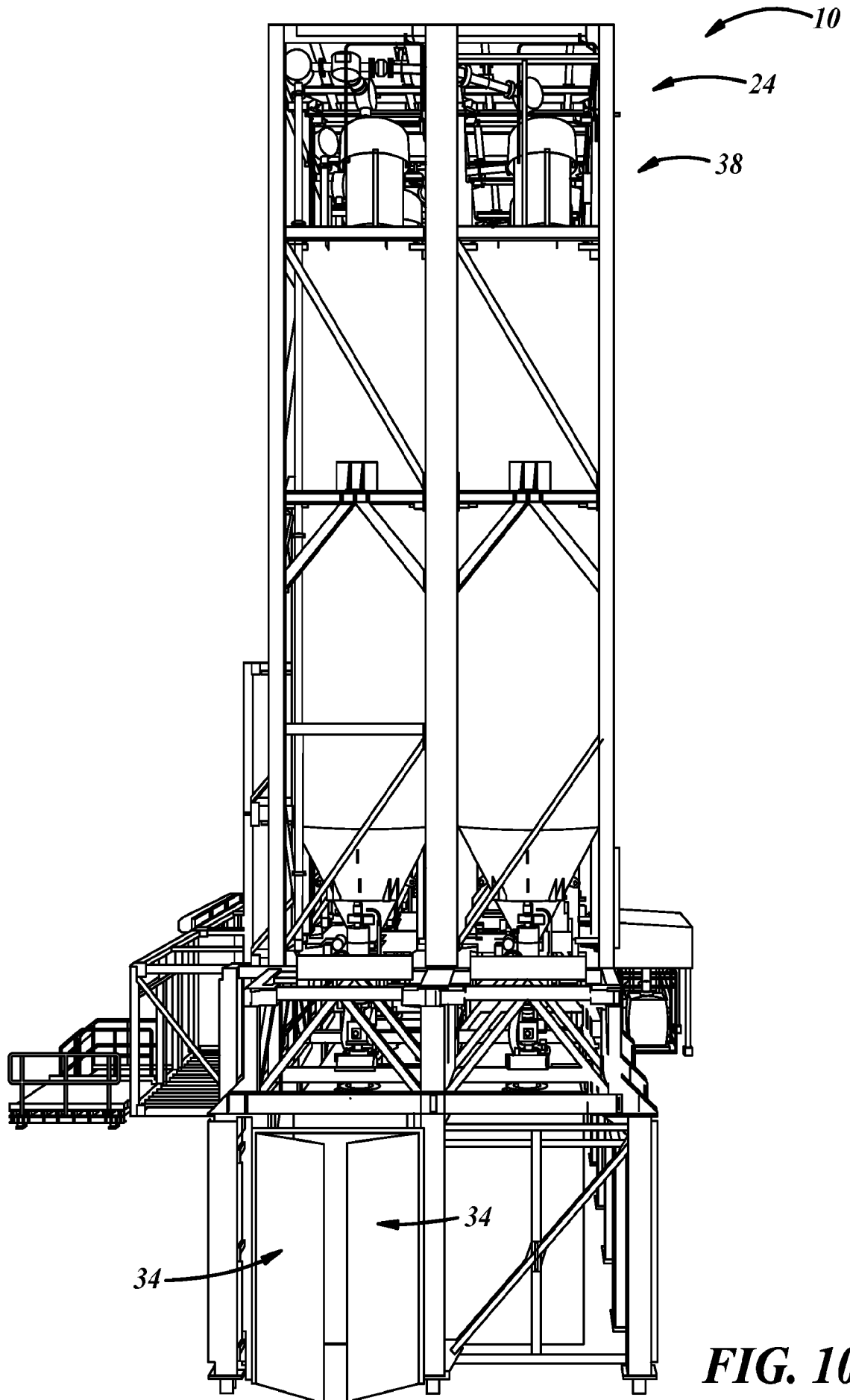


FIG. 10

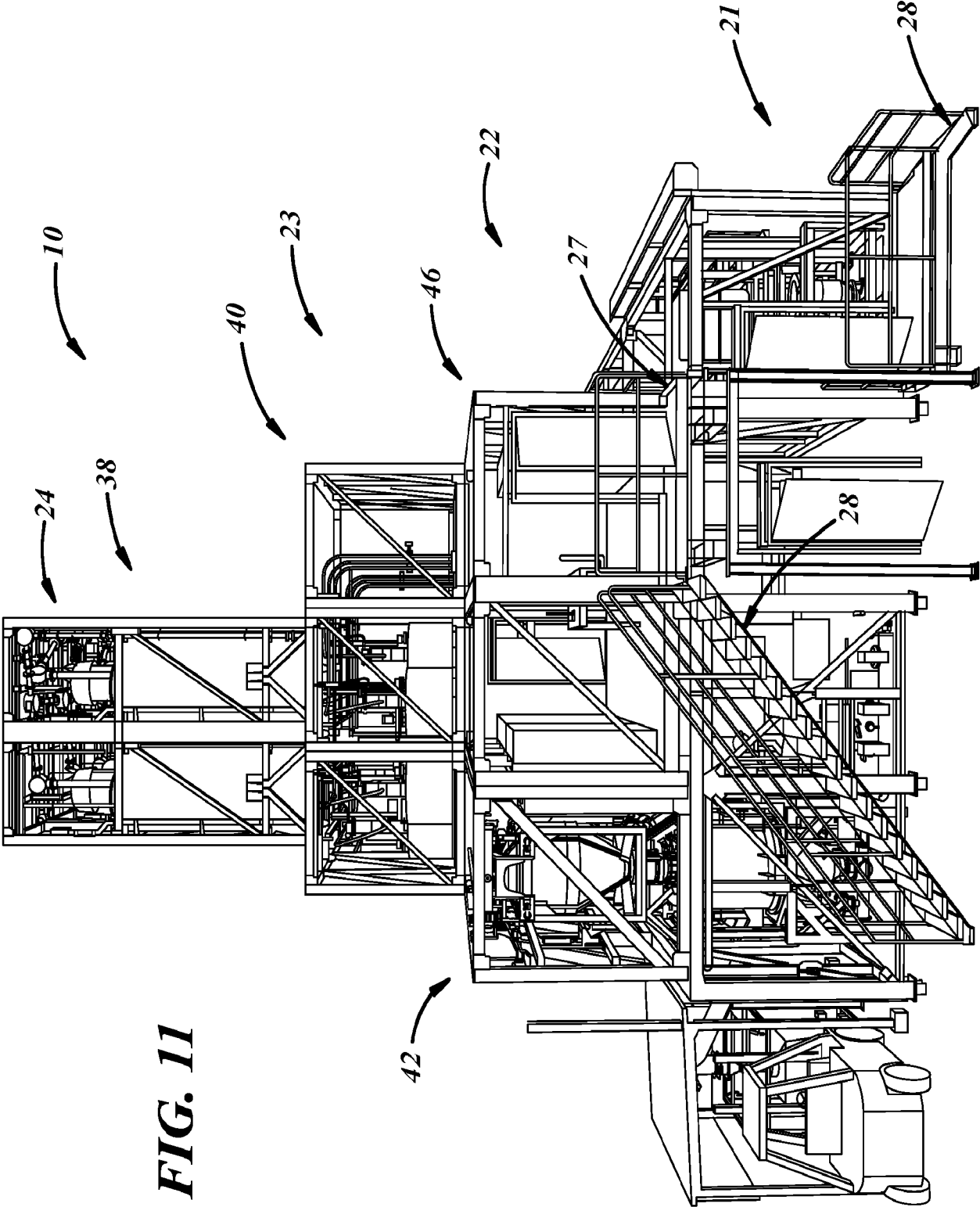


FIG. 11

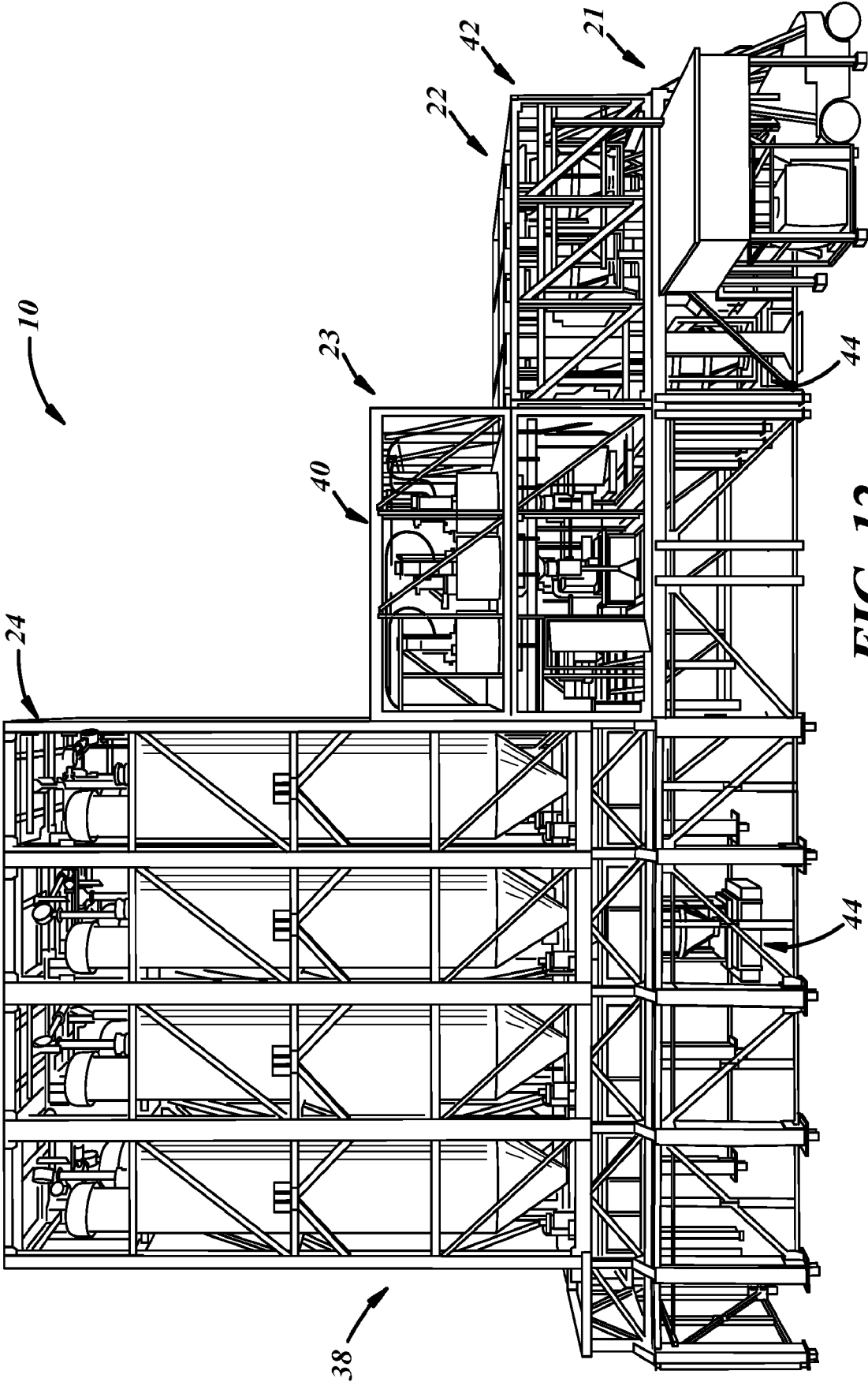


FIG. 12

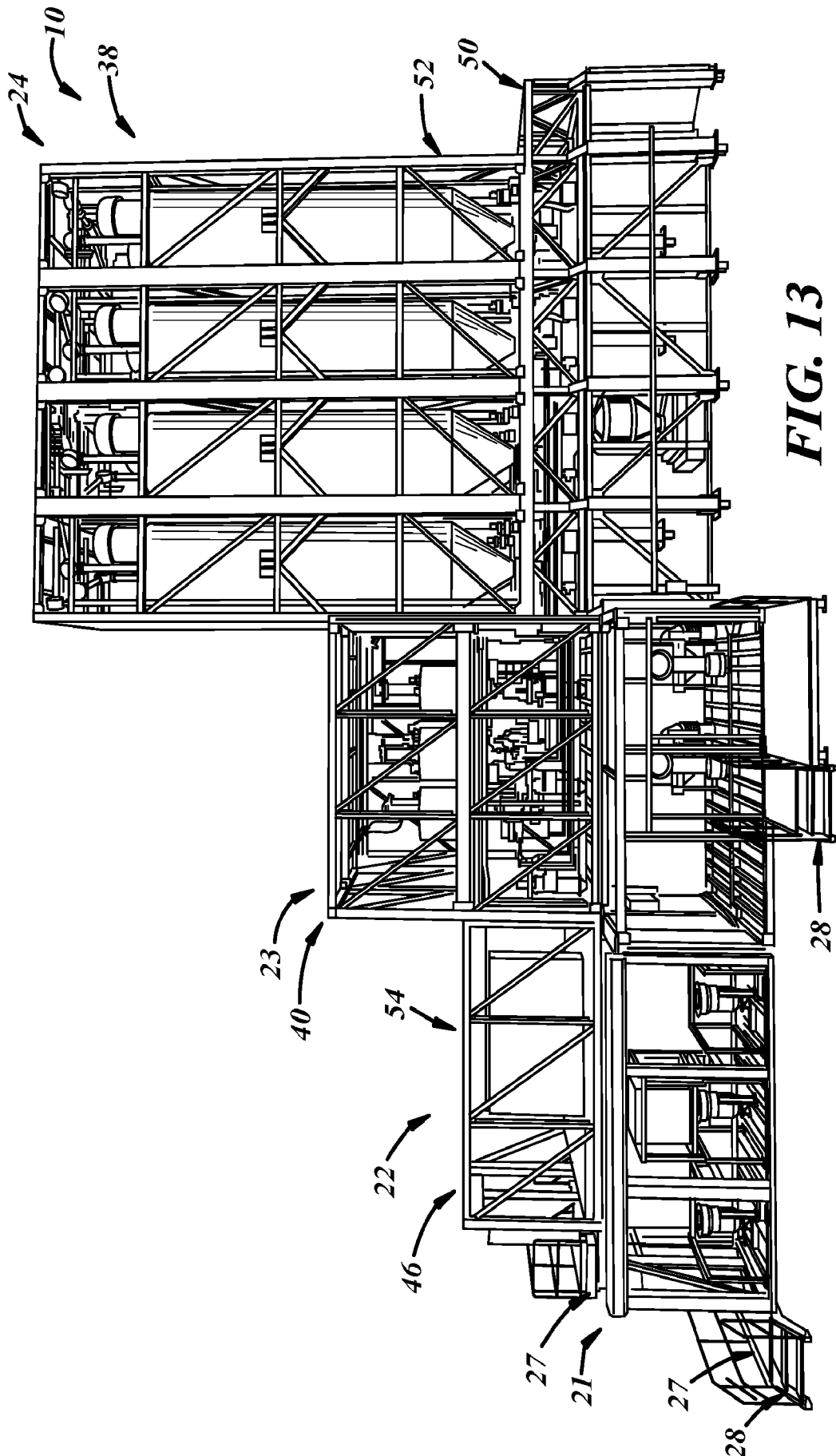


FIG. 13

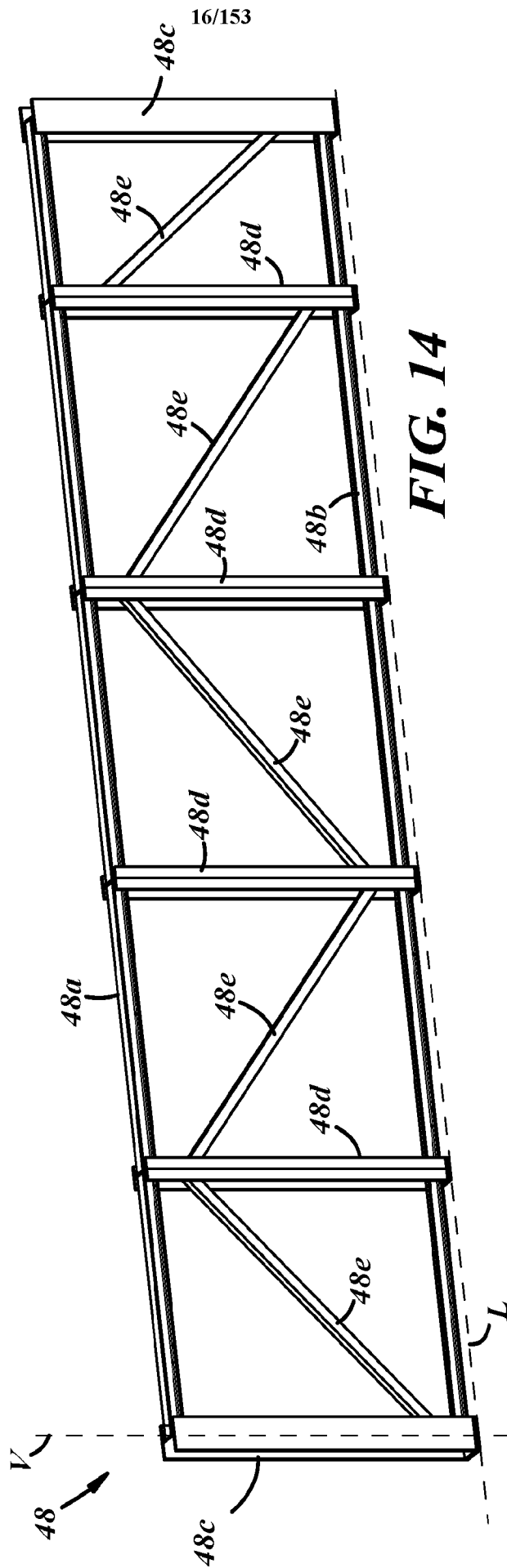


FIG. 14

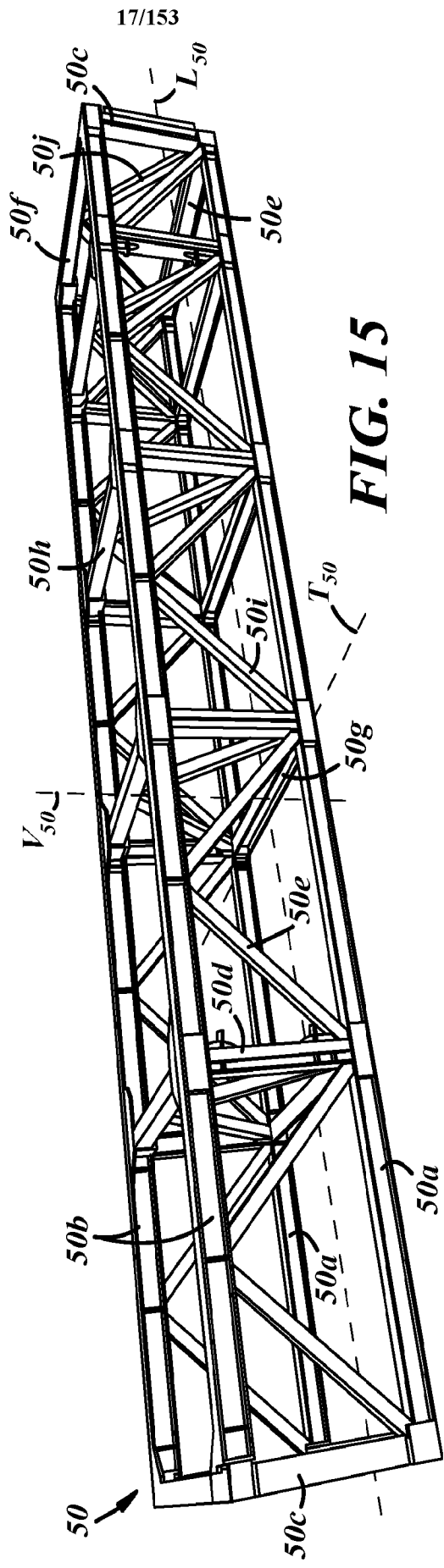


FIG. 15

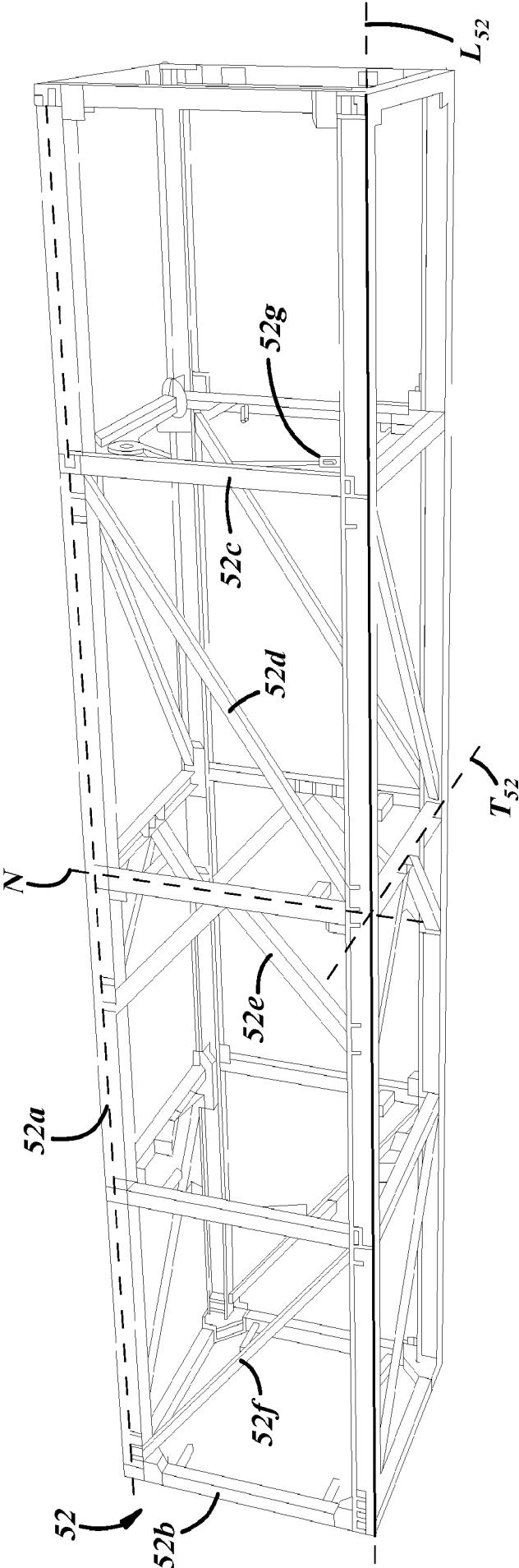
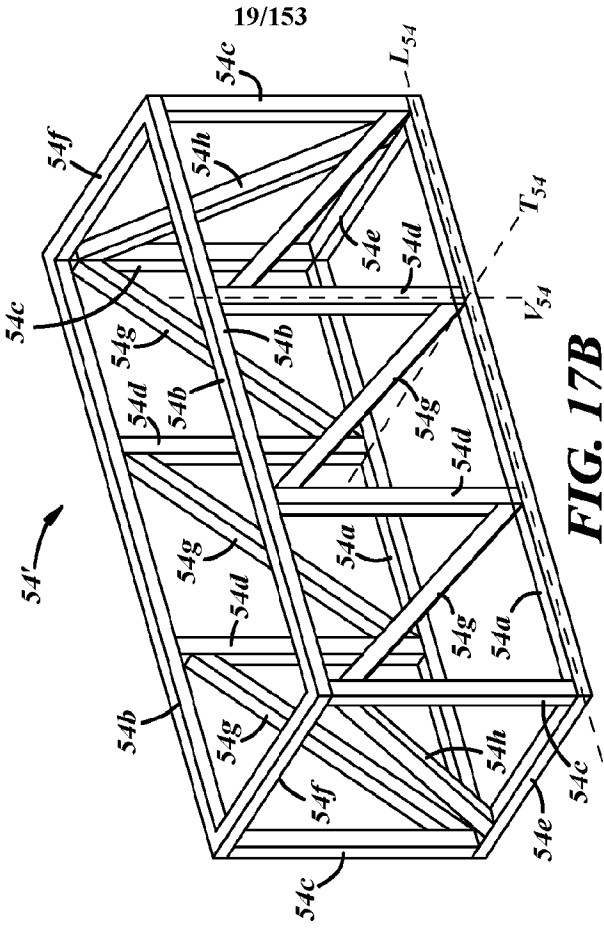
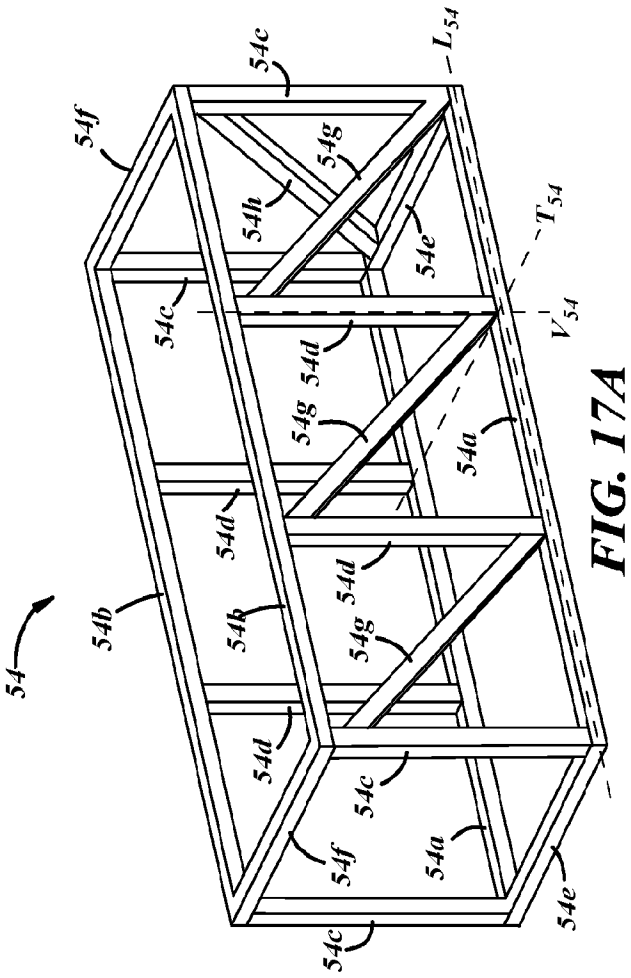


FIG. 16



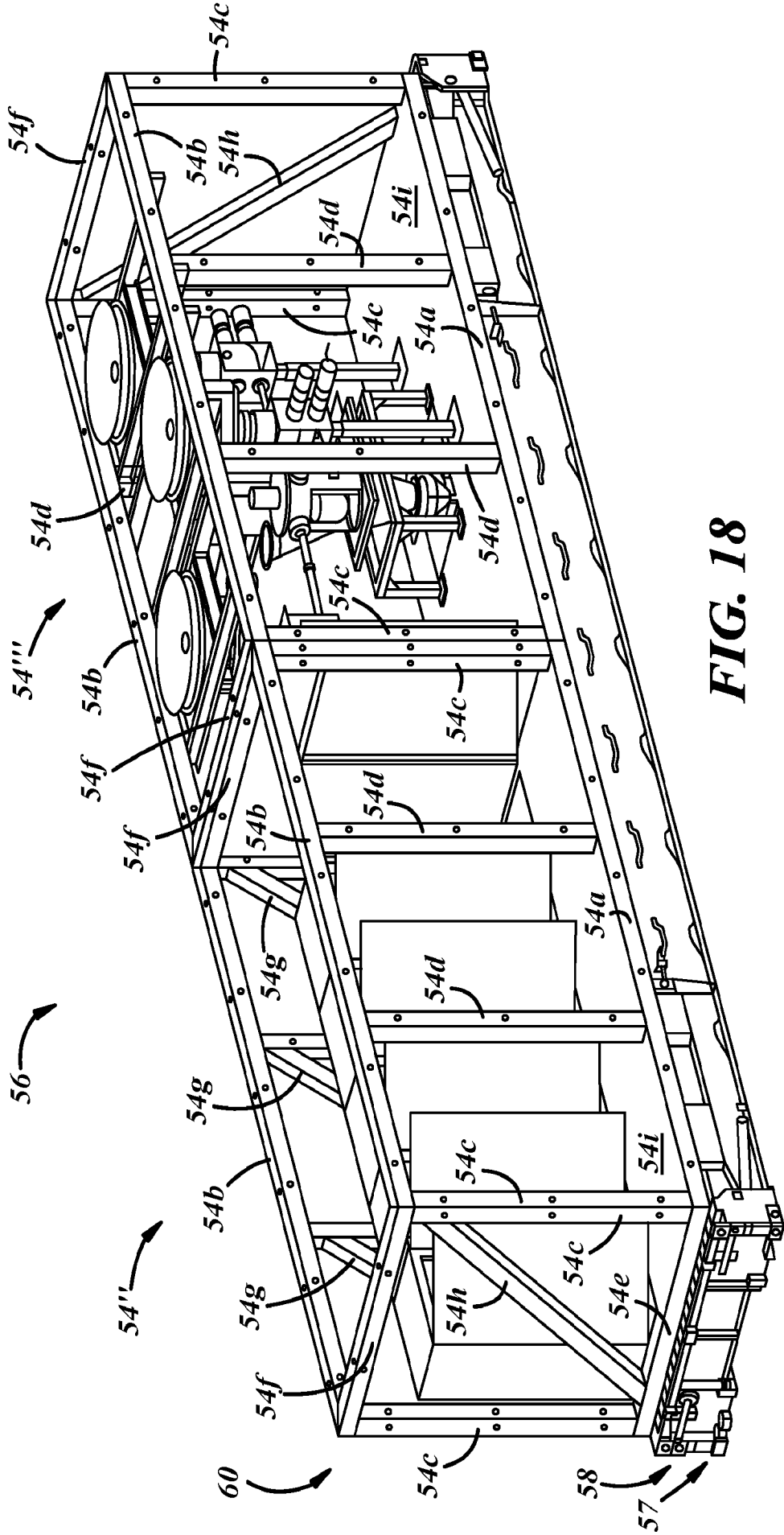


FIG. 18

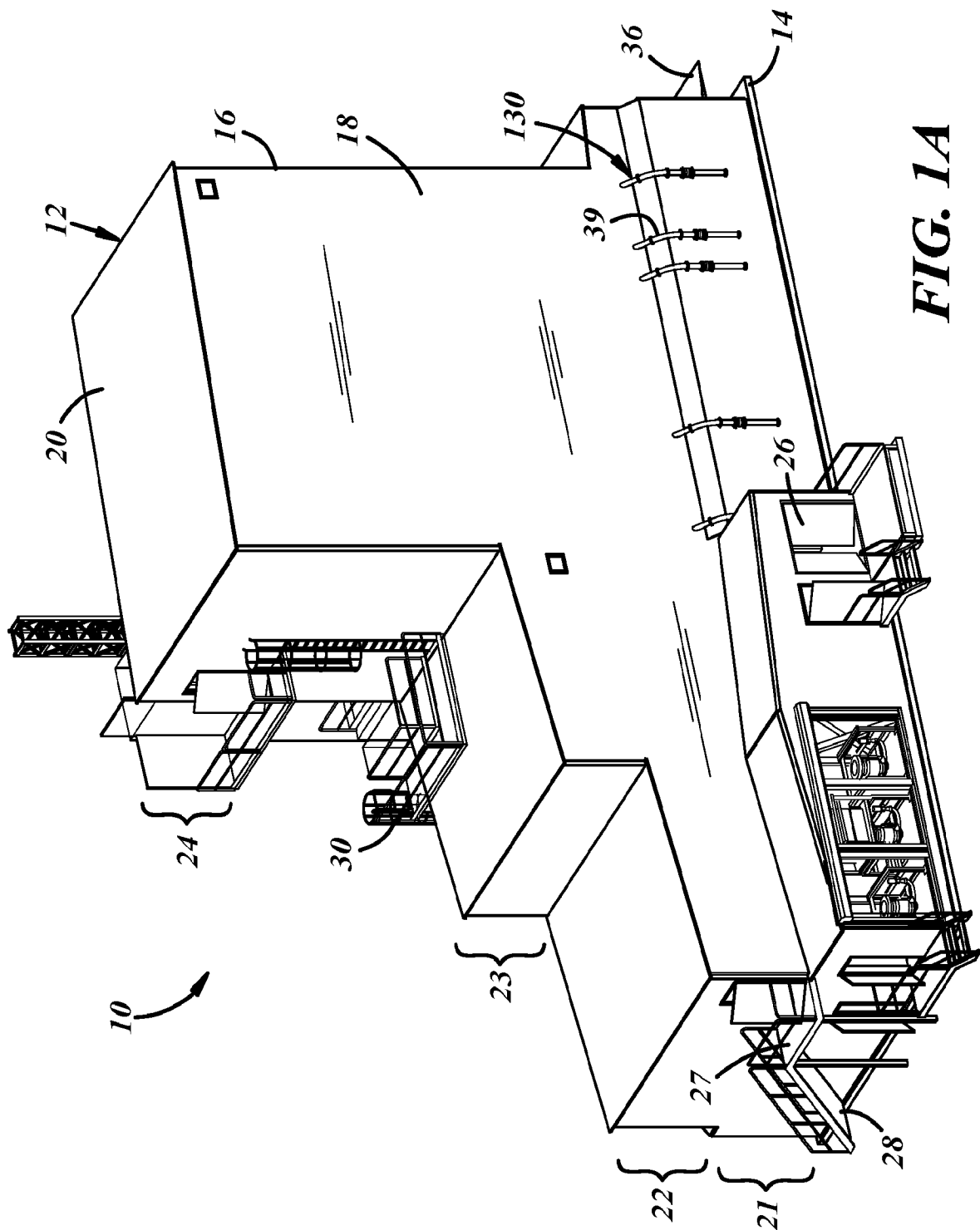
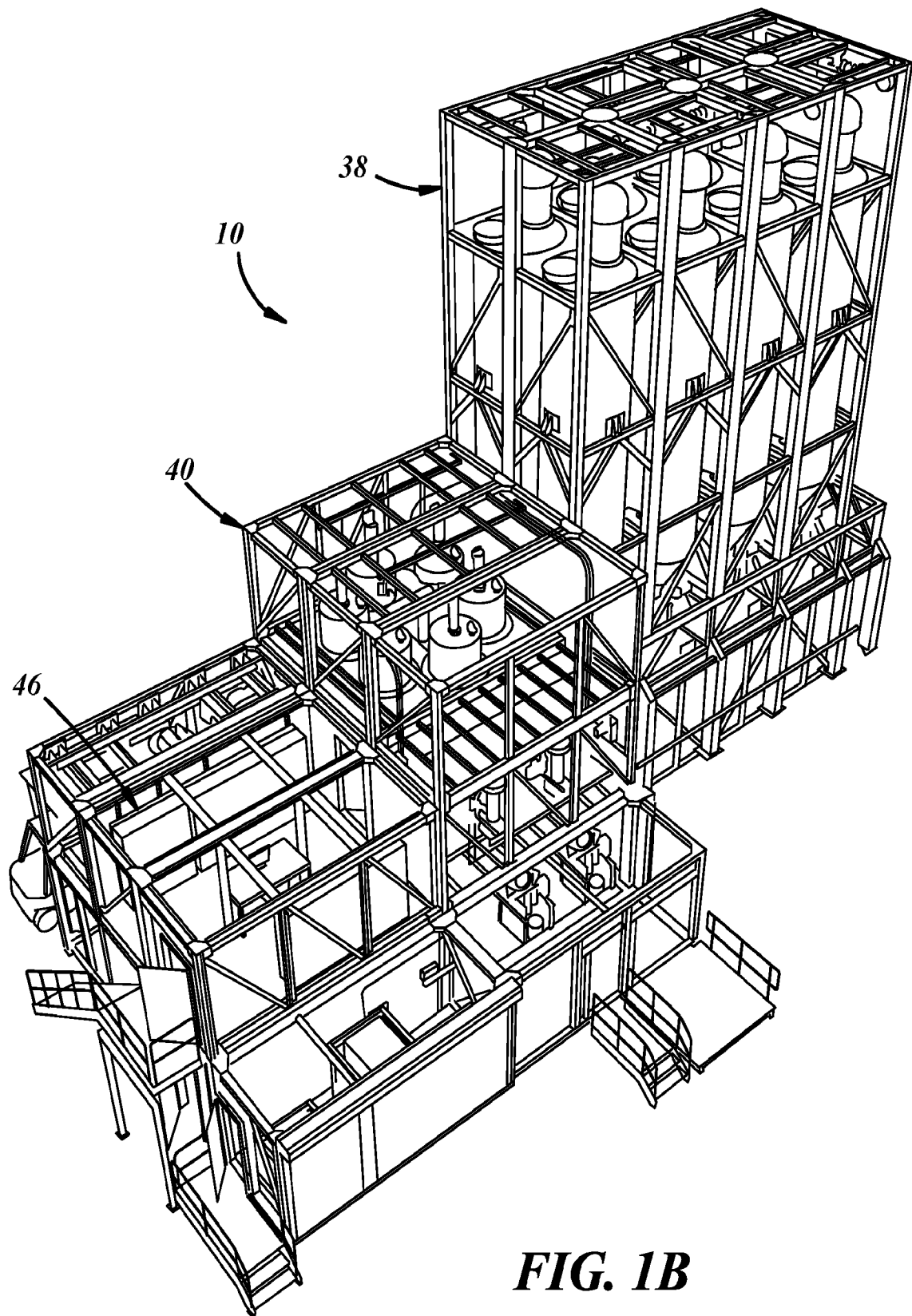


FIG. 1A

**FIG. 1B**

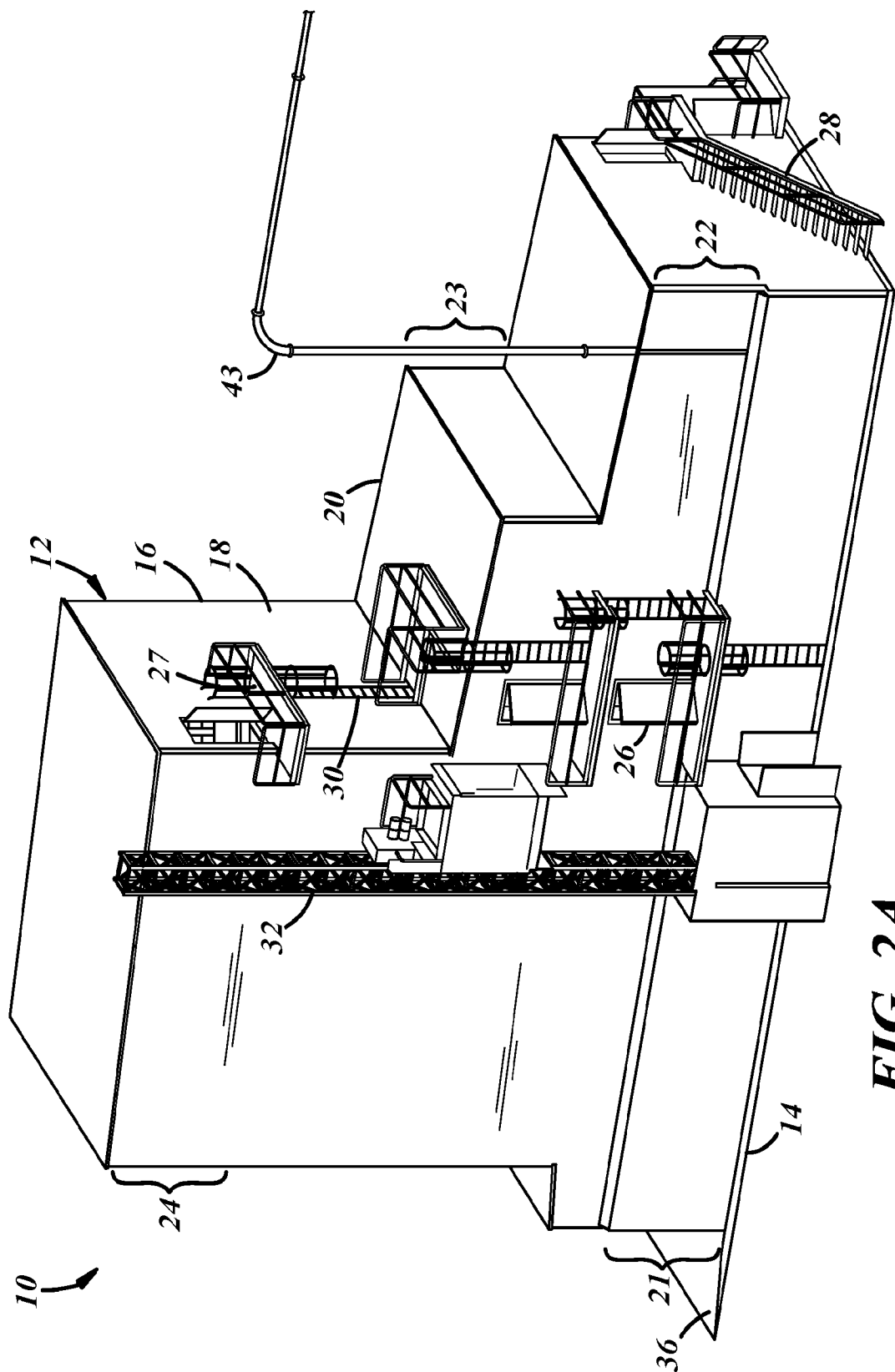
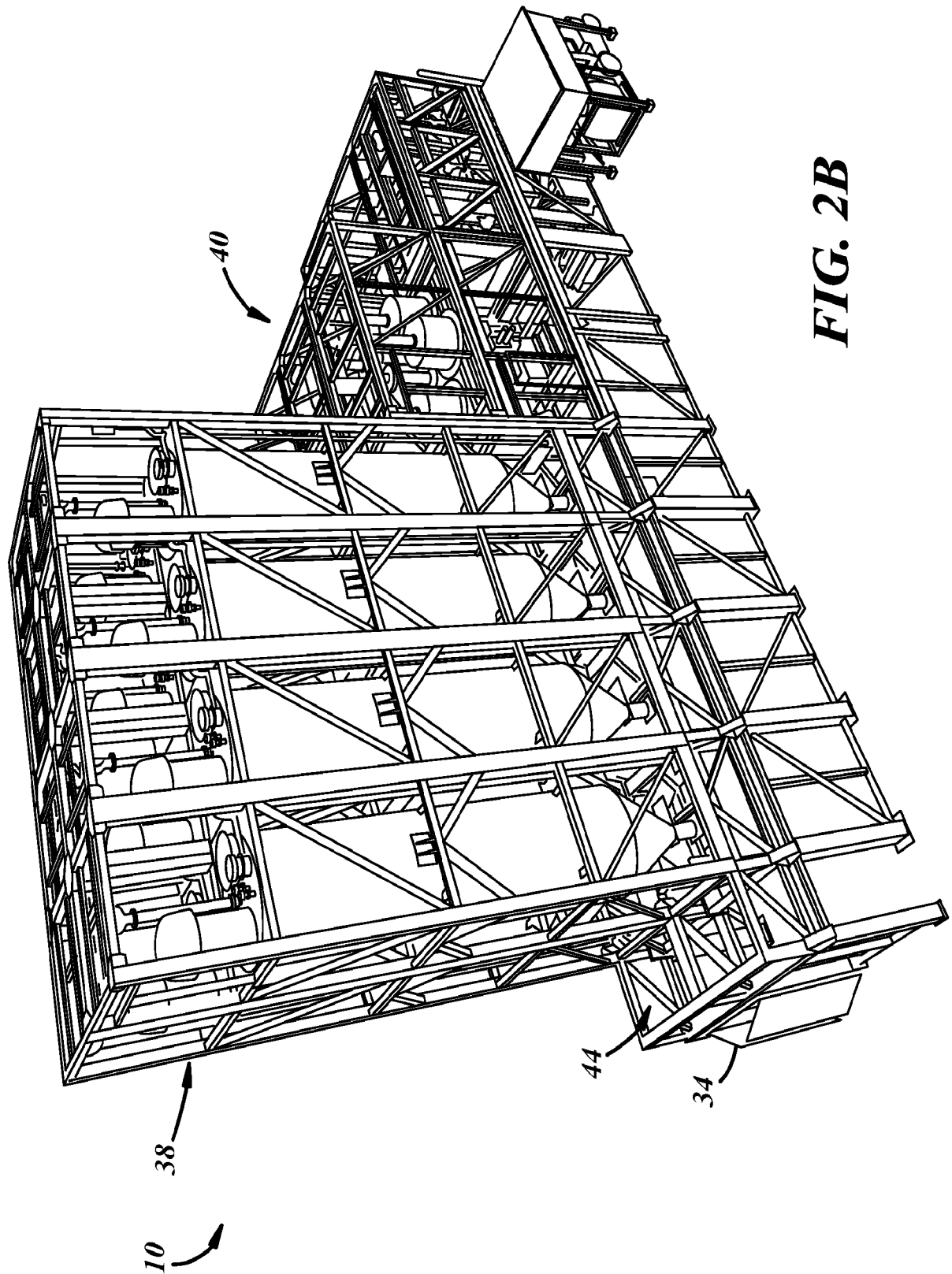


FIG. 2A



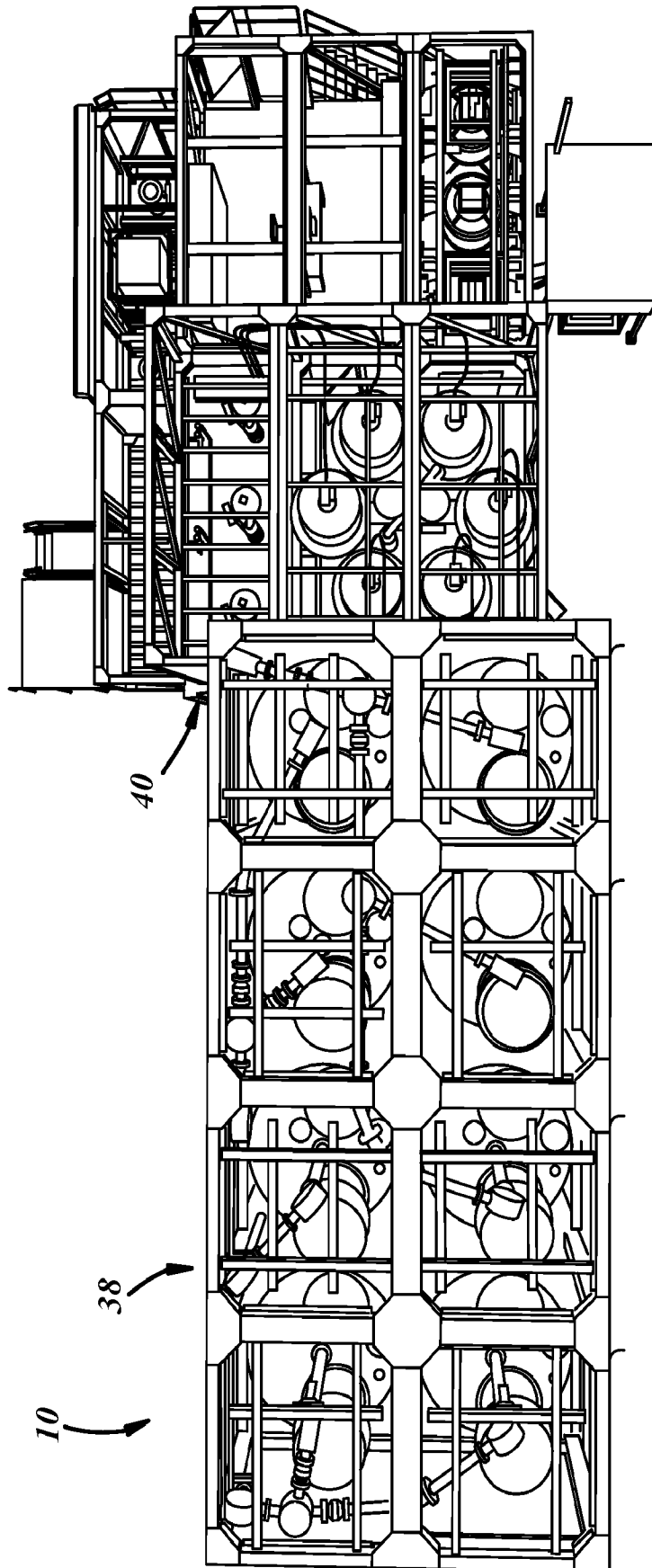


FIG. 3

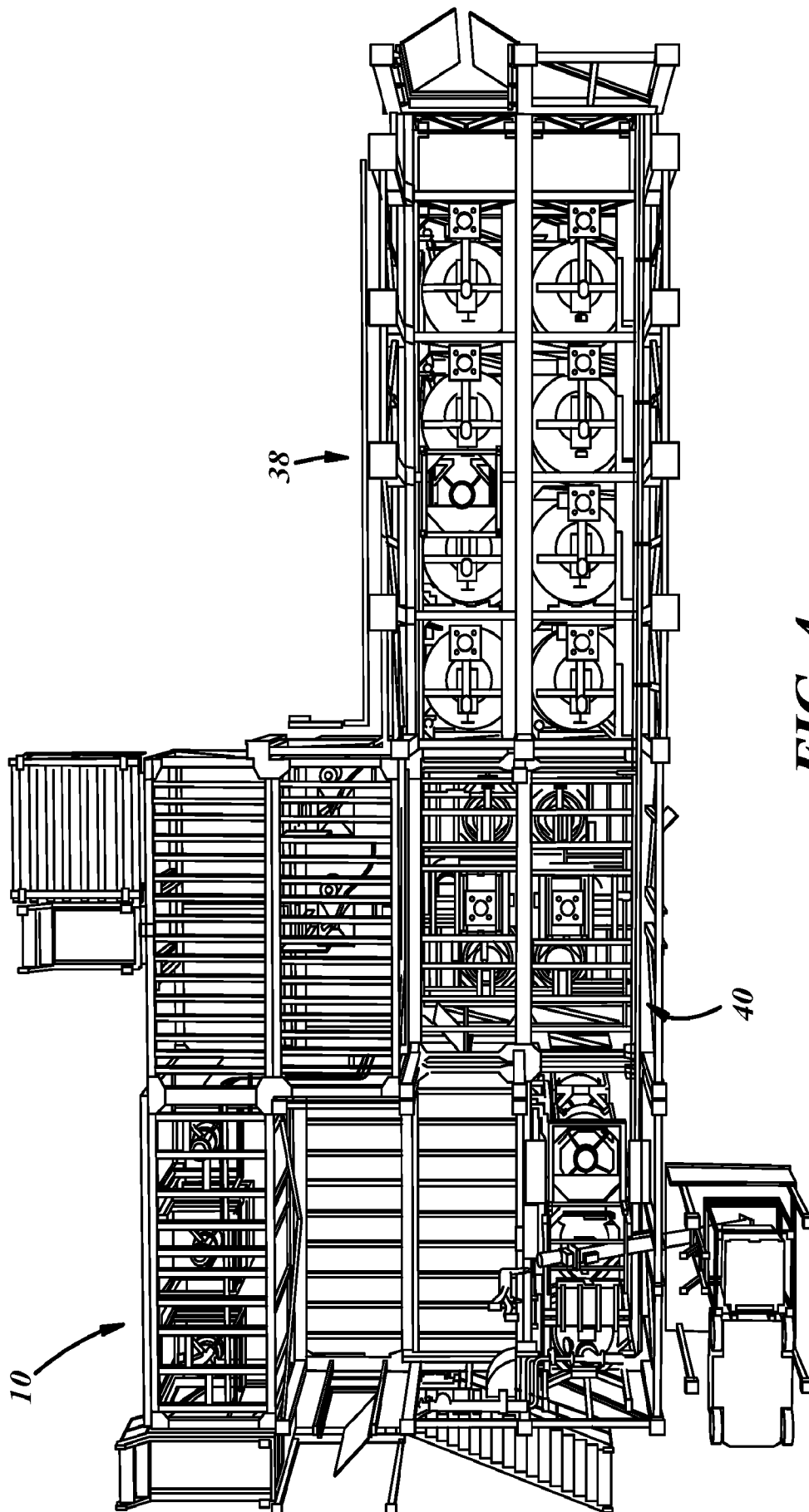


FIG. 4

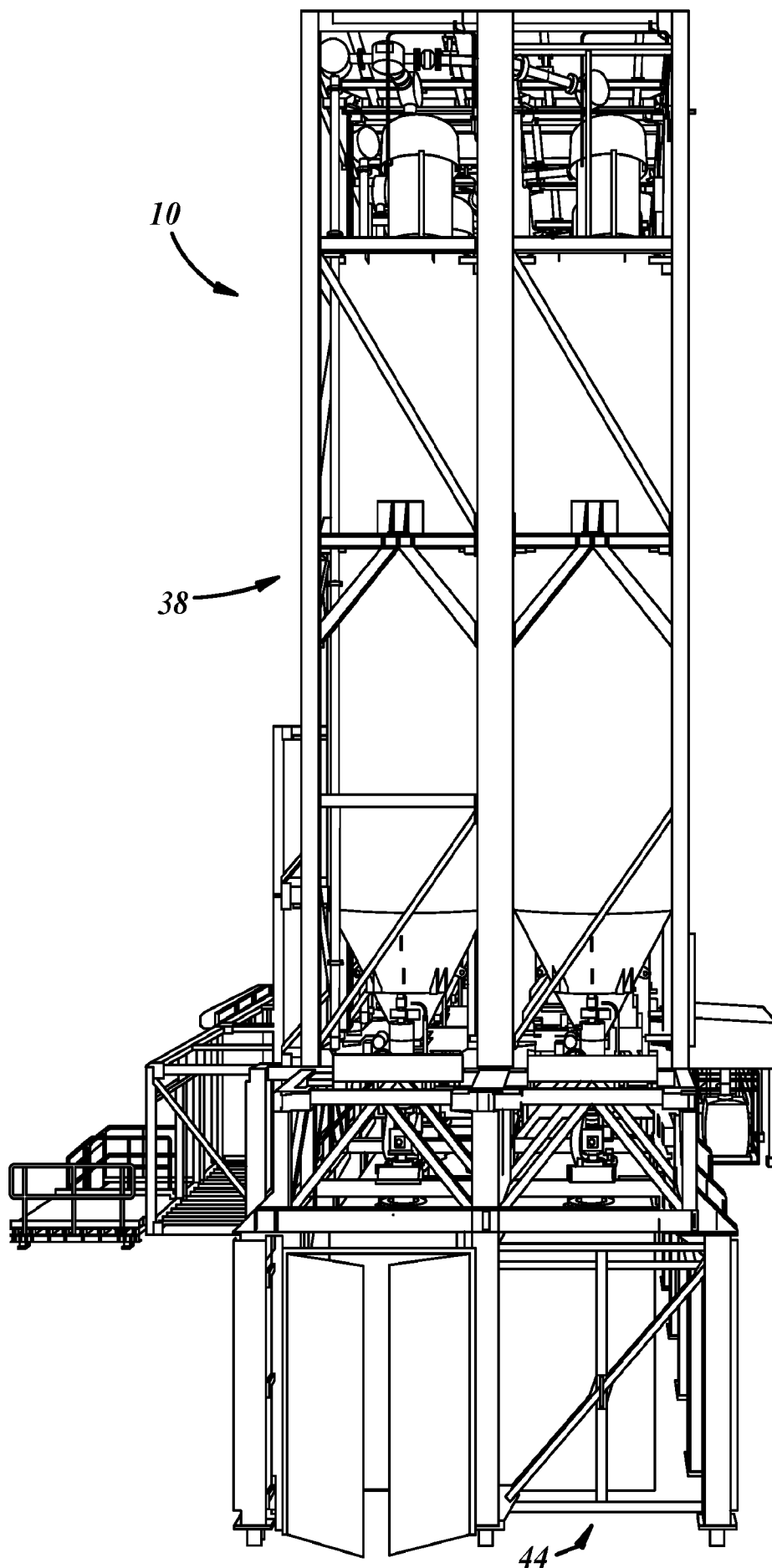


FIG. 5

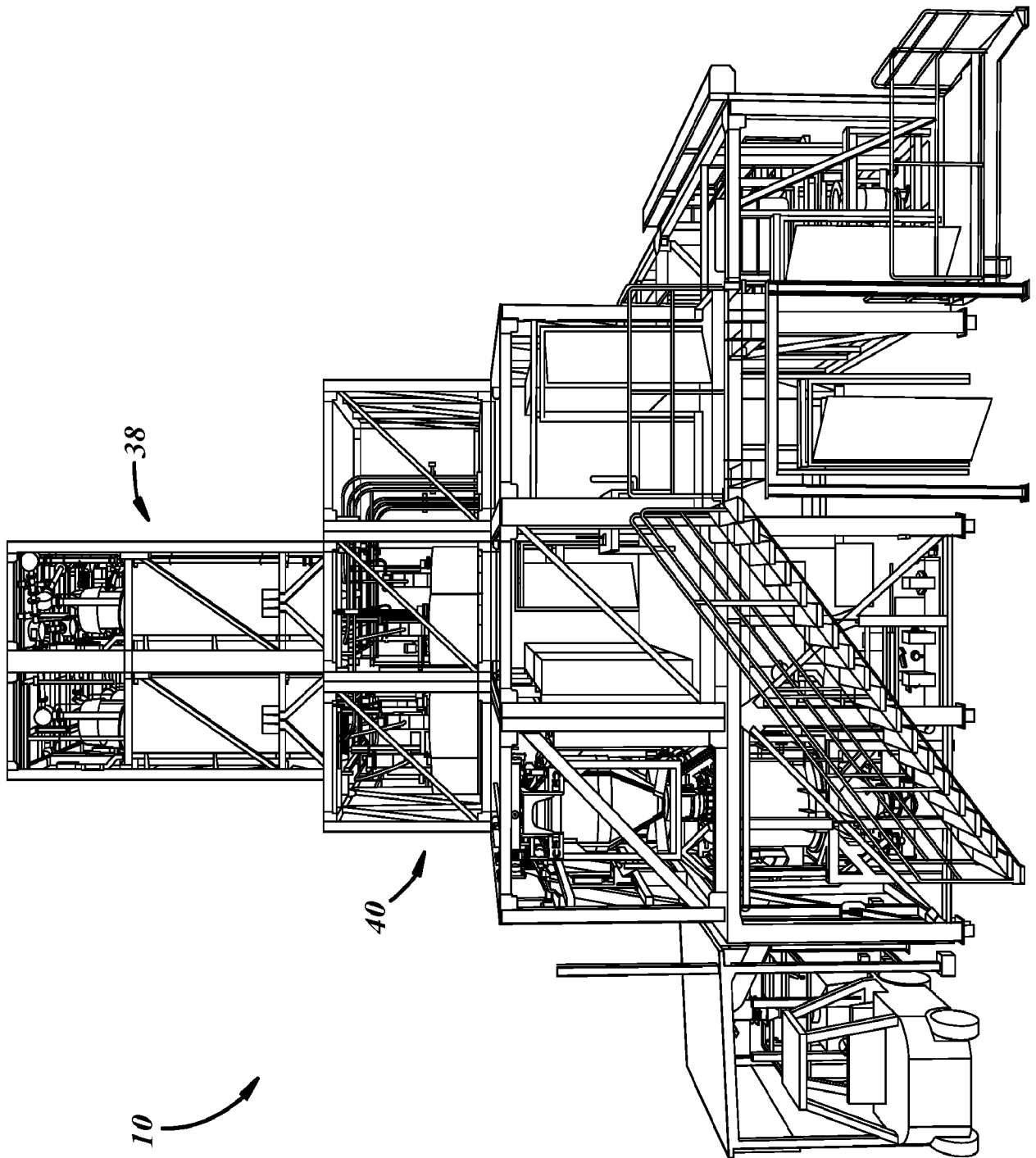
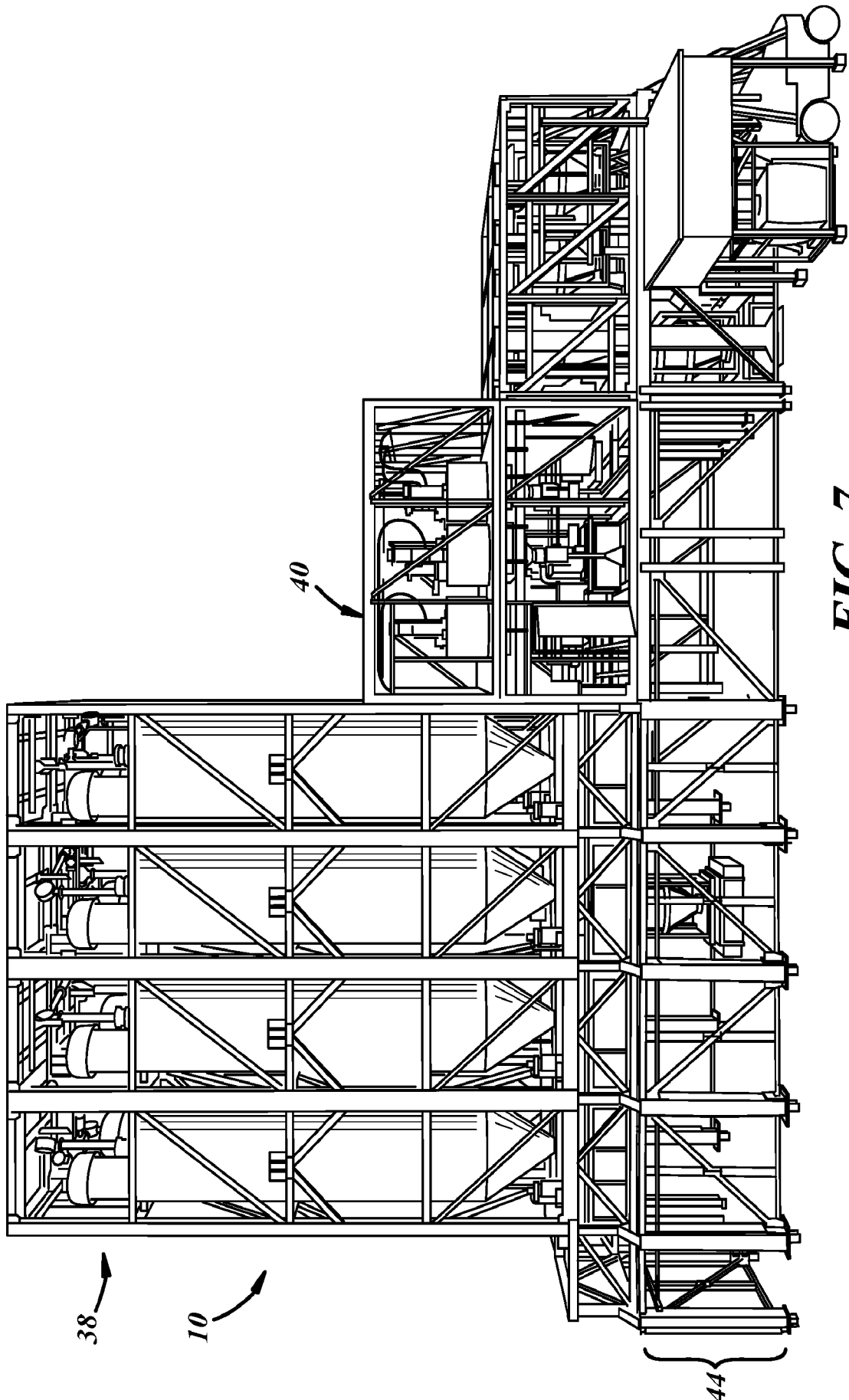


FIG. 6



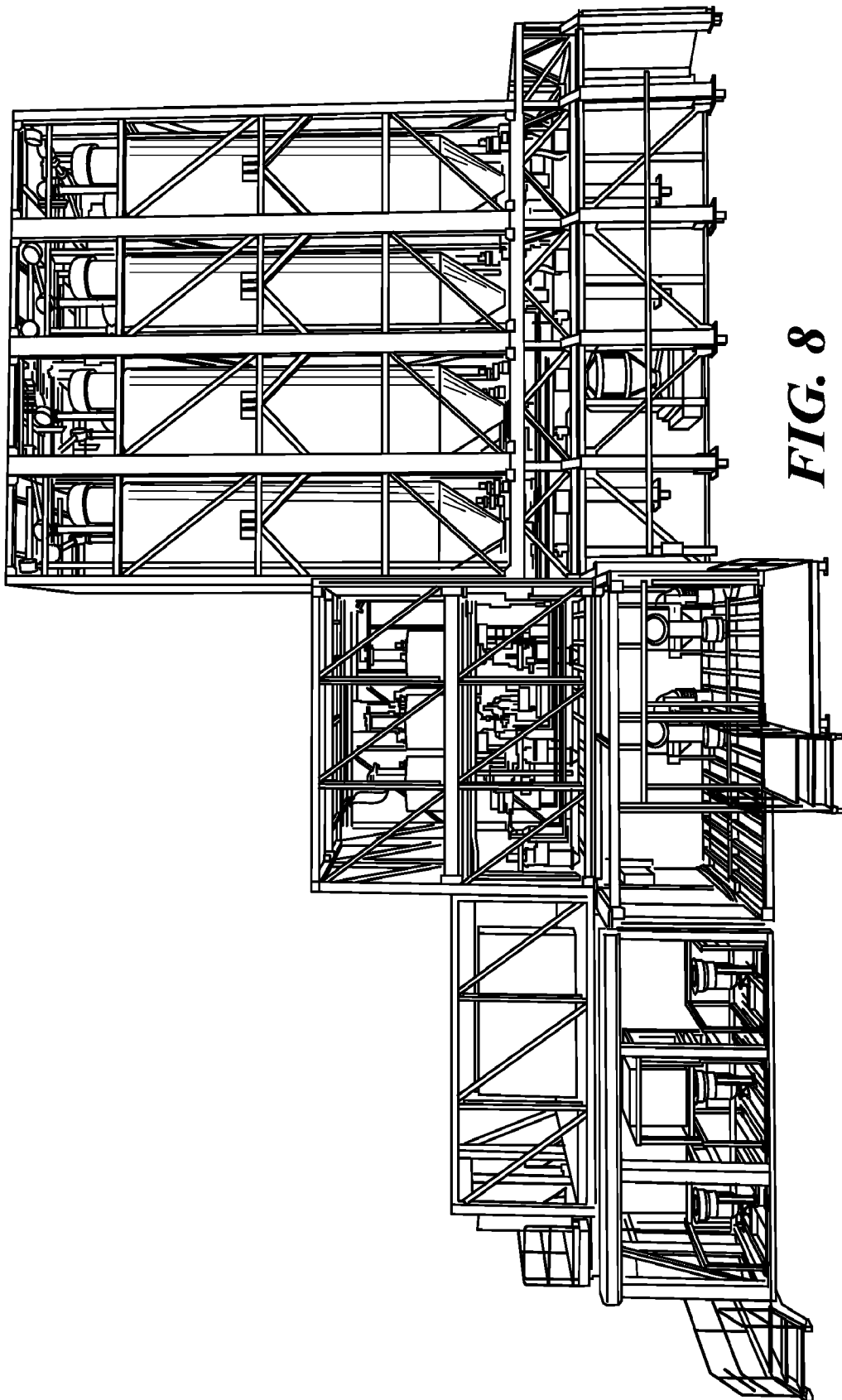
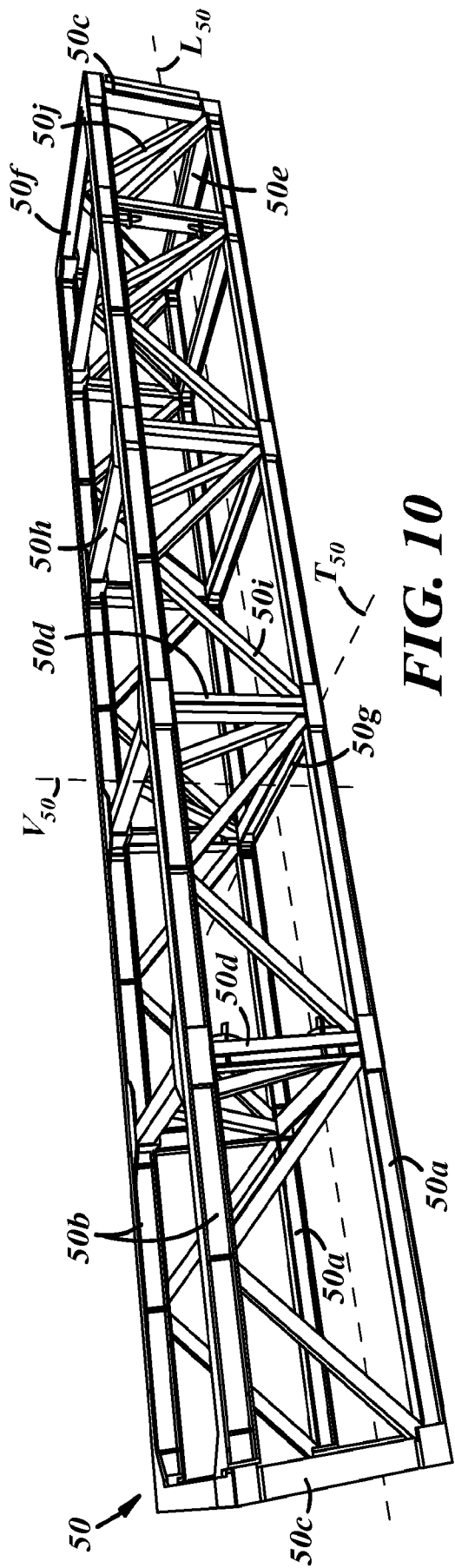
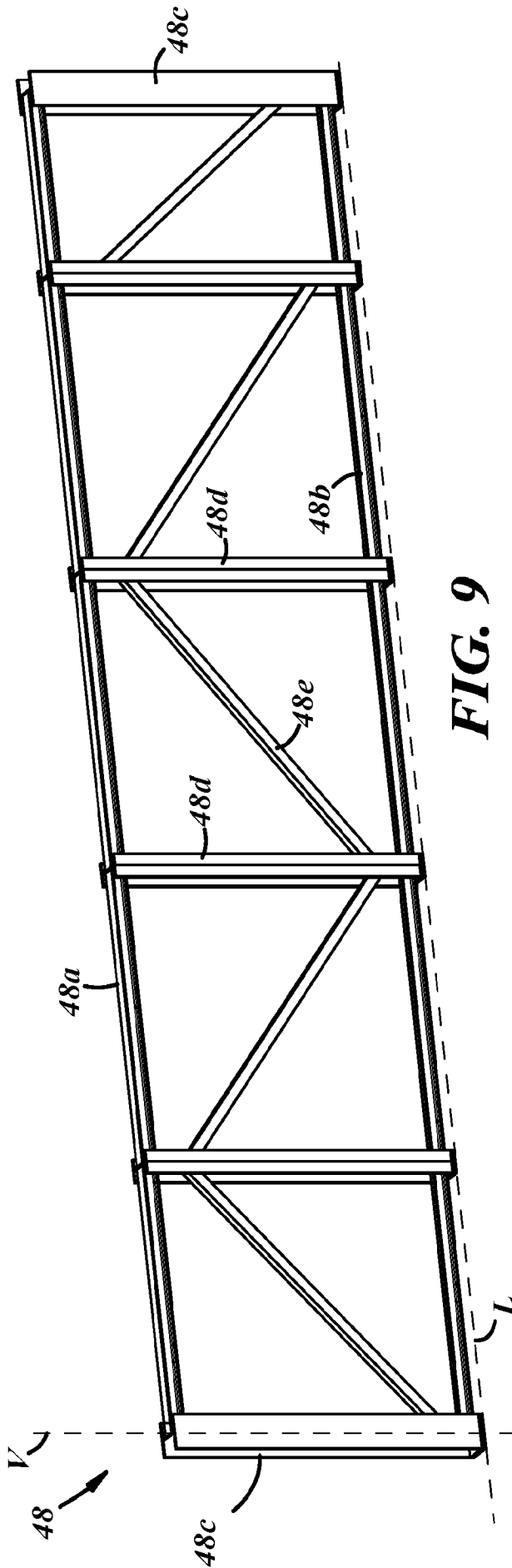


FIG. 8



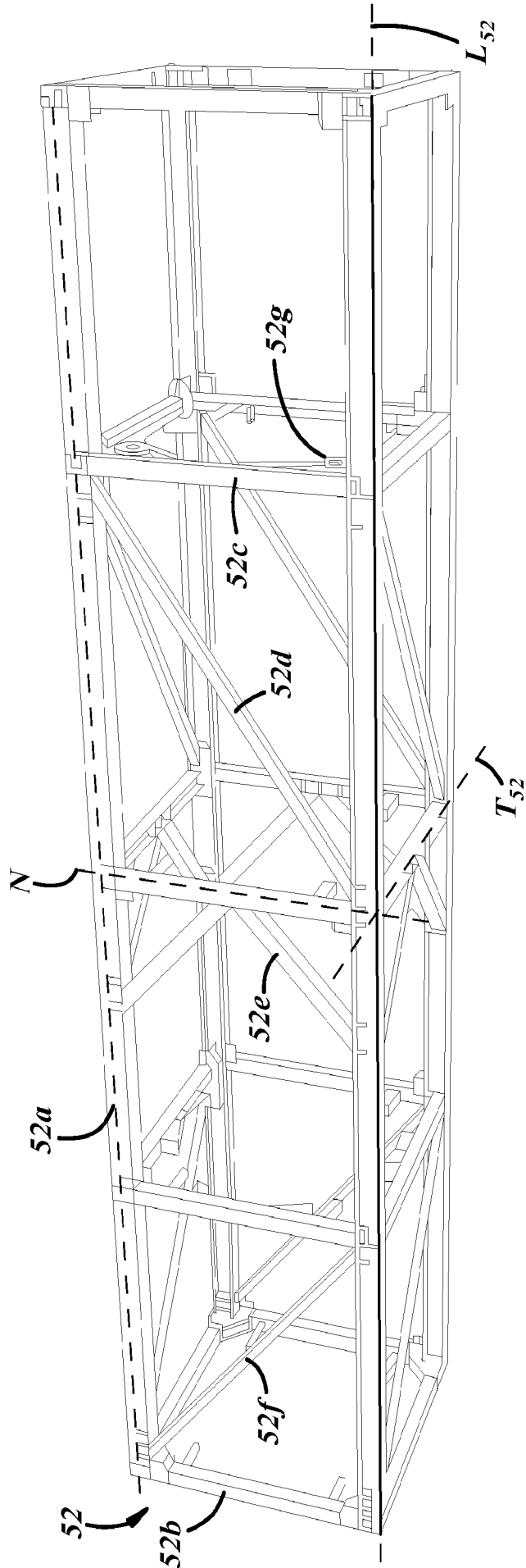
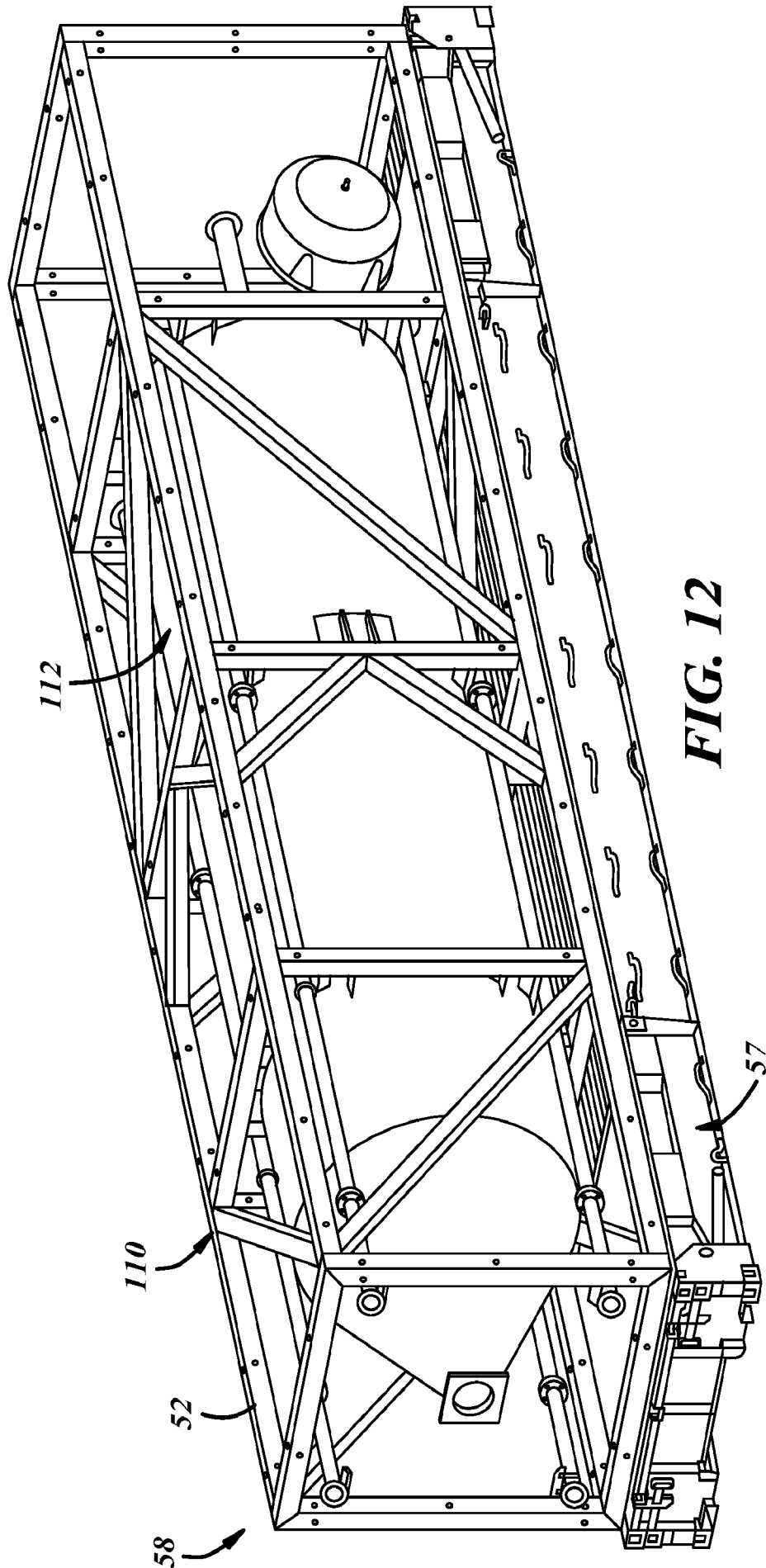
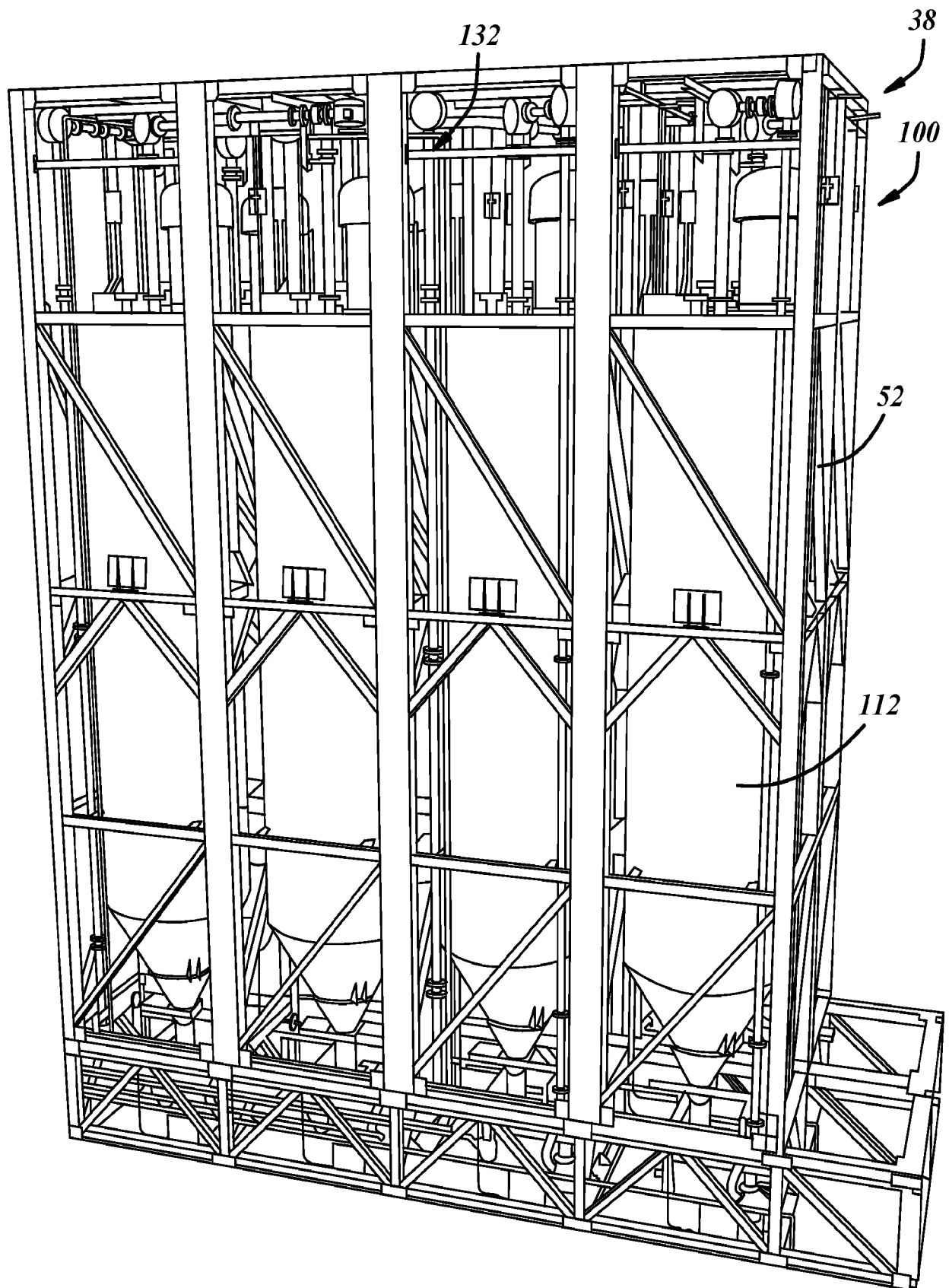
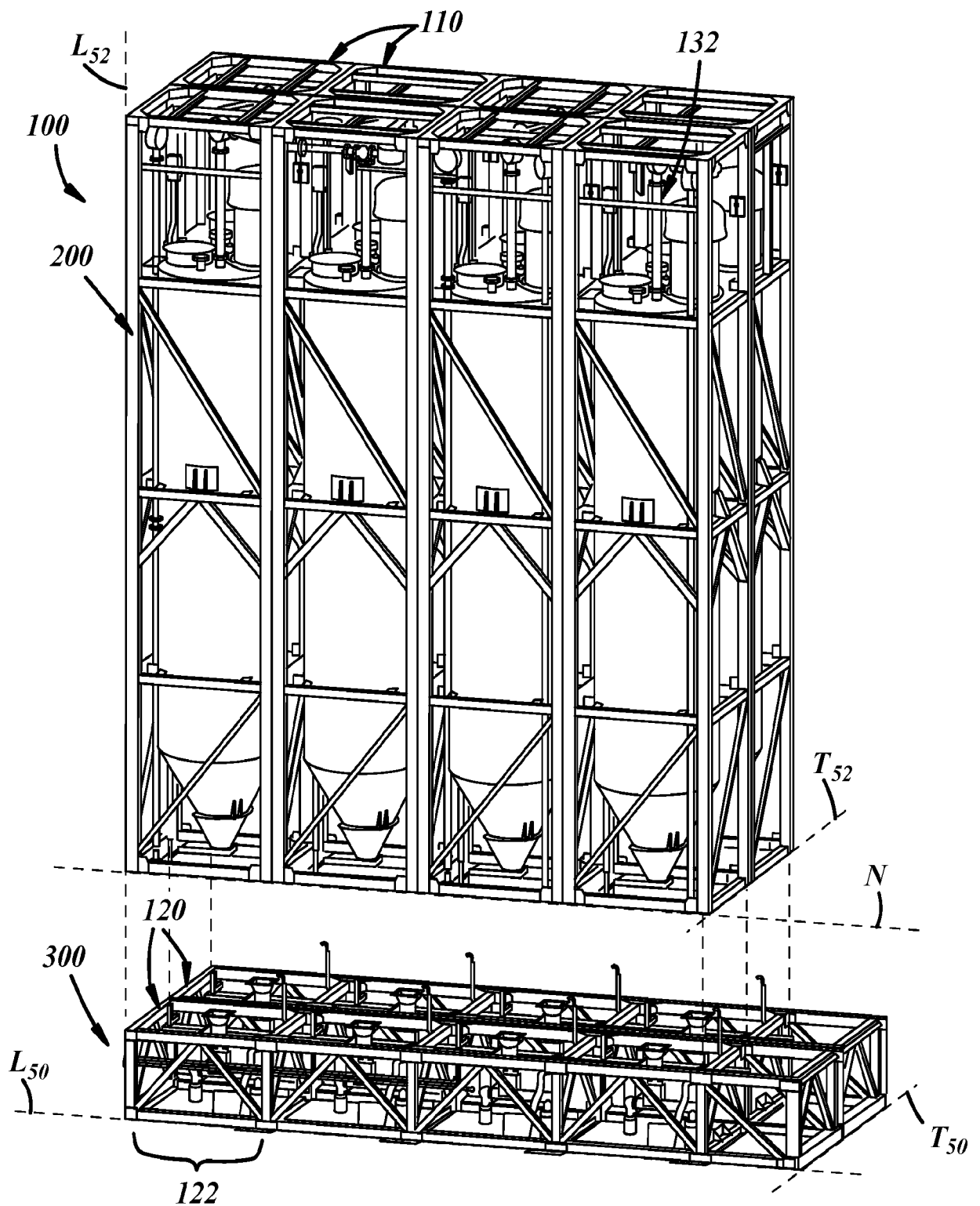
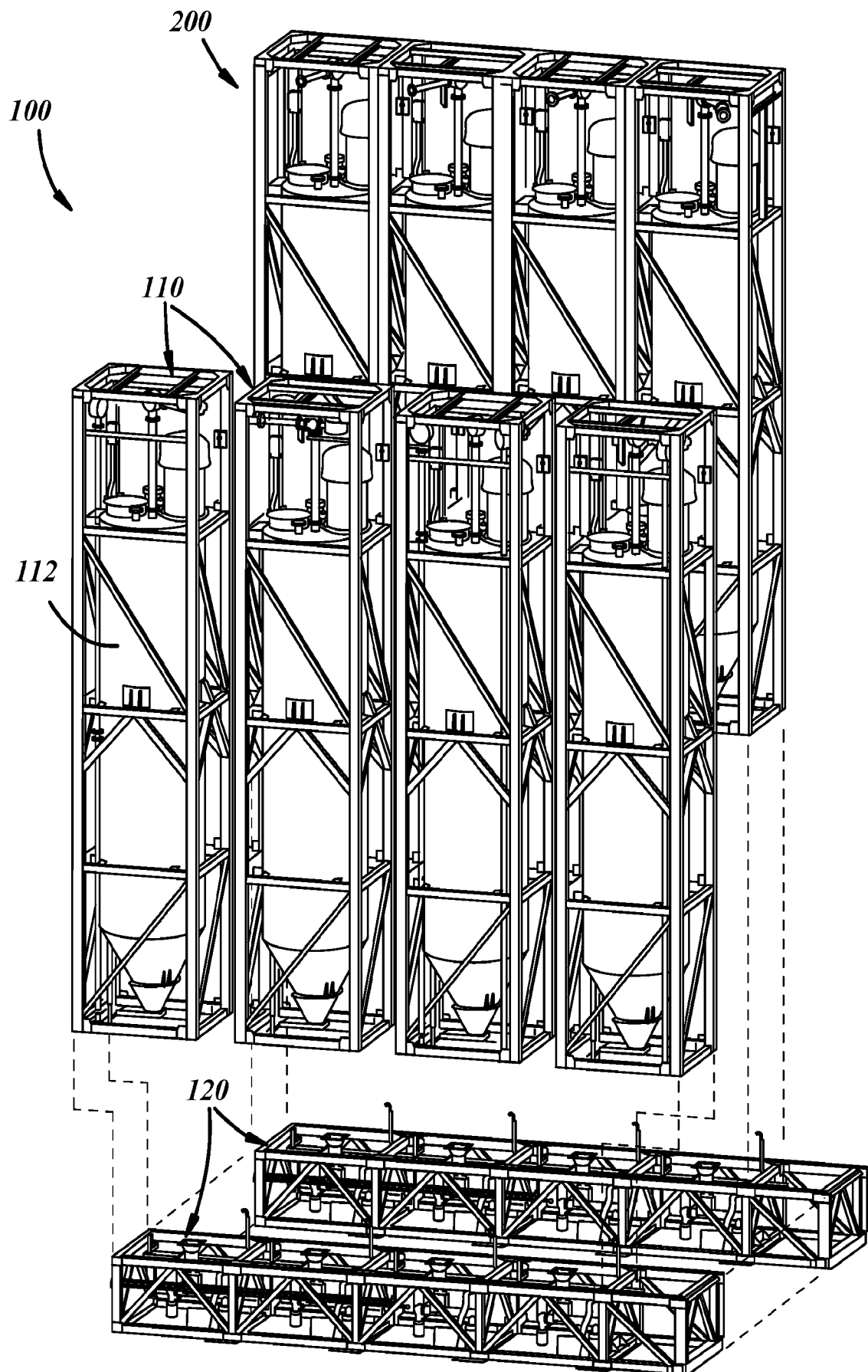


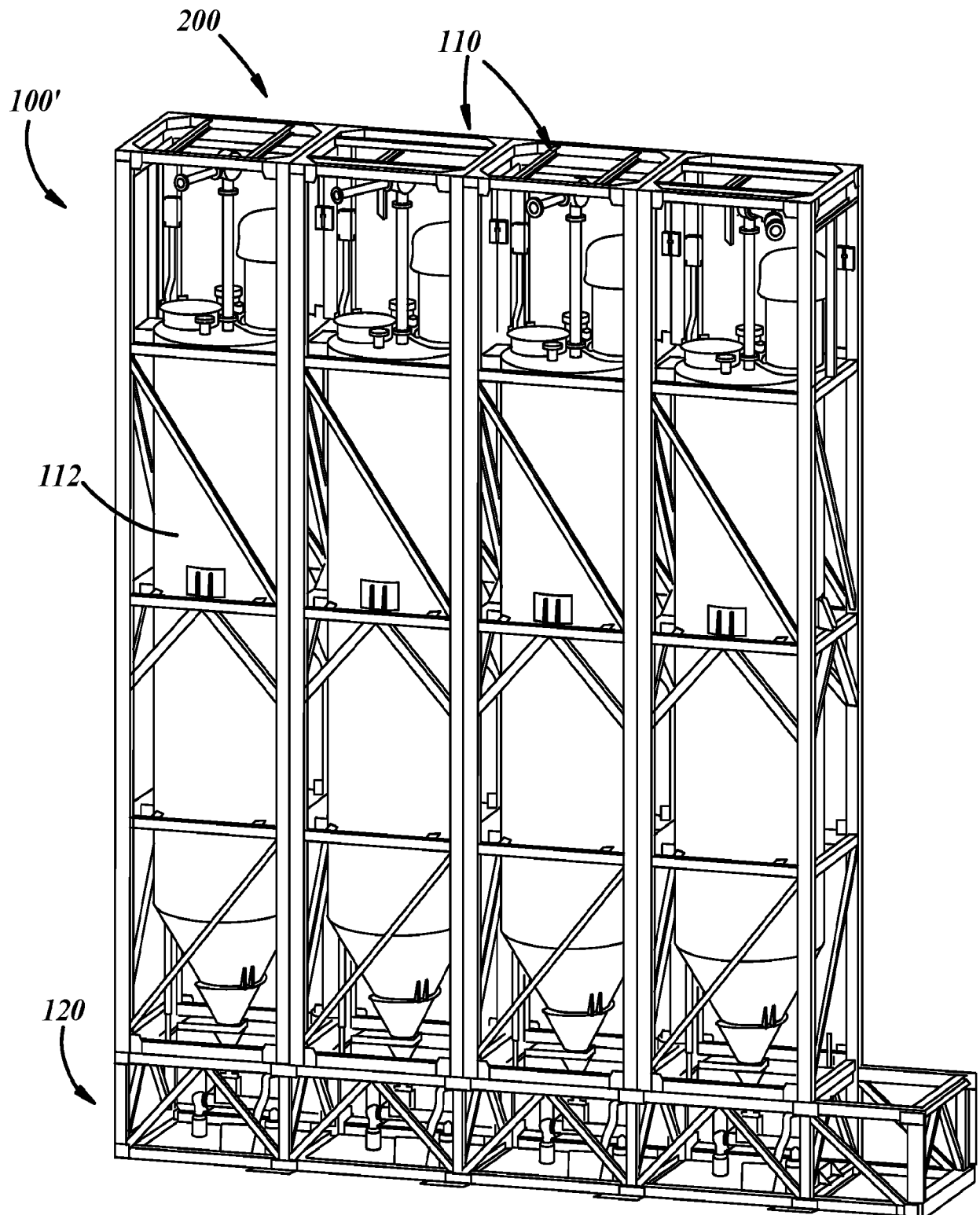
FIG. 11



**FIG. 13**

**FIG. 14**

**FIG. 15**

**FIG. 16**

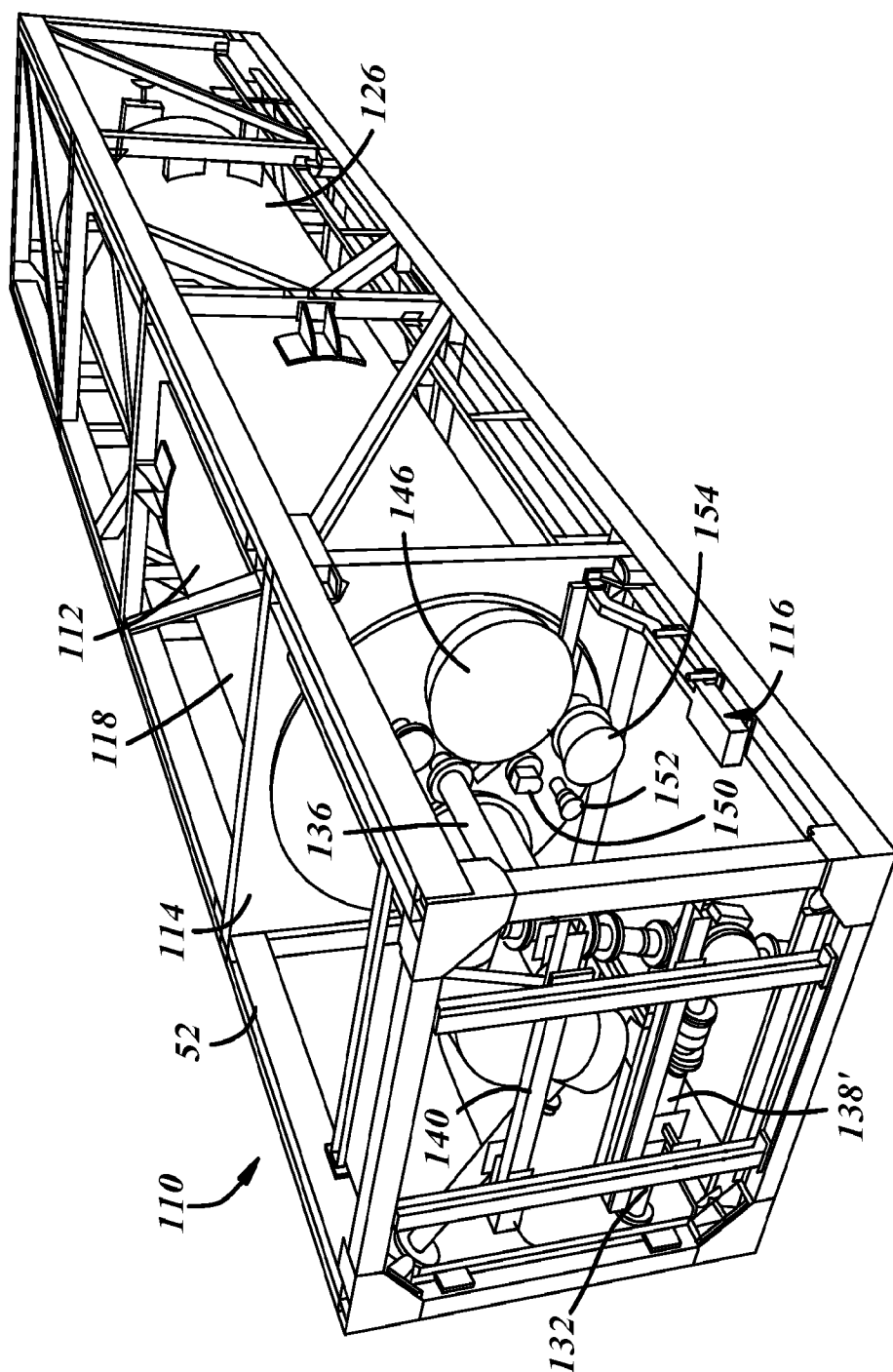


FIG. 17

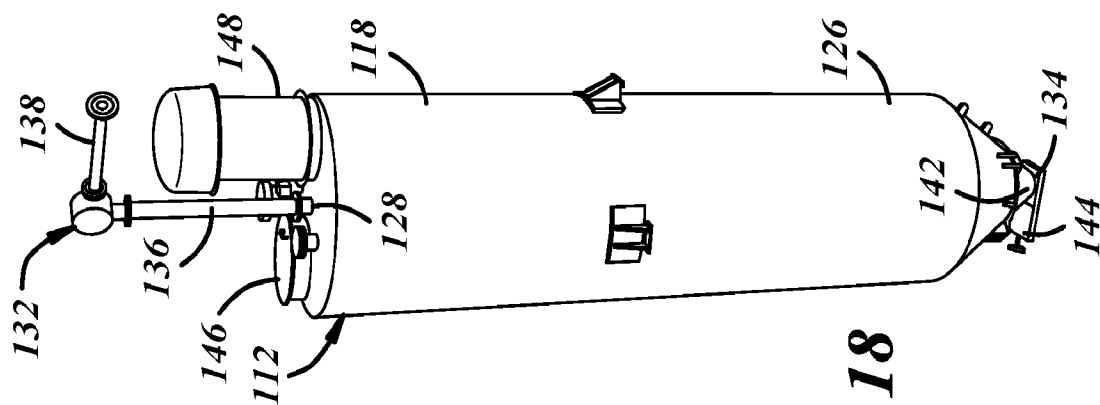


FIG. 18

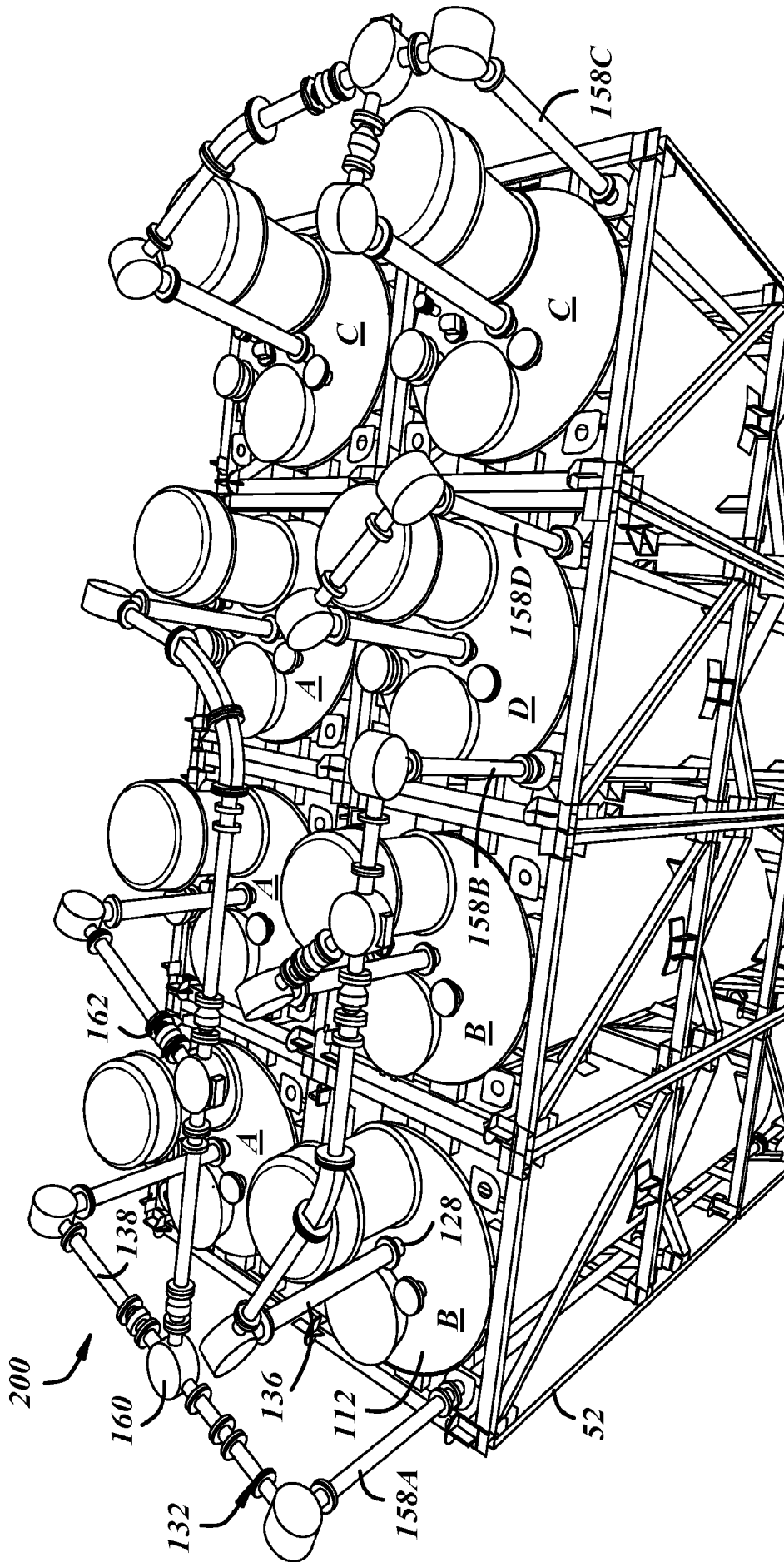


FIG. 19

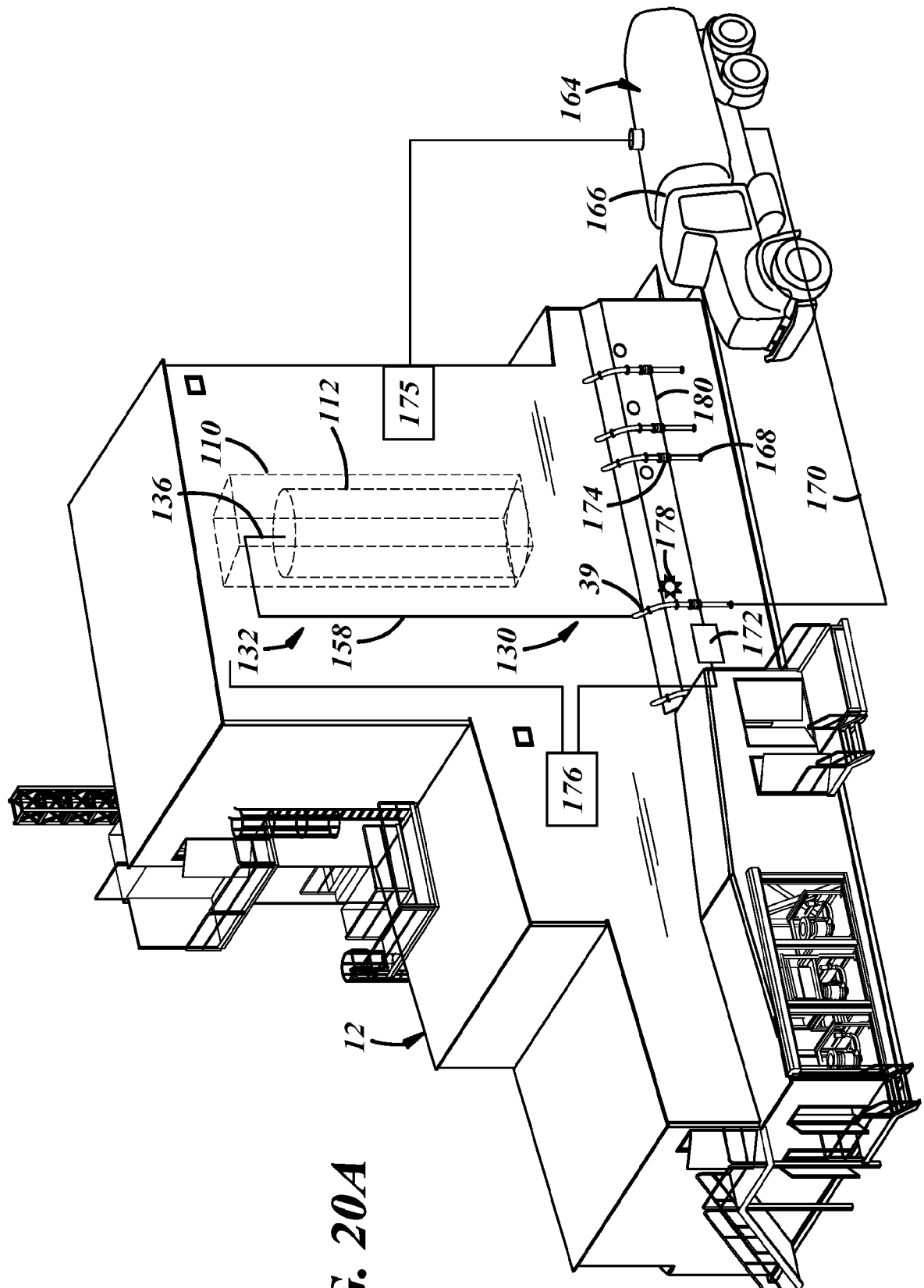


FIG. 20A

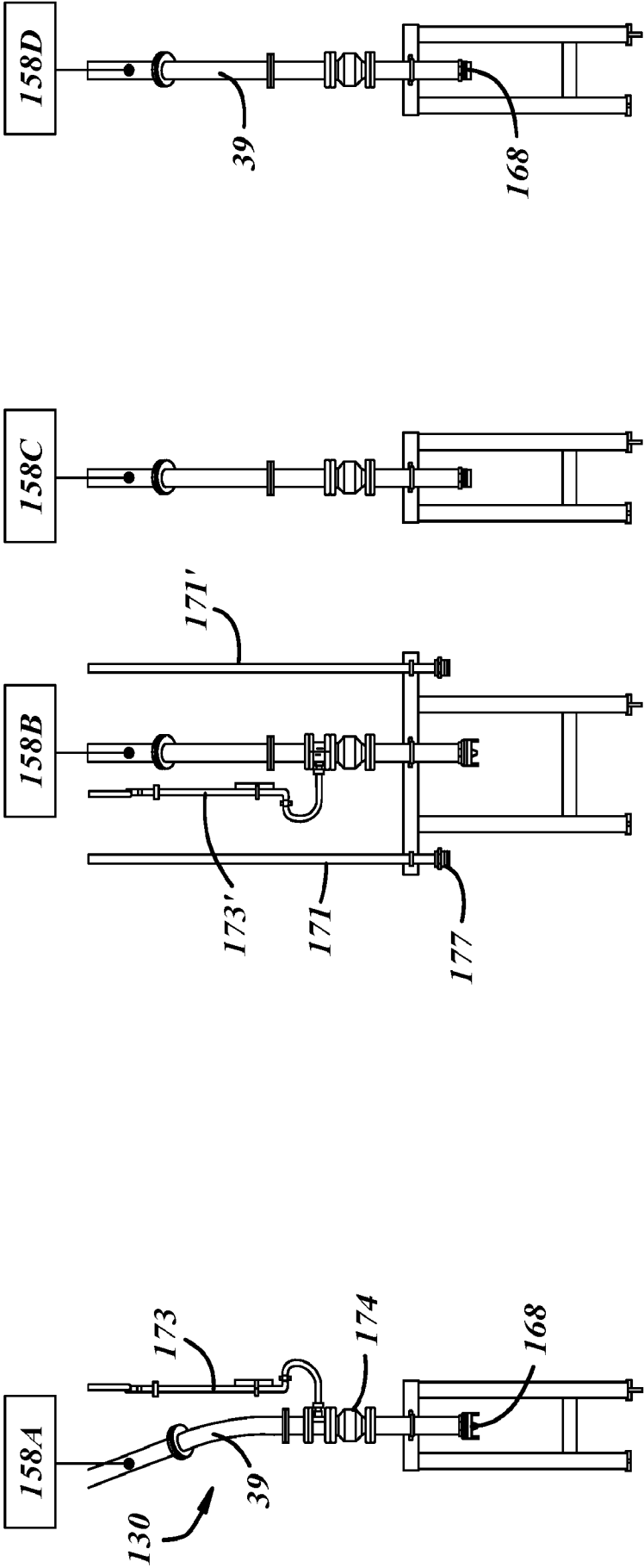


FIG. 20B

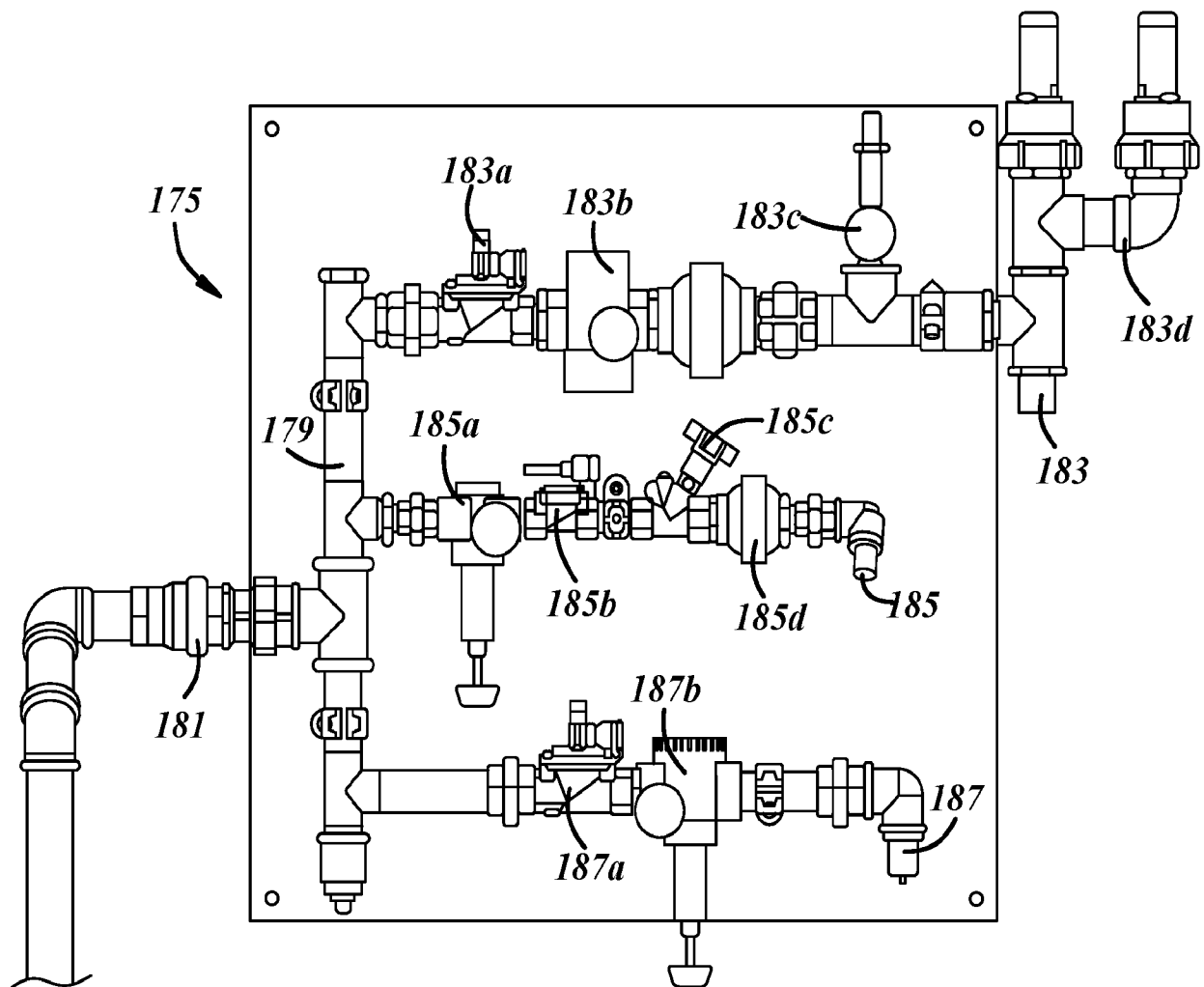


FIG. 20C

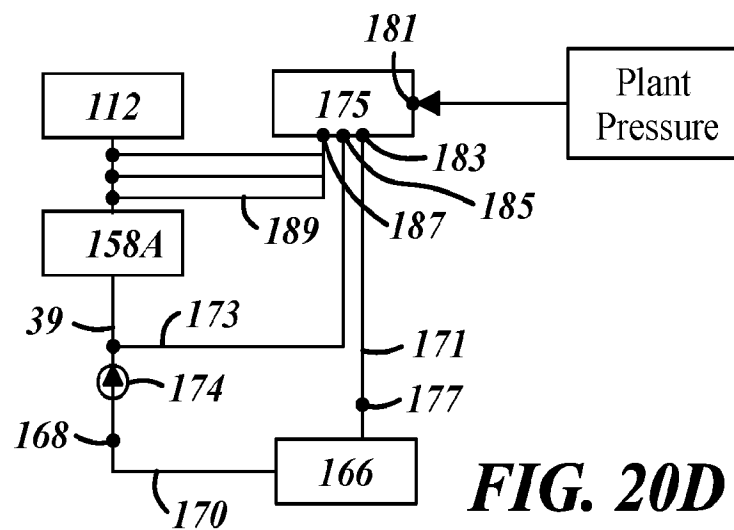
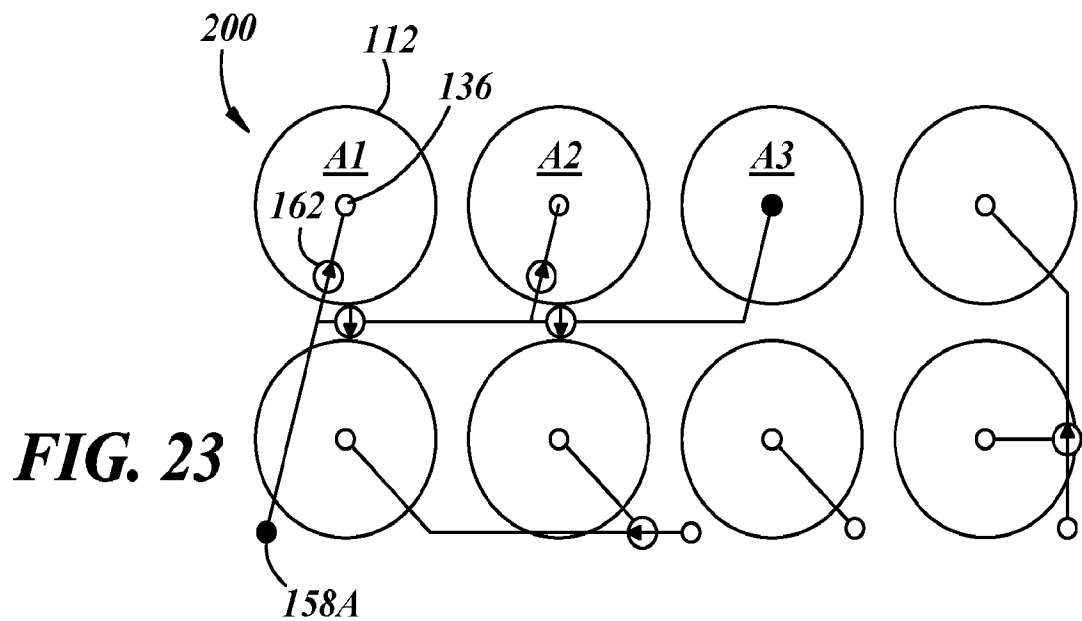
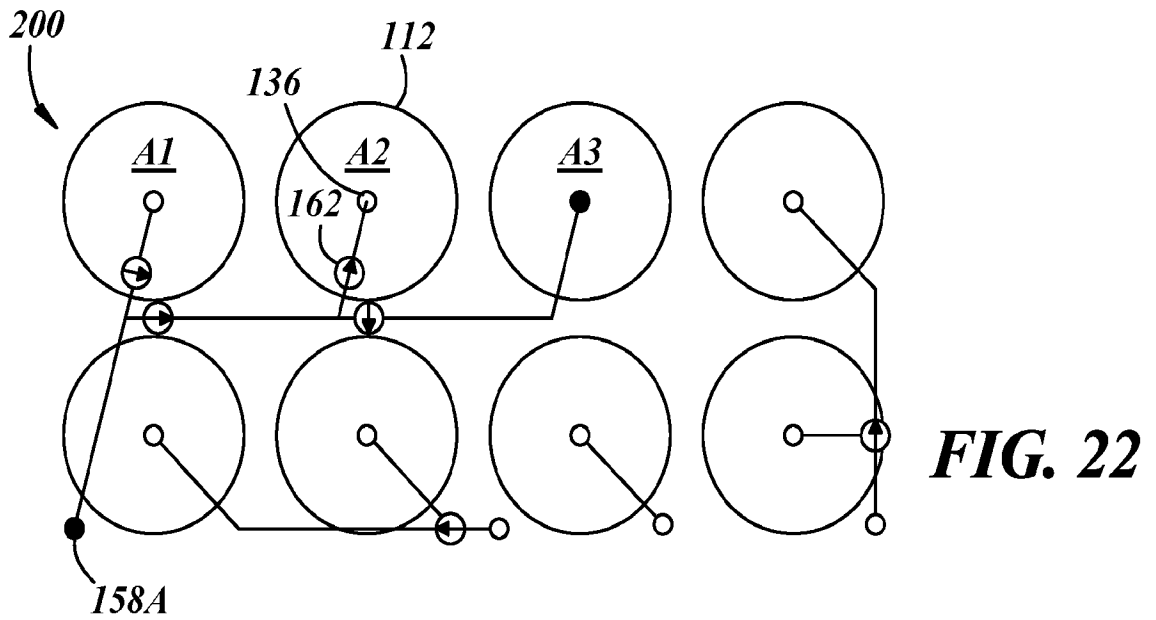
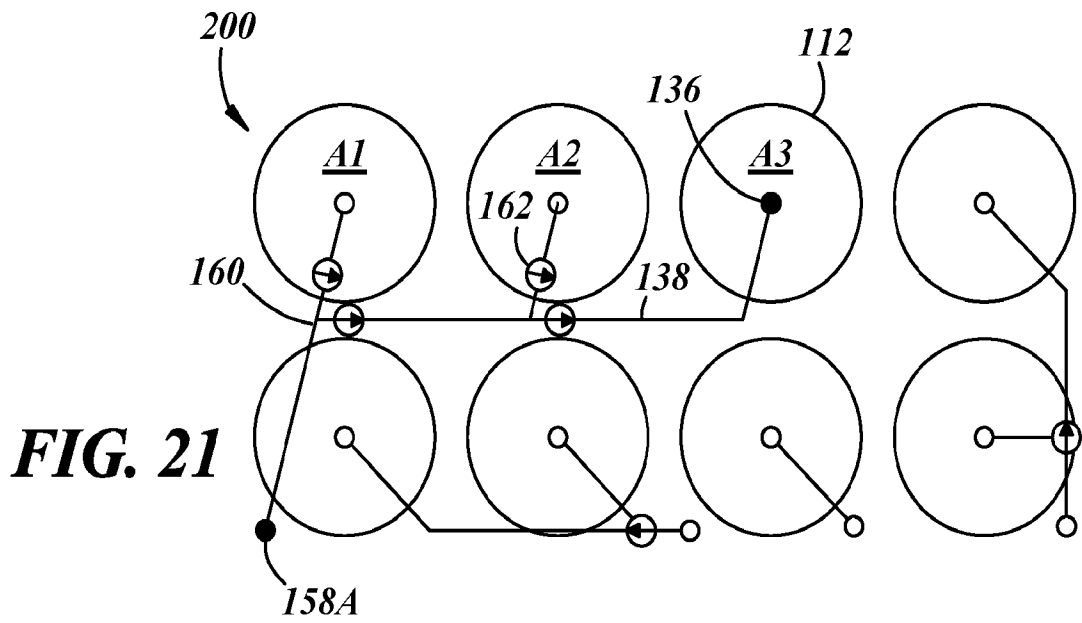


FIG. 20D



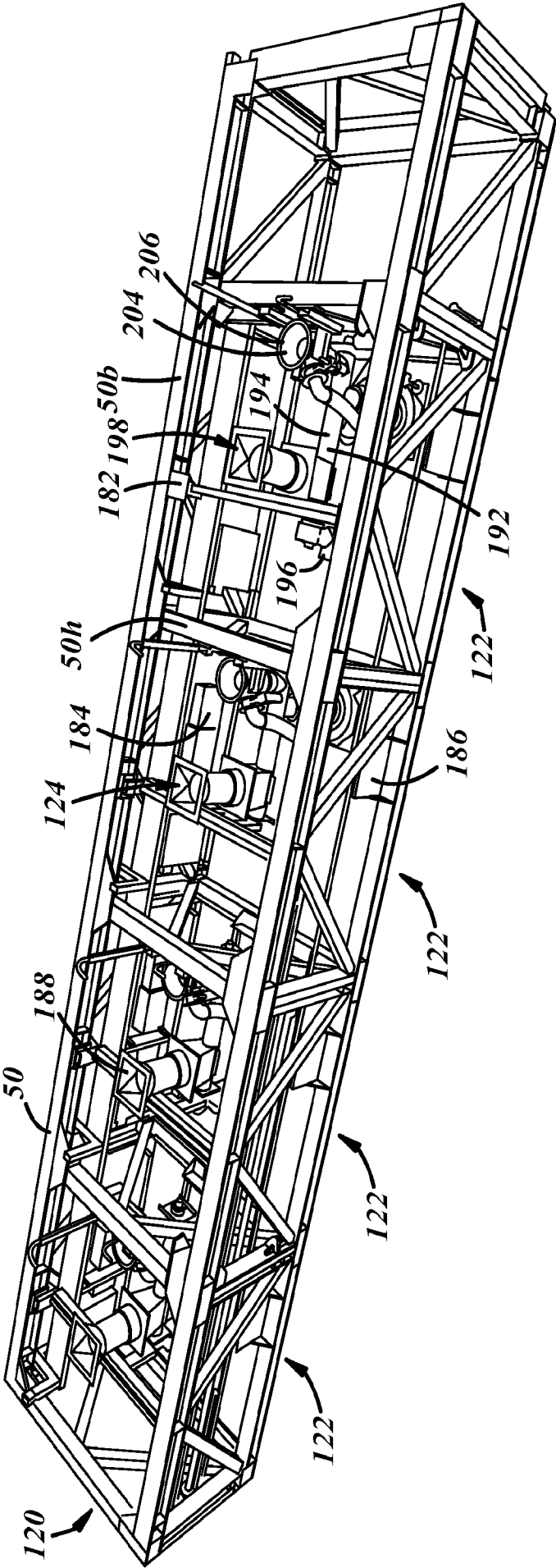


FIG. 24

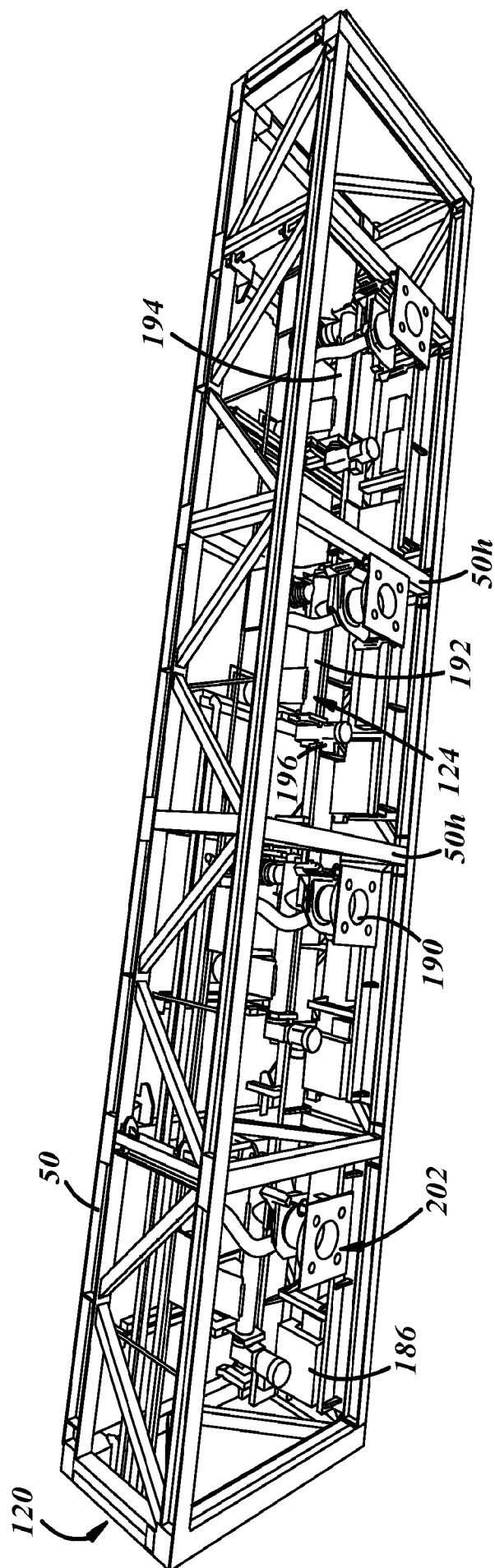
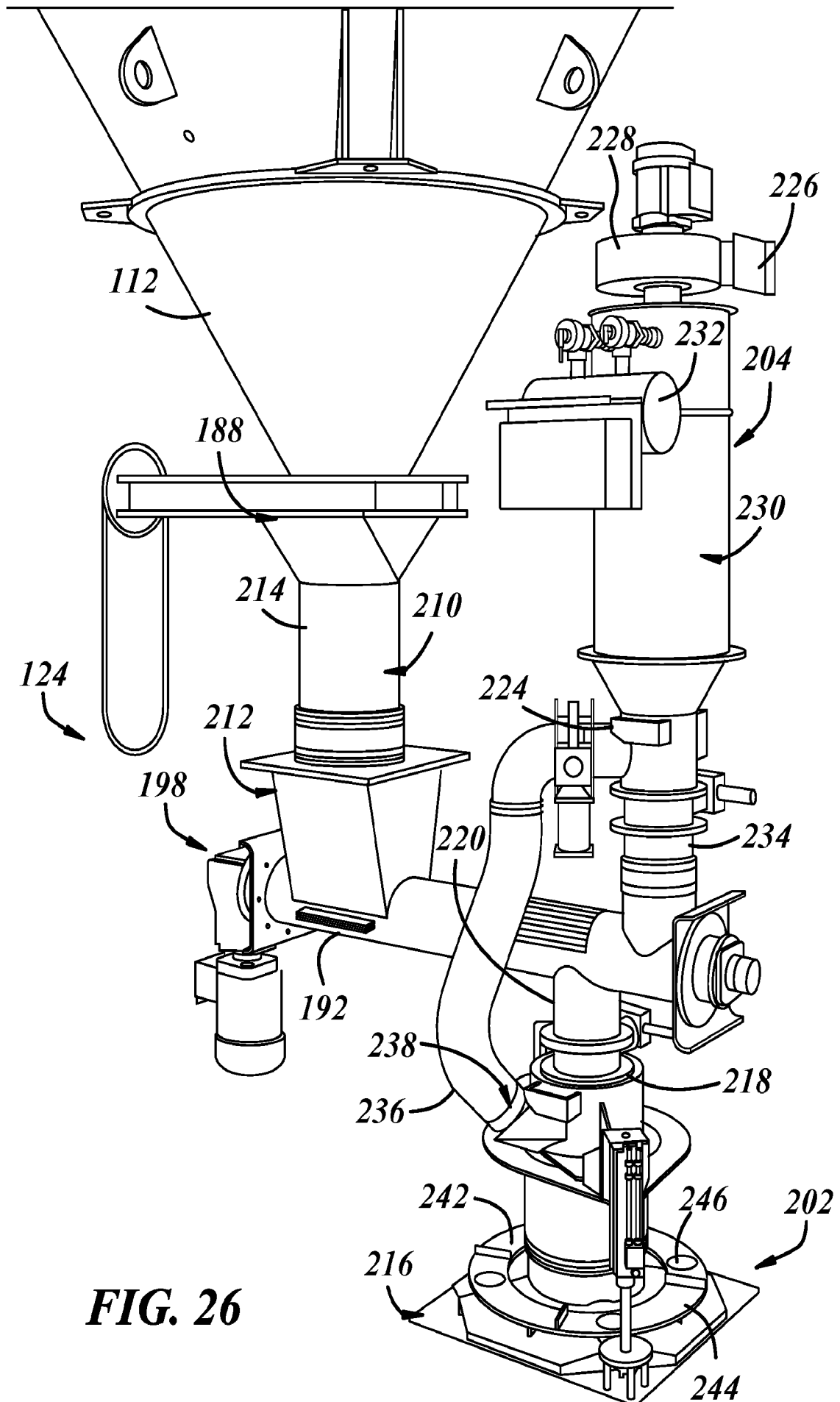
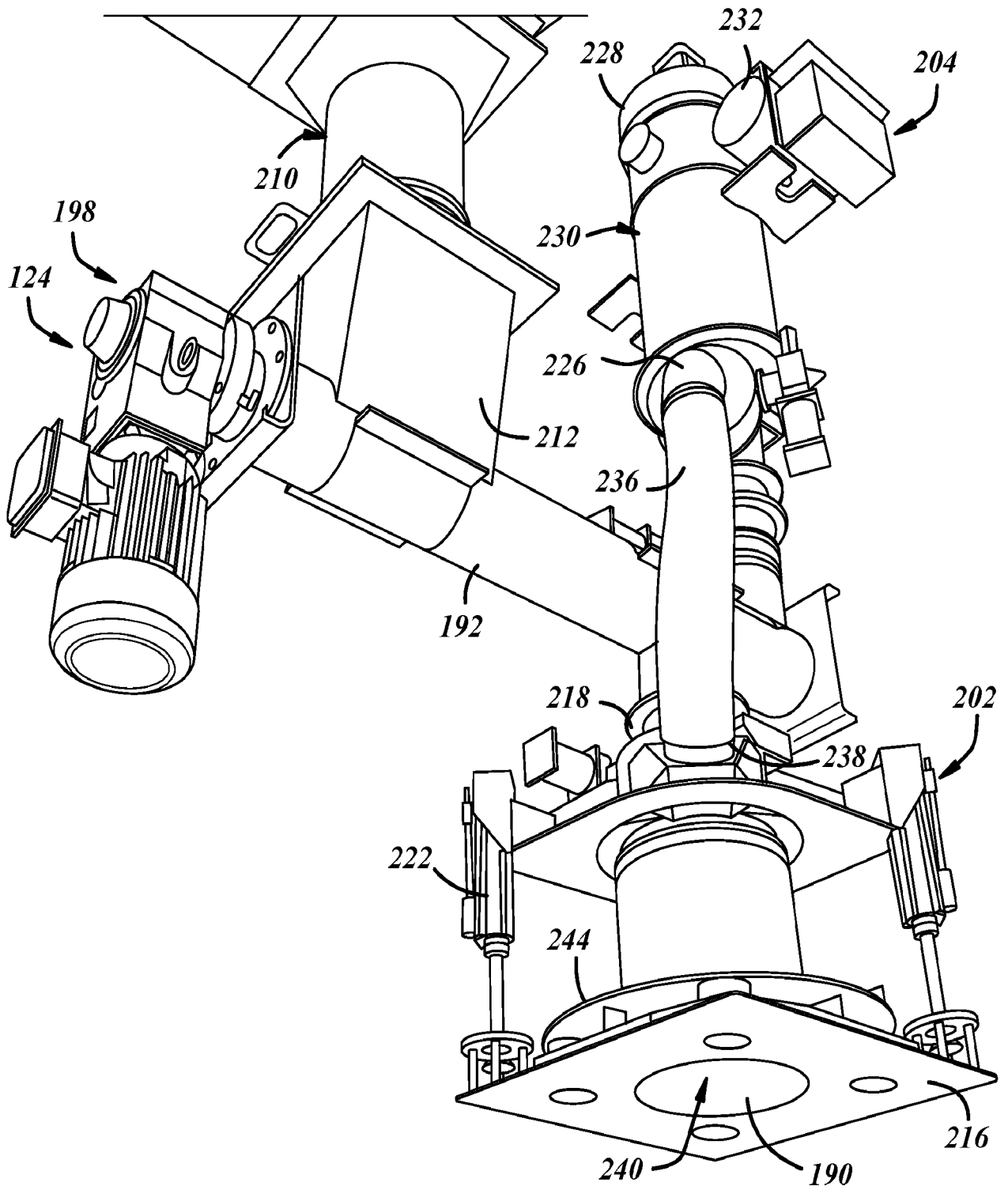
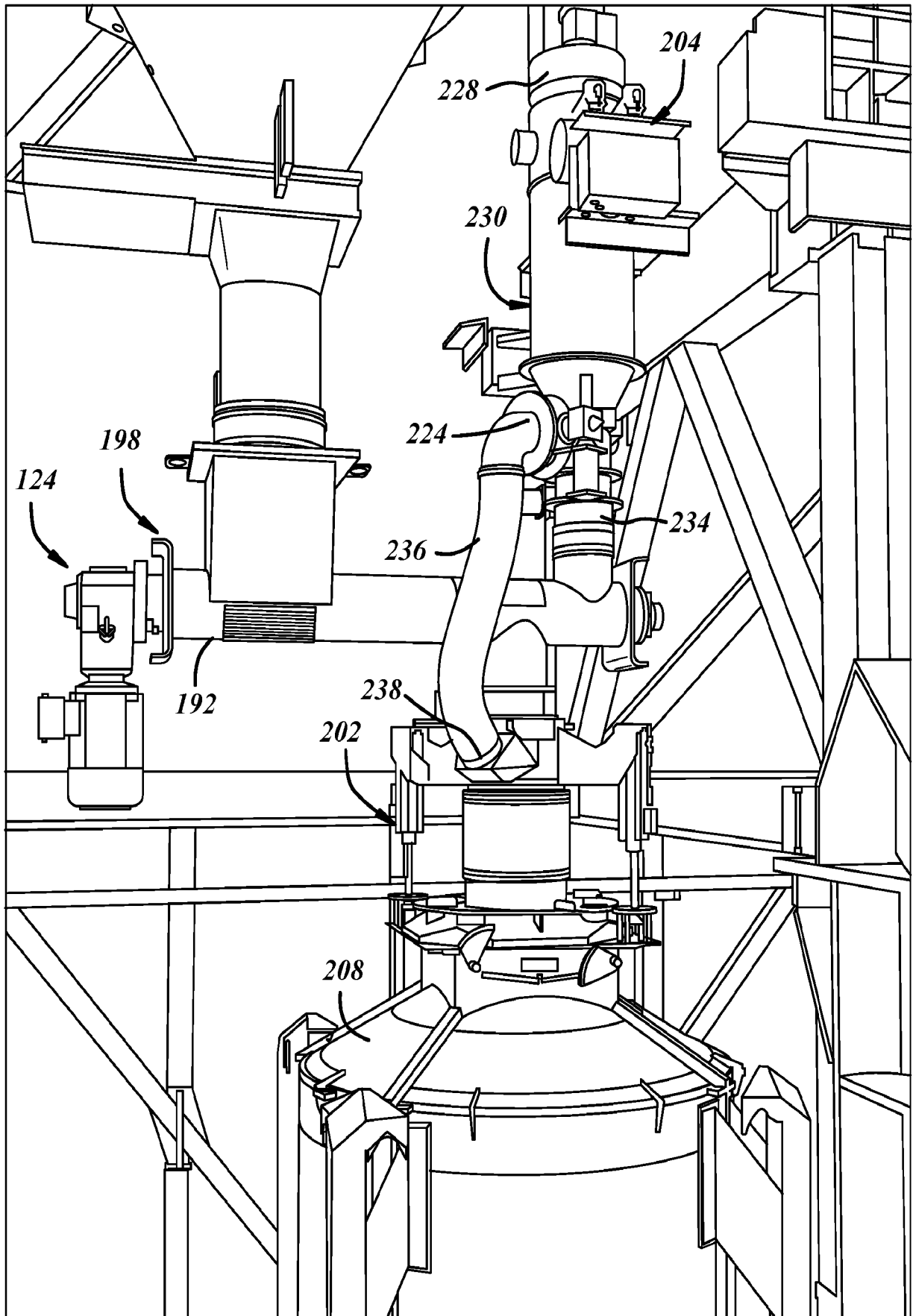
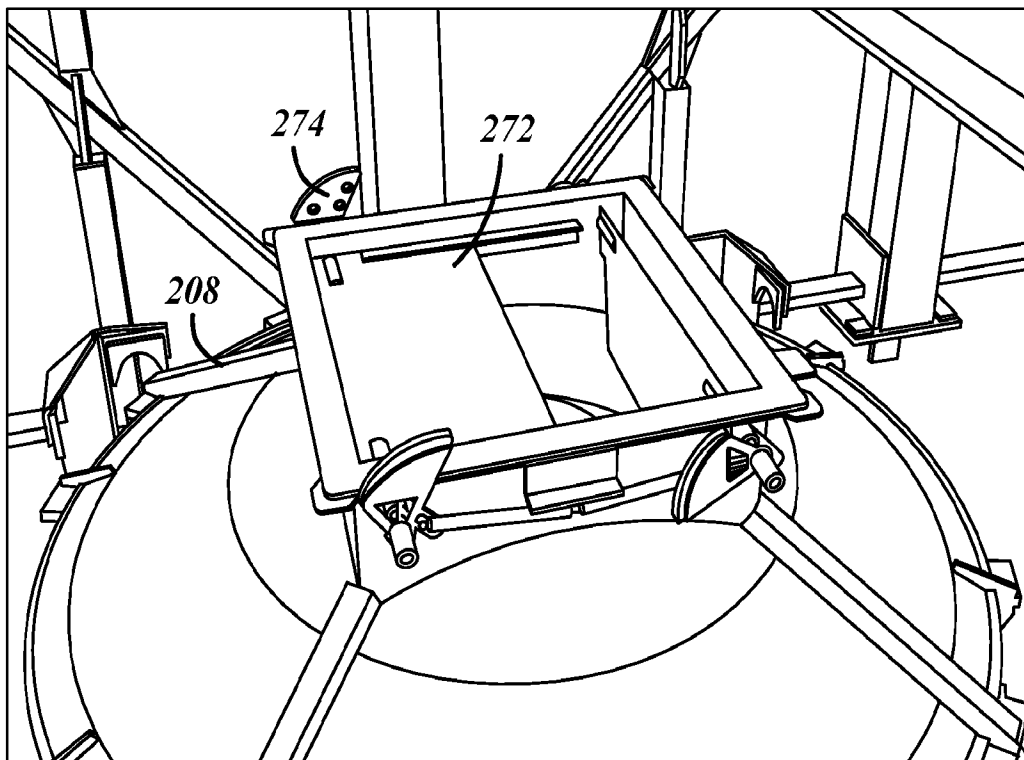
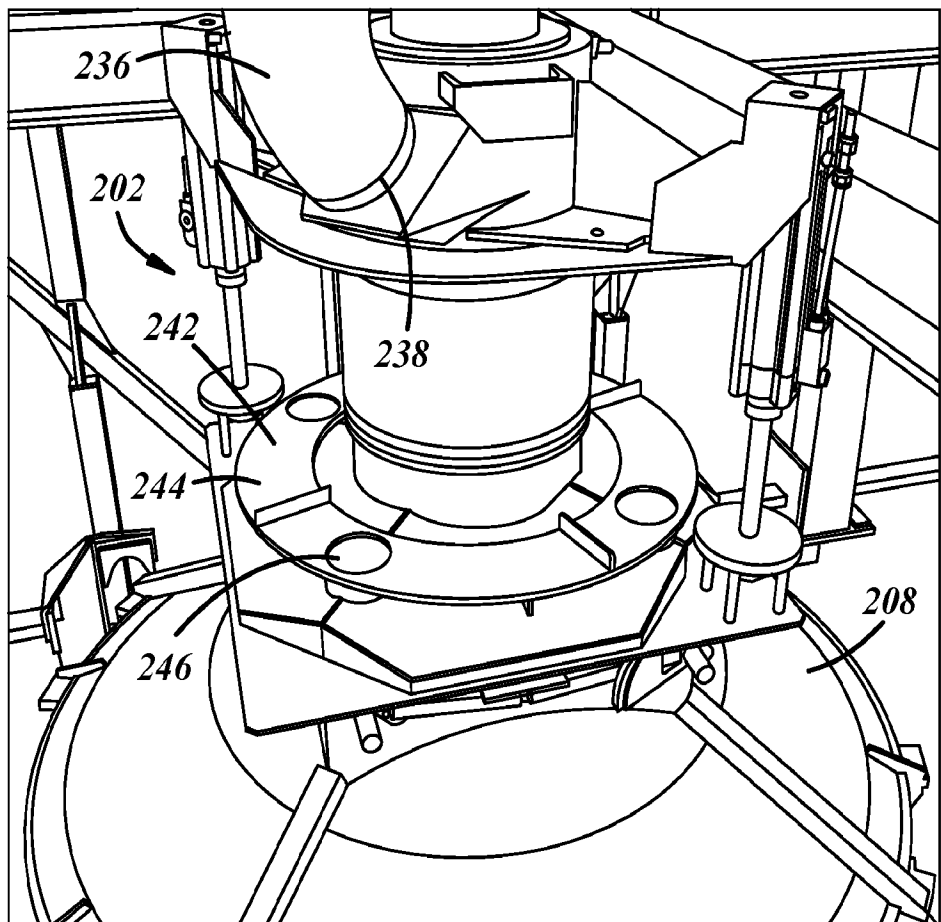


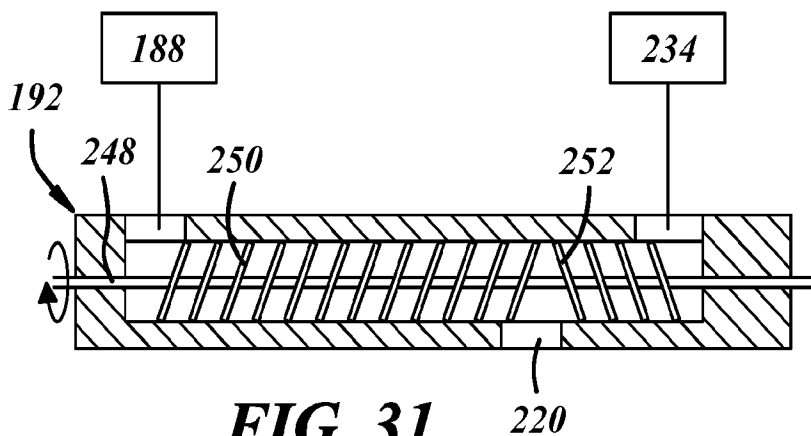
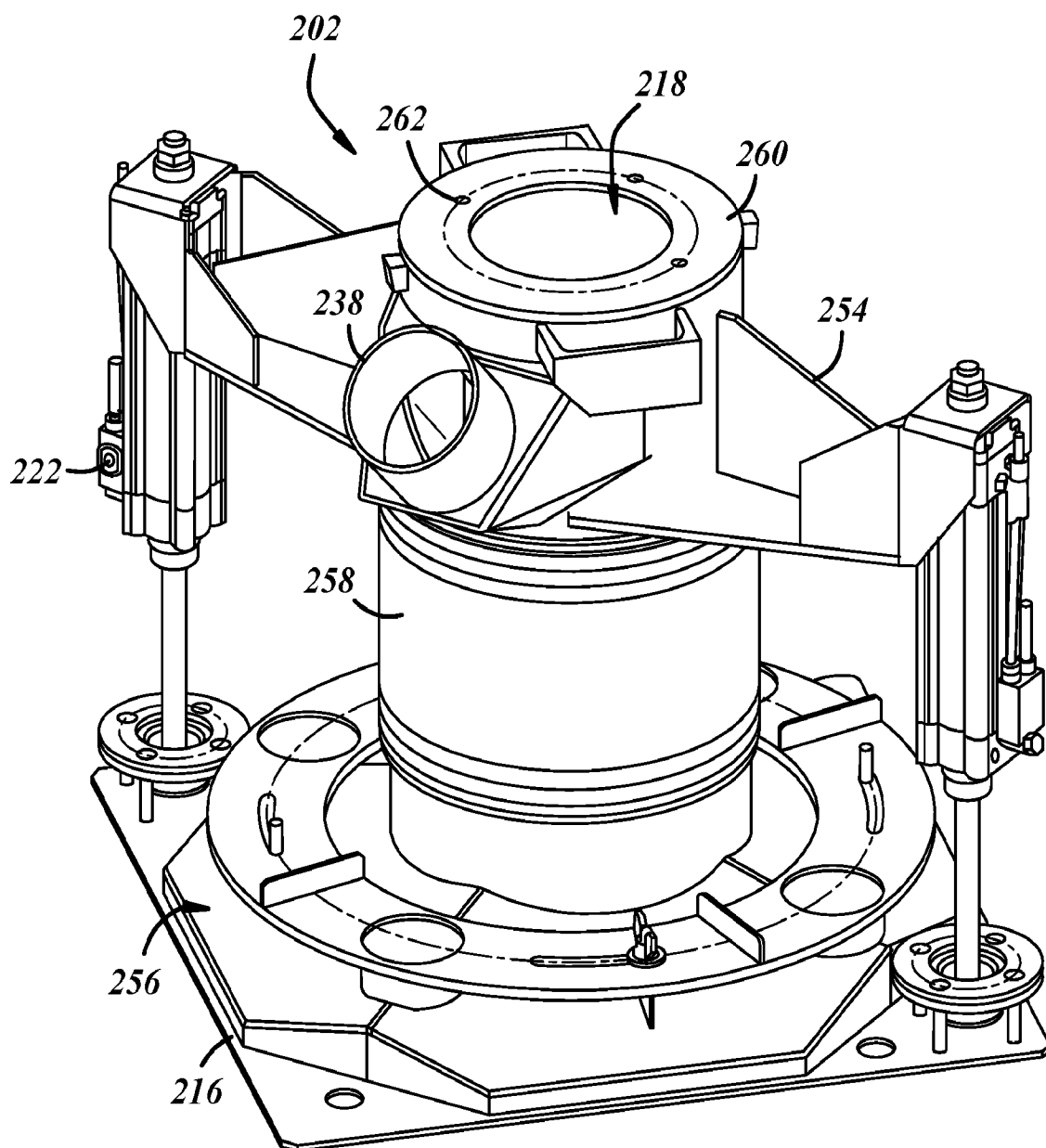
FIG. 25



**FIG. 27**

**FIG. 28**

**FIG. 29****FIG. 30**

**FIG. 31****FIG. 32**

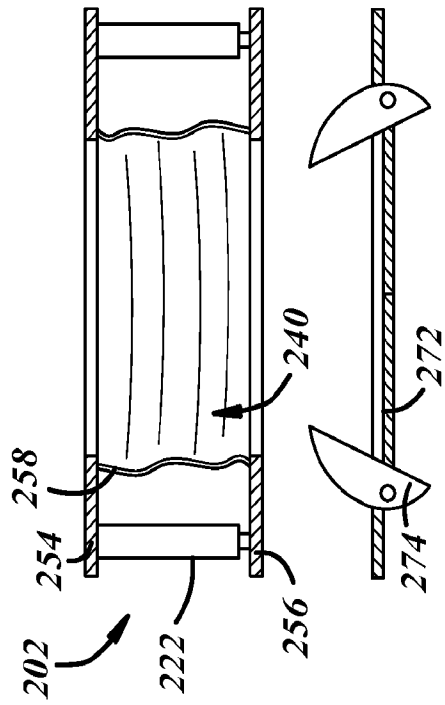


FIG. 34

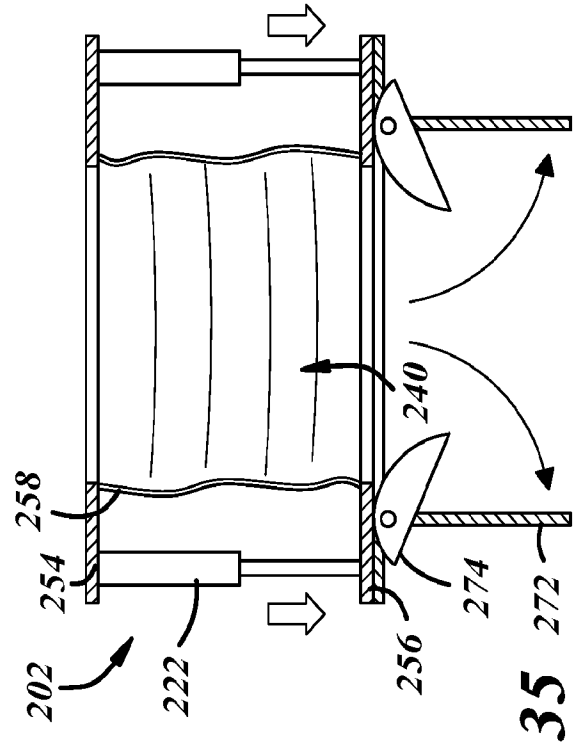


FIG. 35

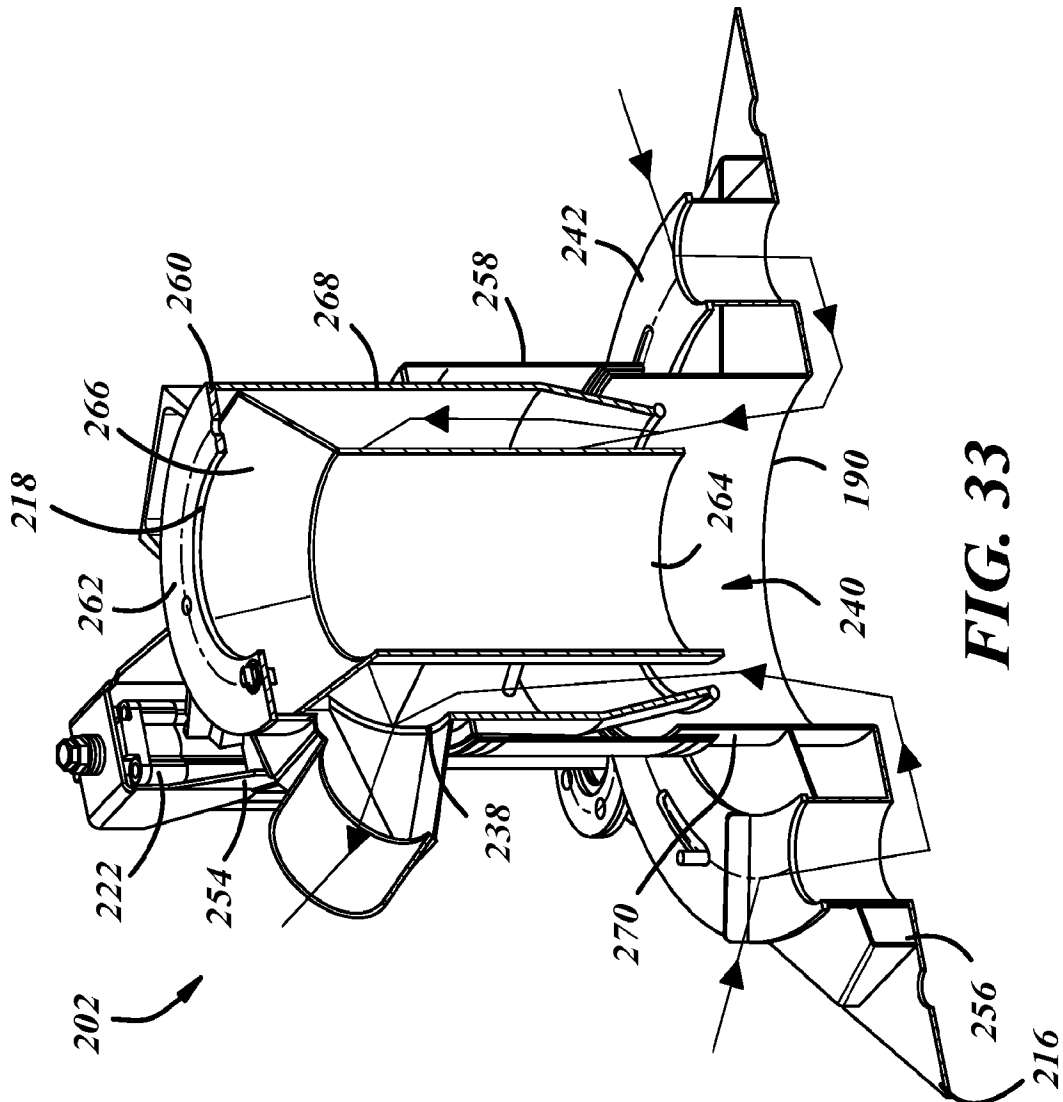
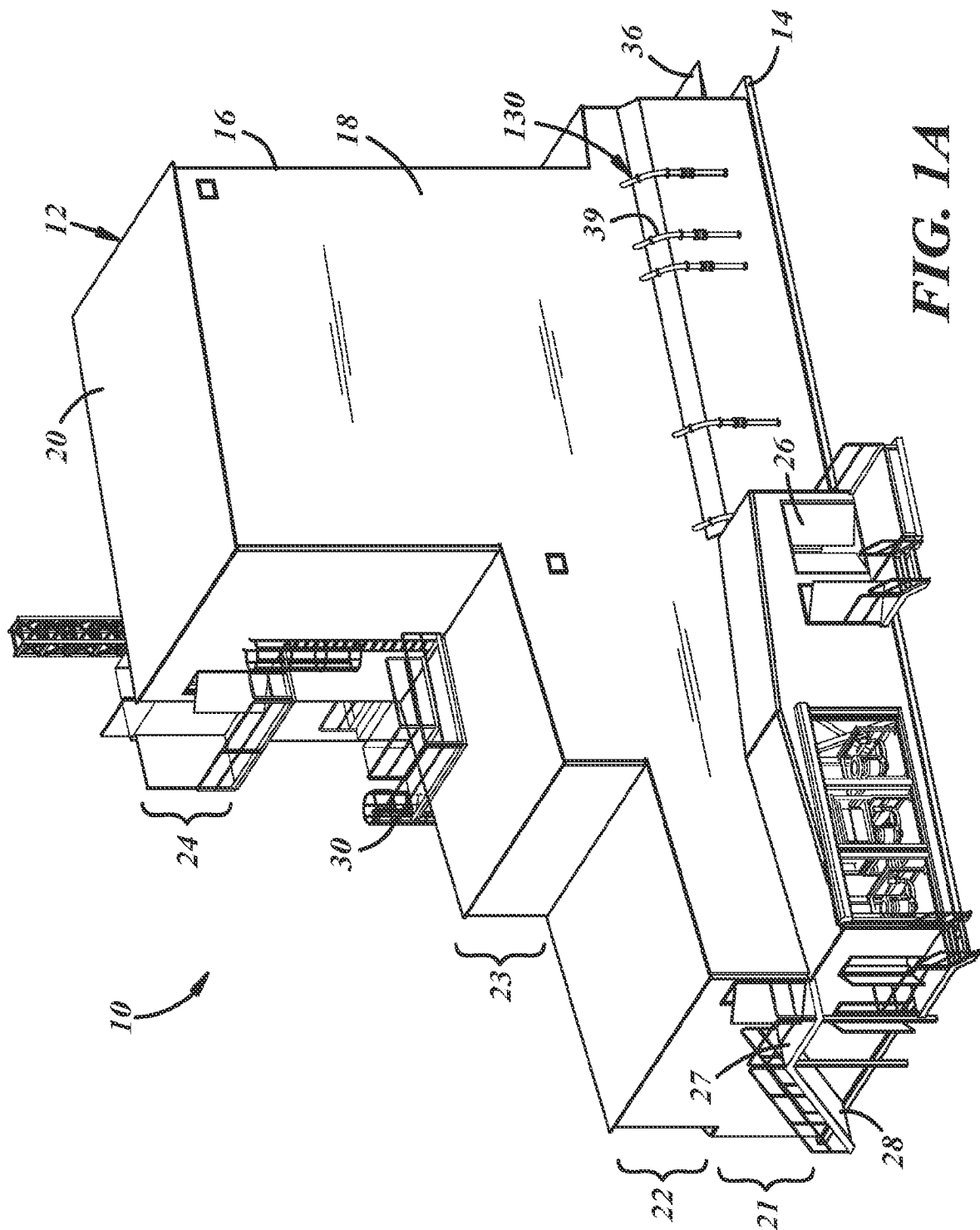
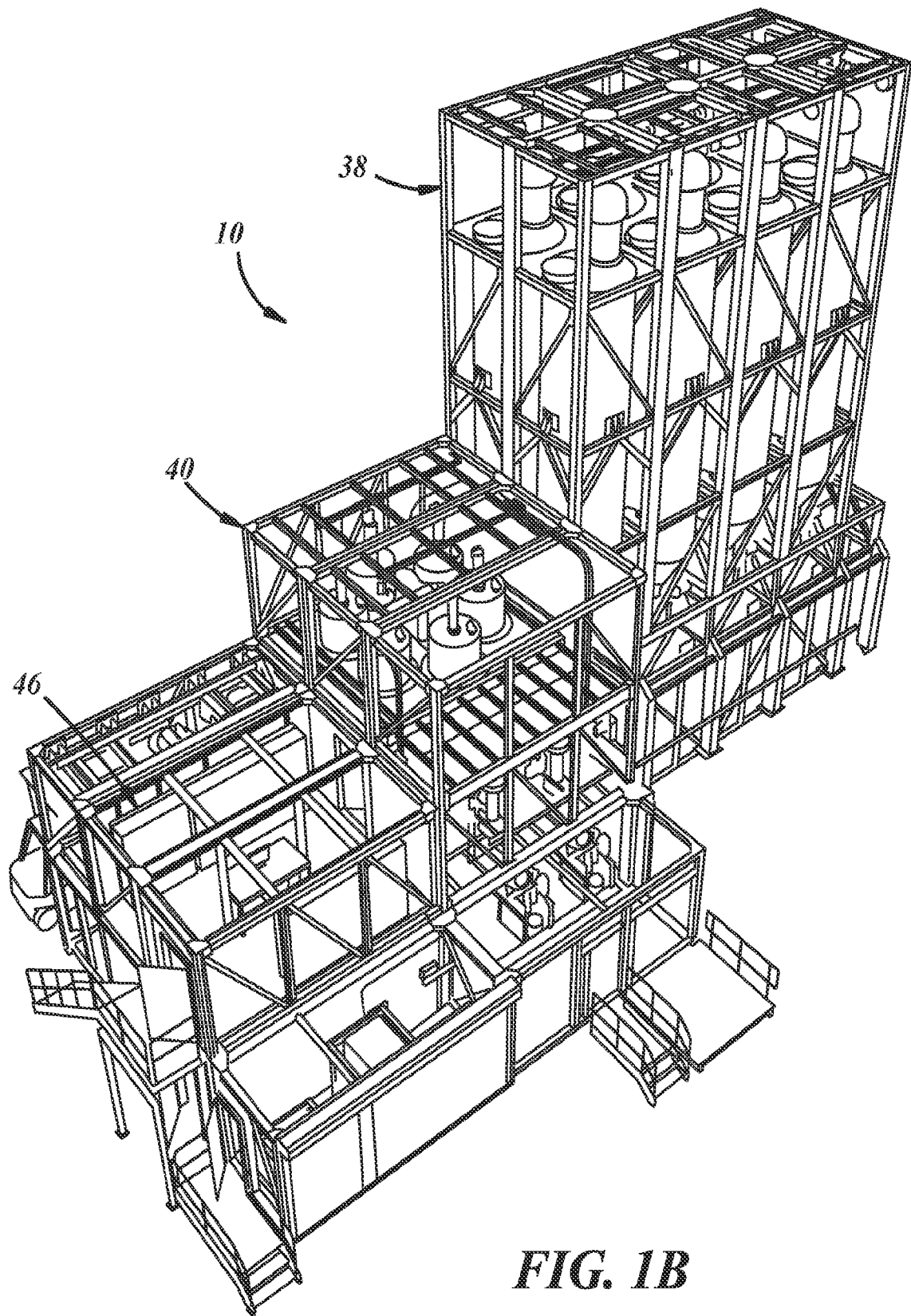


FIG. 33



**FIG. 1B**

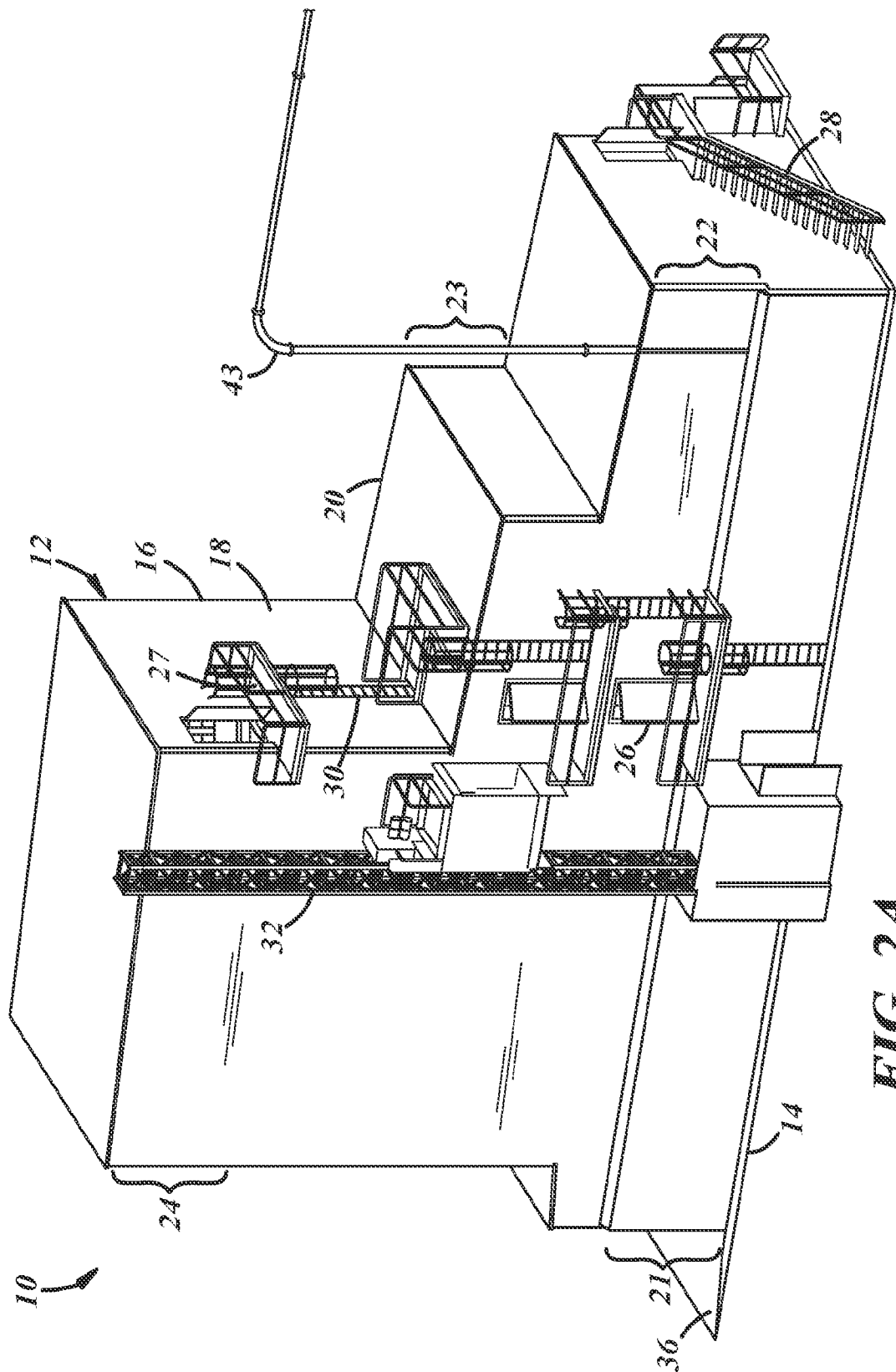


FIG. 2A

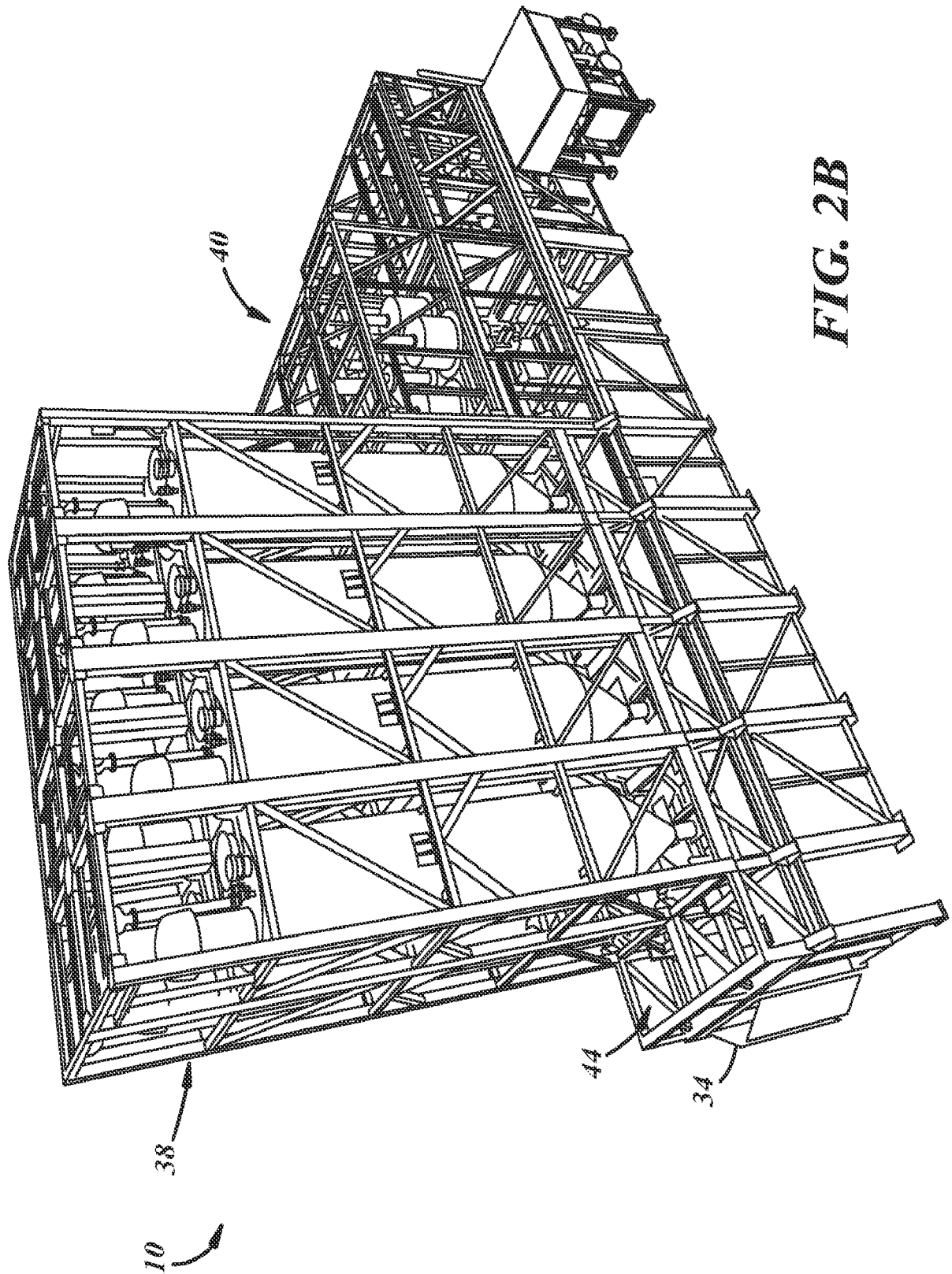


FIG. 2B

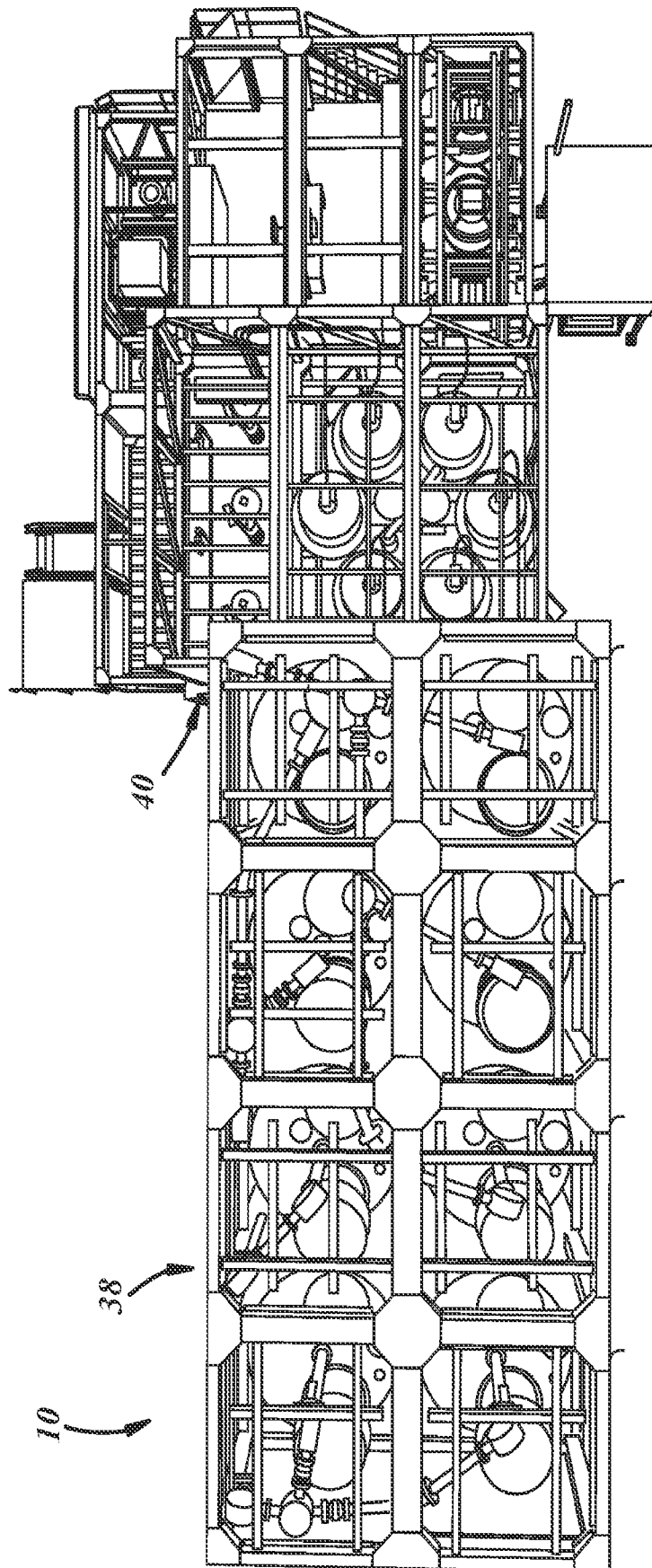


FIG. 3

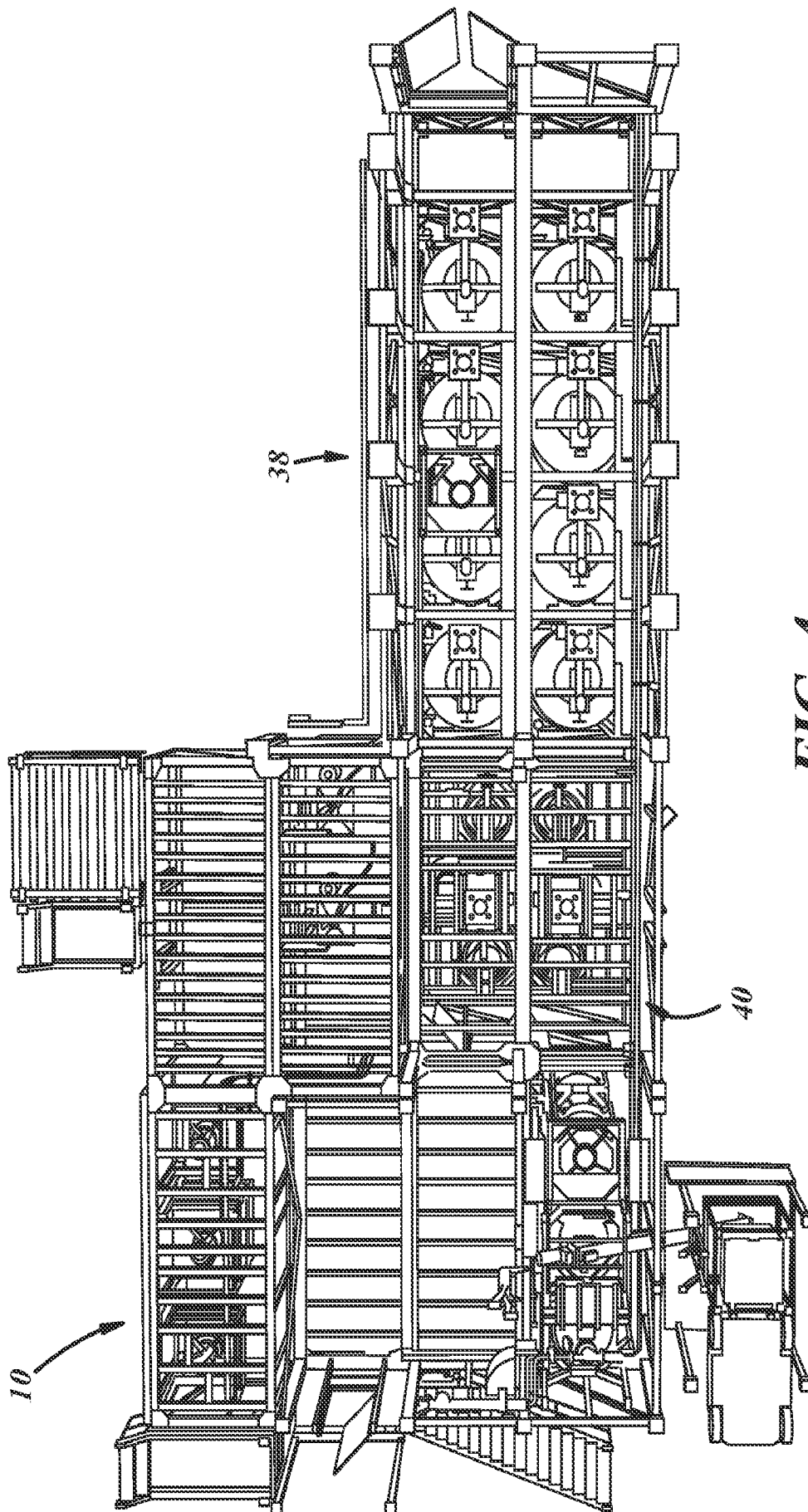


FIG. 4

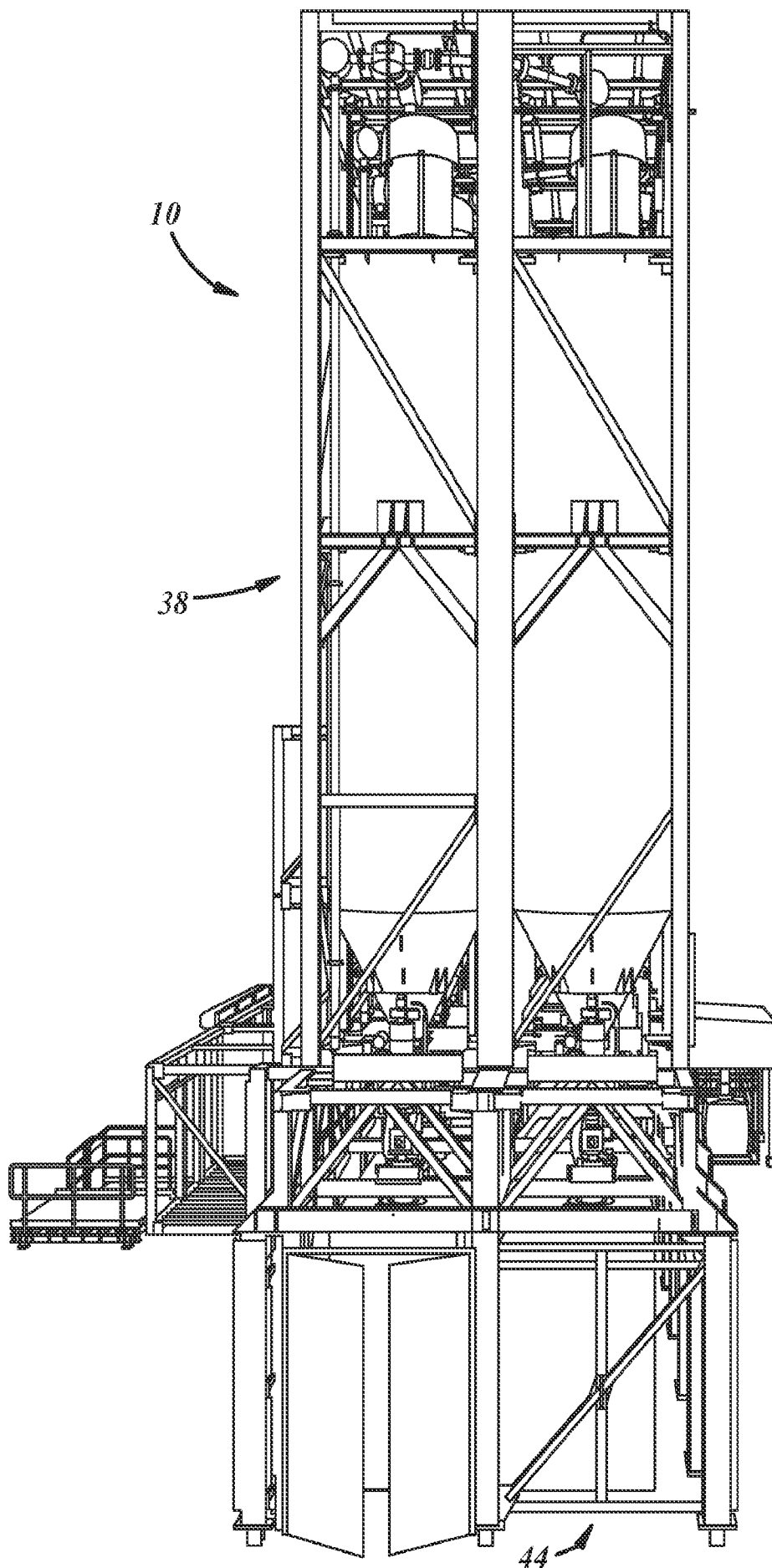


FIG. 5

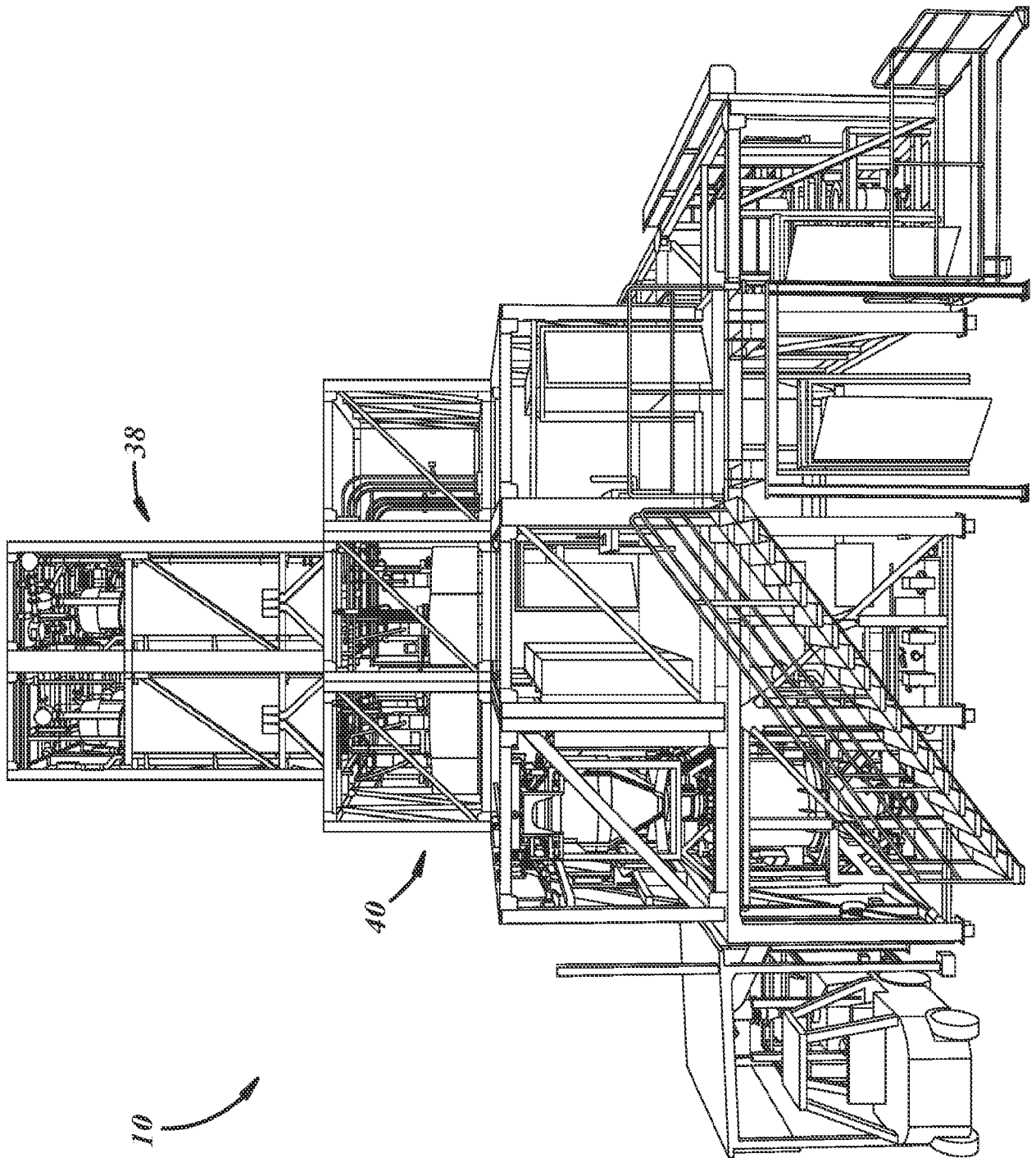


FIG. 6

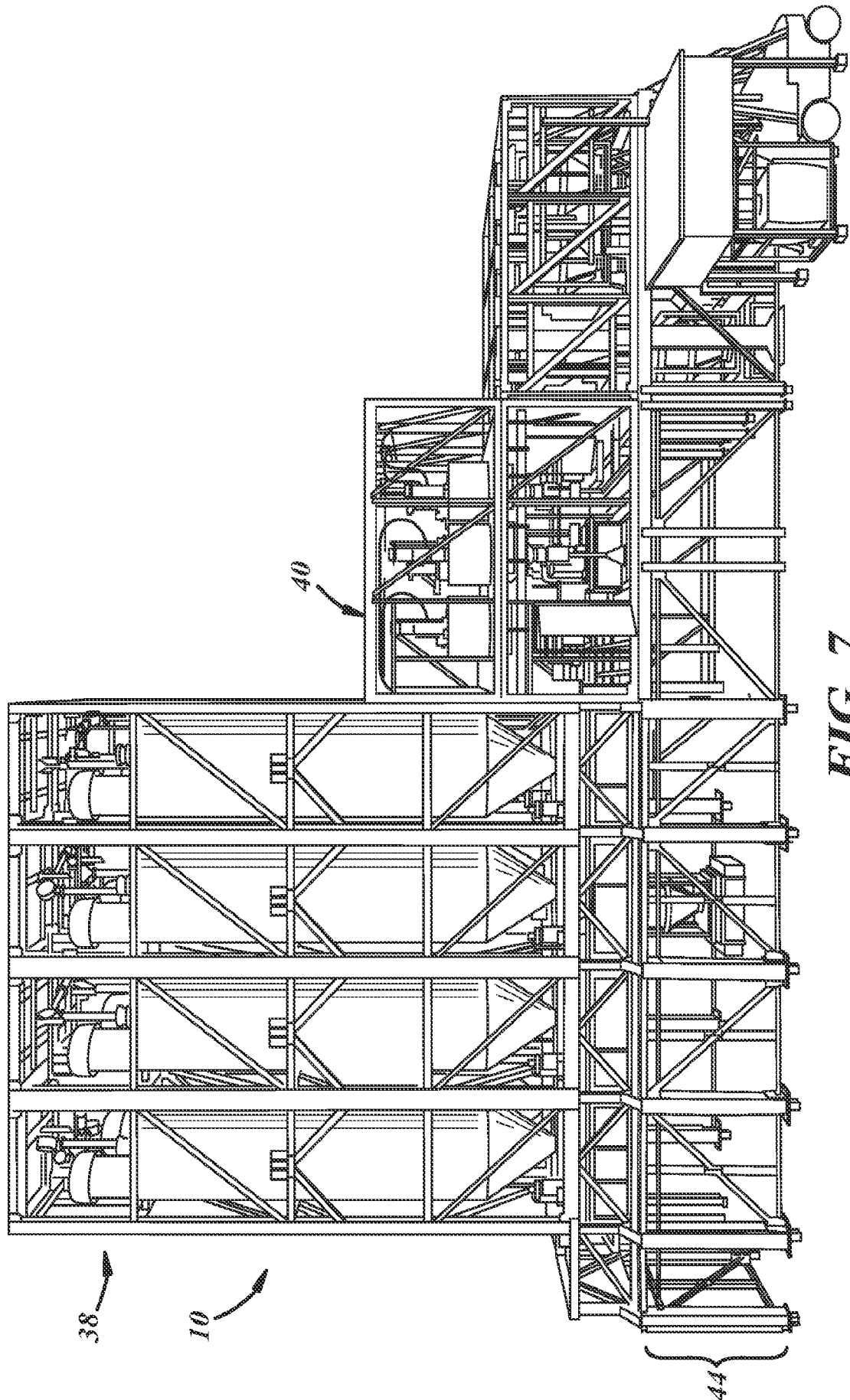


FIG. 7

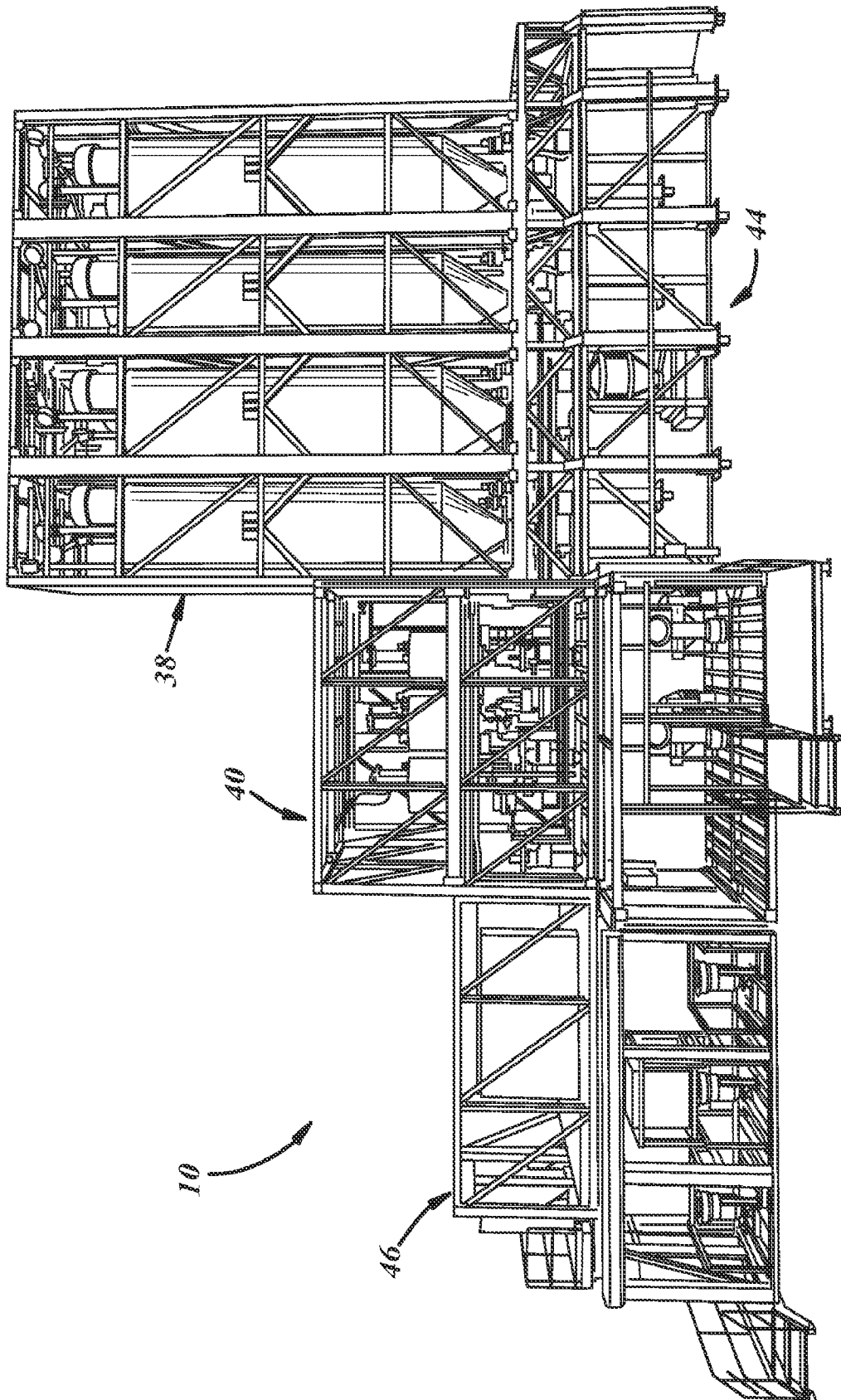


FIG. 8

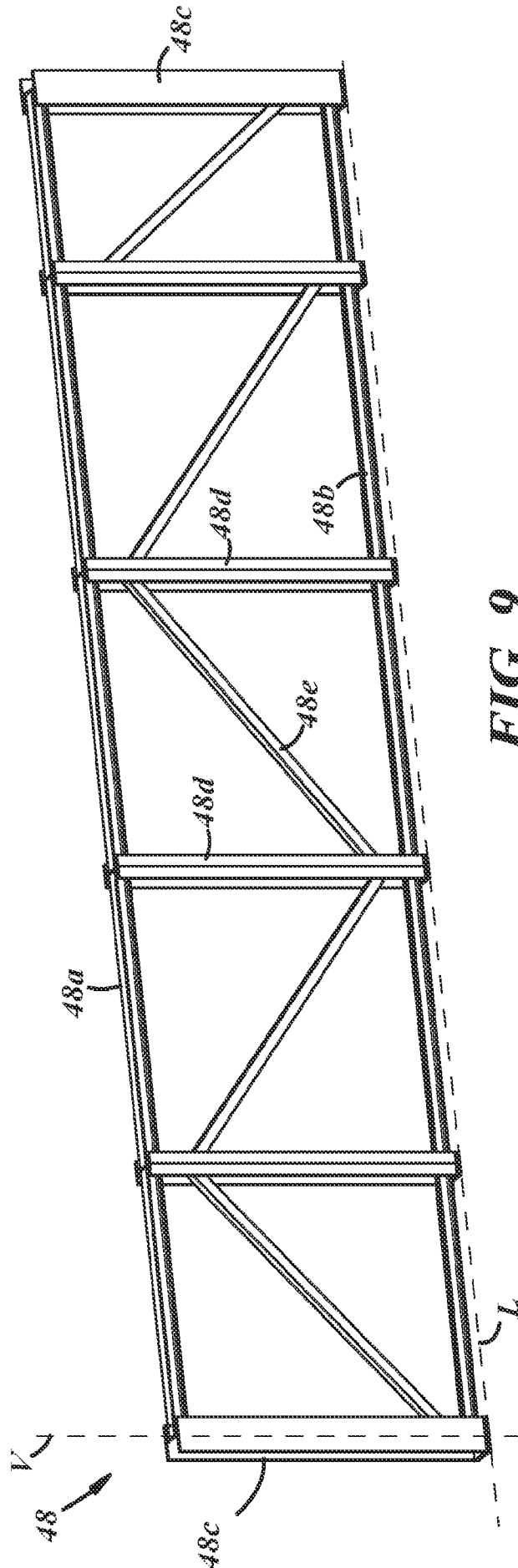


FIG. 9

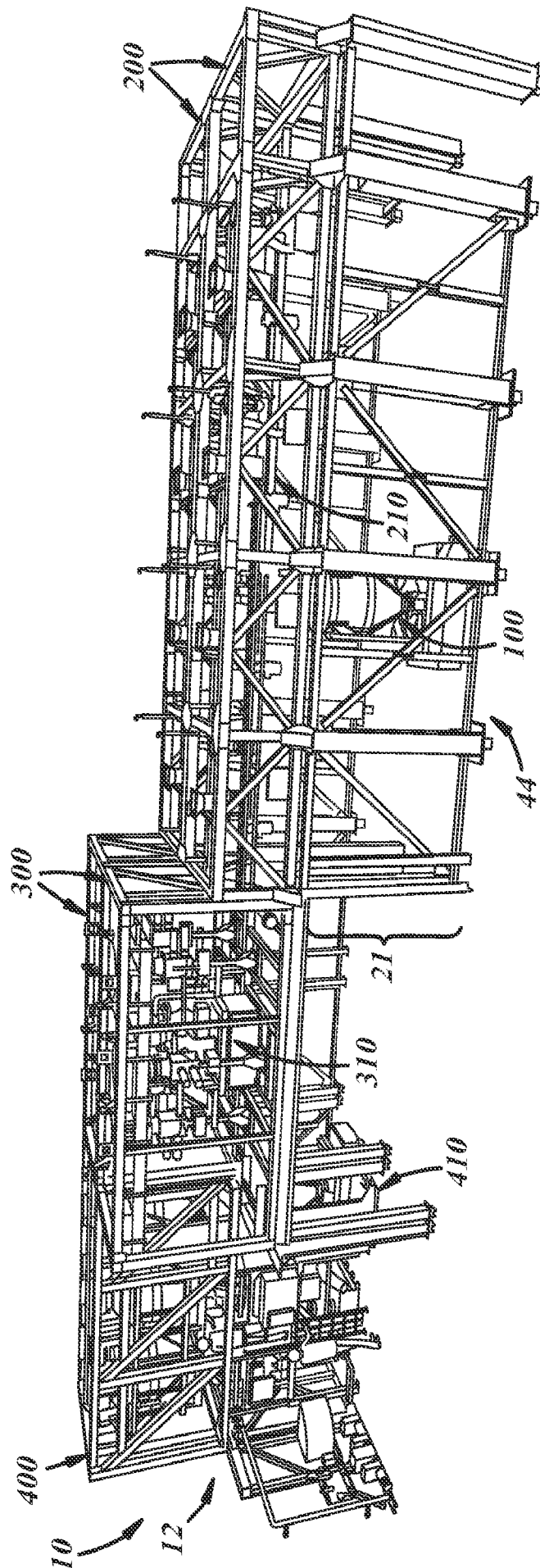


FIG. 10

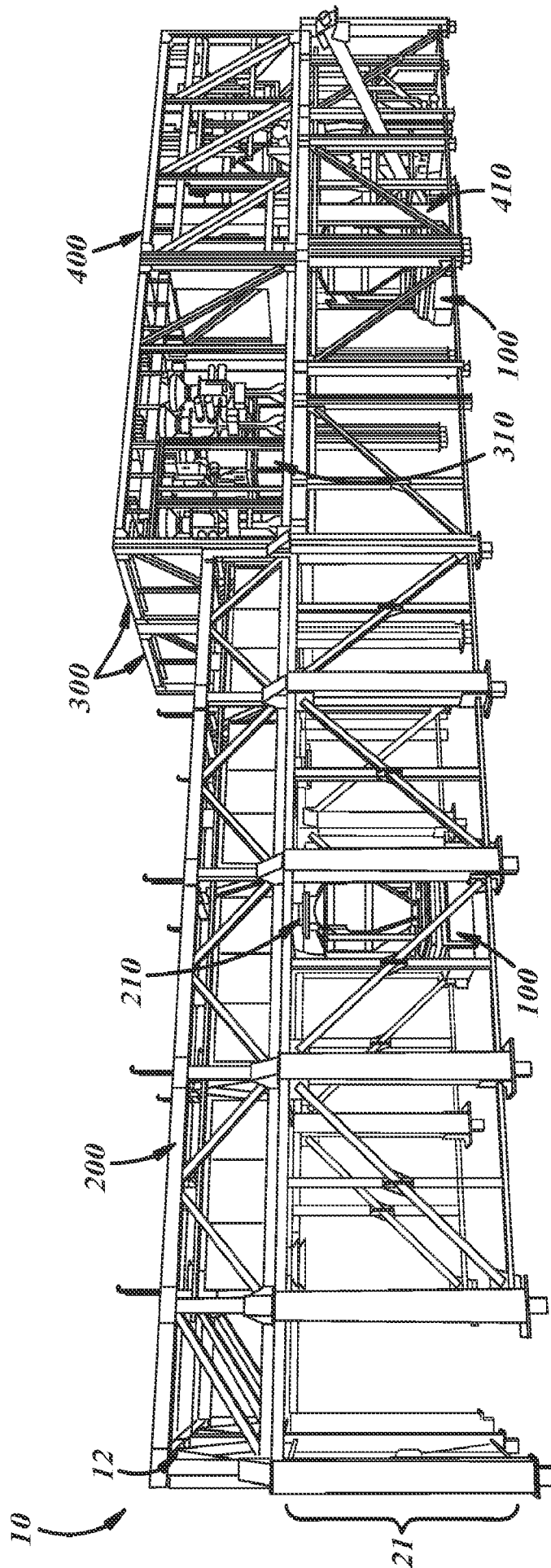


FIG. 11

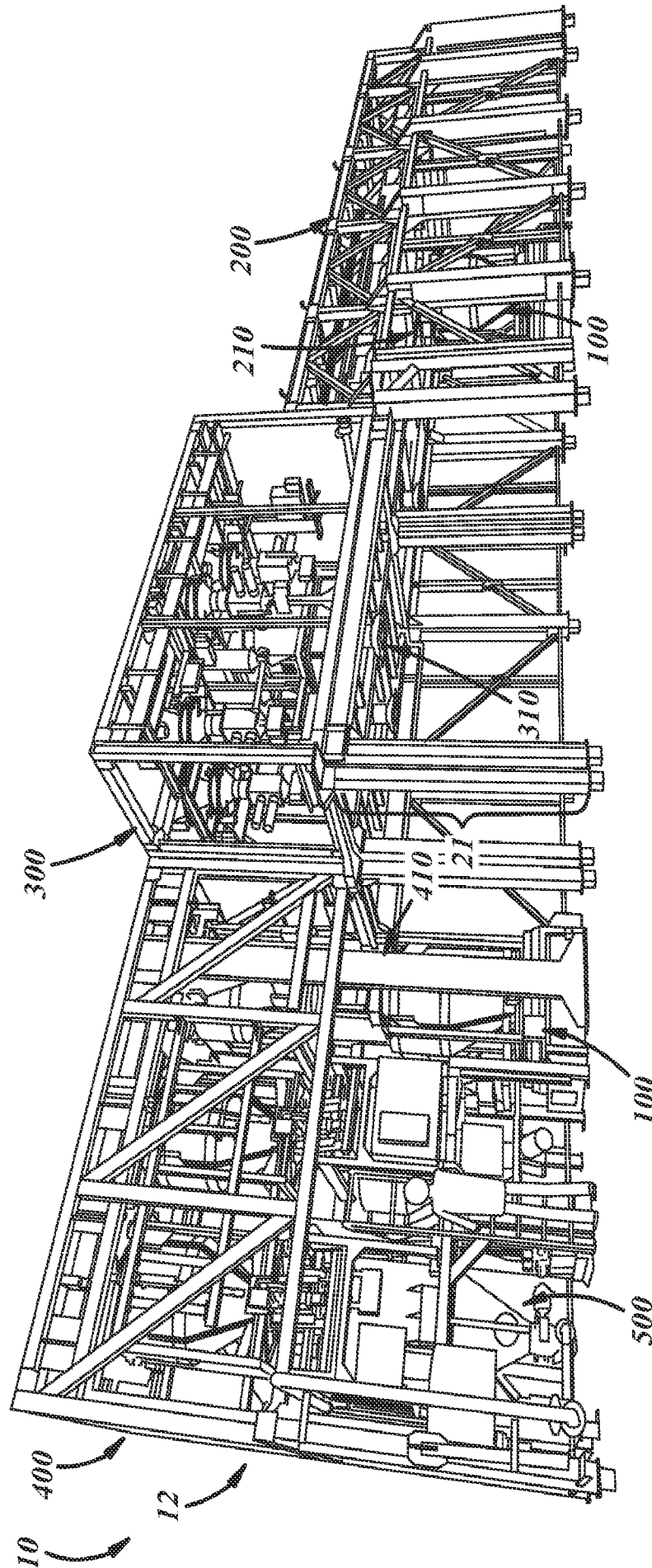


FIG. 12

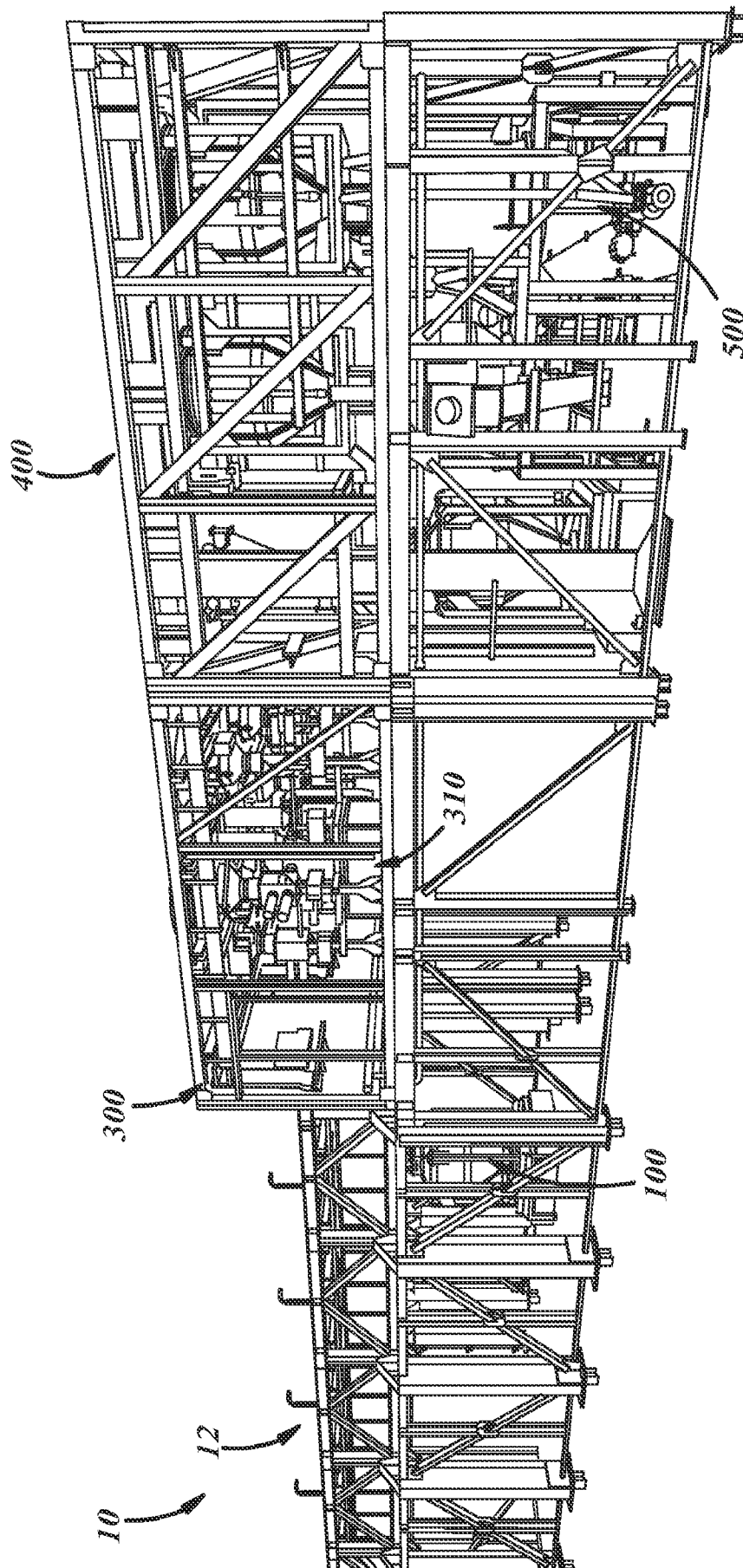
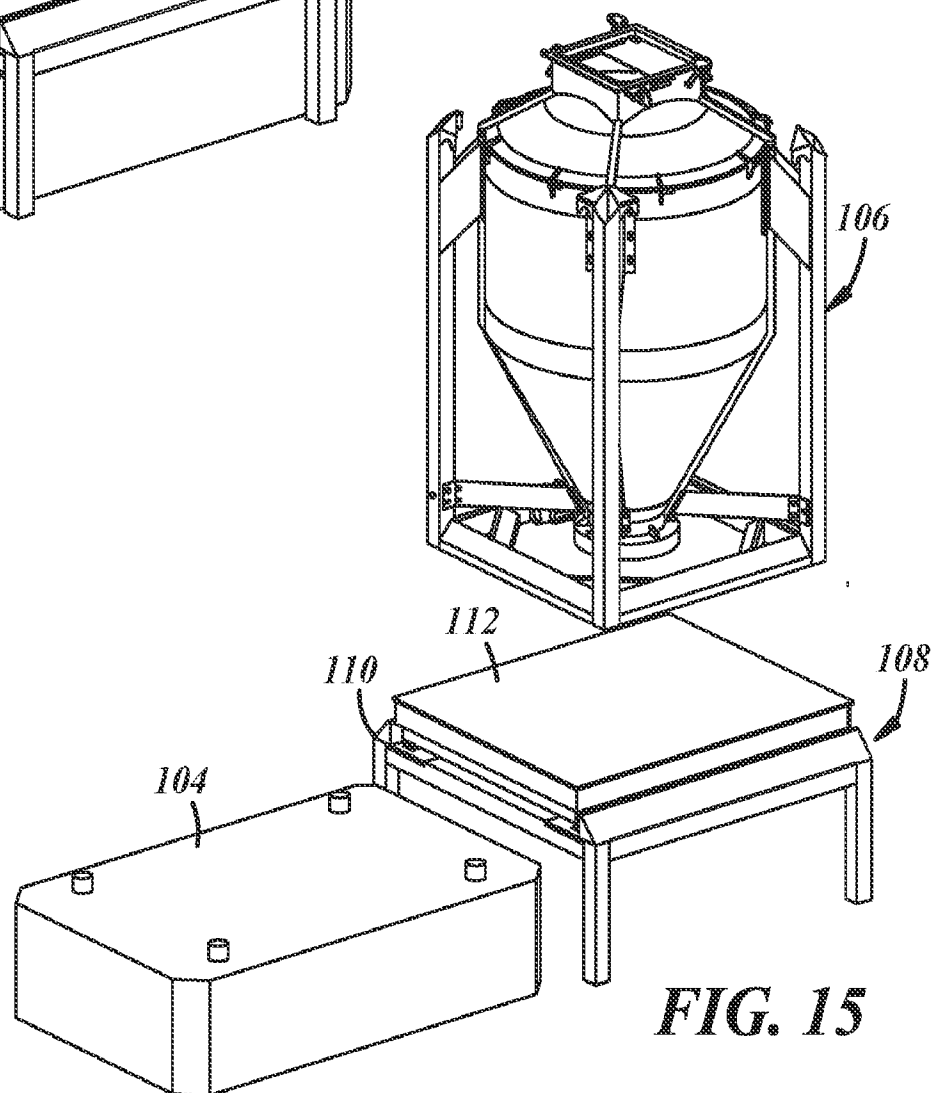
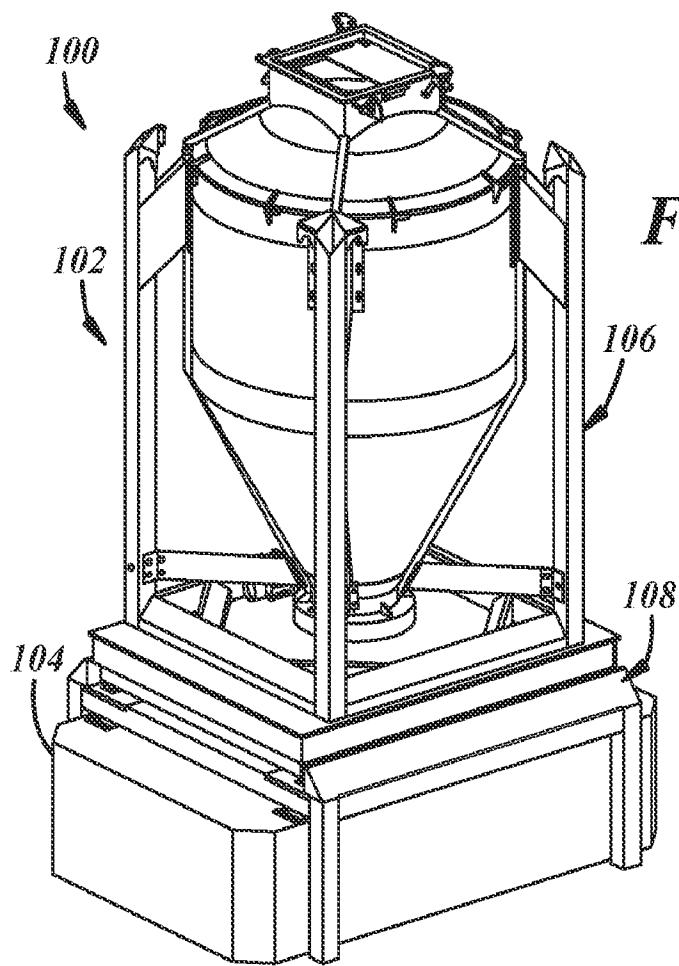


FIG. 13



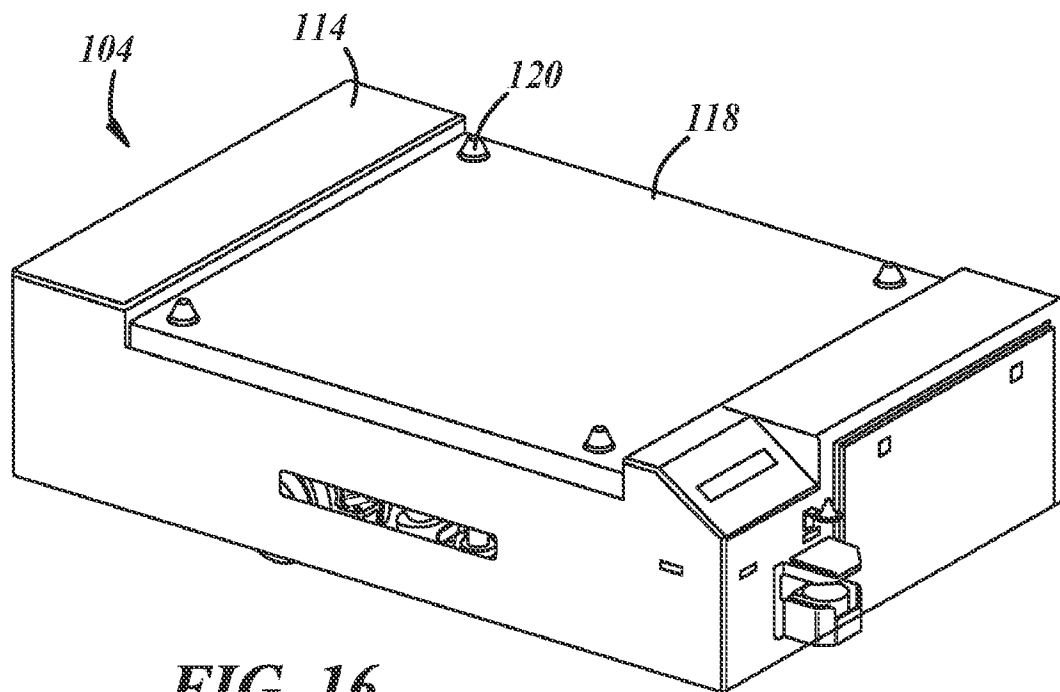


FIG. 16

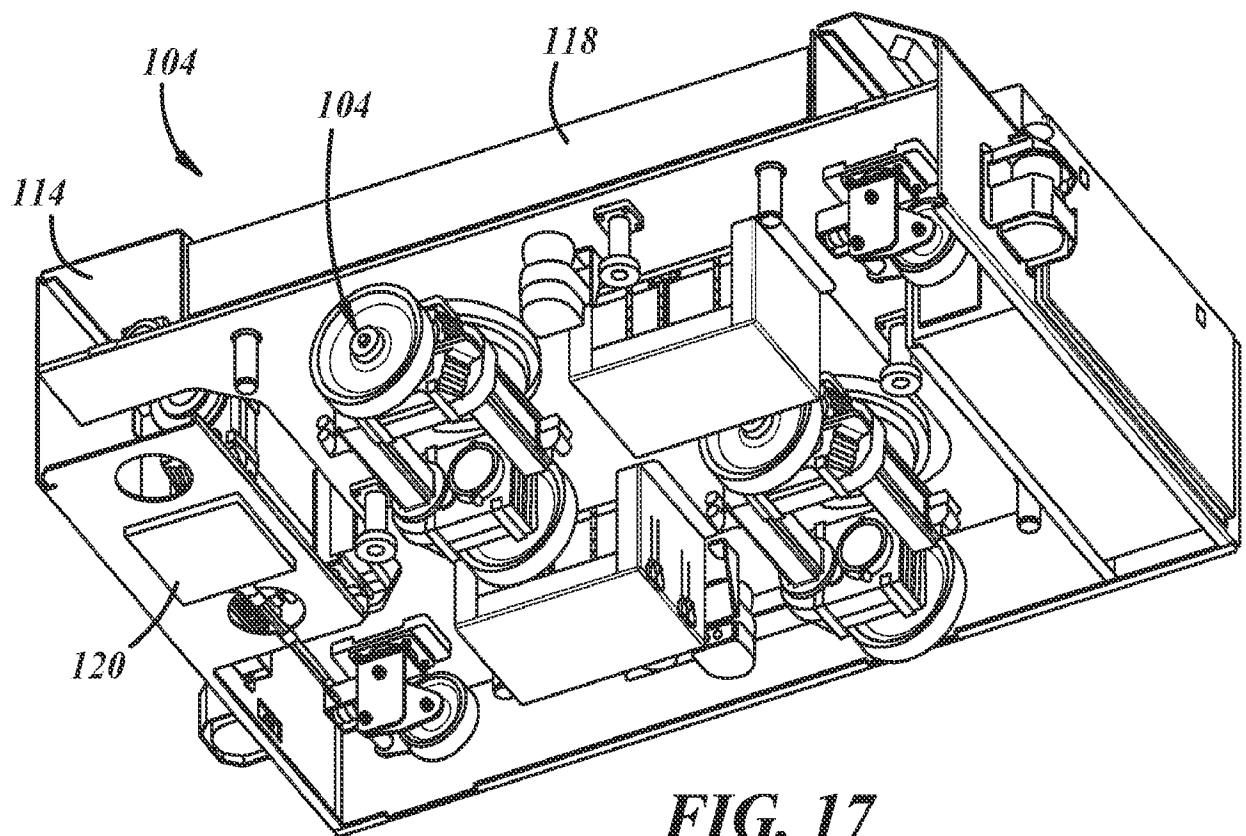
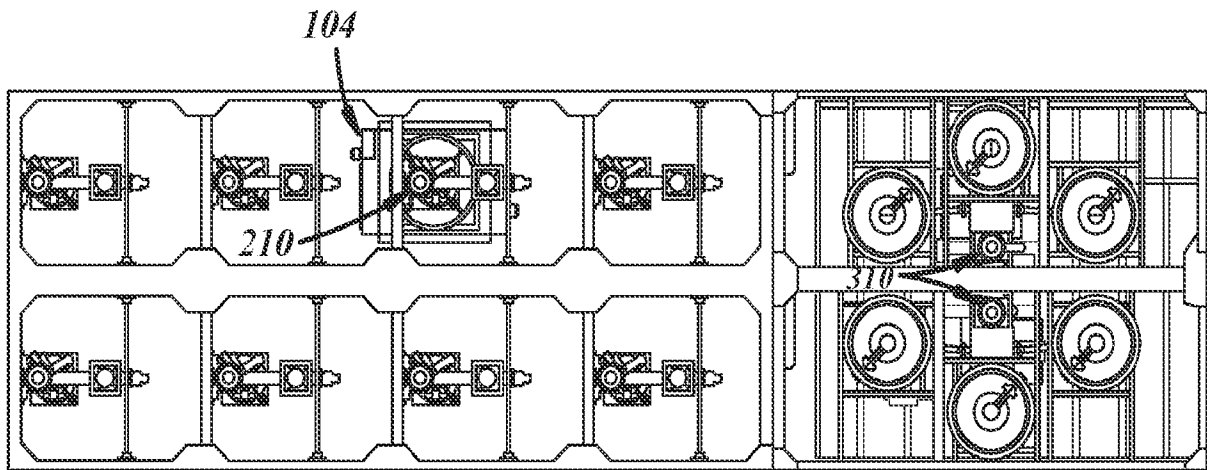
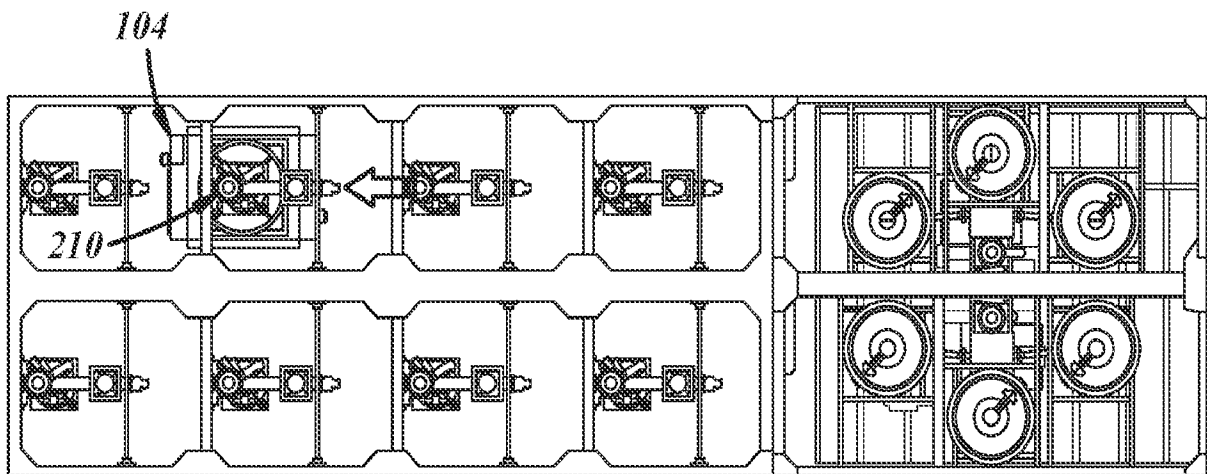
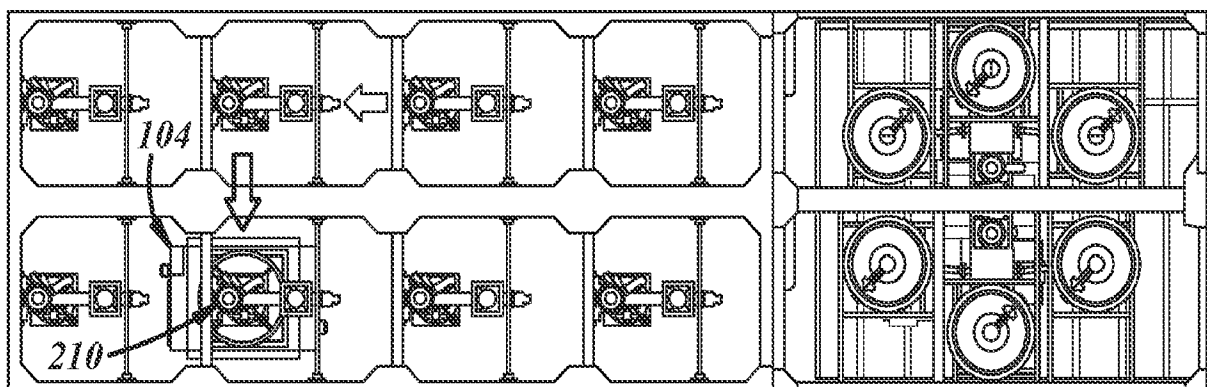
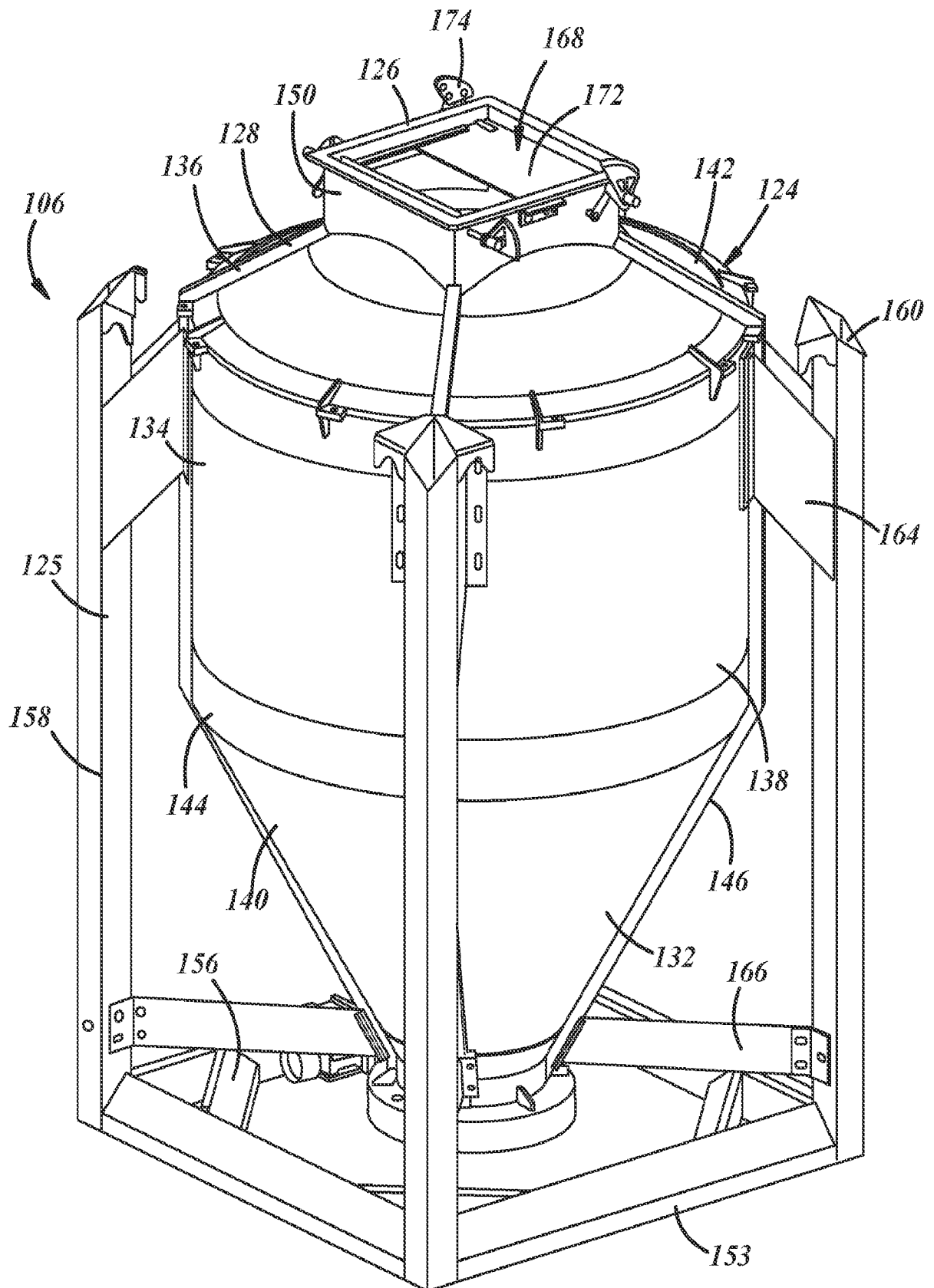
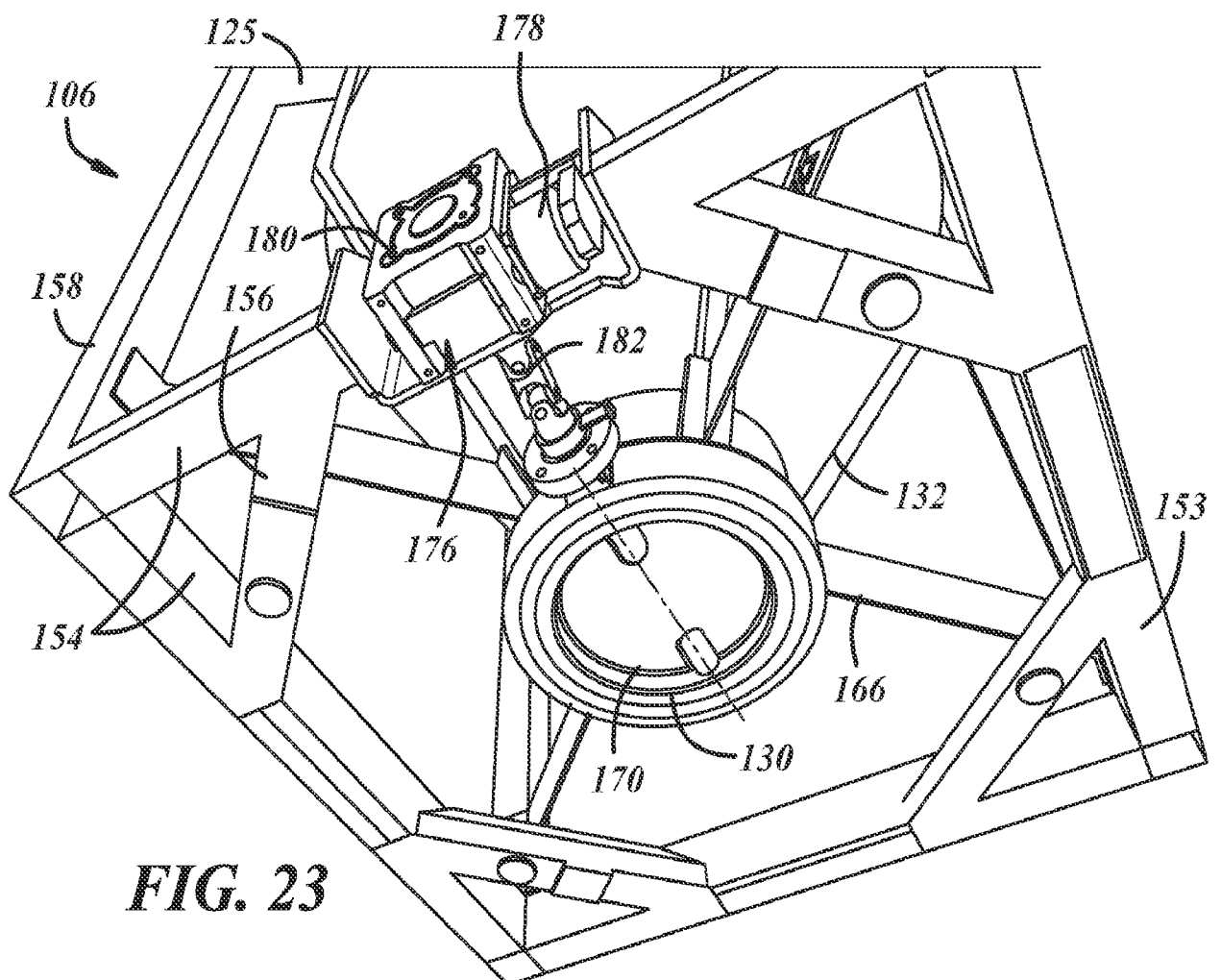
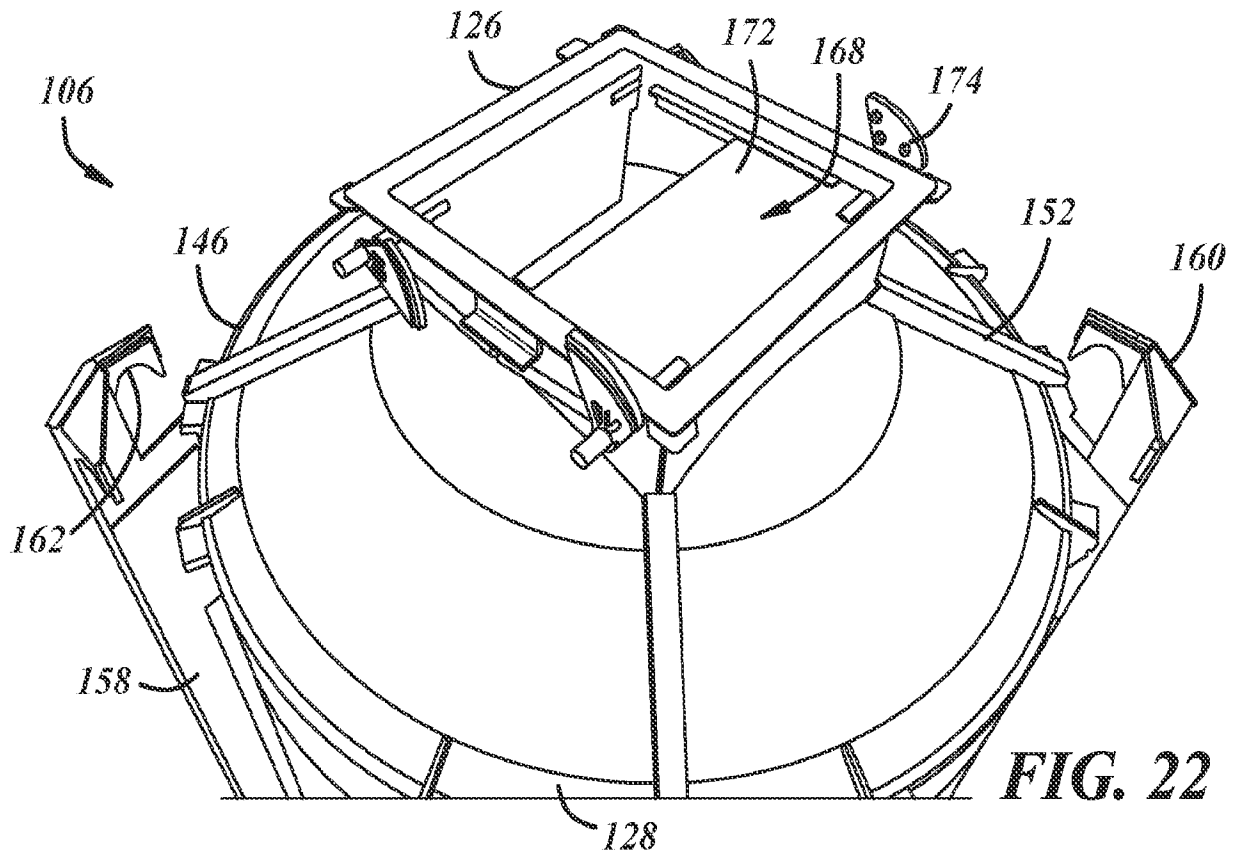


FIG. 17

**FIG. 18****FIG. 19****FIG. 20**

**FIG. 21**



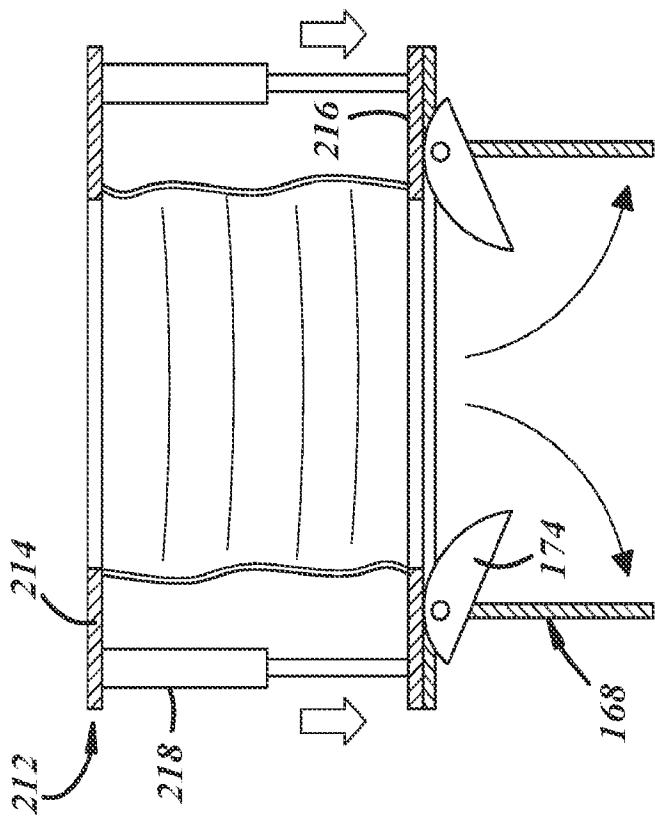


FIG. 25

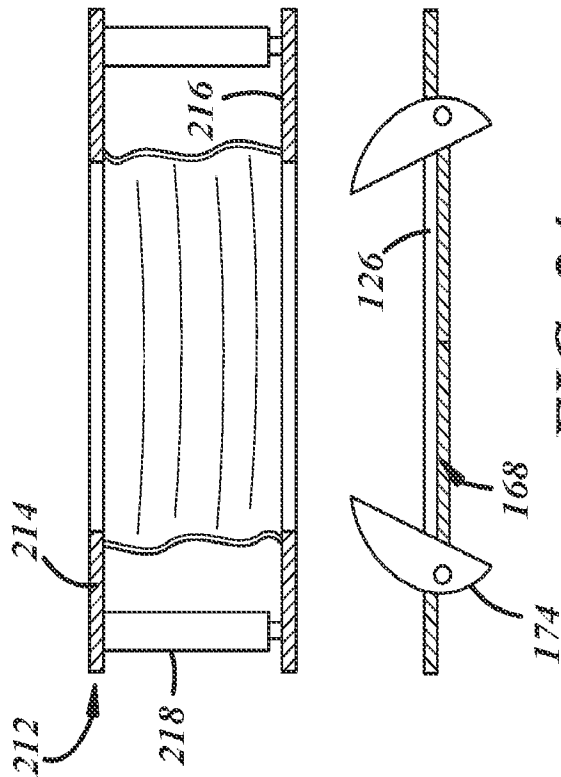


FIG. 24

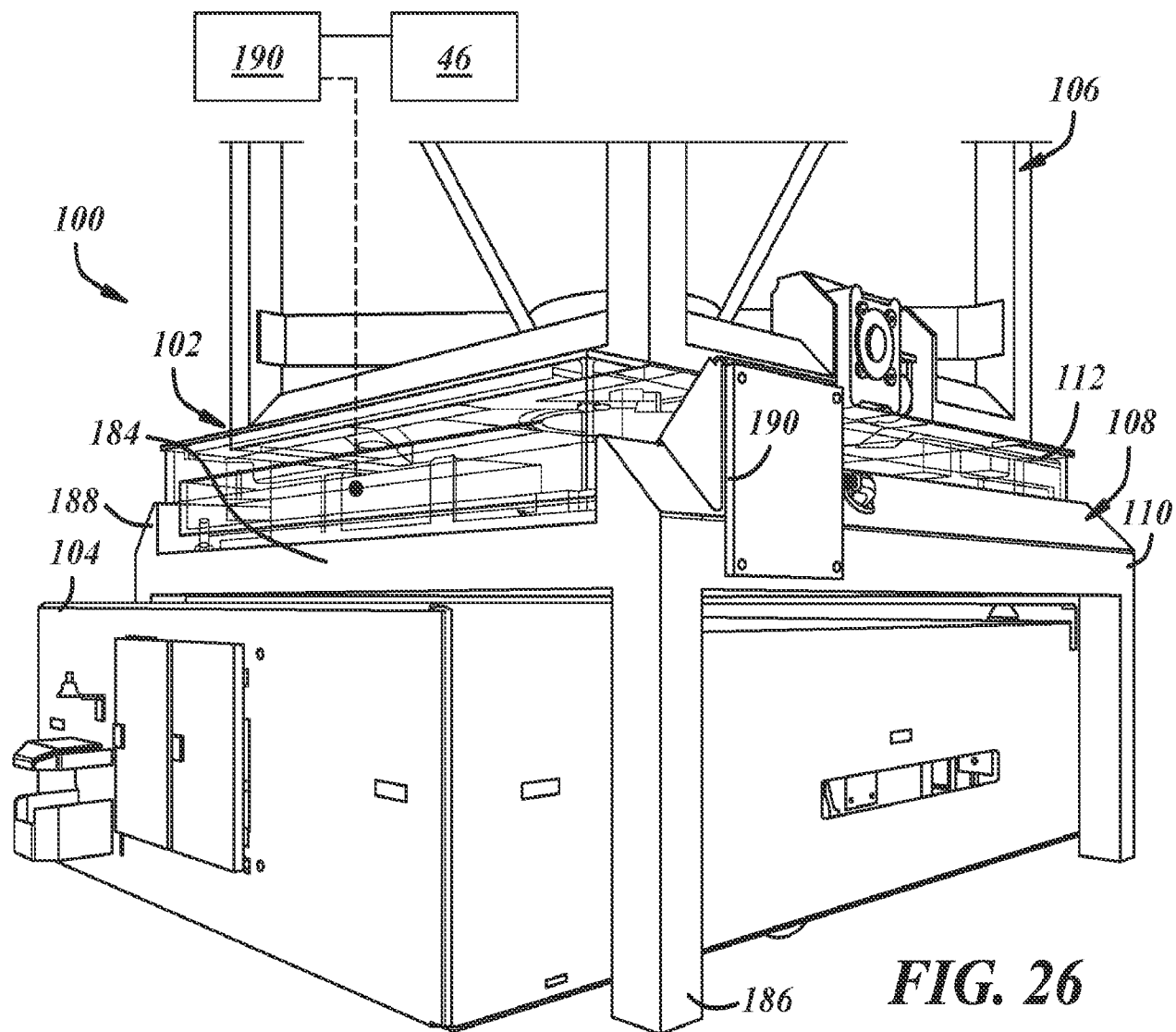


FIG. 26

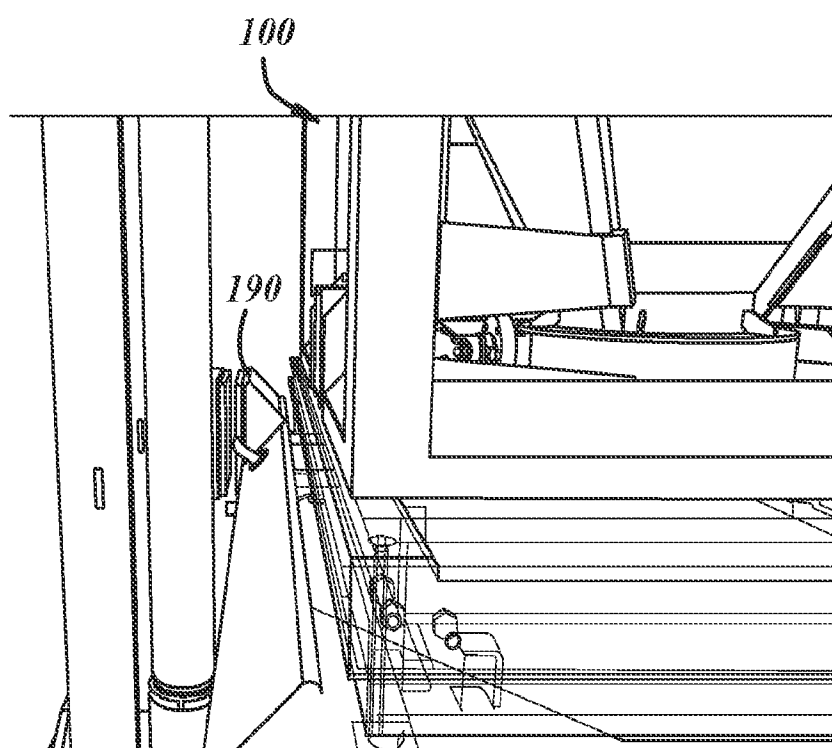
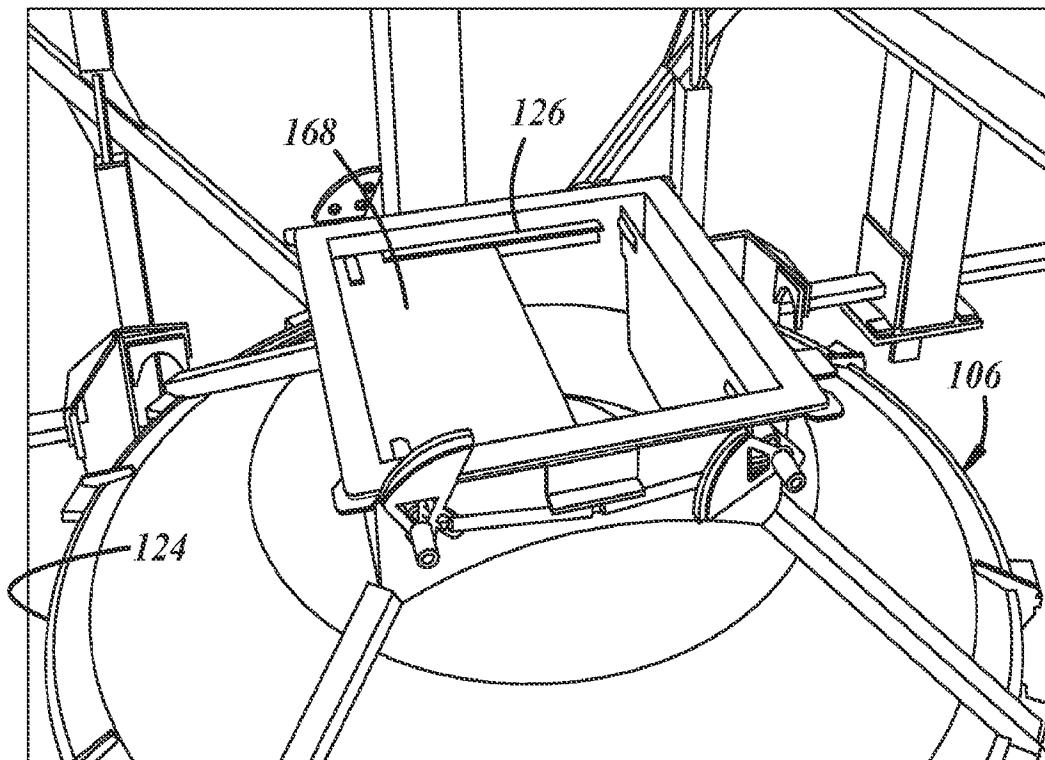
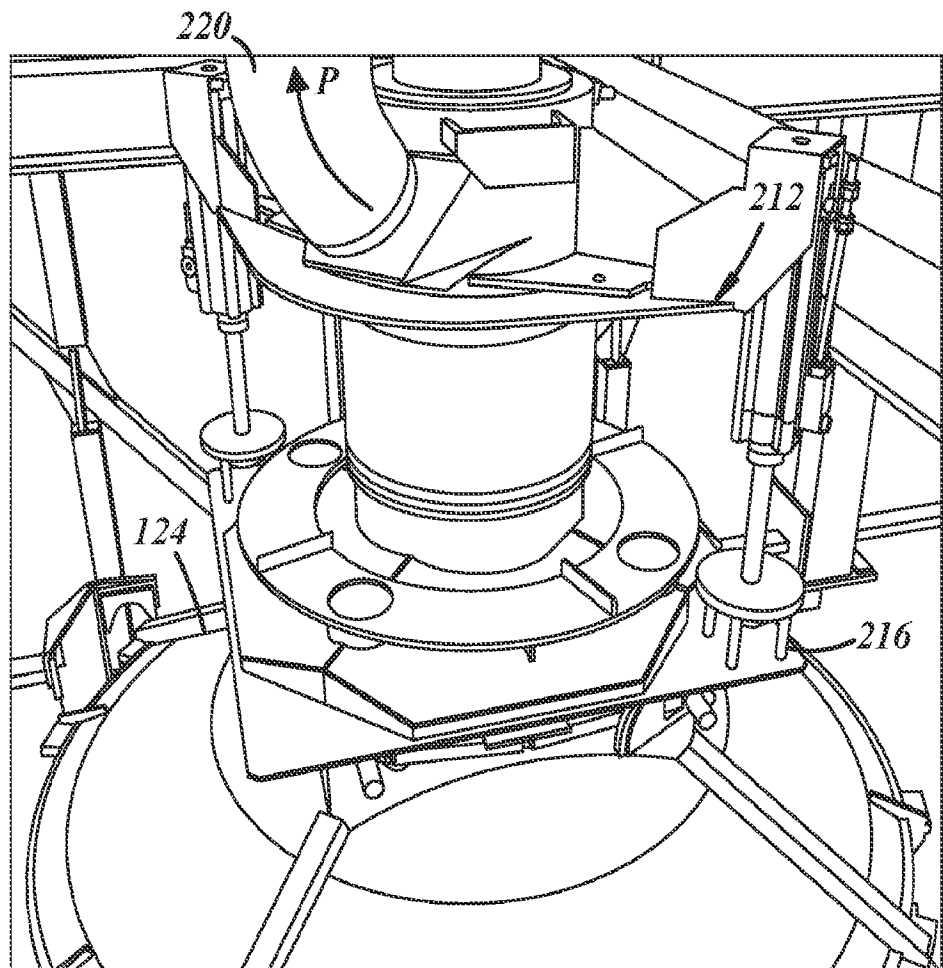
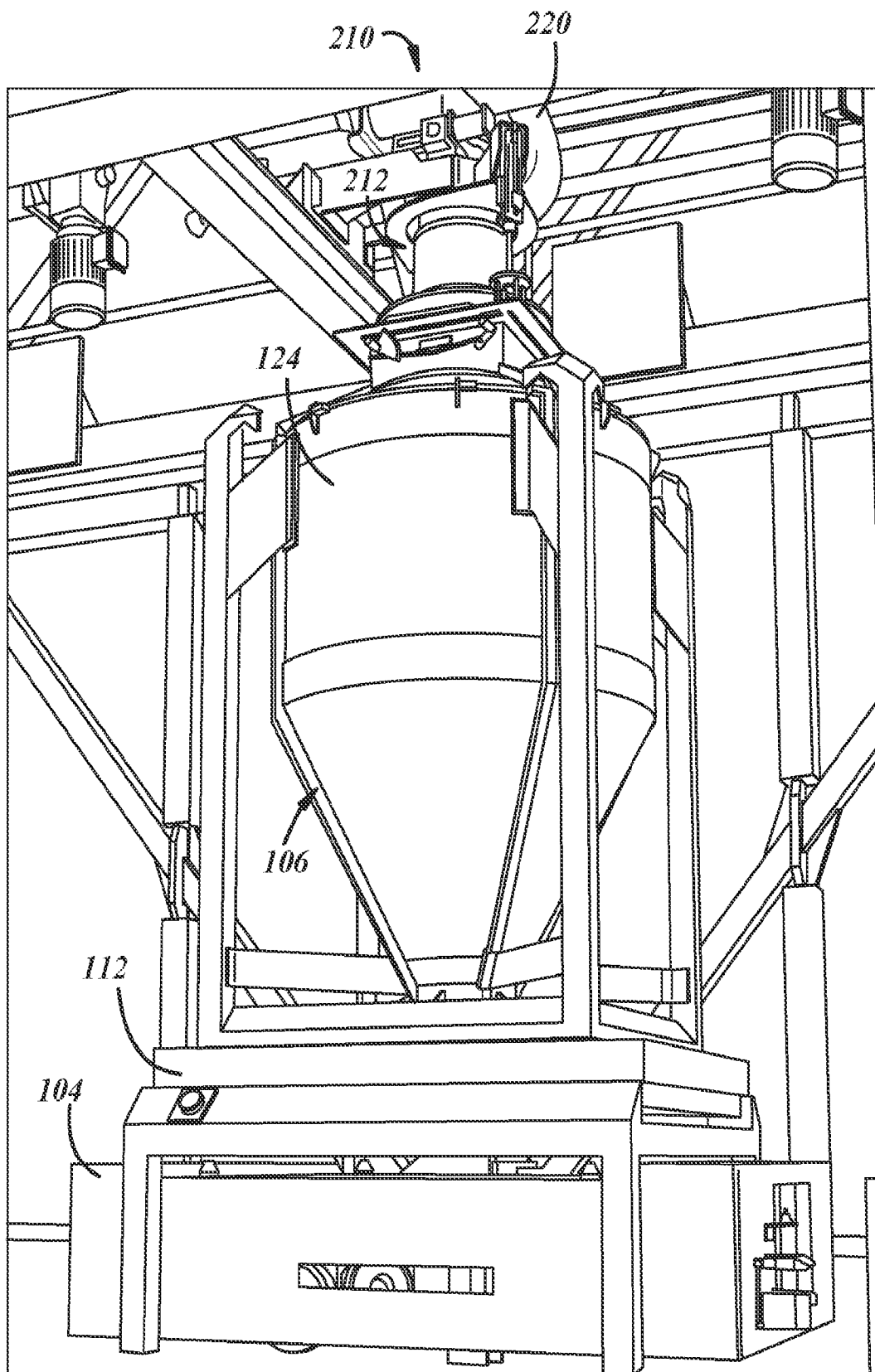
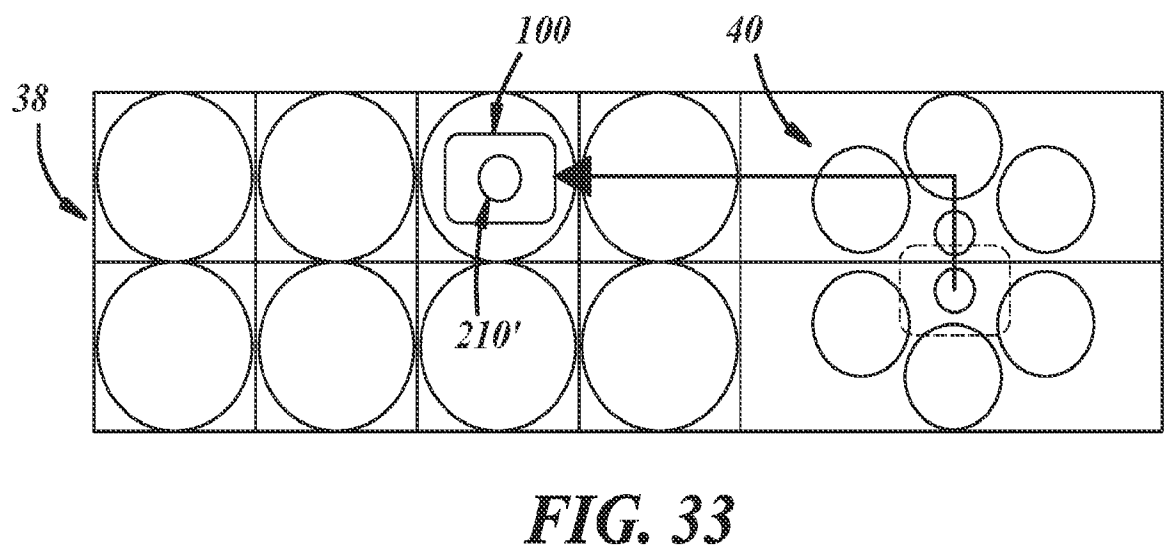
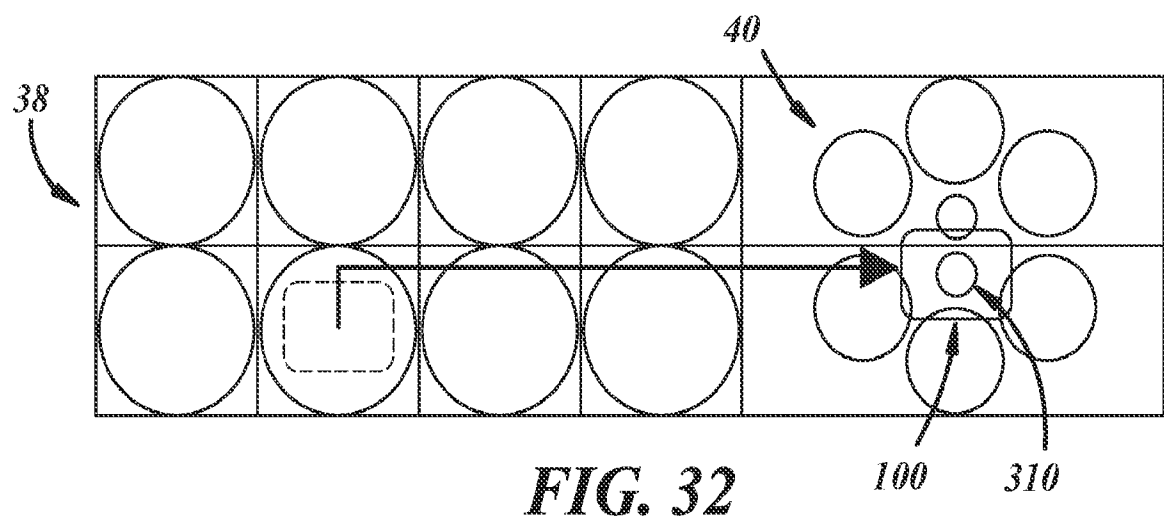
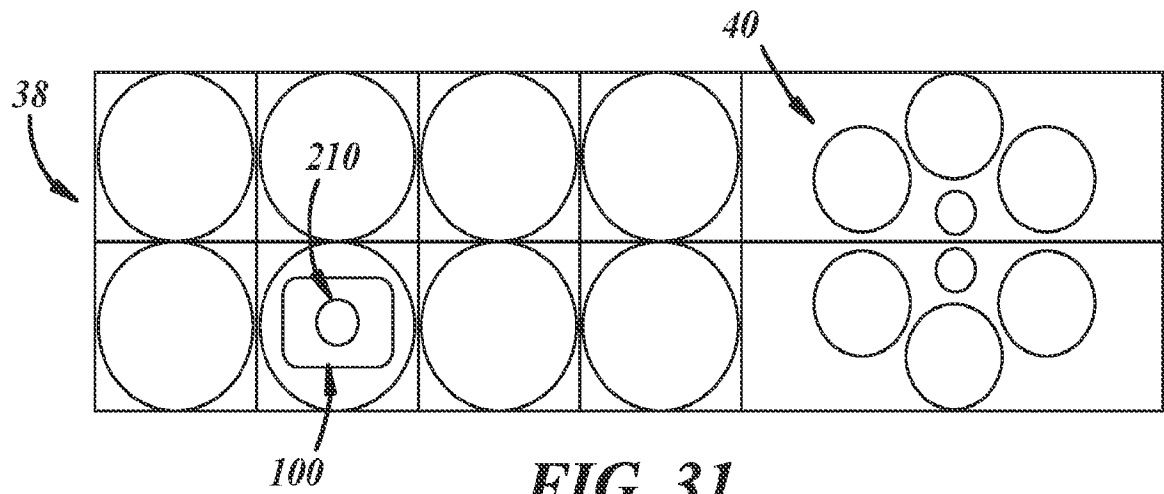


FIG. 27

**FIG. 28****FIG. 29**

**FIG. 30**



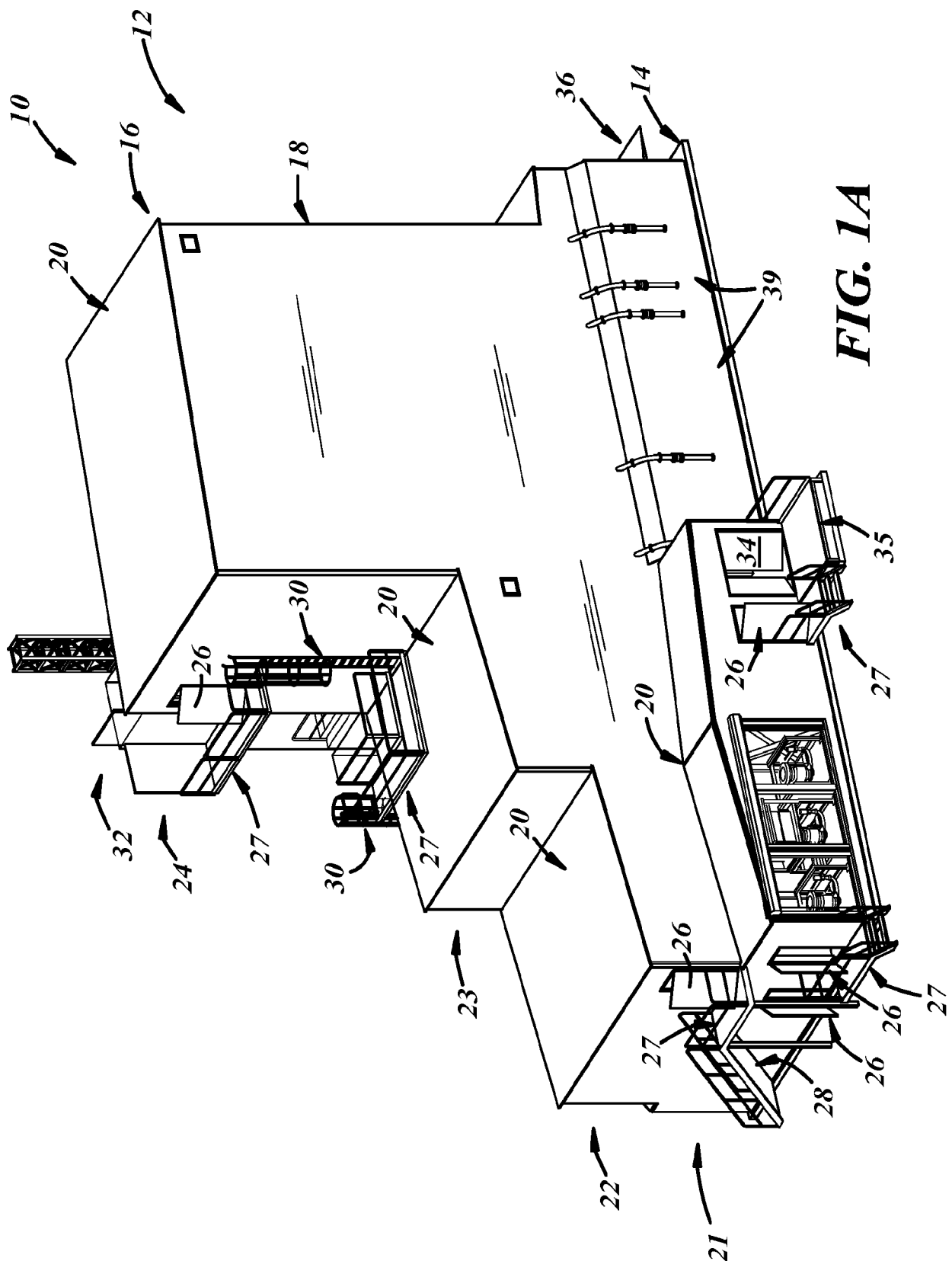
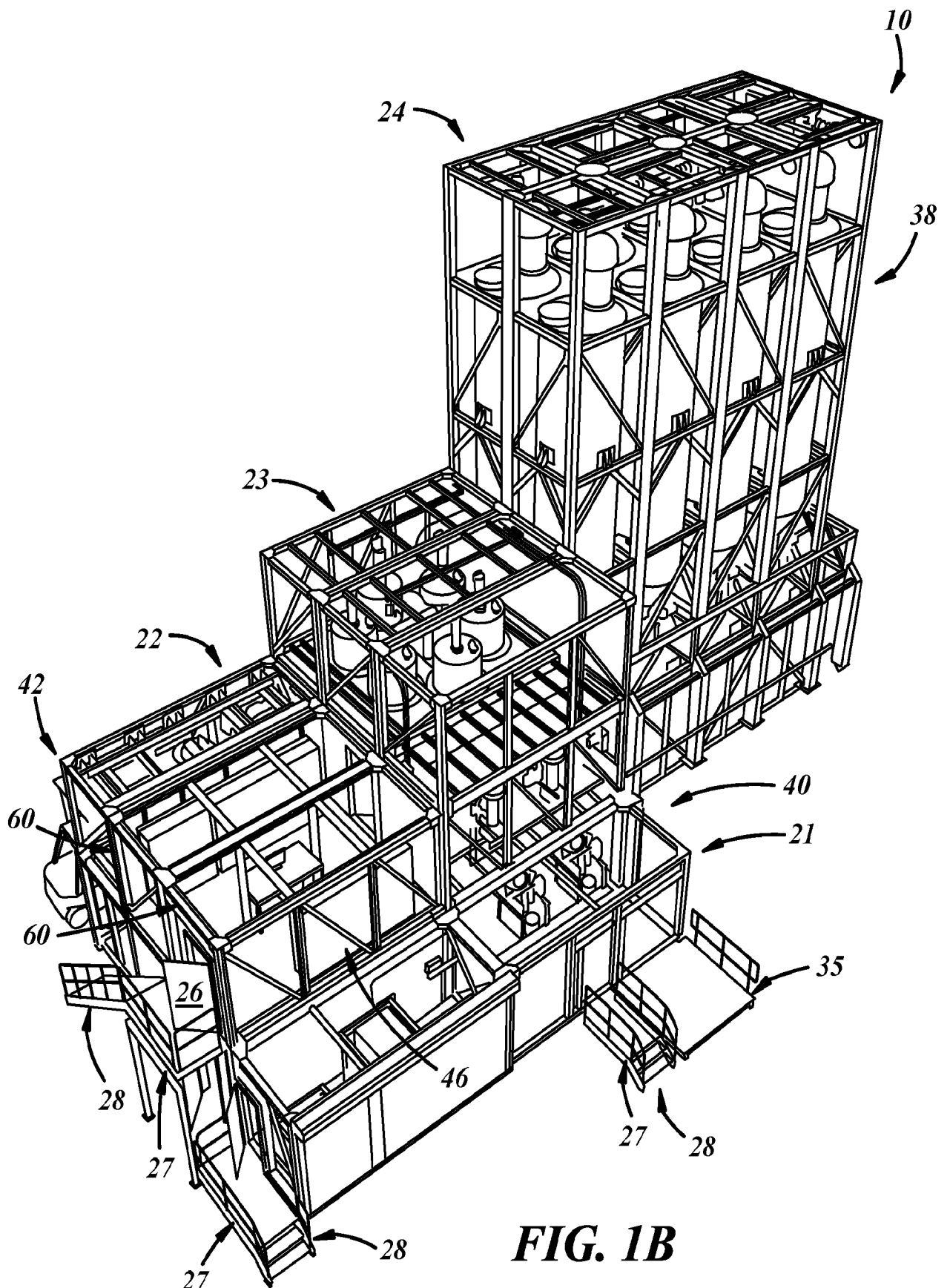


FIG. 1A



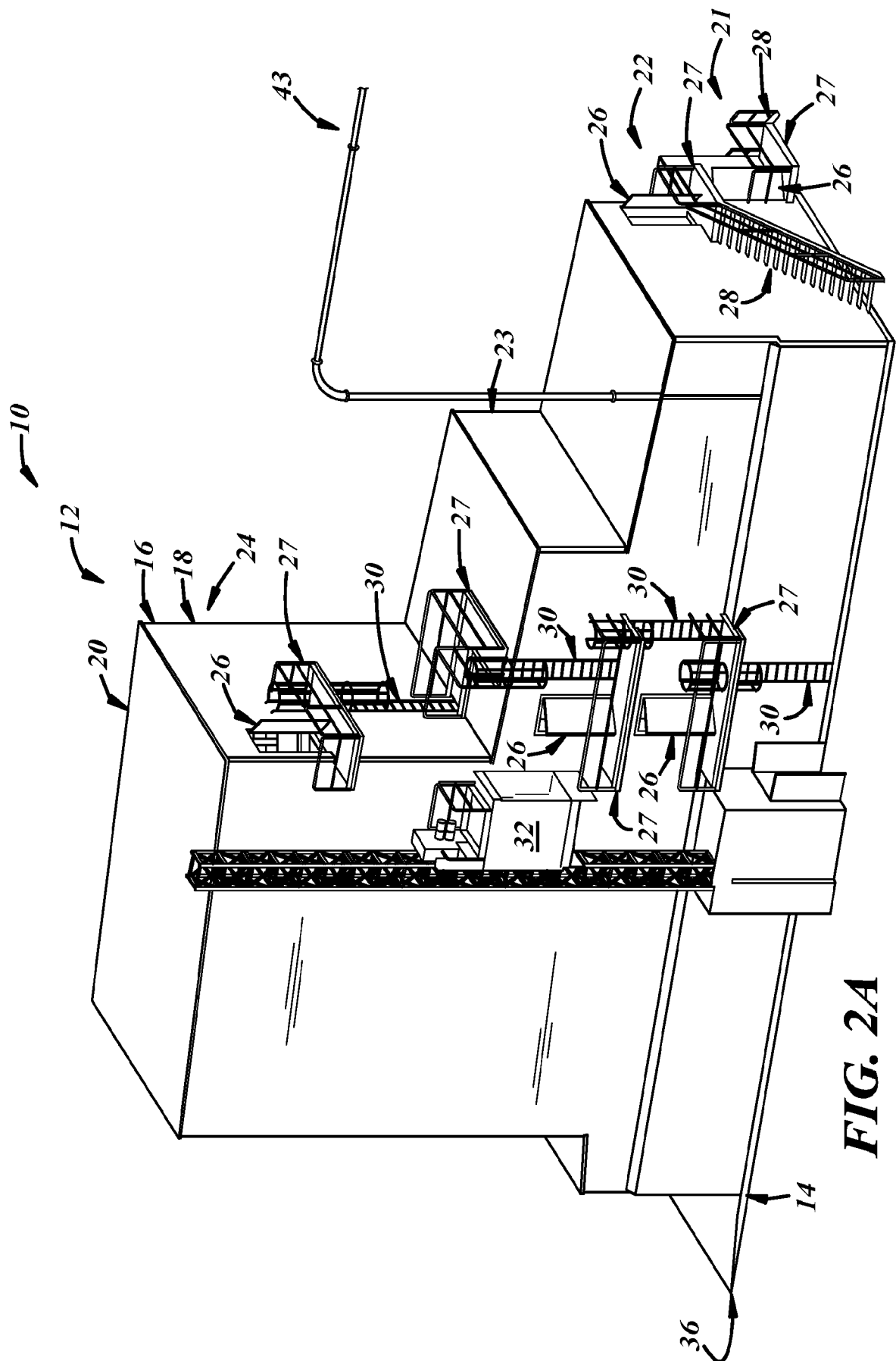


FIG. 2A

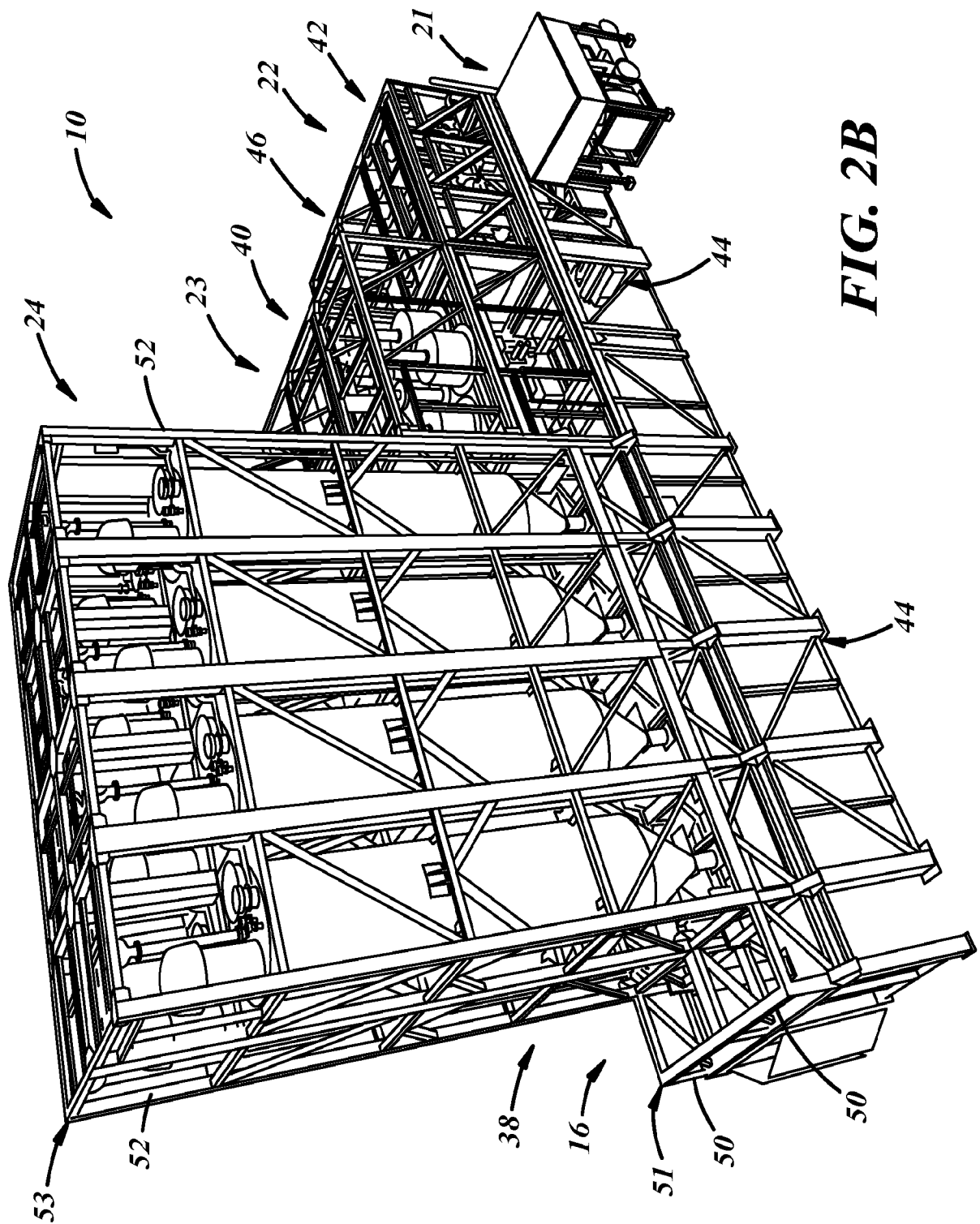


FIG. 2B

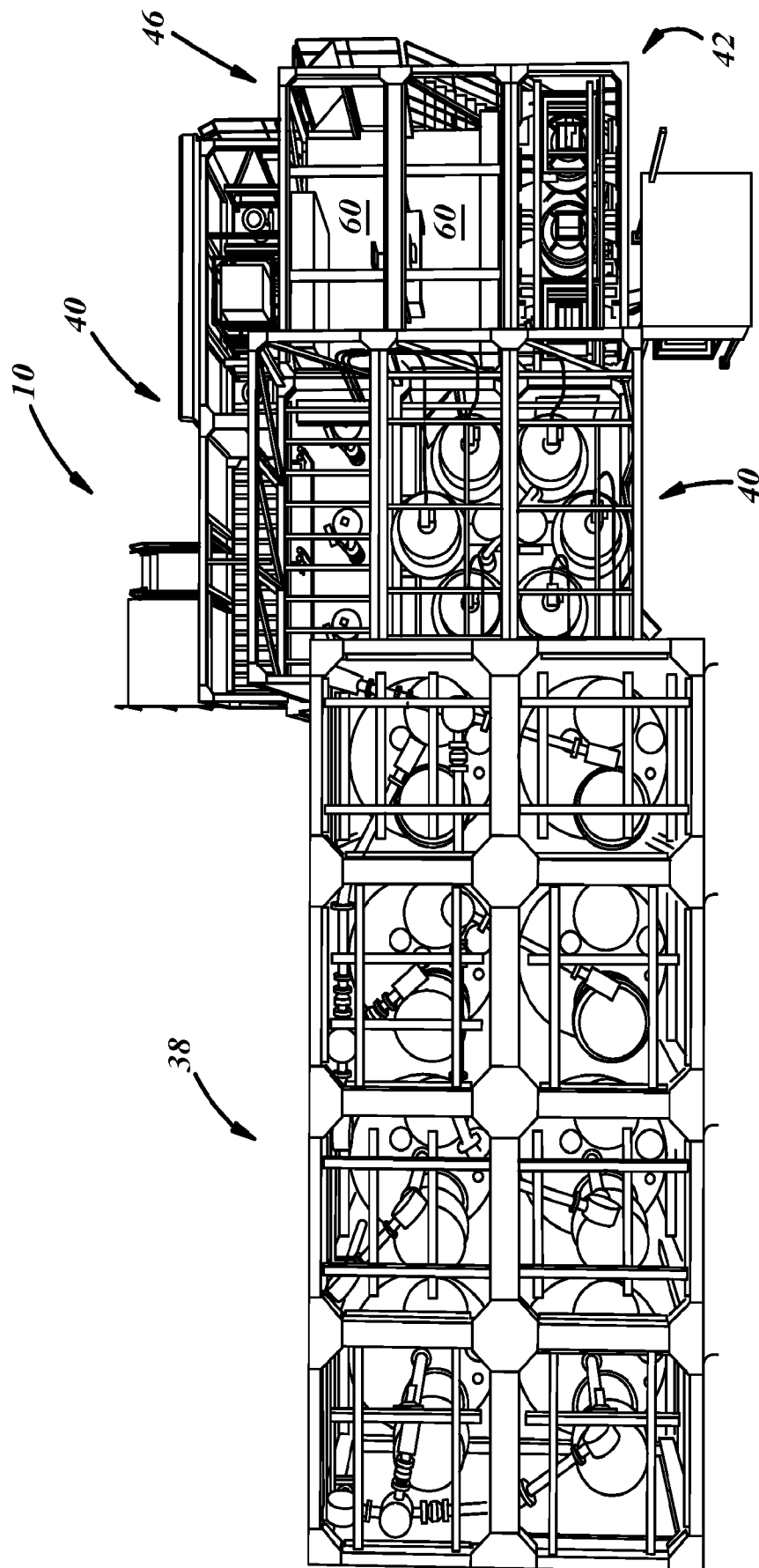


FIG. 3

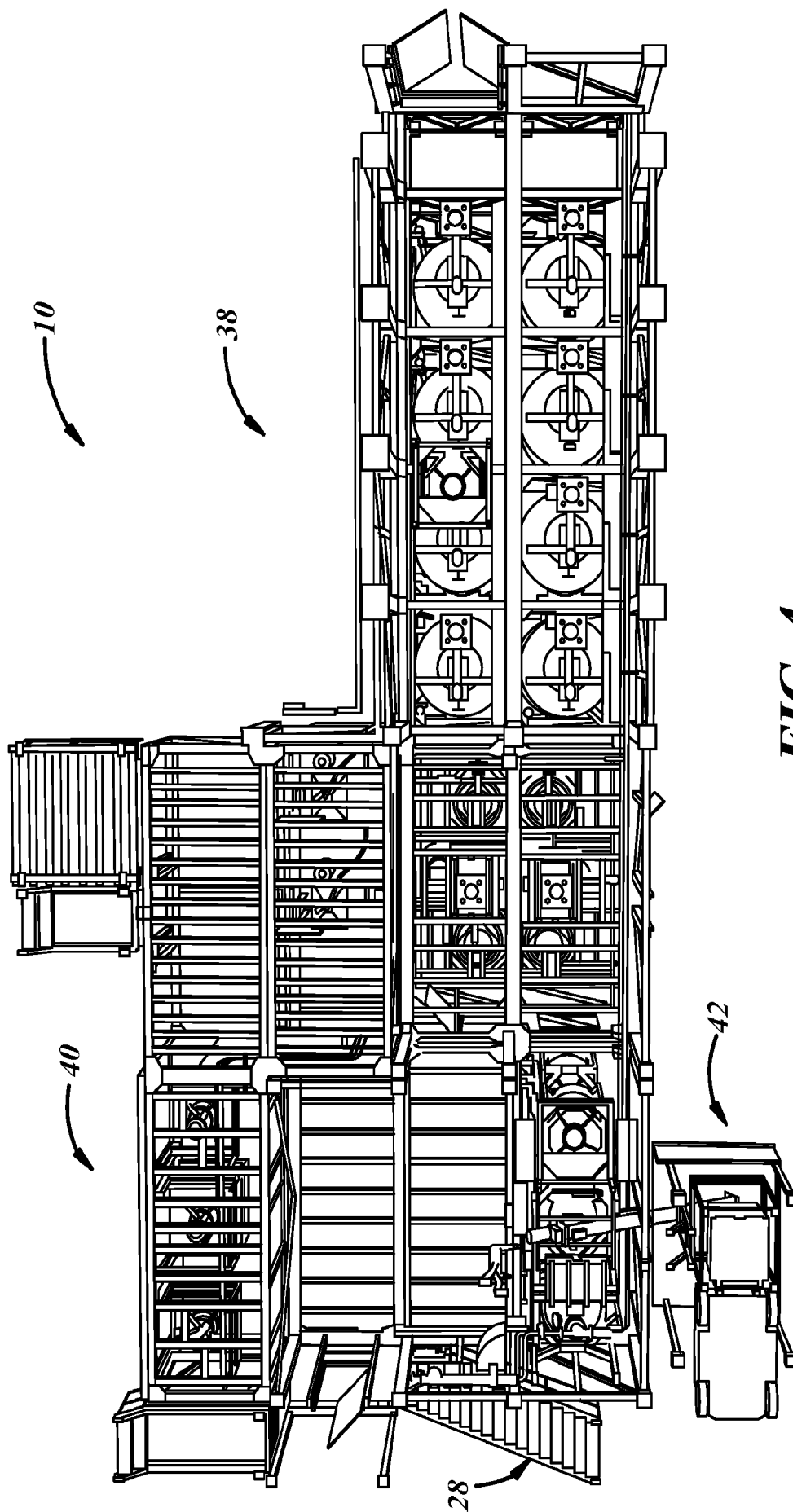
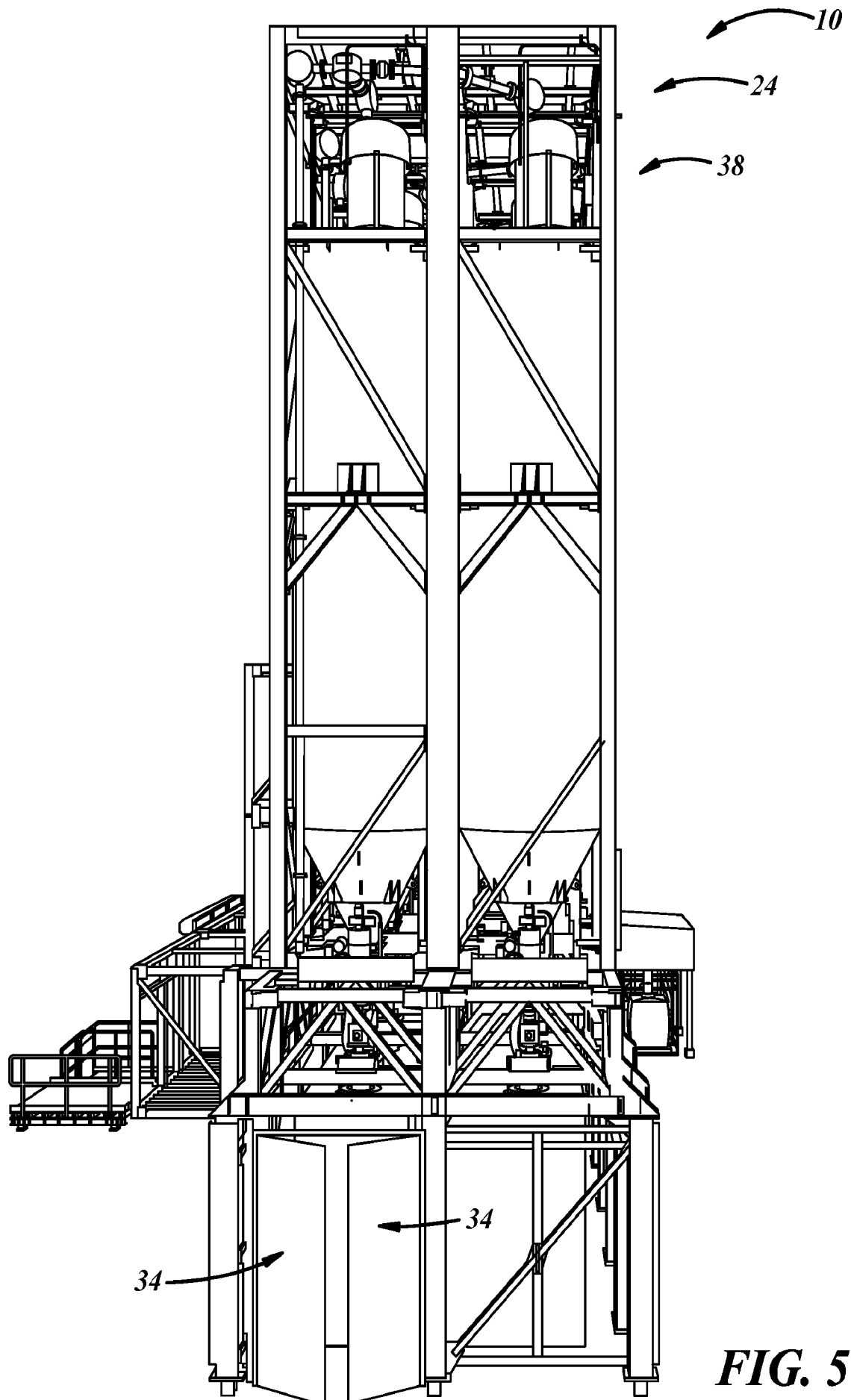


FIG. 4



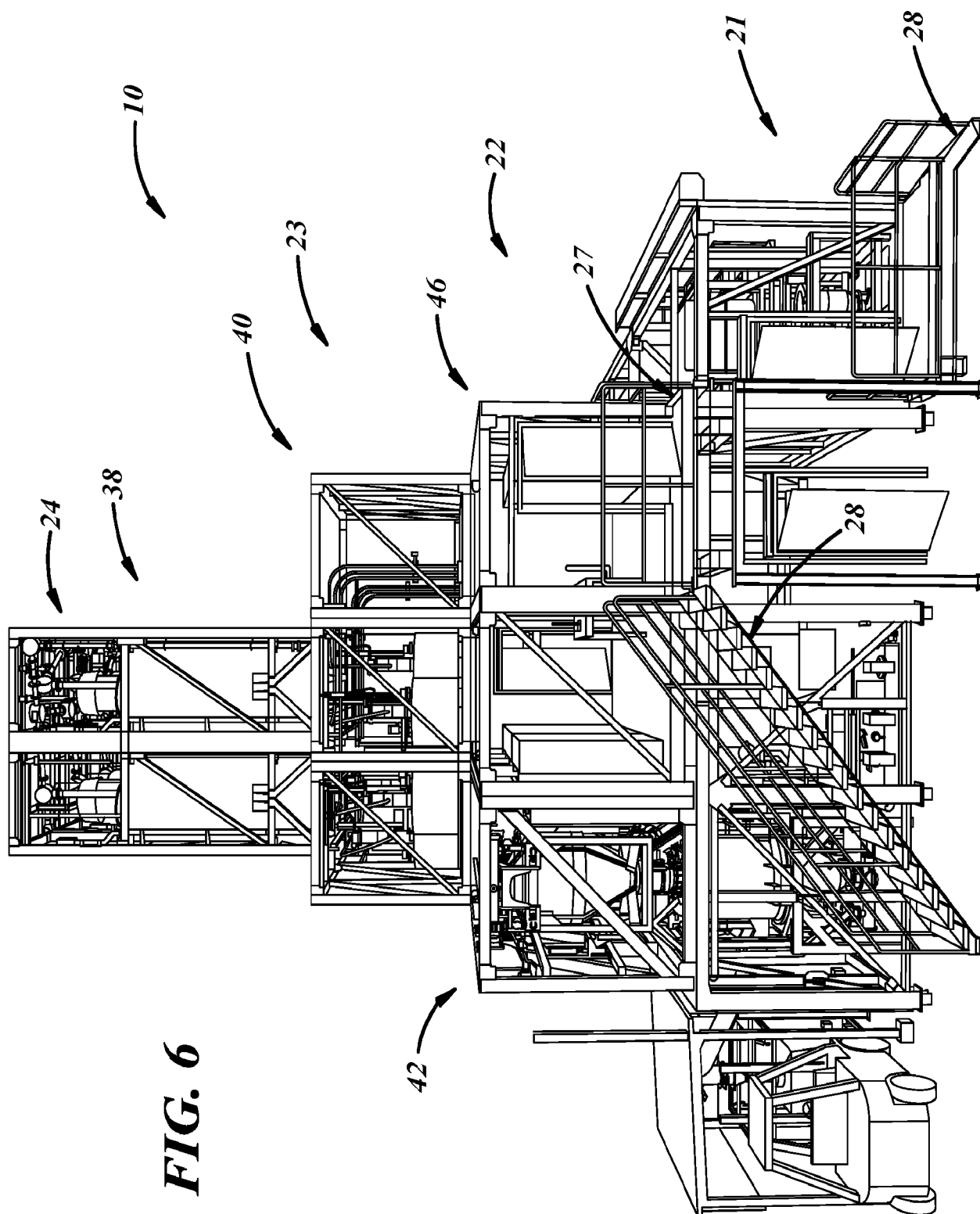


FIG. 6

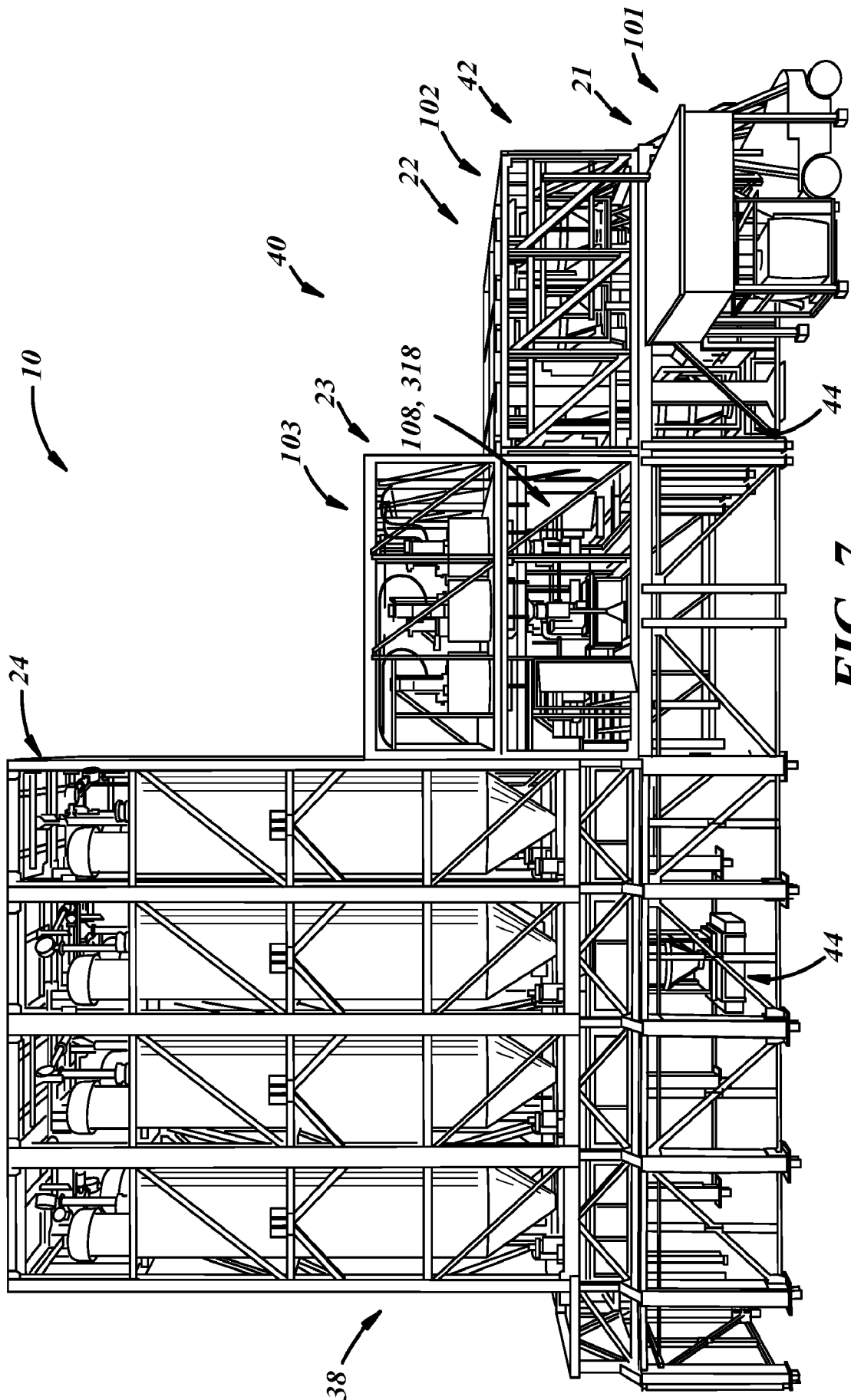
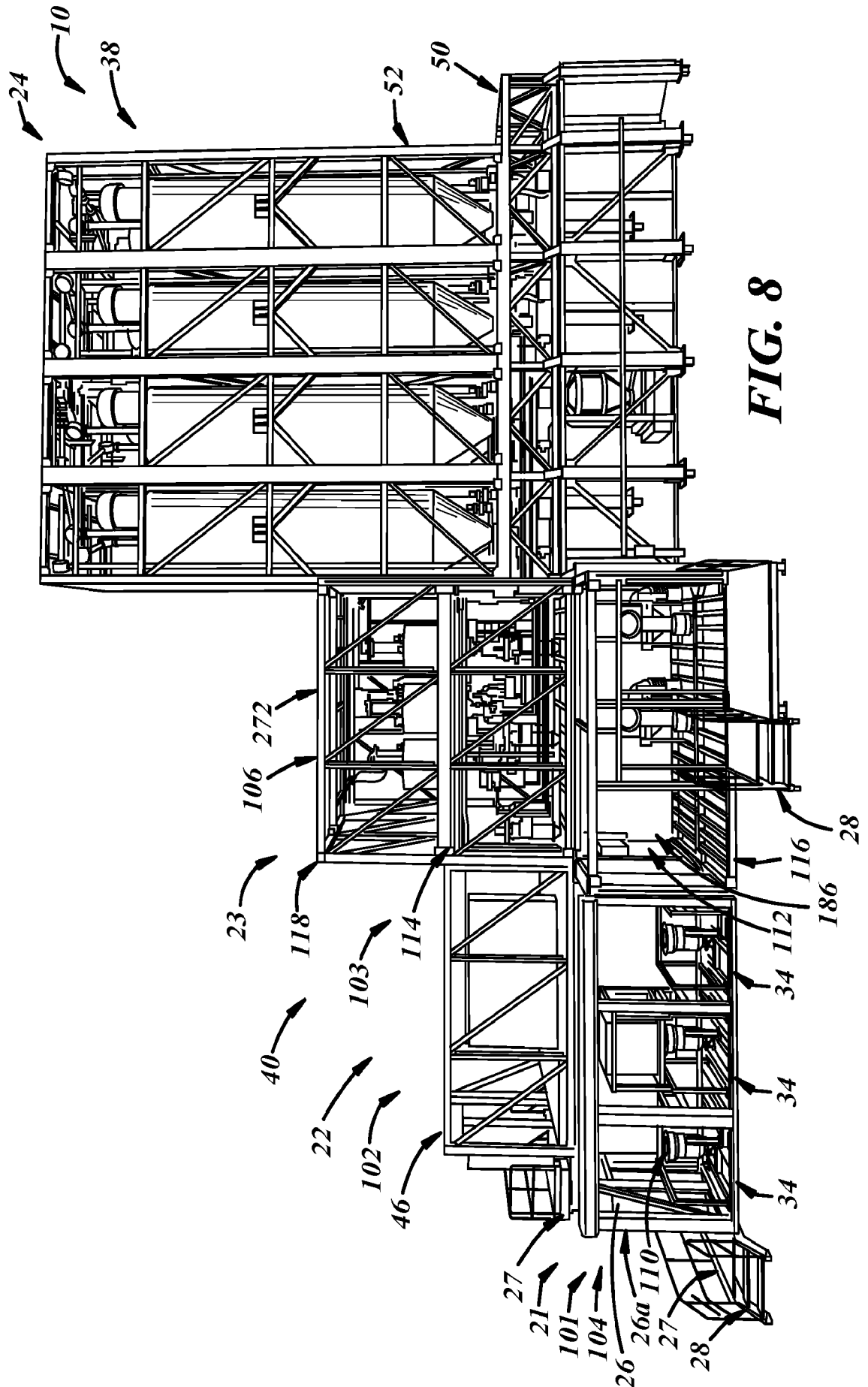
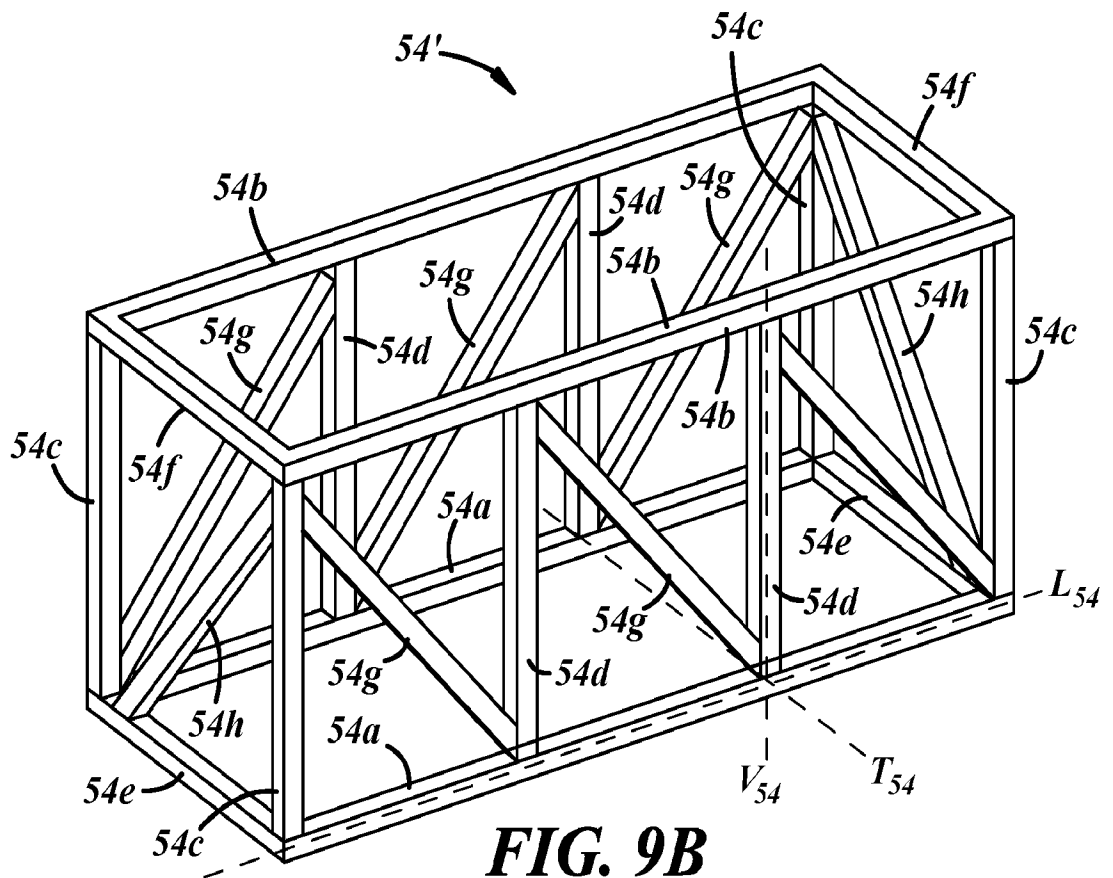
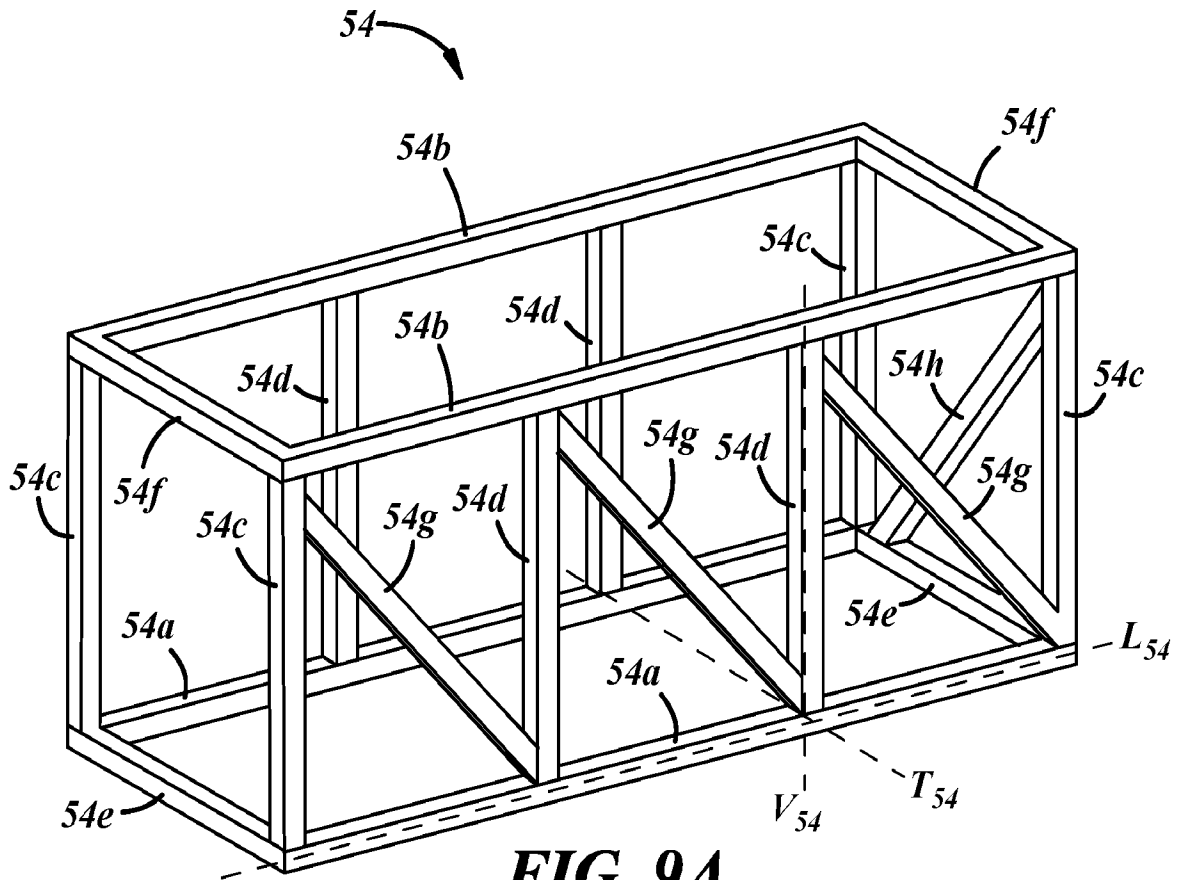


FIG. 7





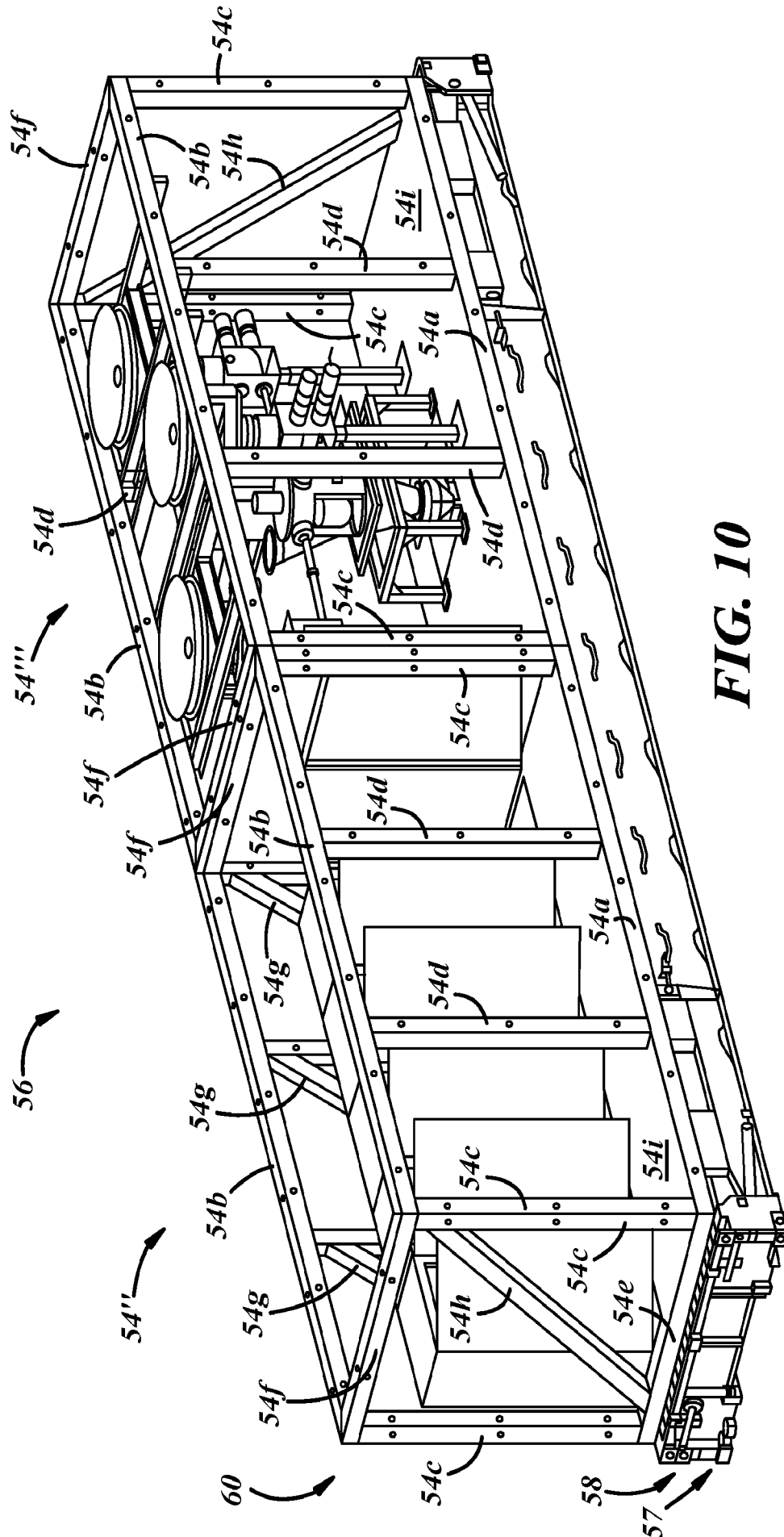


FIG. 10

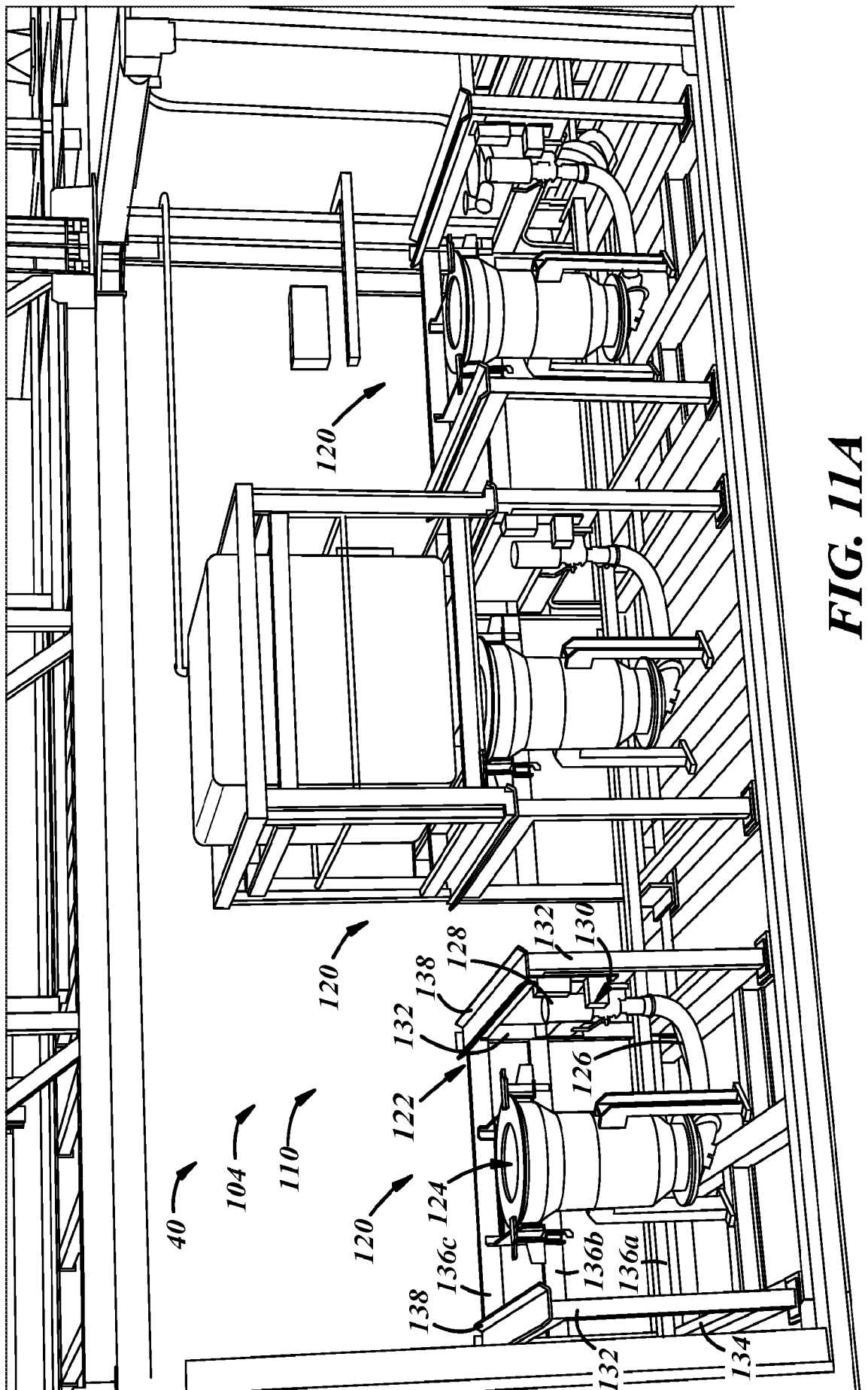
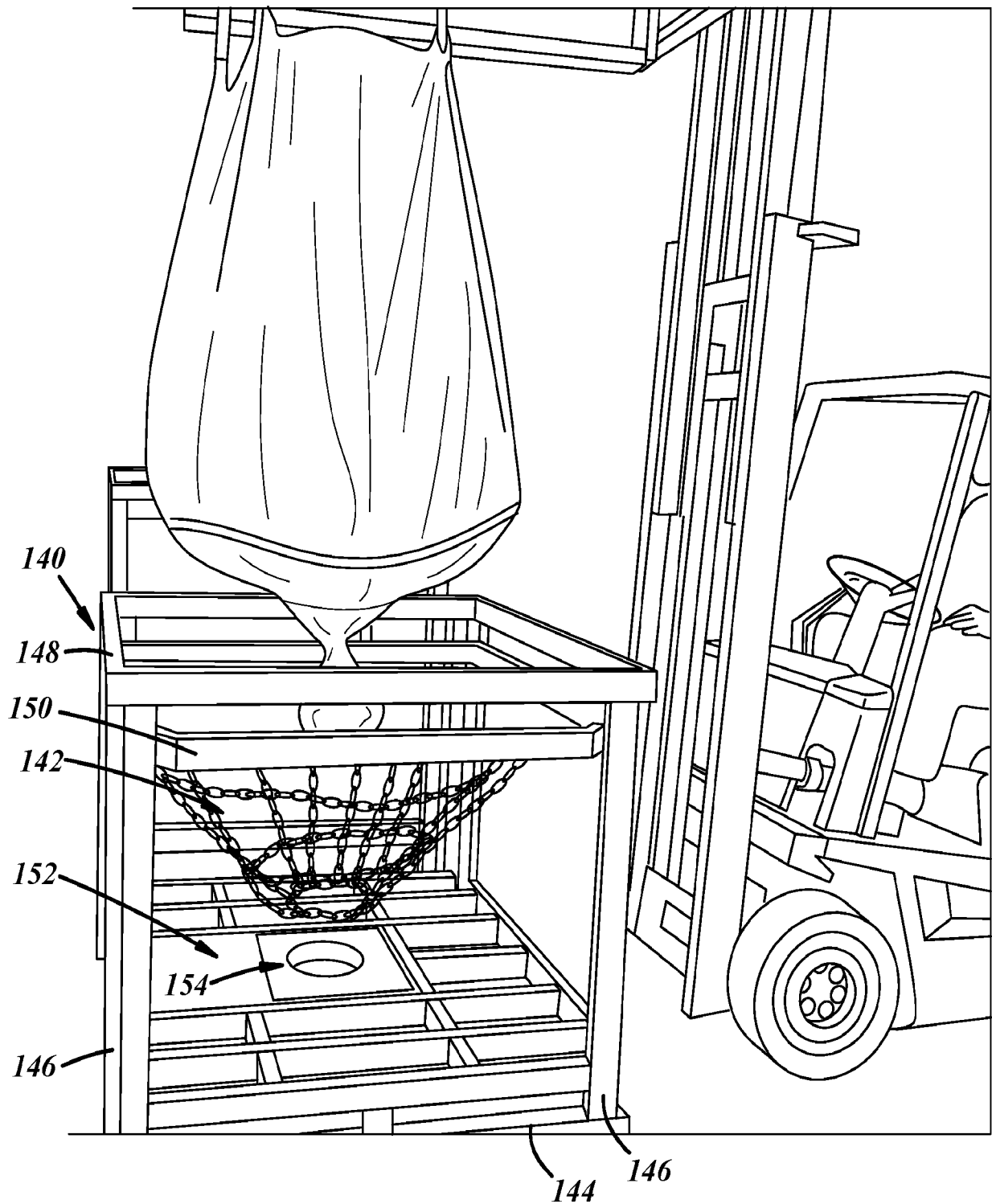
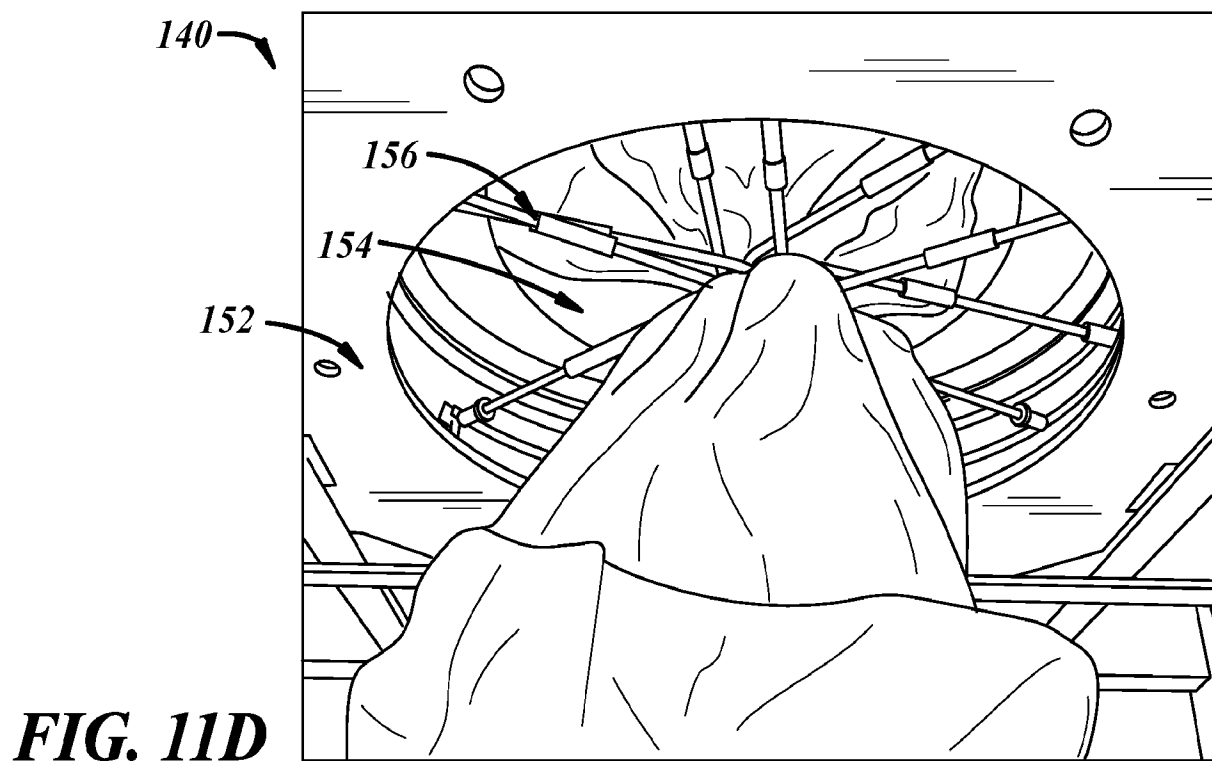
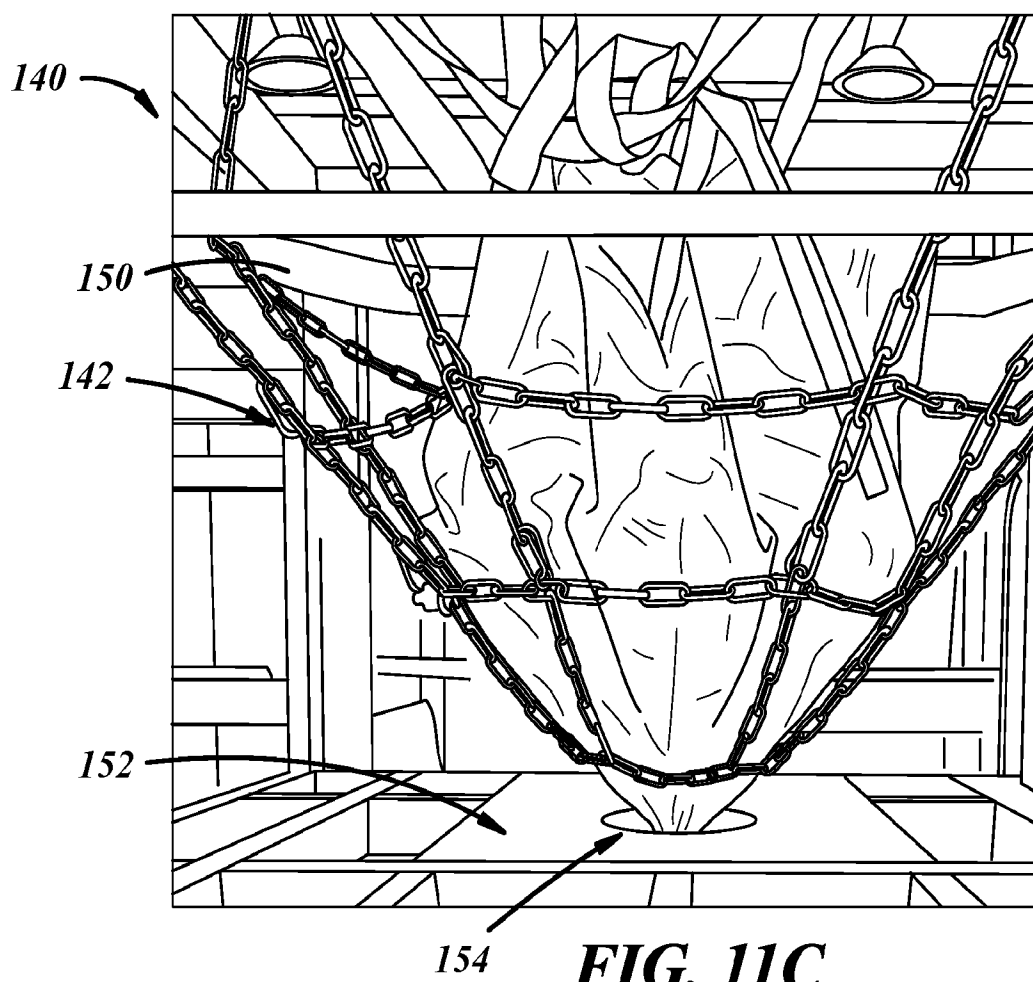
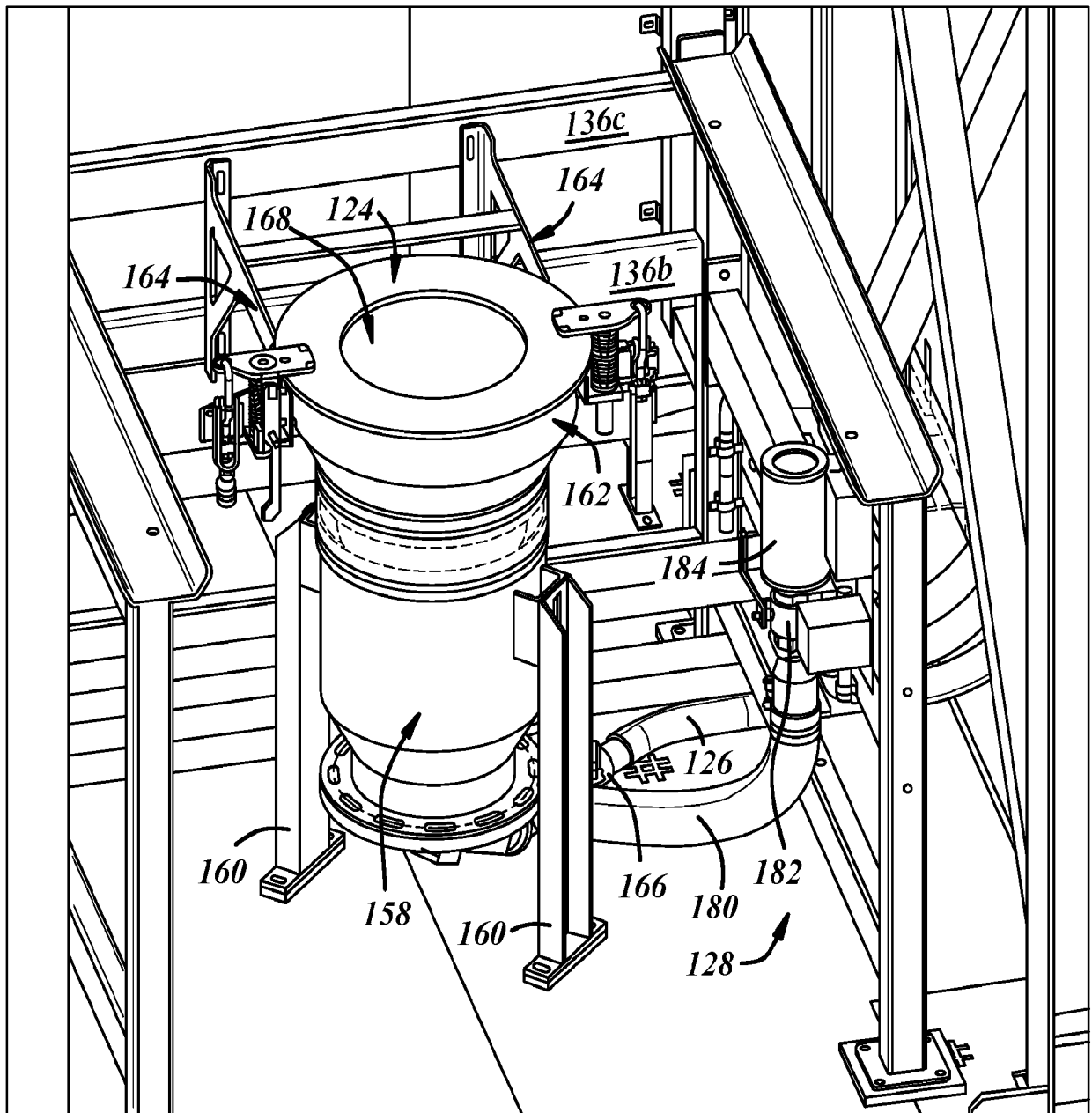
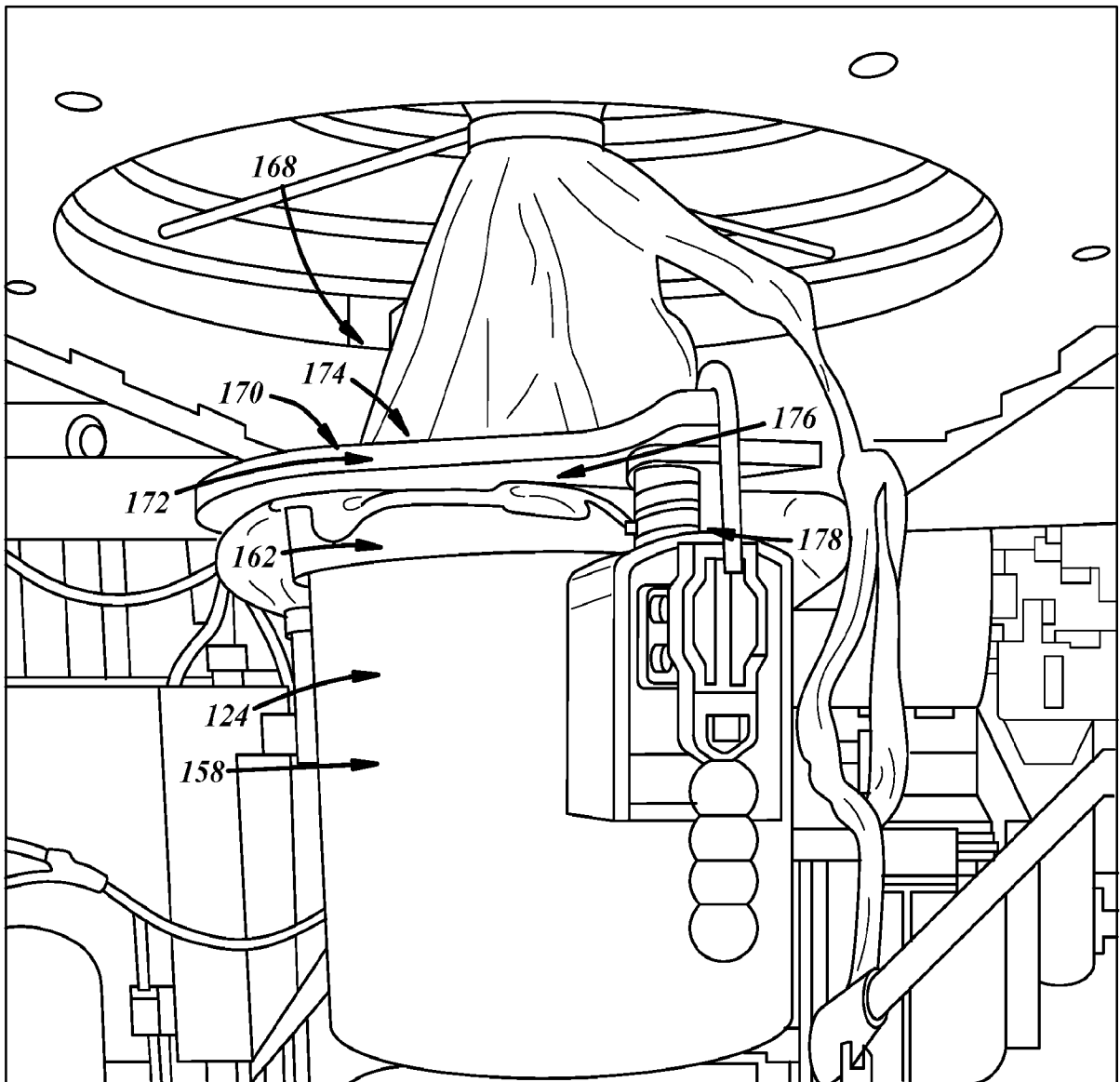


FIG. 11A

**FIG. 11B**



**FIG. 11E**

***FIG. 11F***

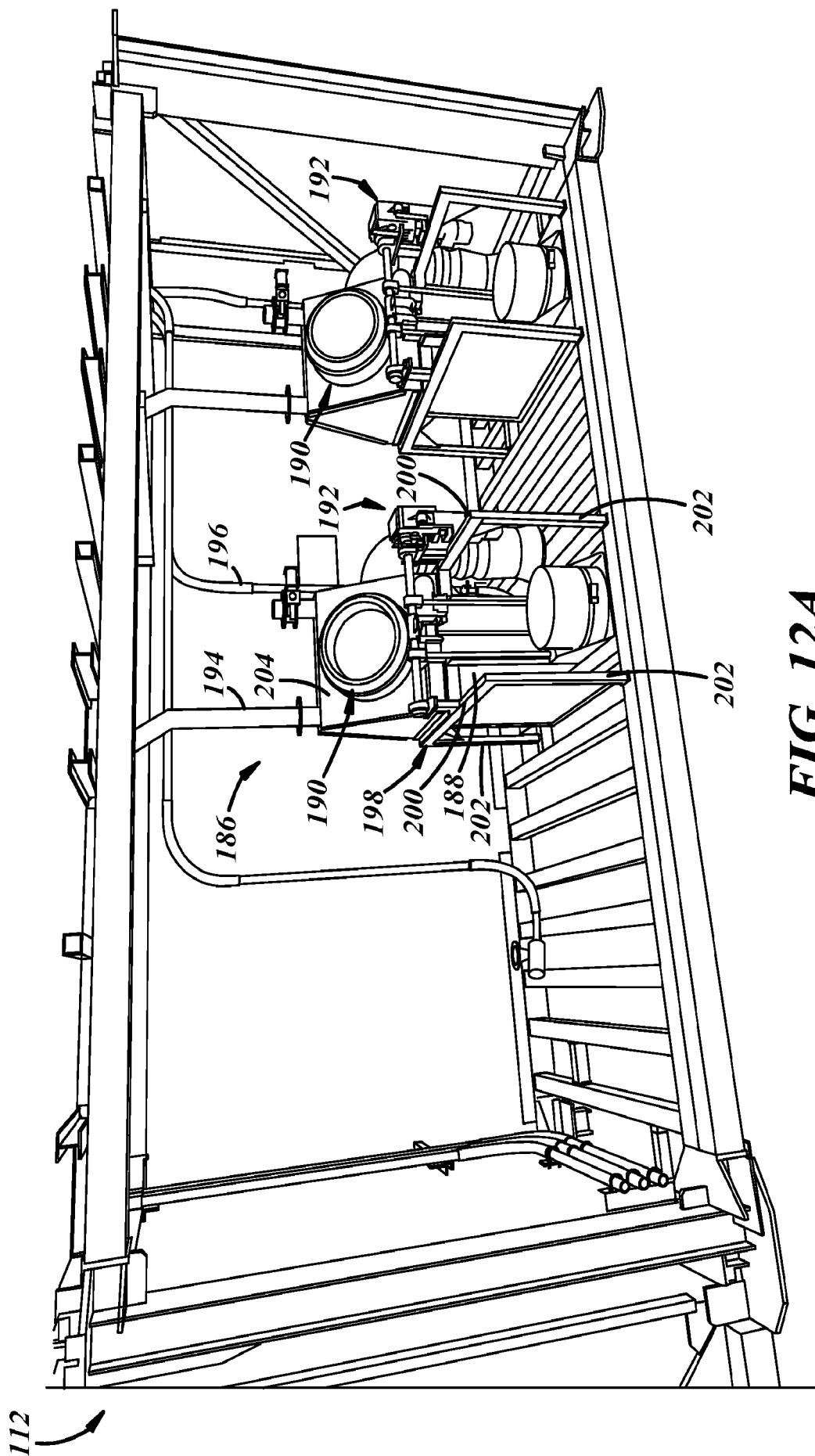


FIG. 12A

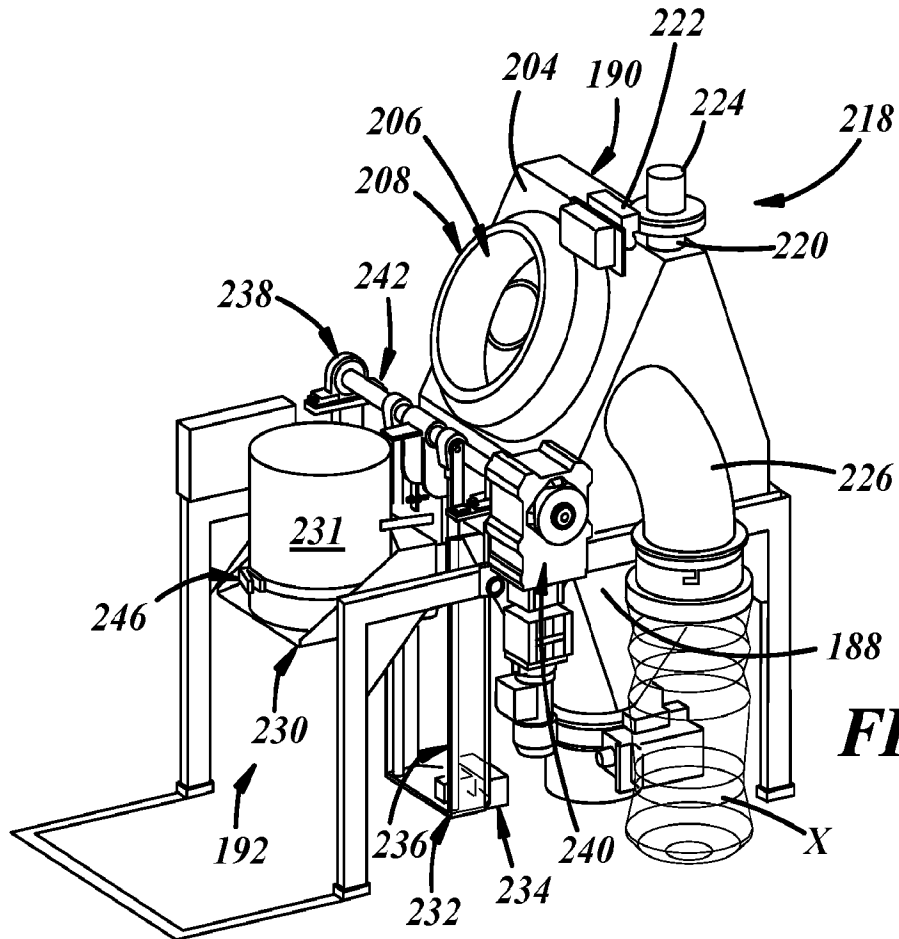


FIG. 12B

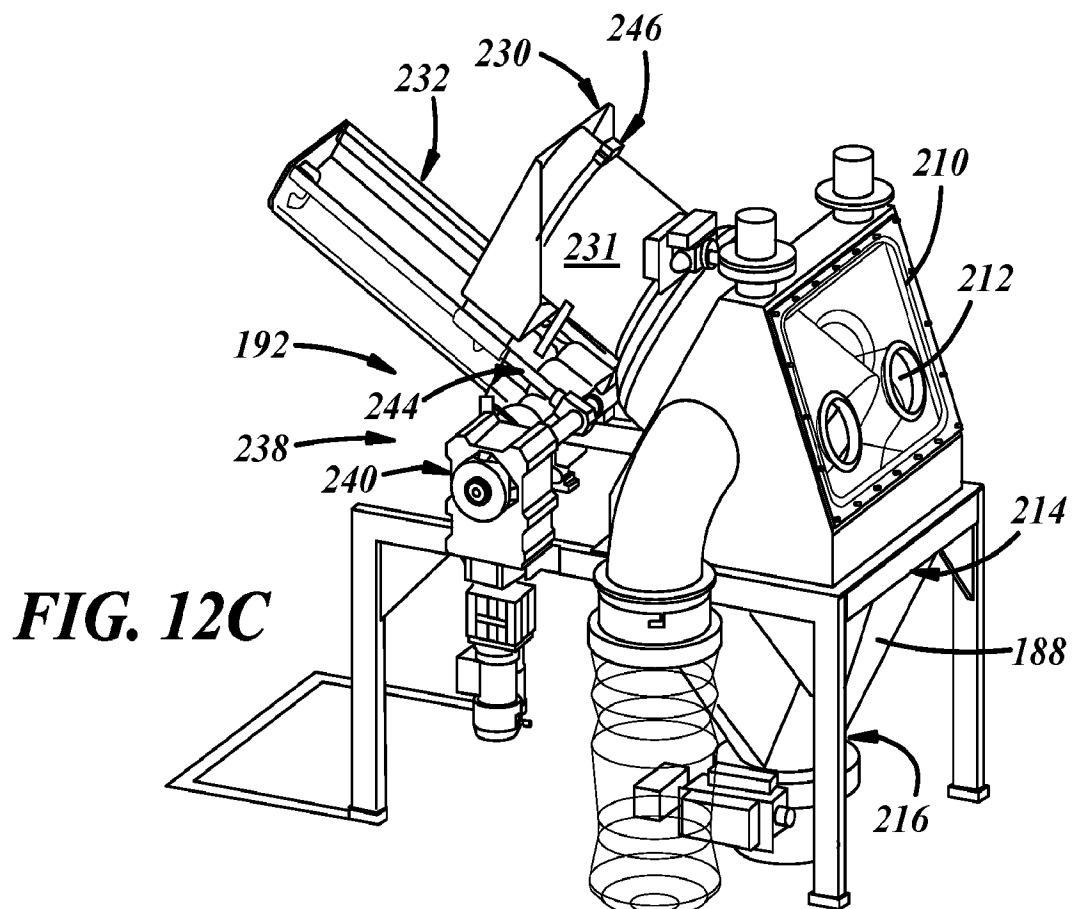


FIG. 12C

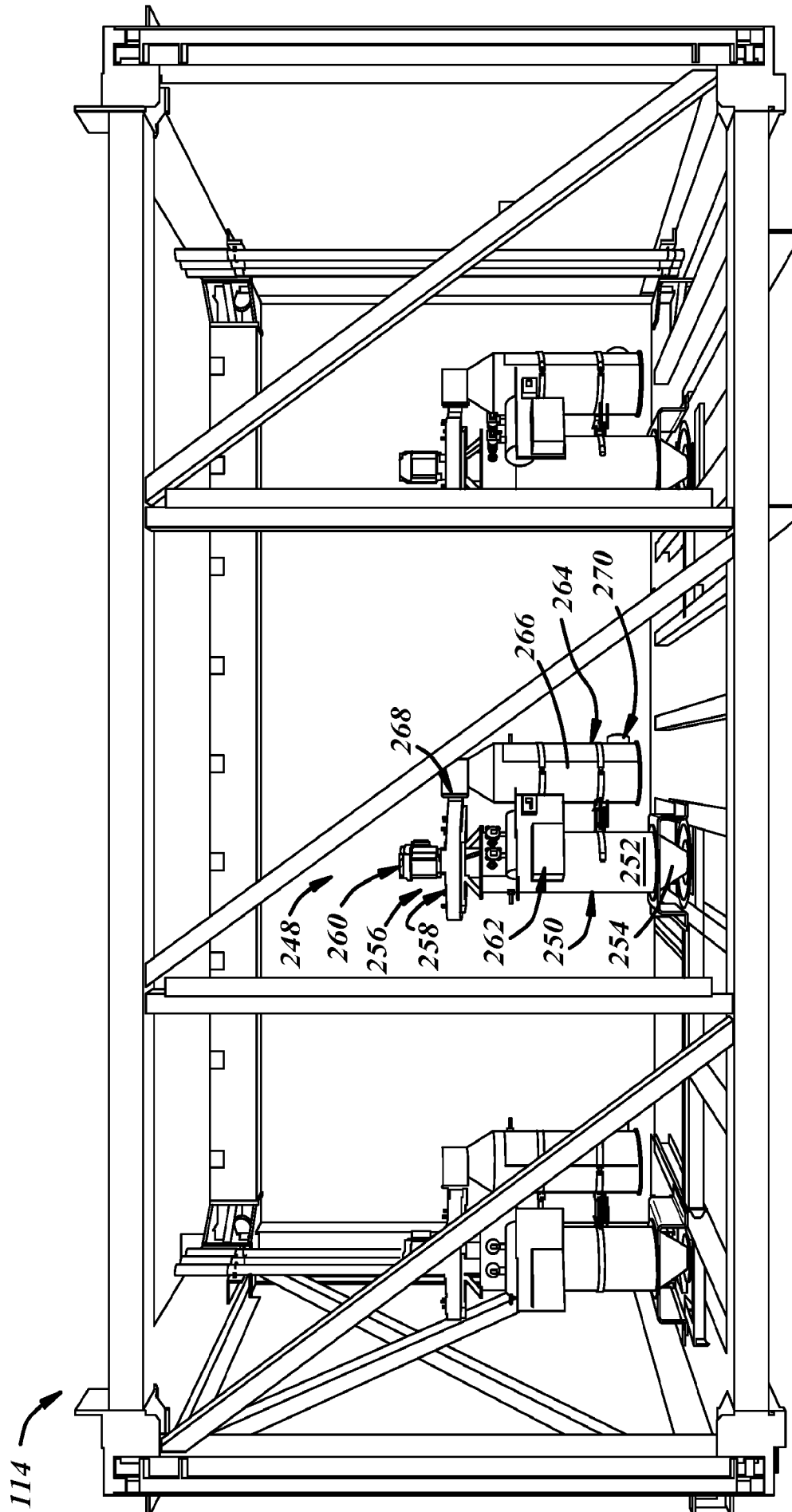
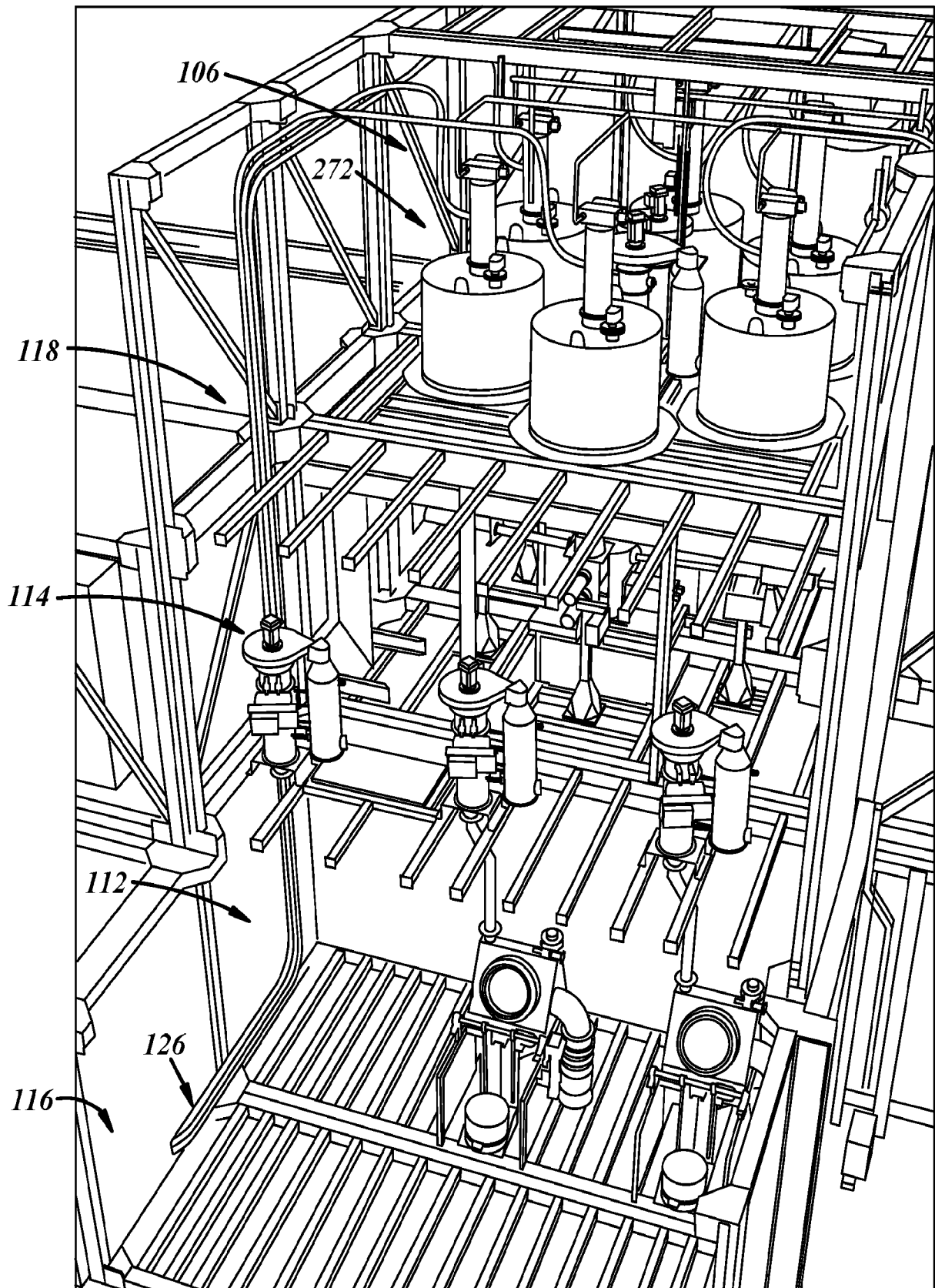
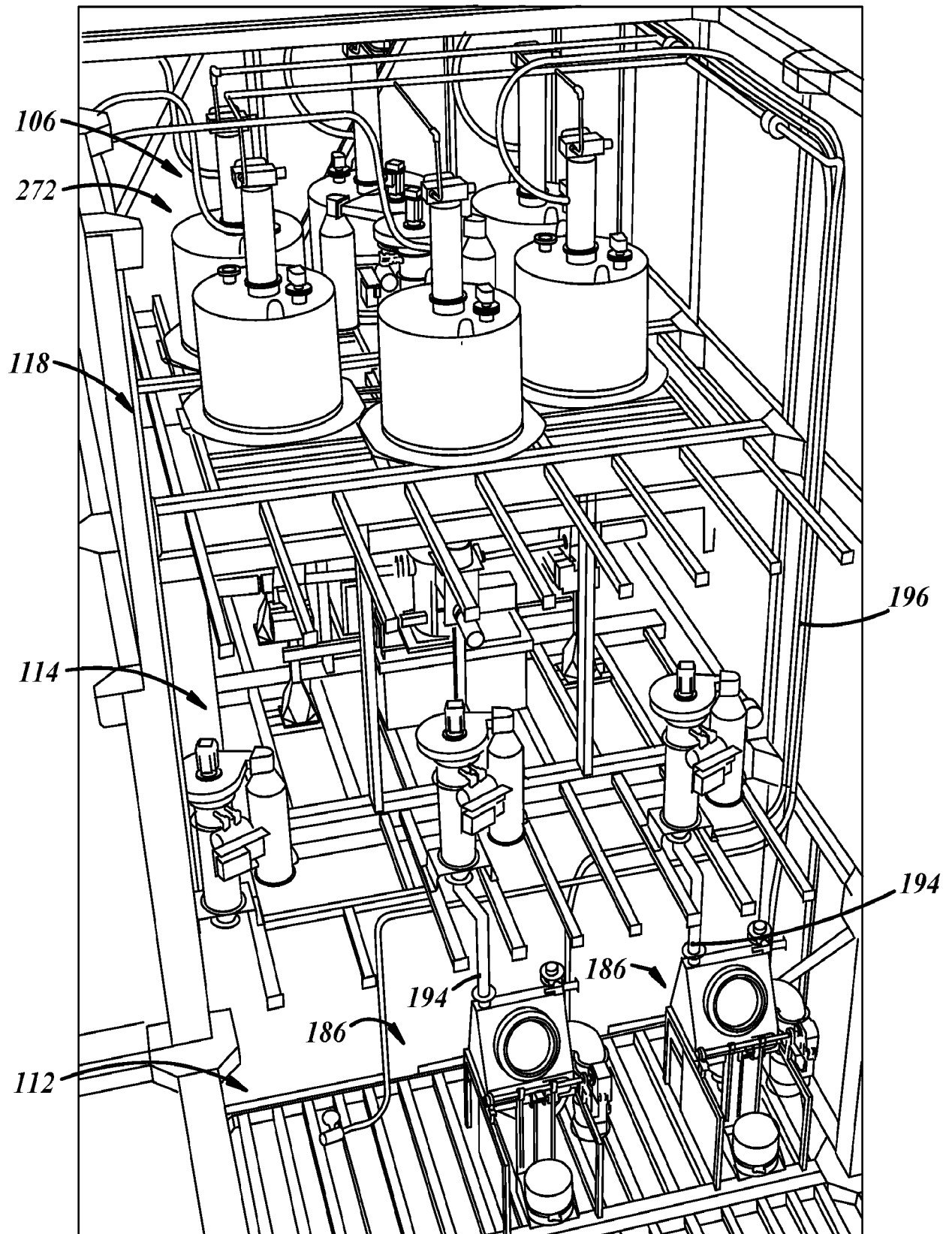


FIG. 13

**FIG. 14**

**FIG. 15**

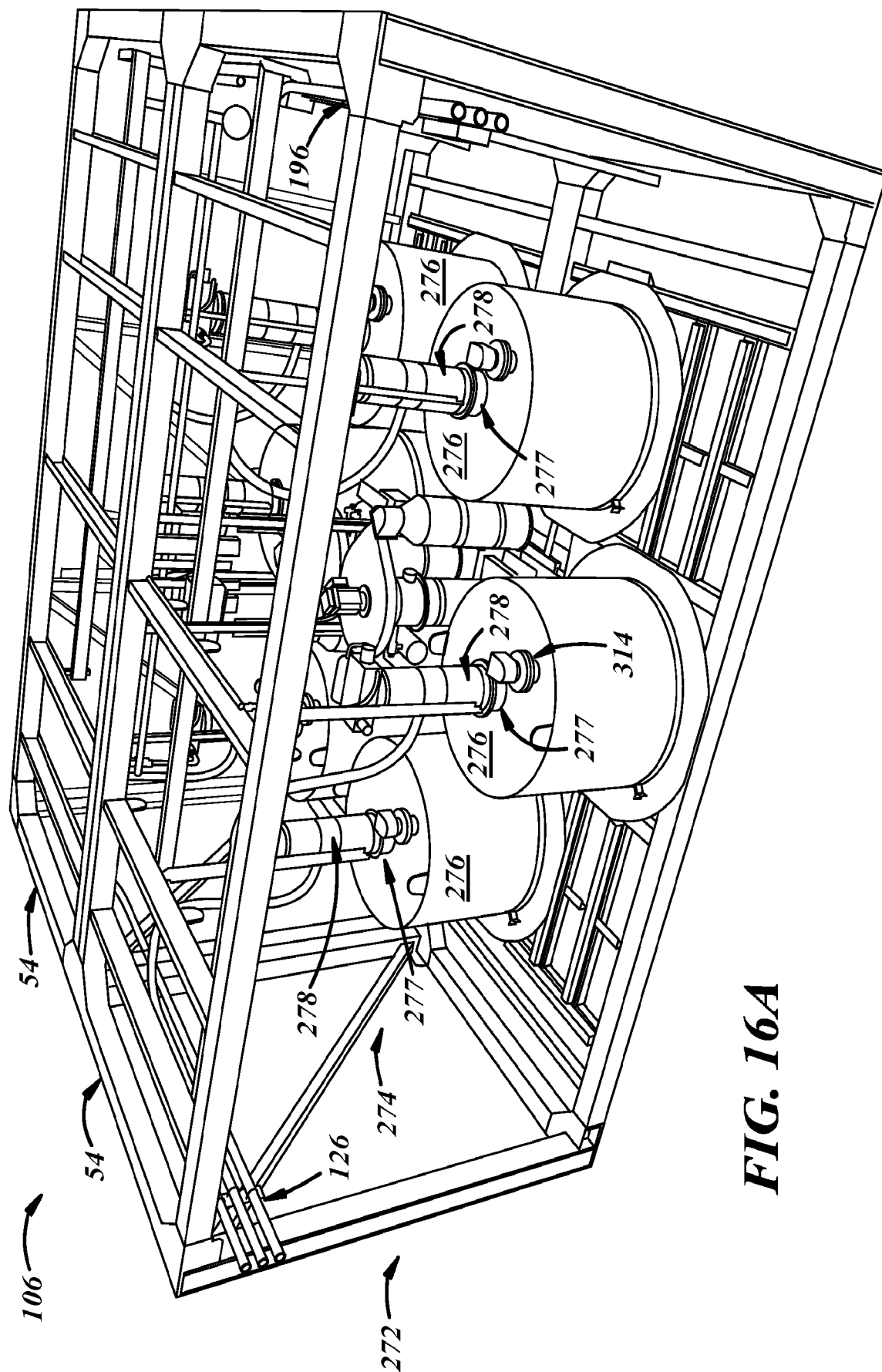


FIG. 16A

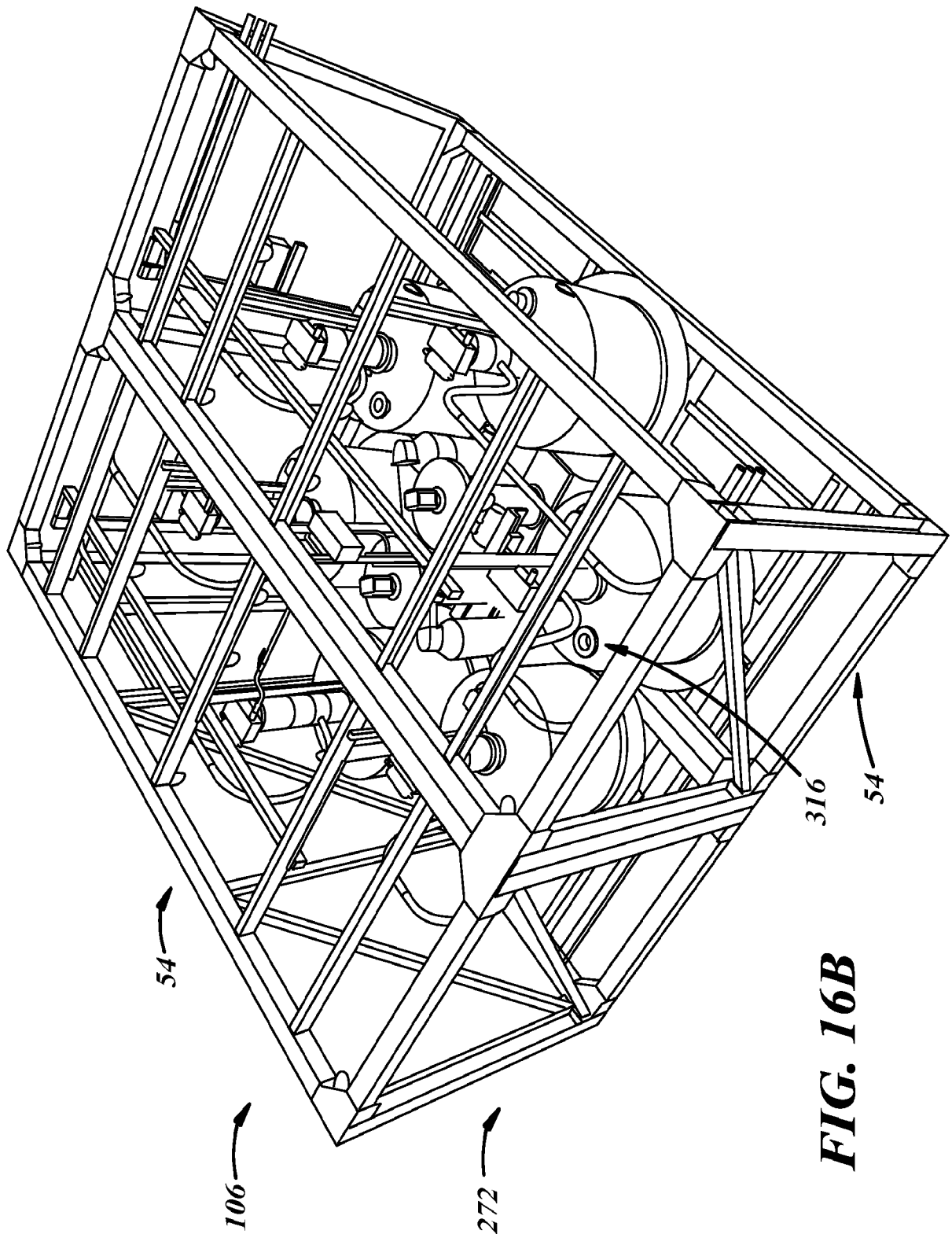


FIG. 16B

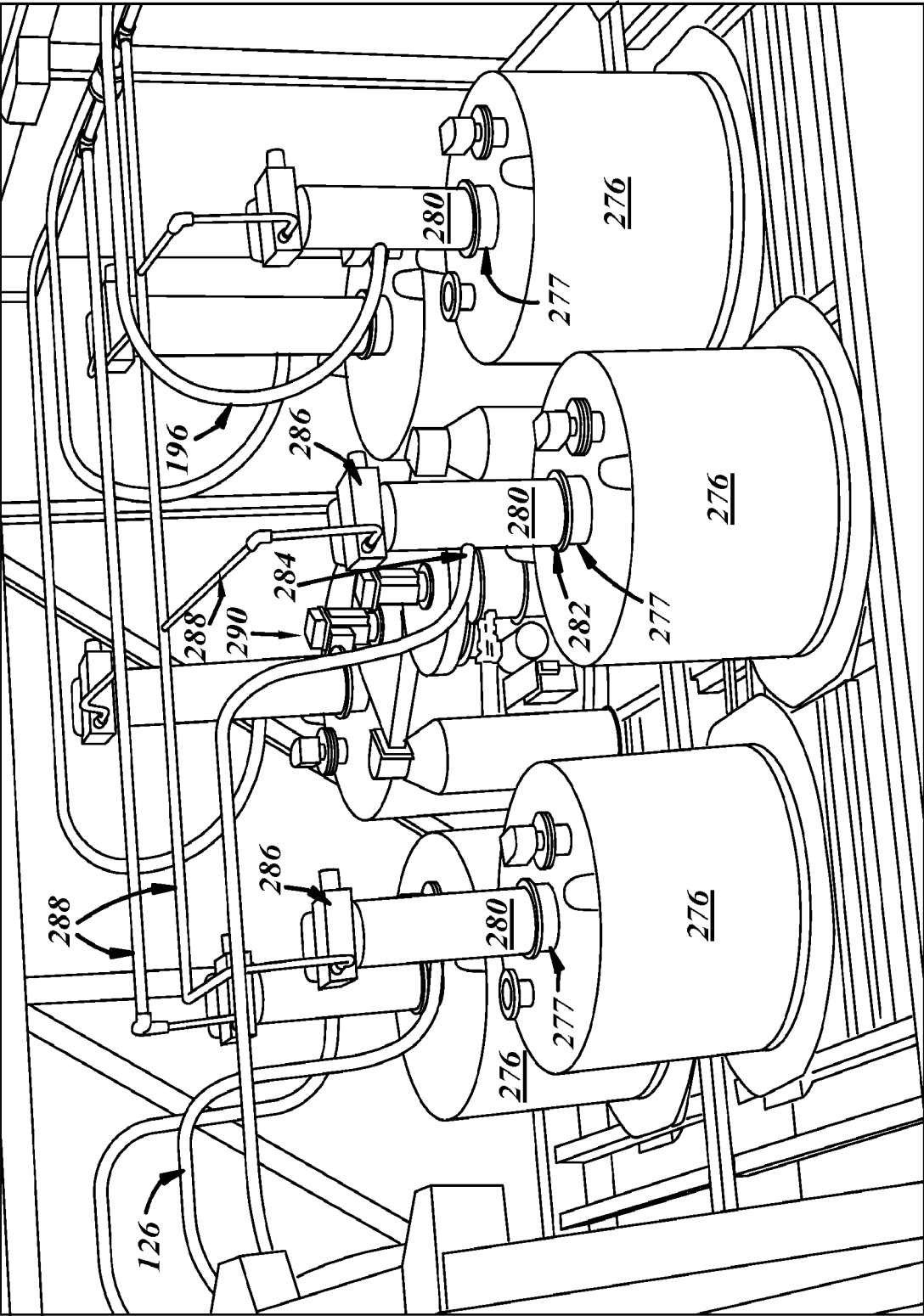


FIG. 16C

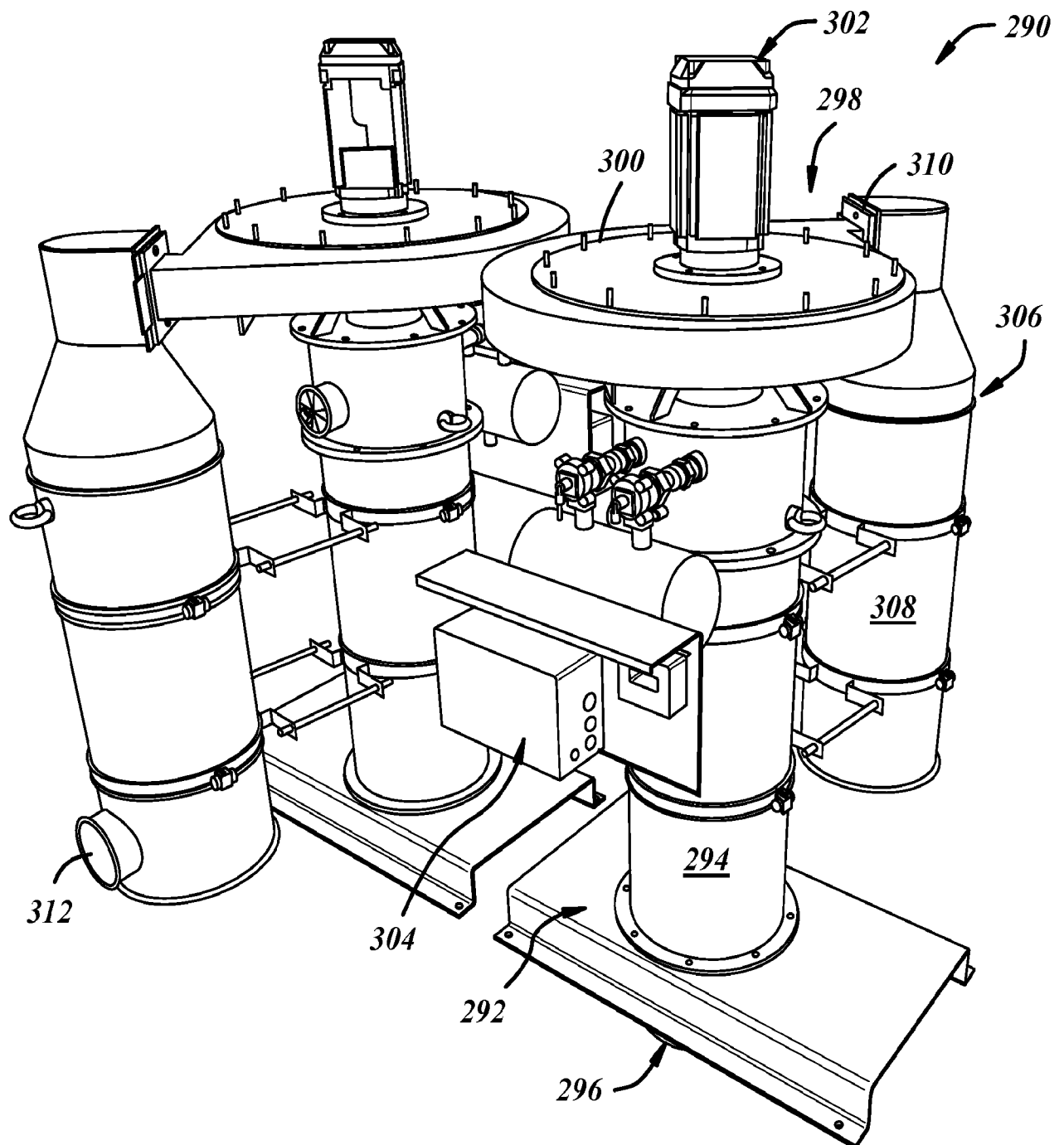
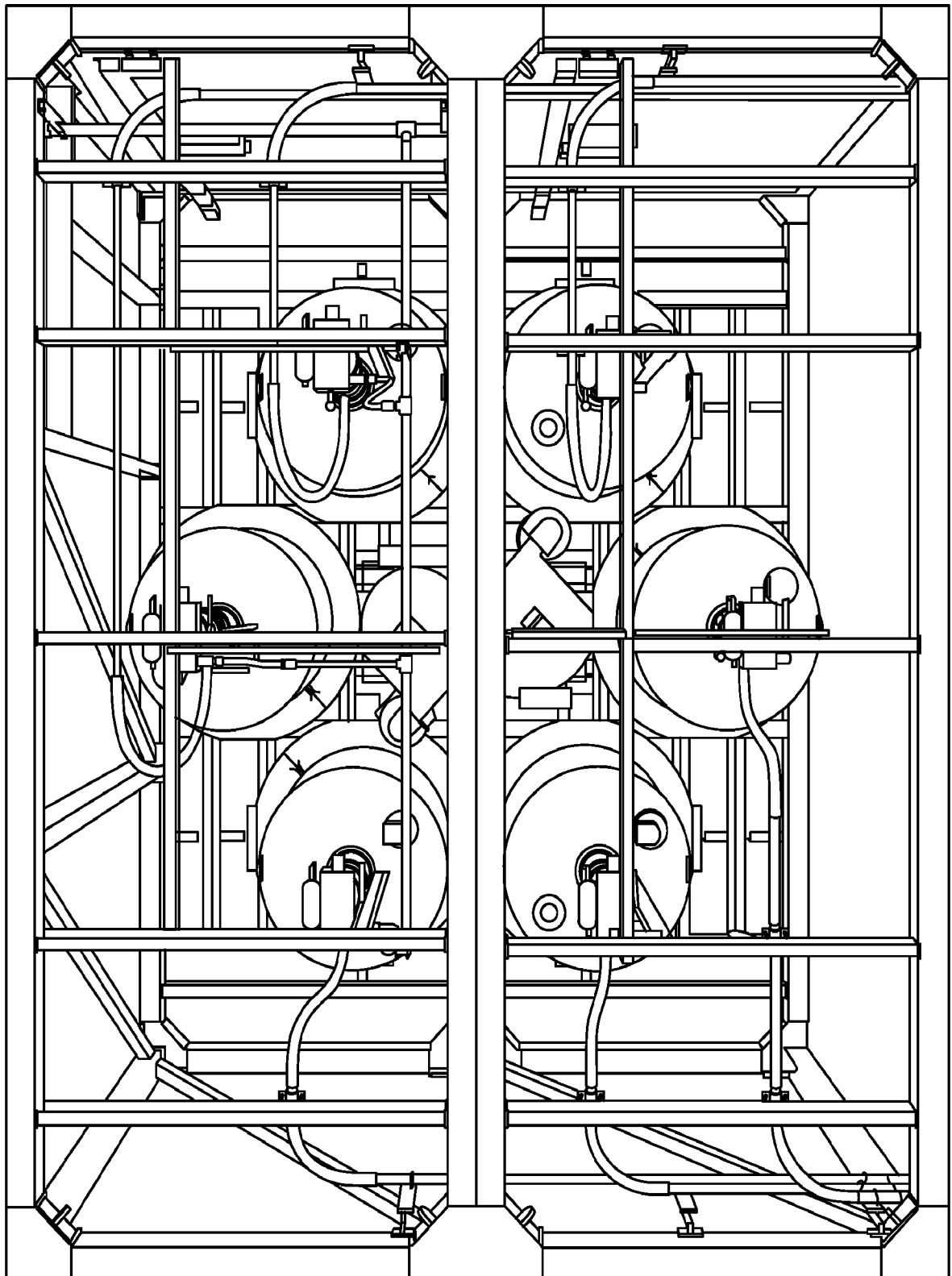


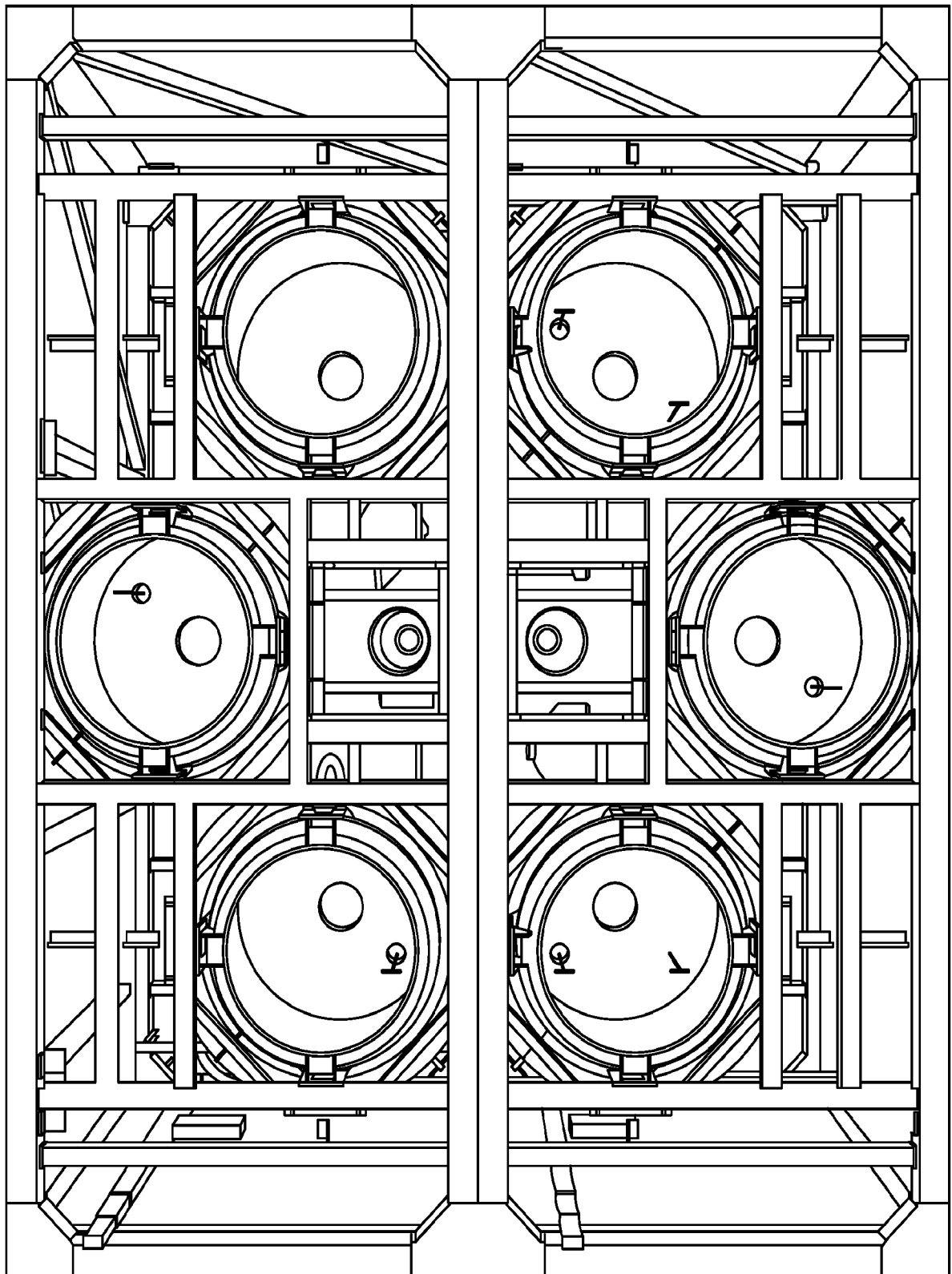
FIG. 16D



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FIG. 16E



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FIG. 16F

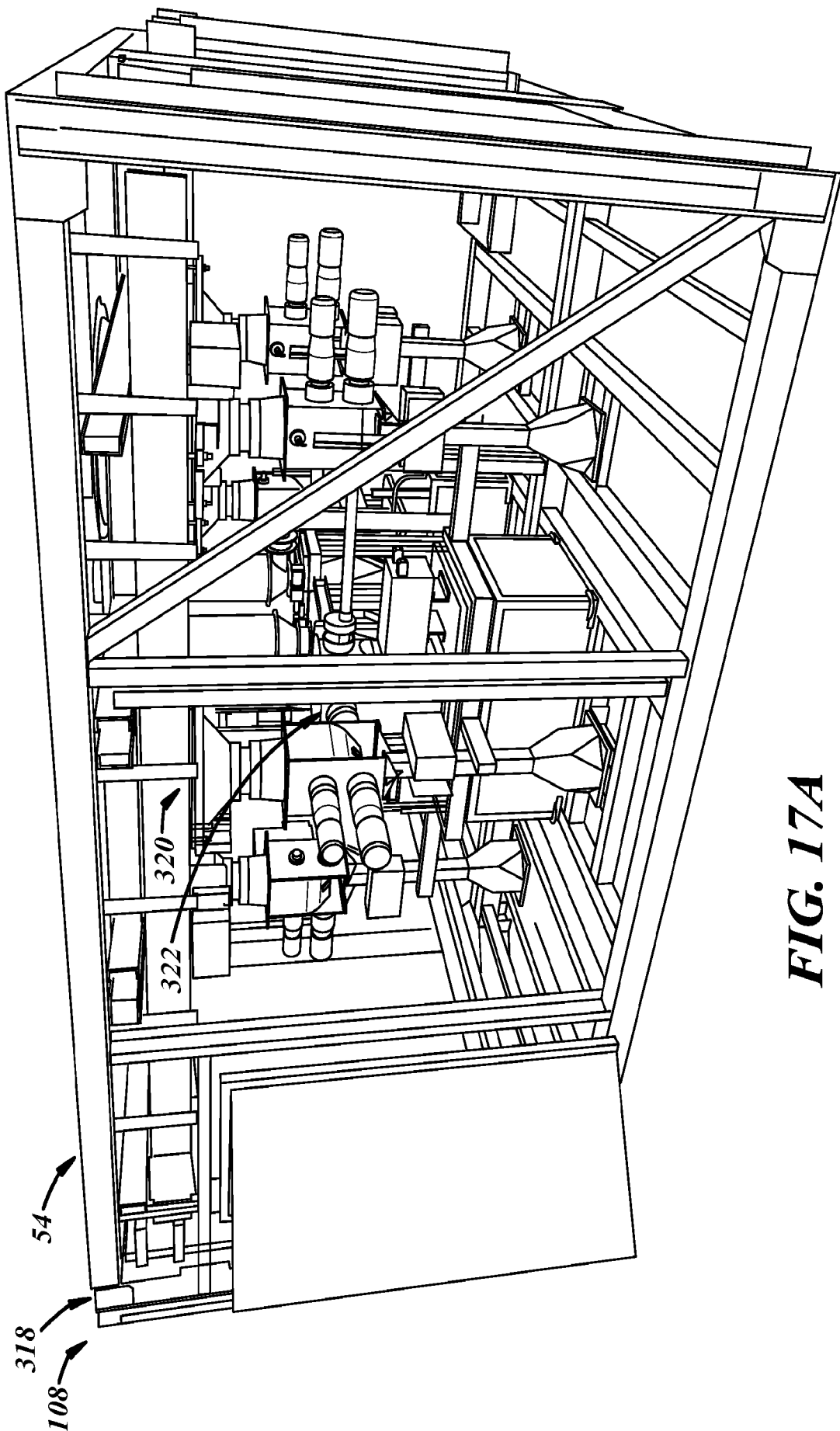


FIG. 17A

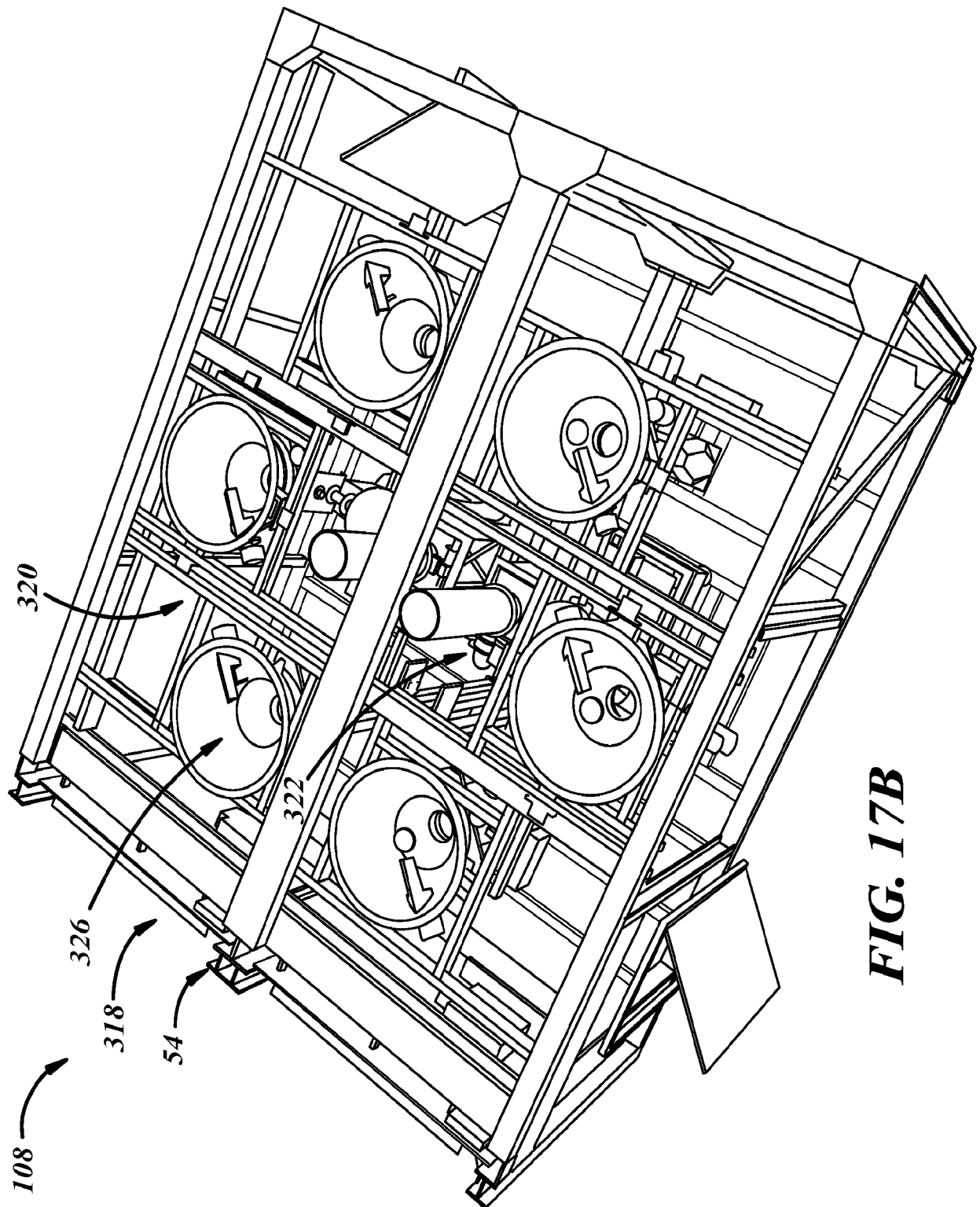


FIG. 17B

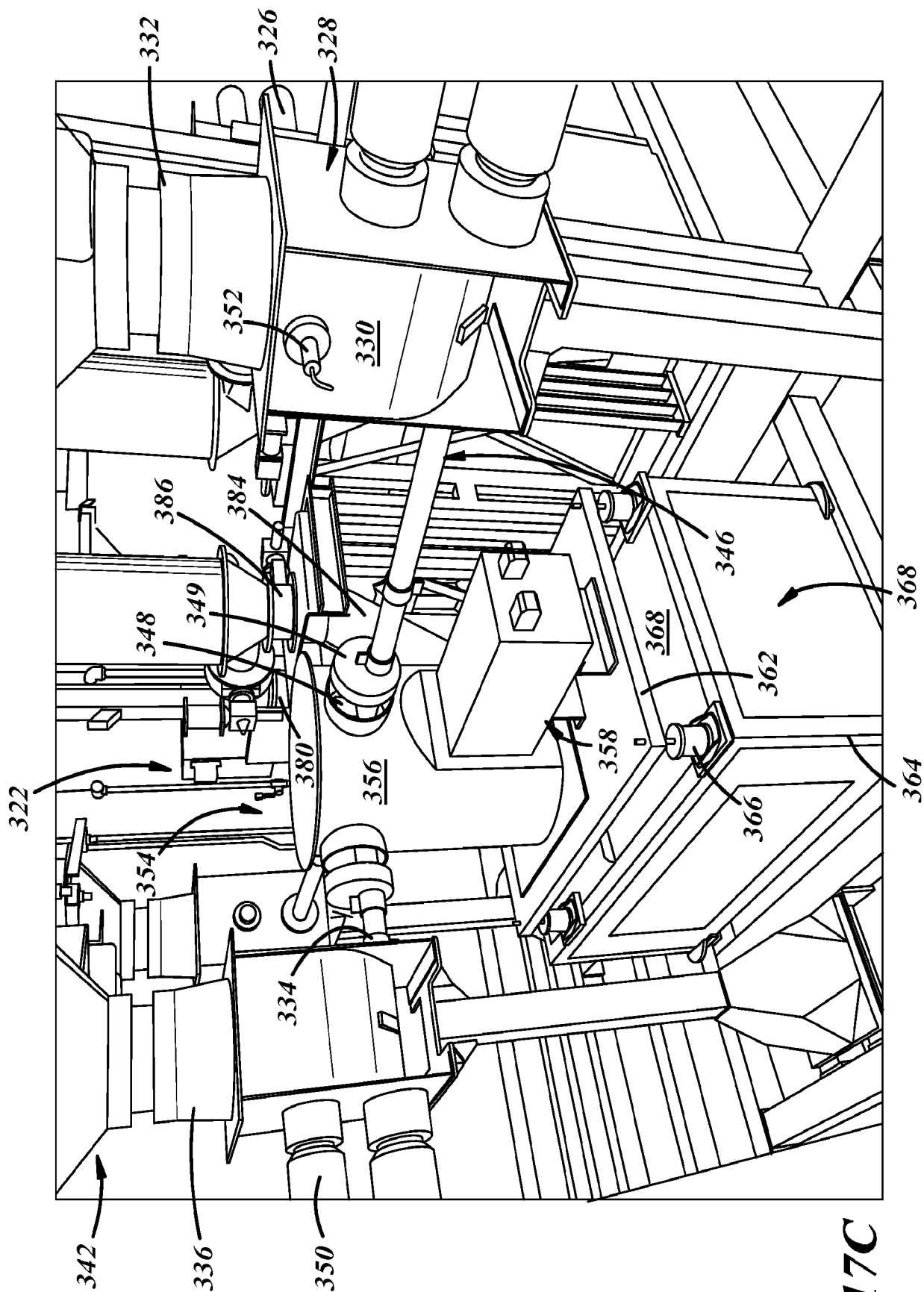


FIG. 17C

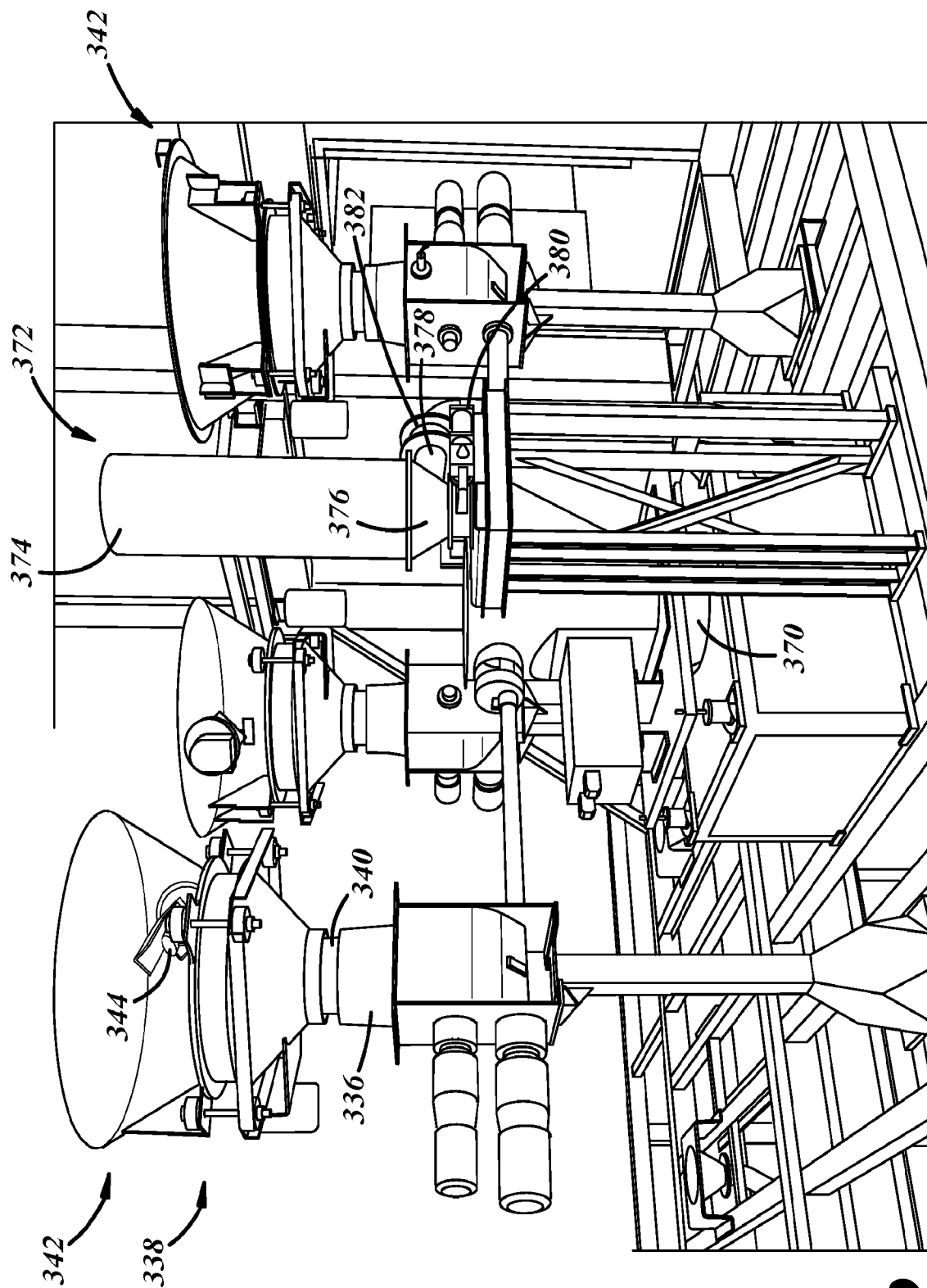
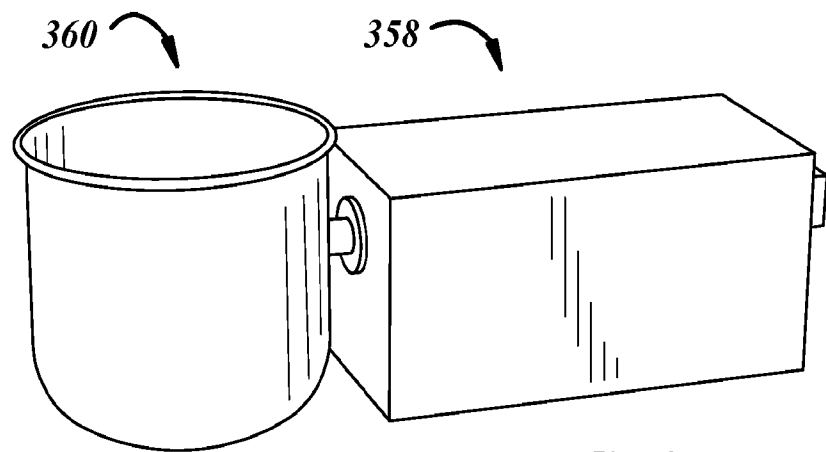
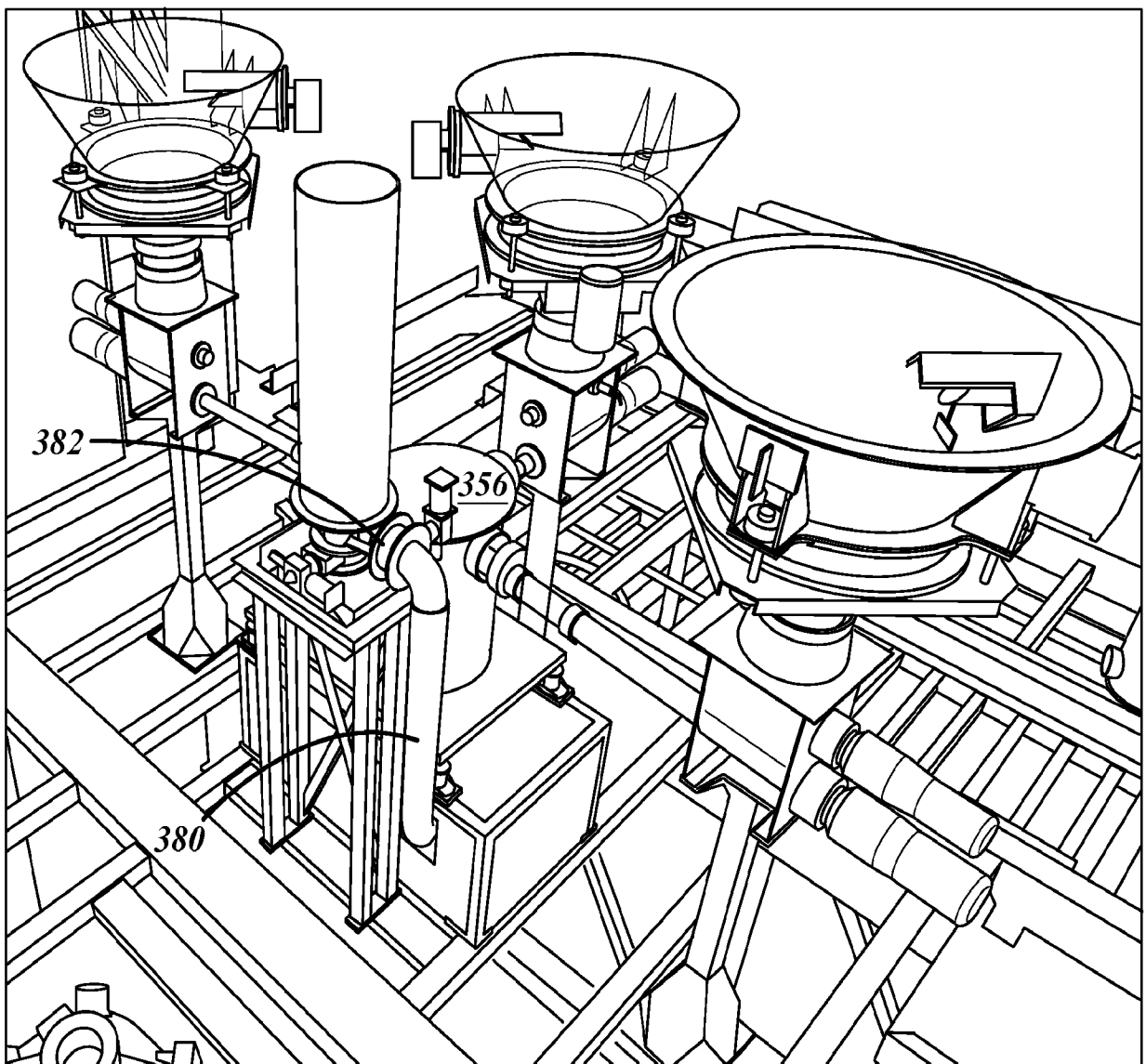
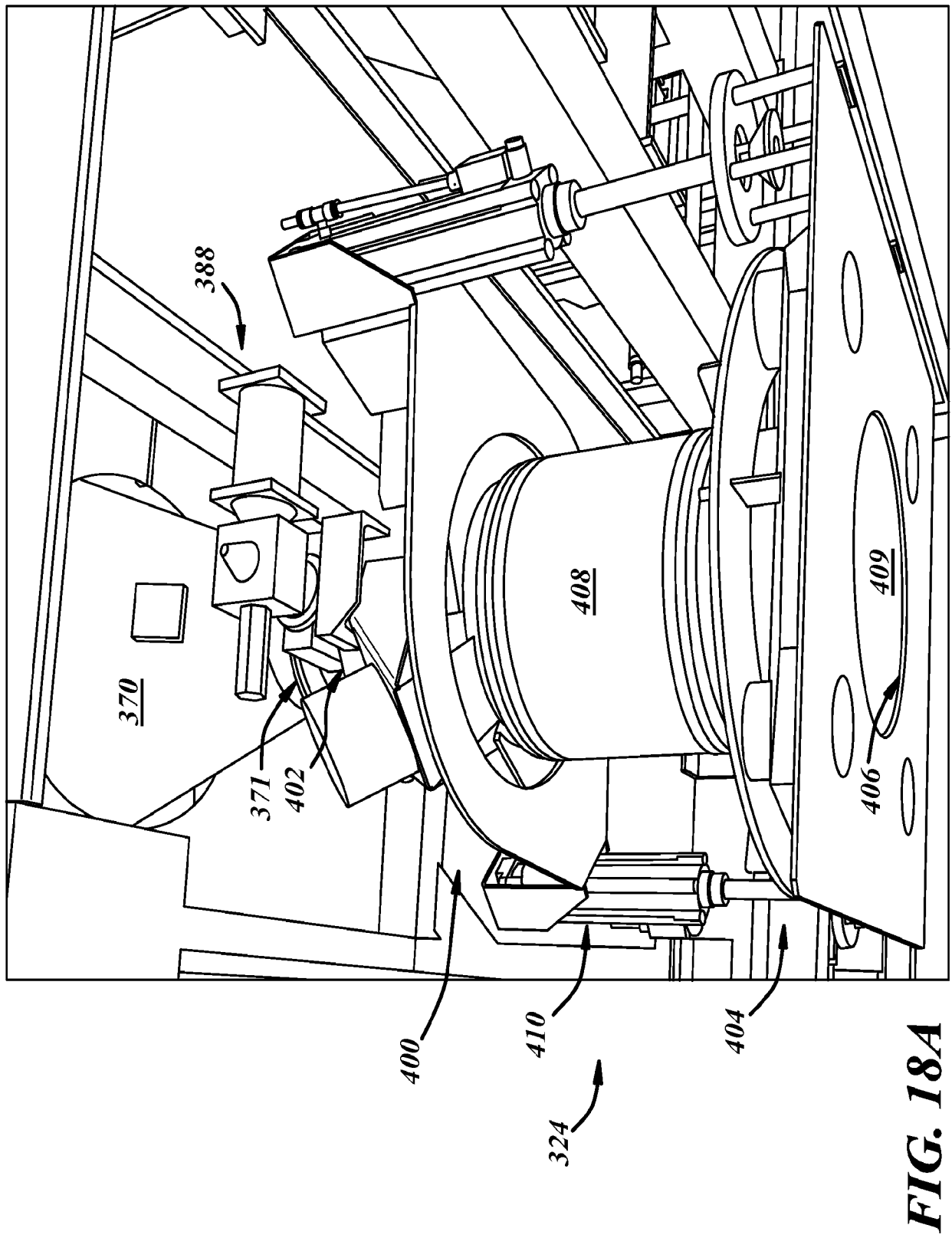


FIG. 17D

**FIG. 17E****FIG. 17F**



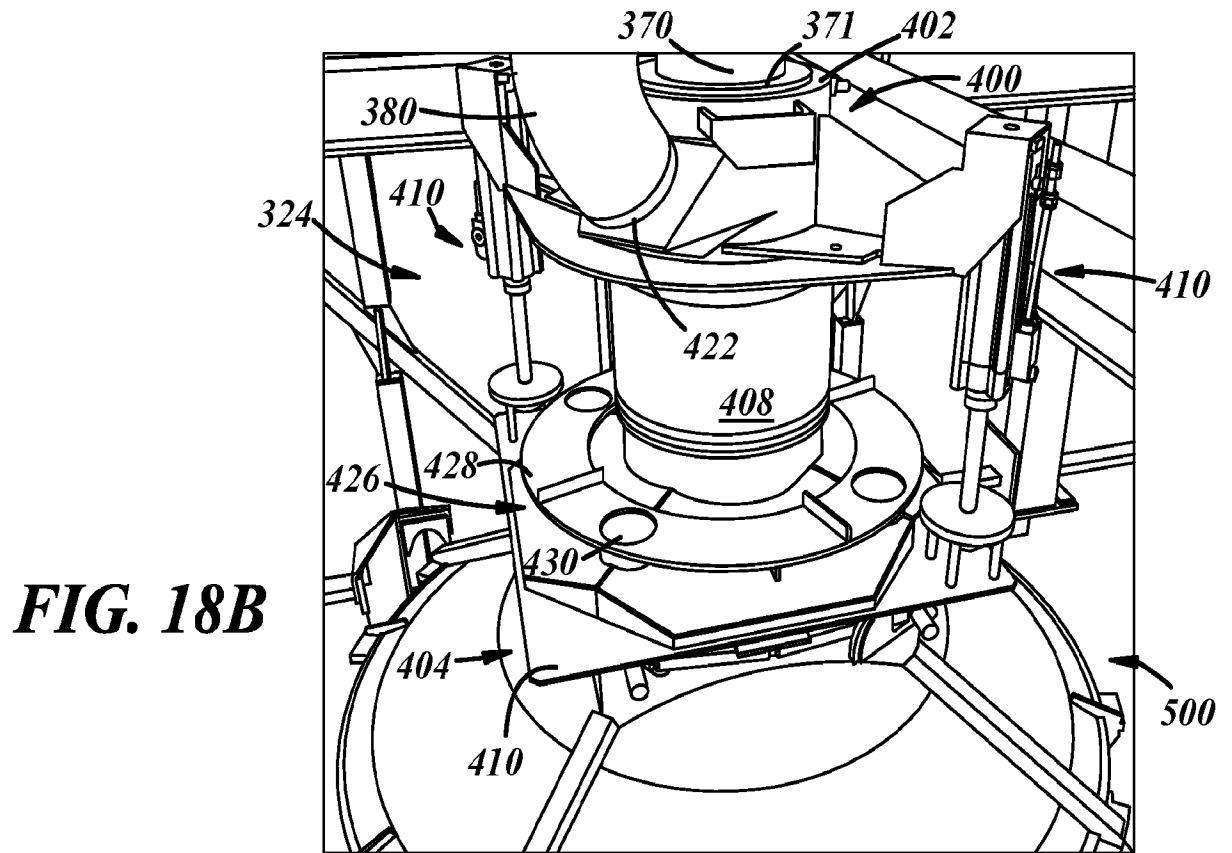


FIG. 18B

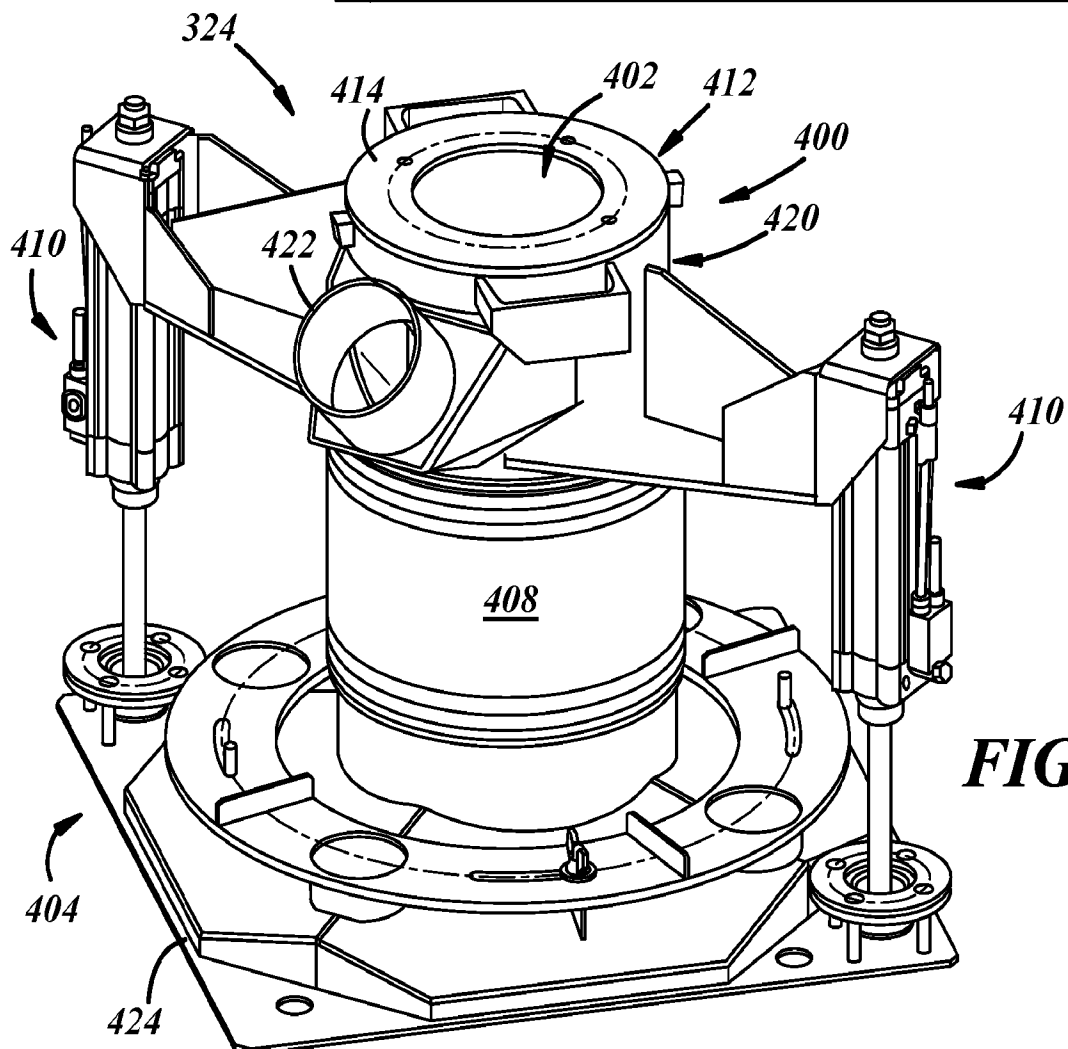
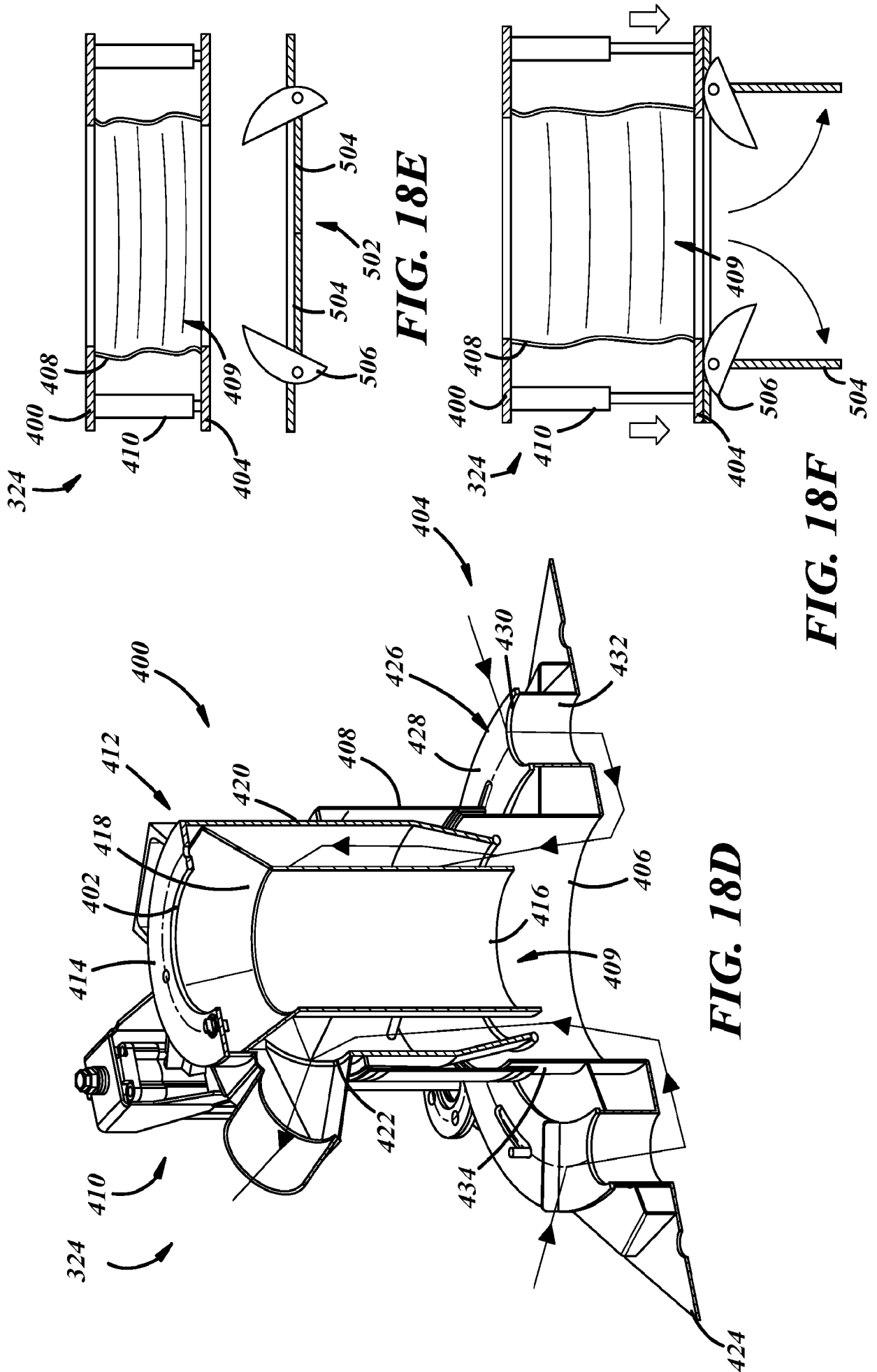
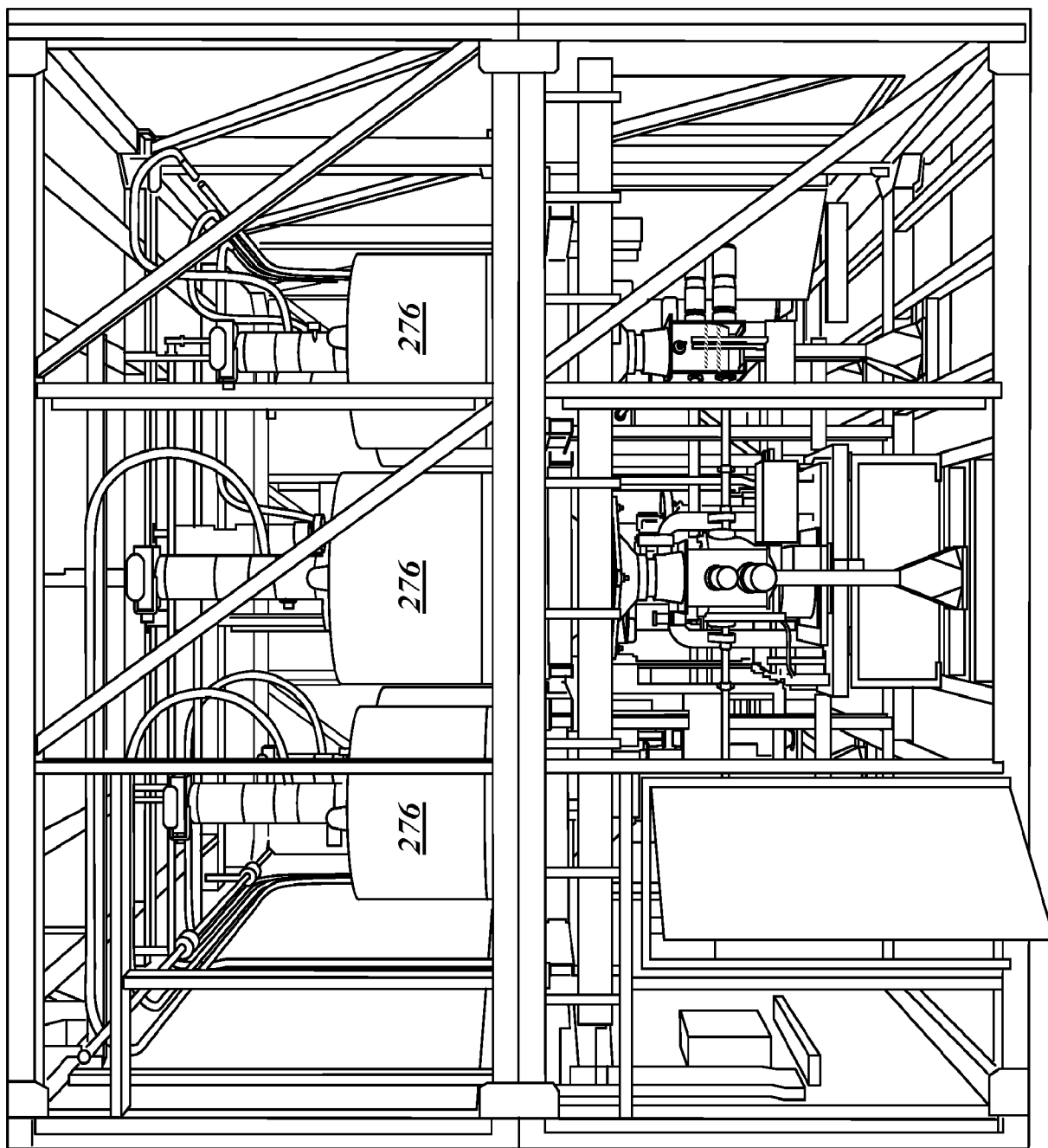


FIG. 18C





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318

FIG. 19

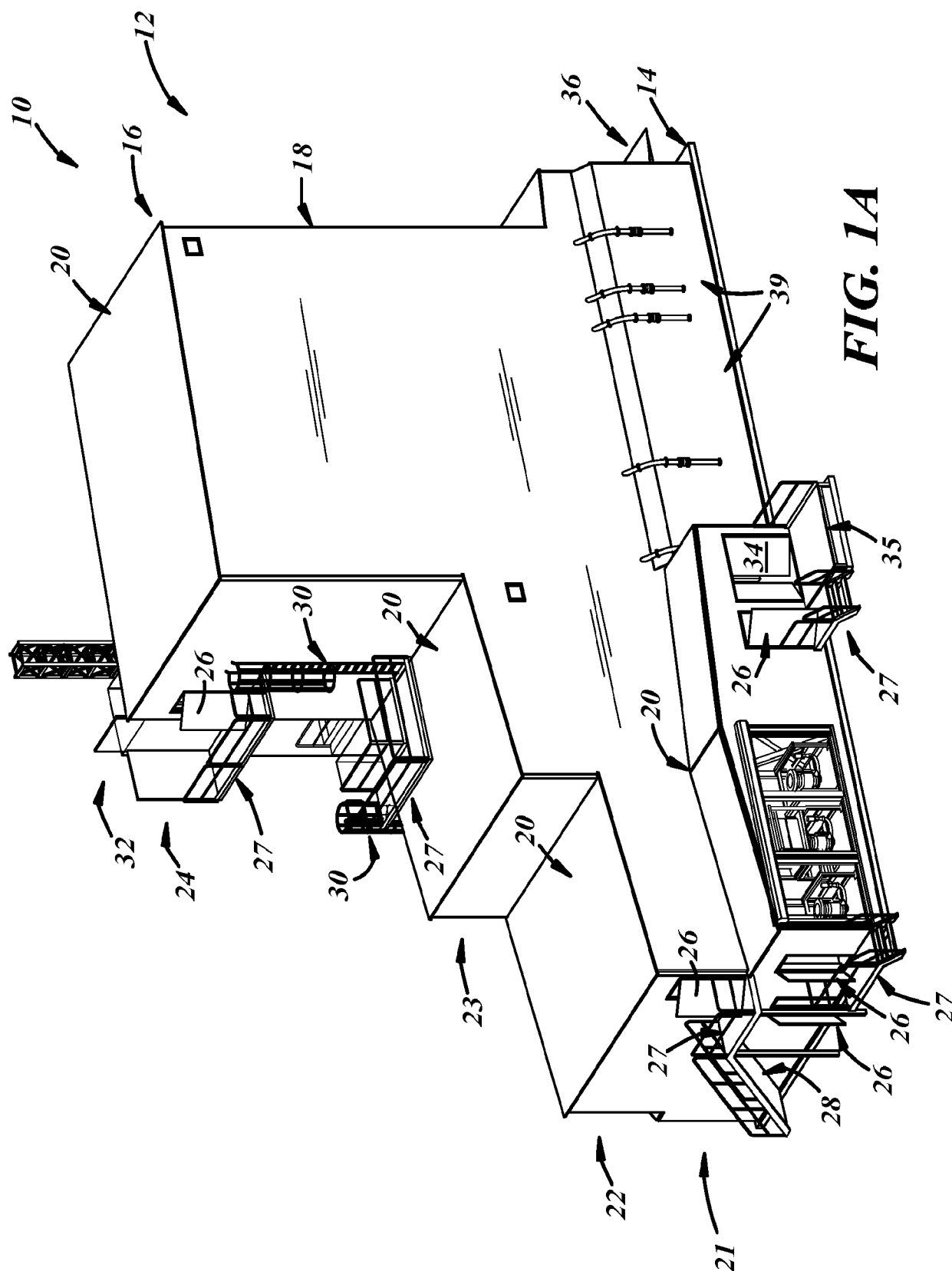
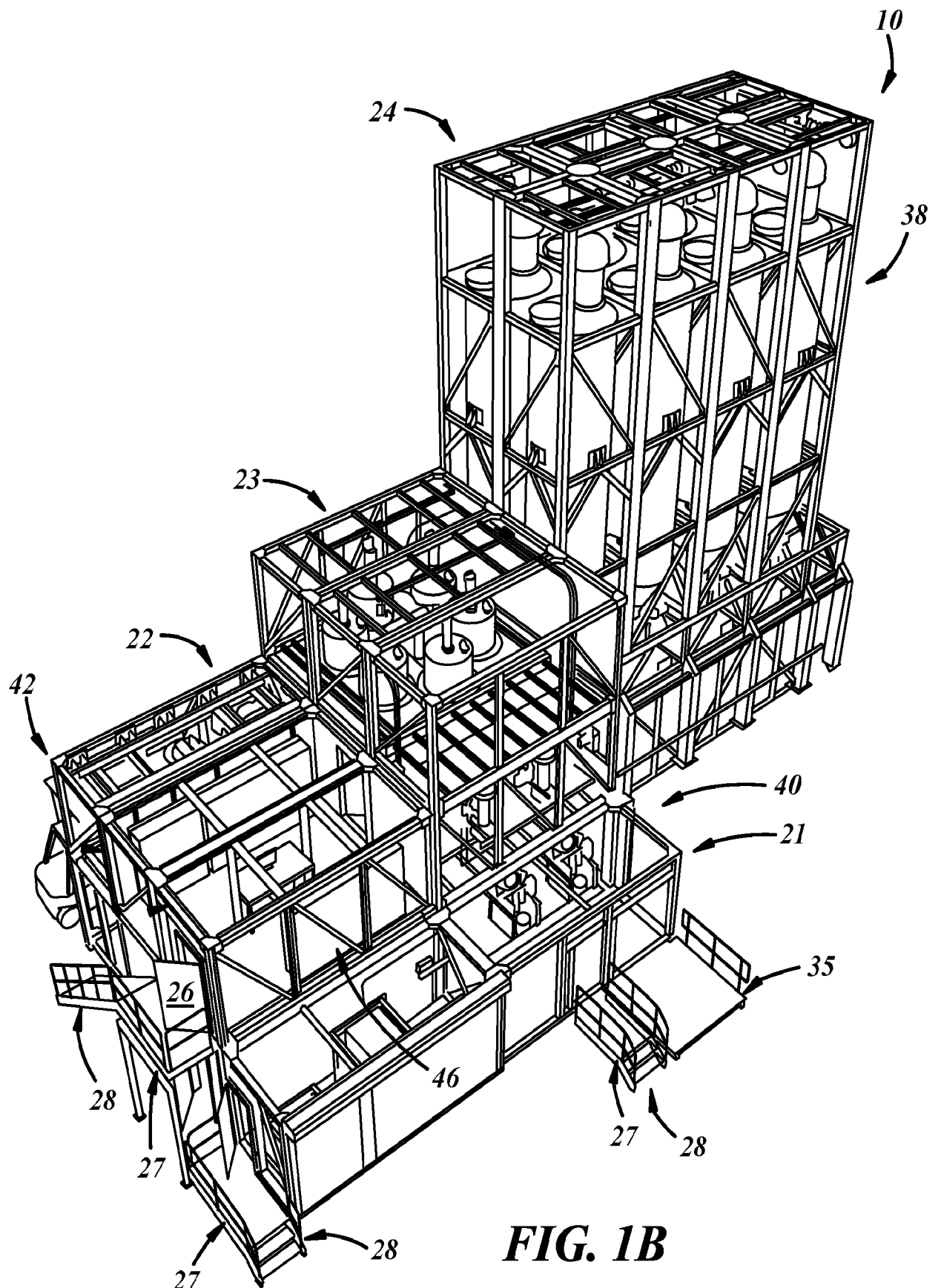


FIG. 1A



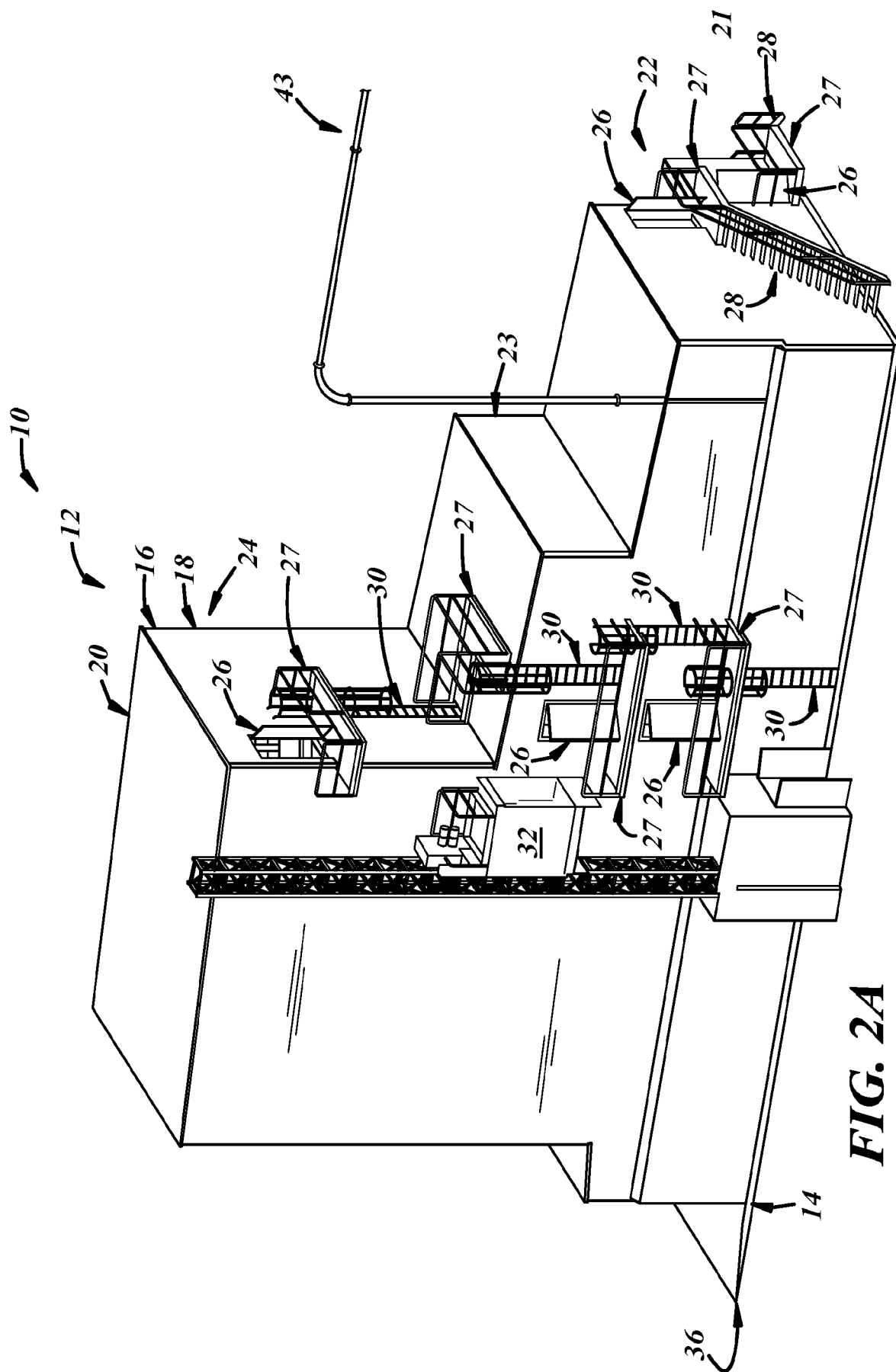


FIG. 2A

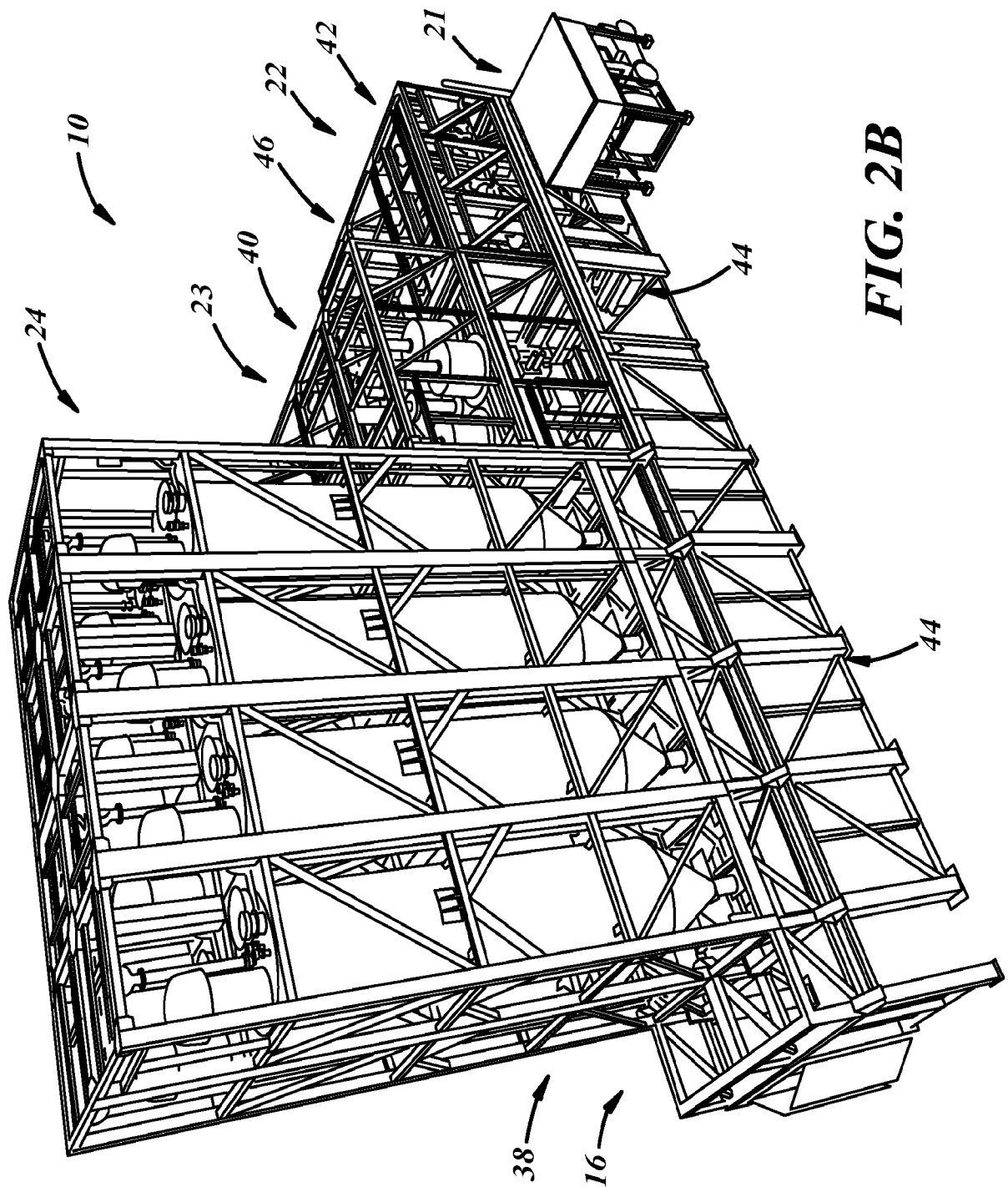


FIG. 2B

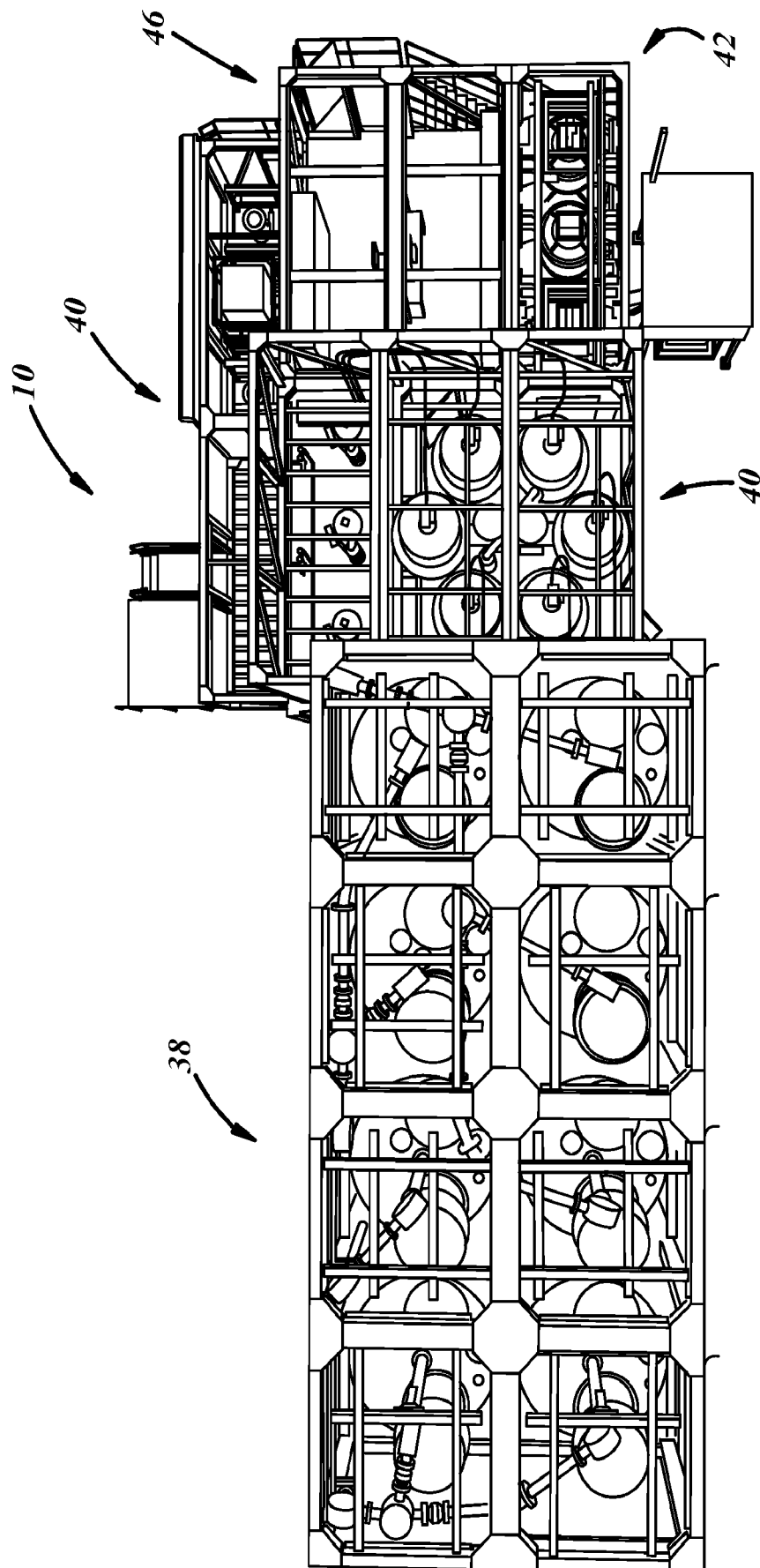


FIG. 3

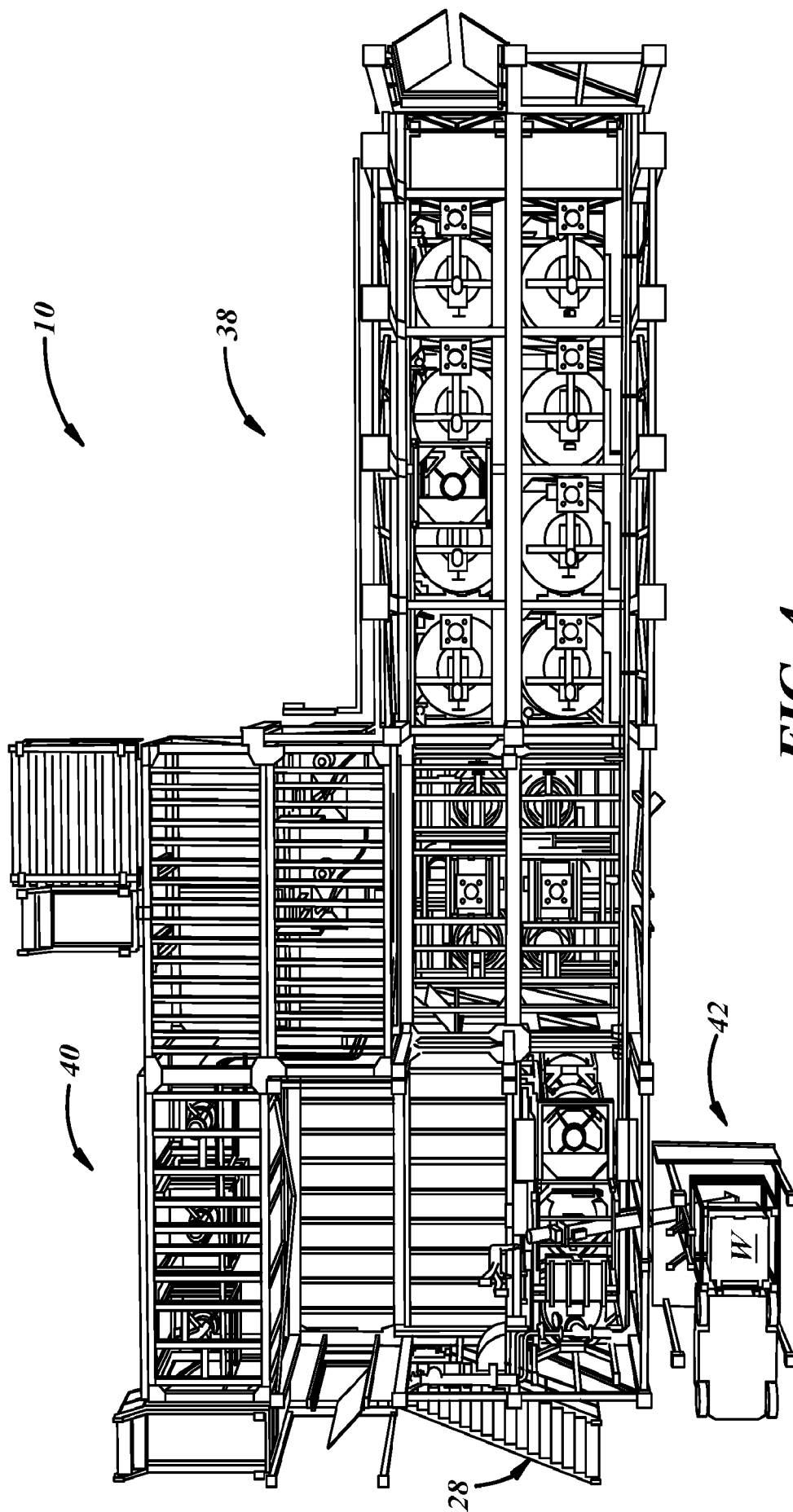
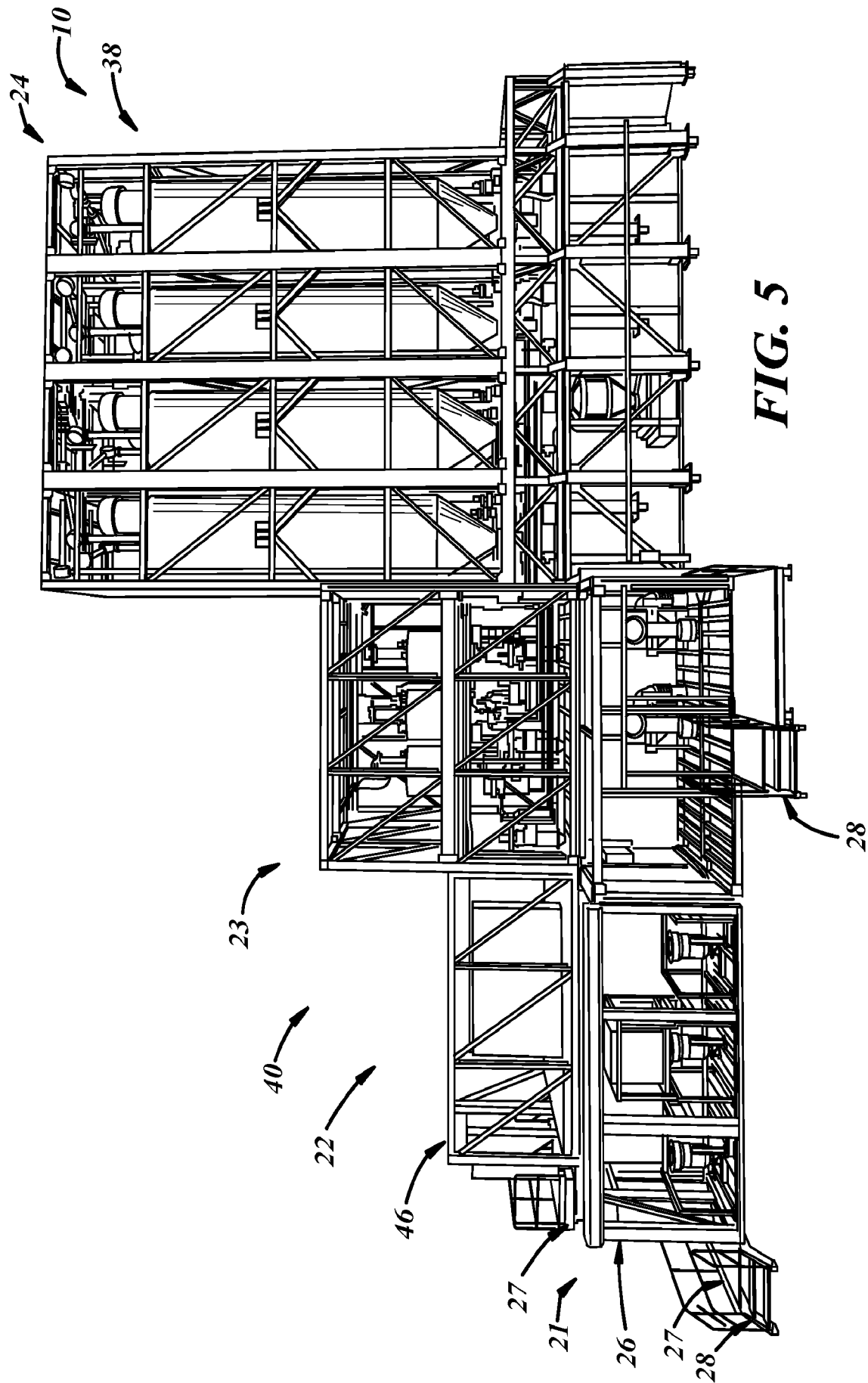
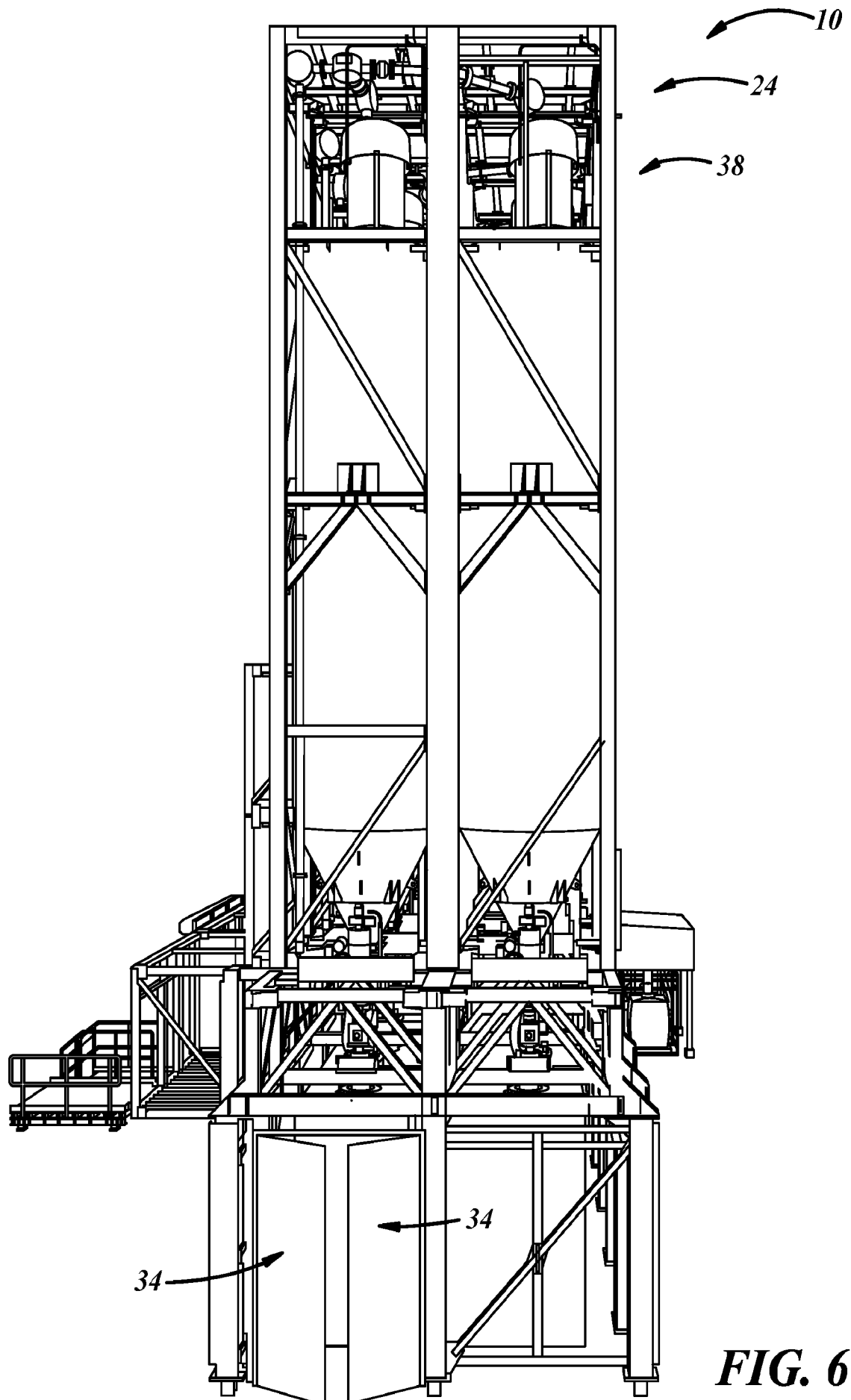


FIG. 4



**FIG. 6**

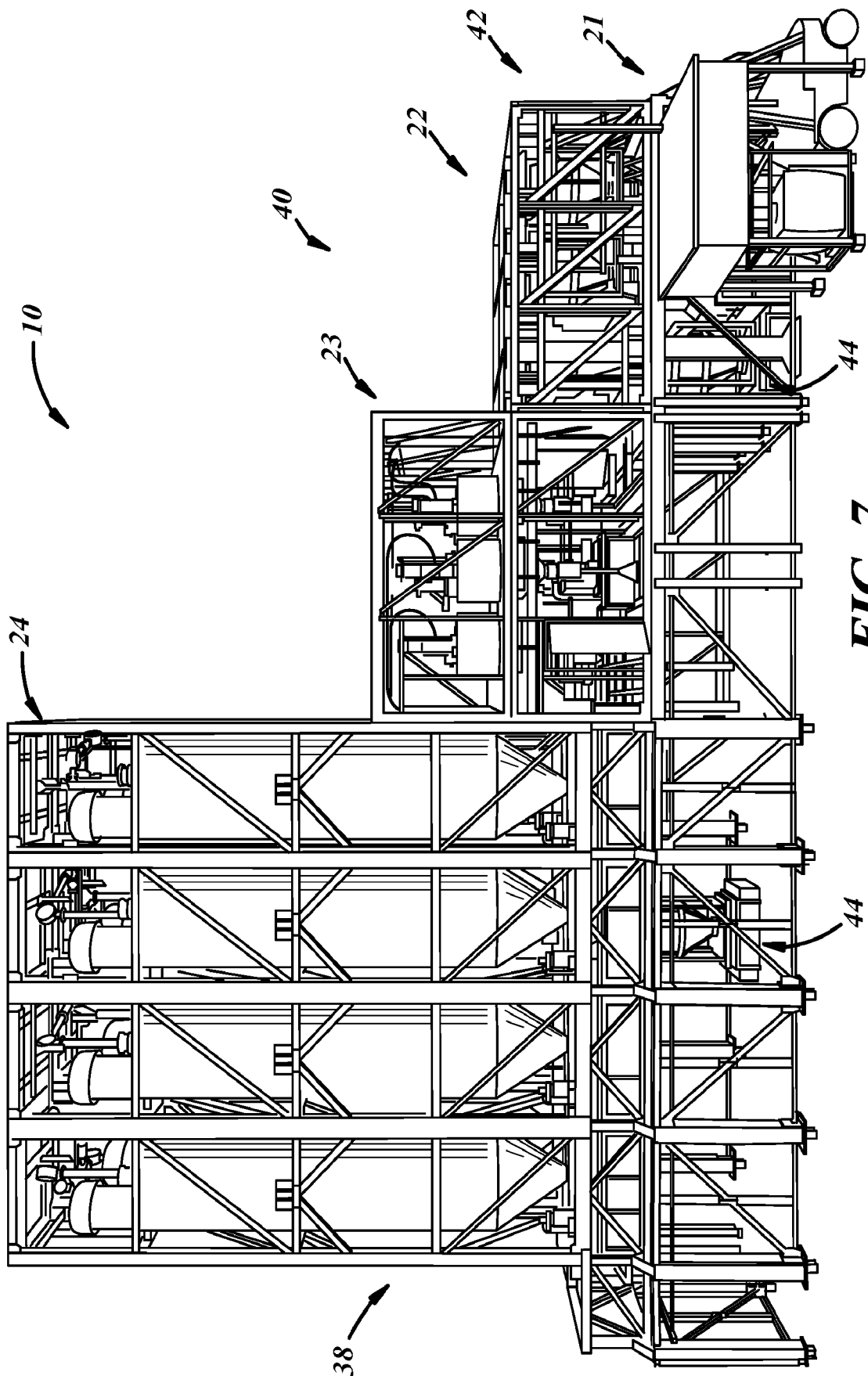


FIG. 7

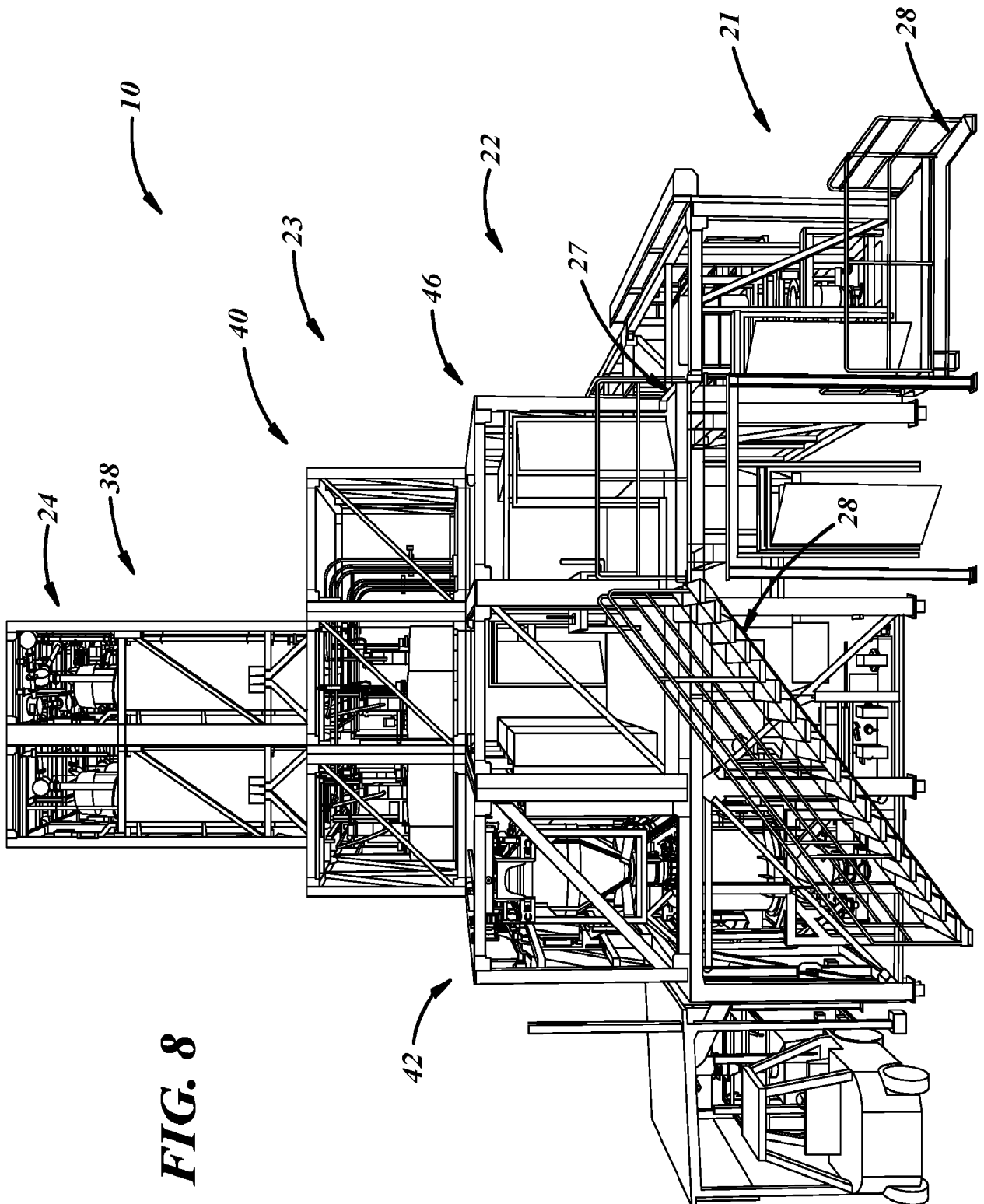


FIG. 8

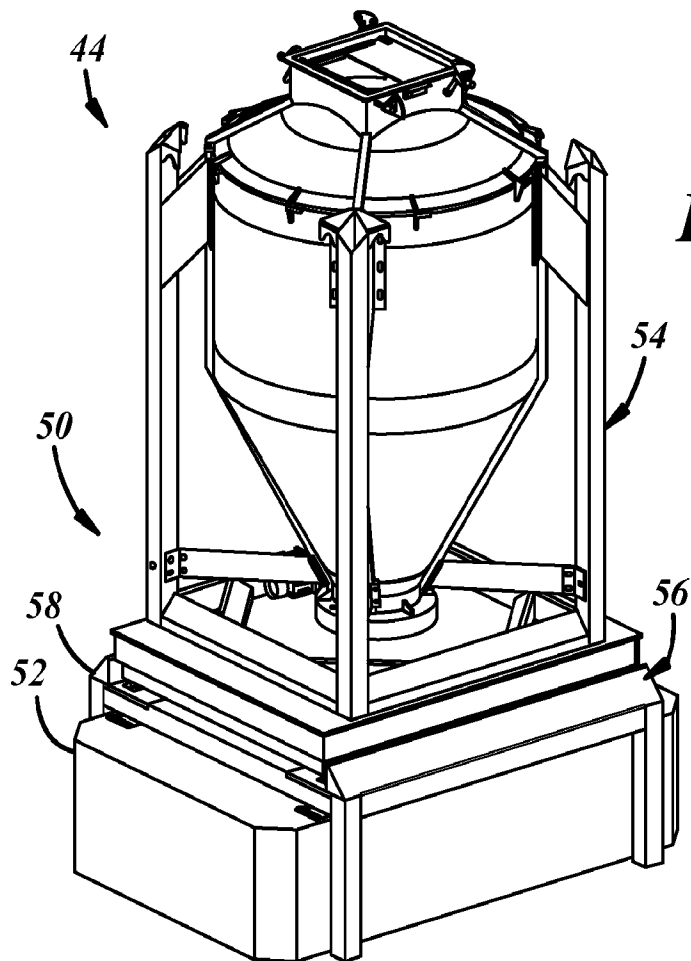


FIG. 9A

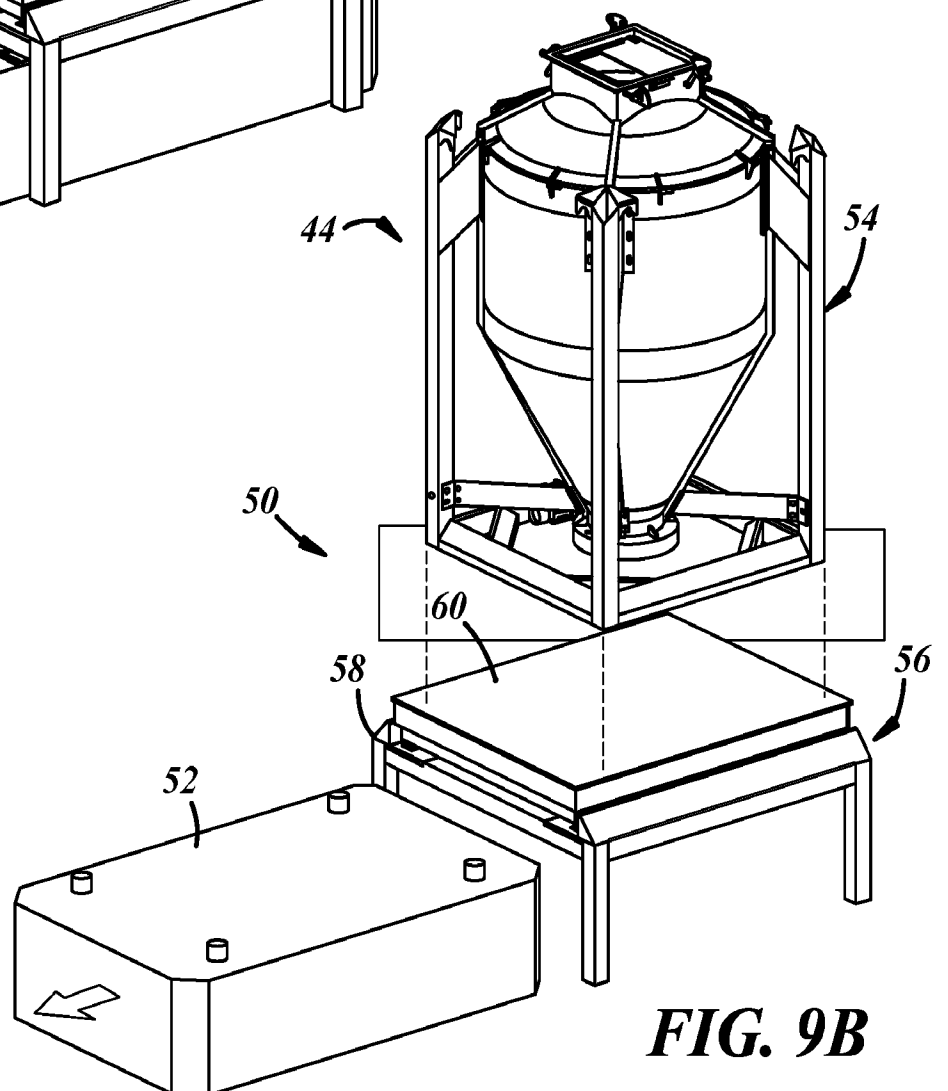
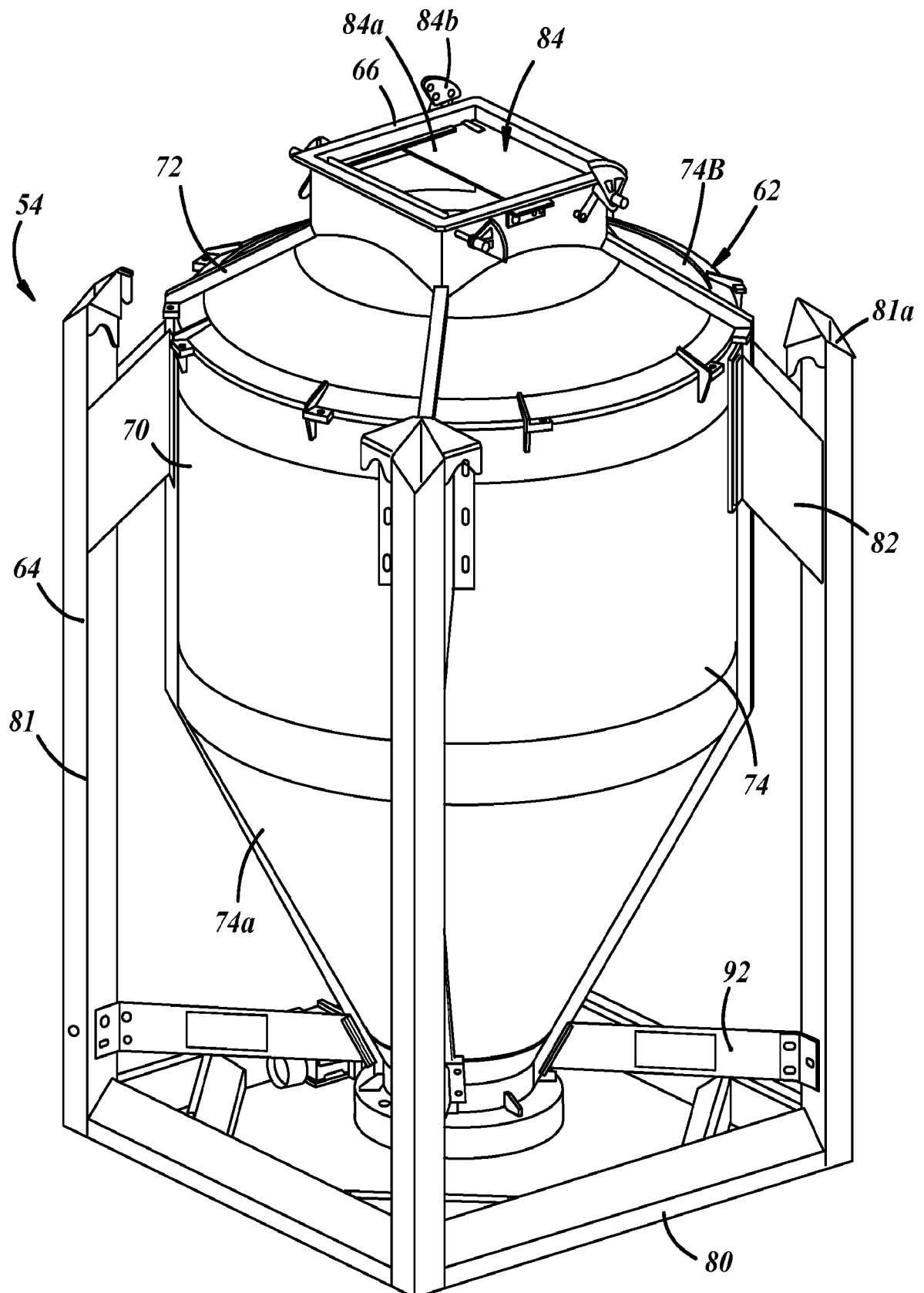
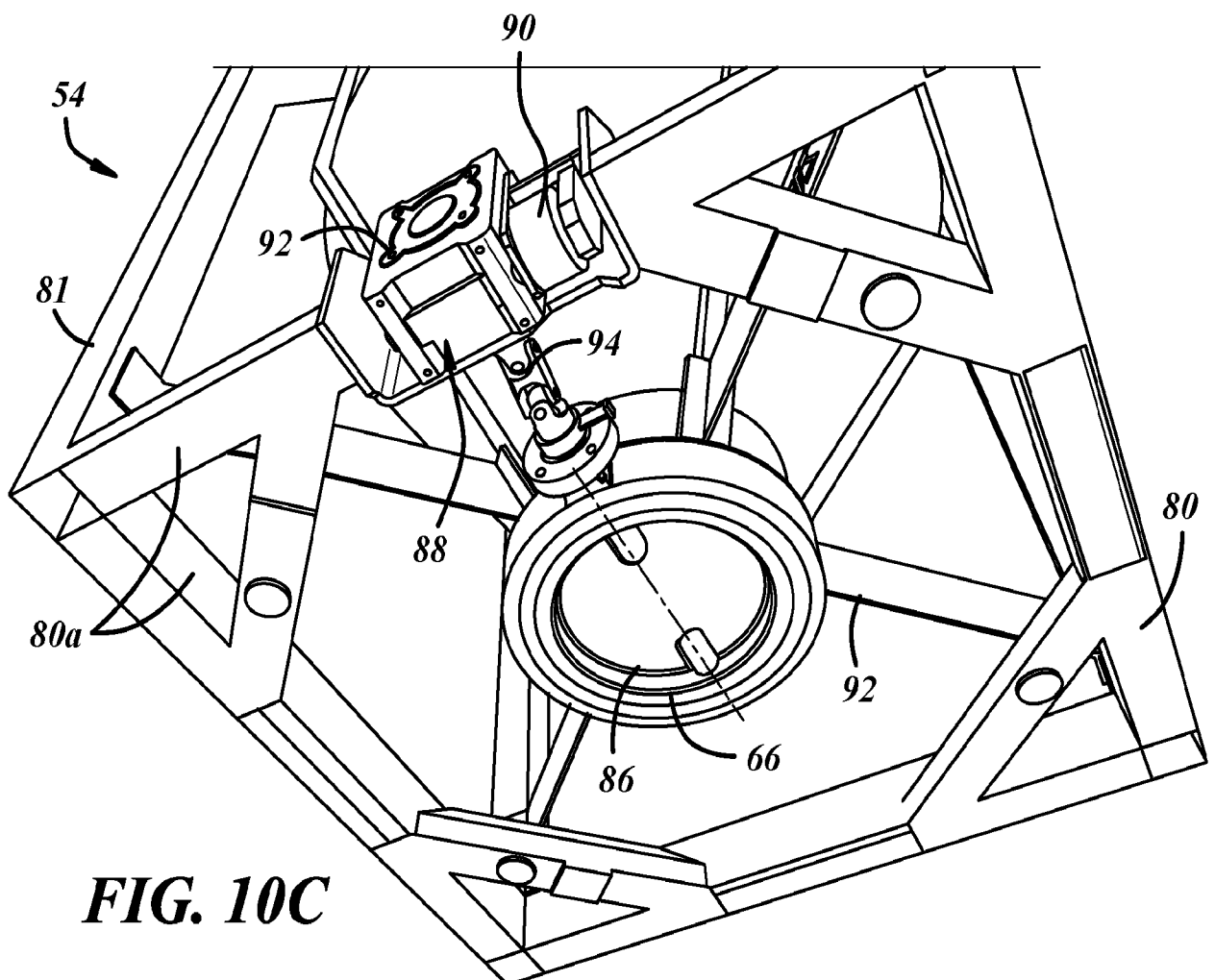
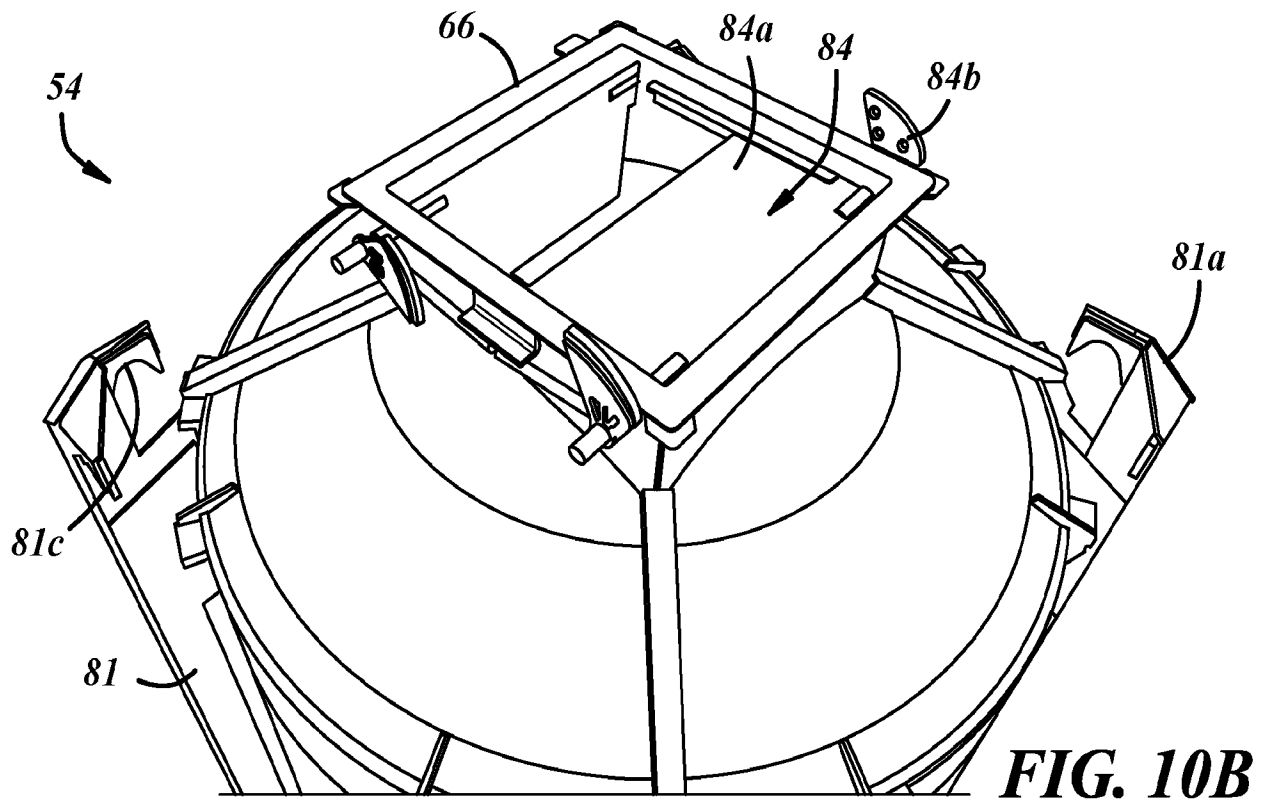
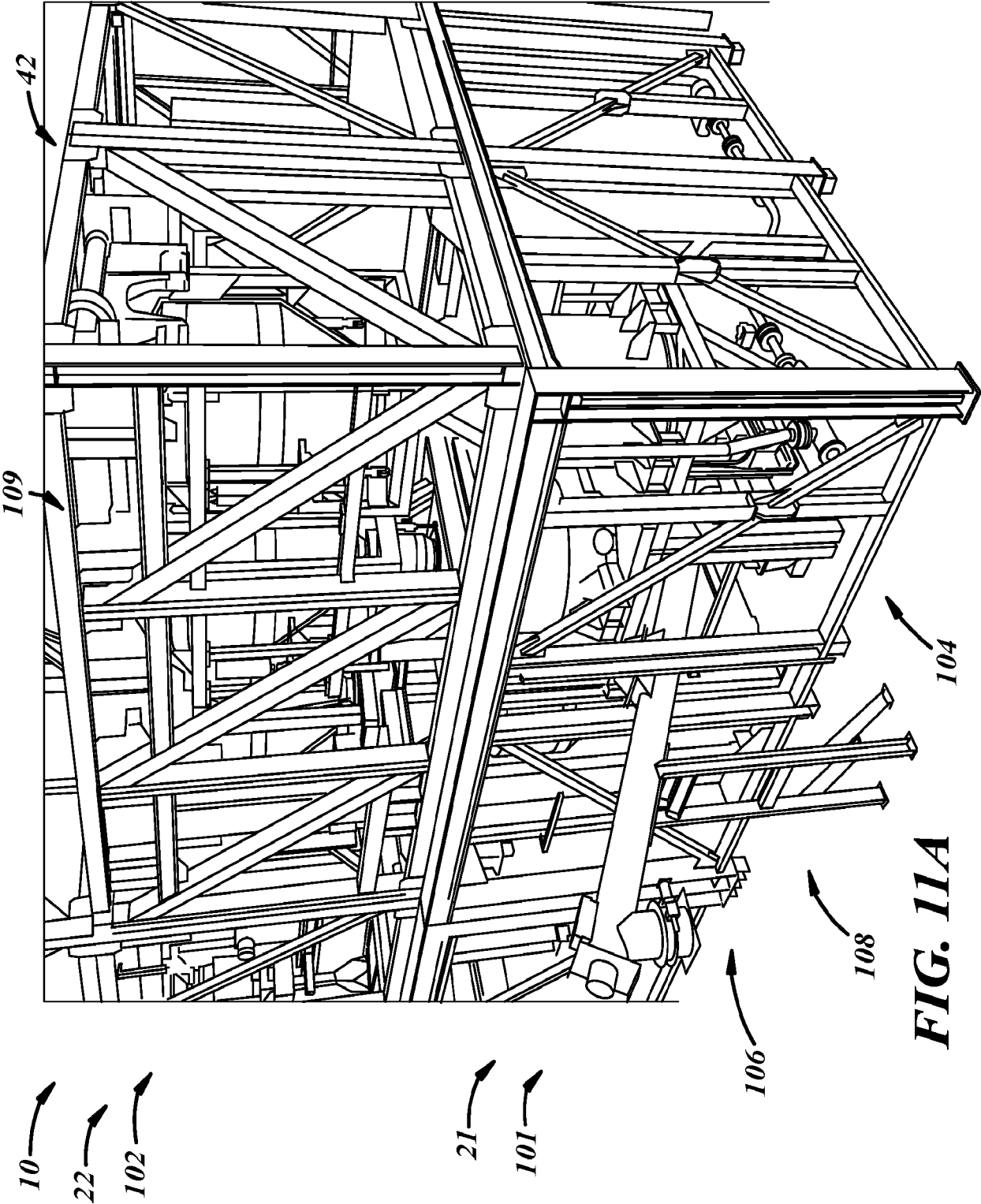
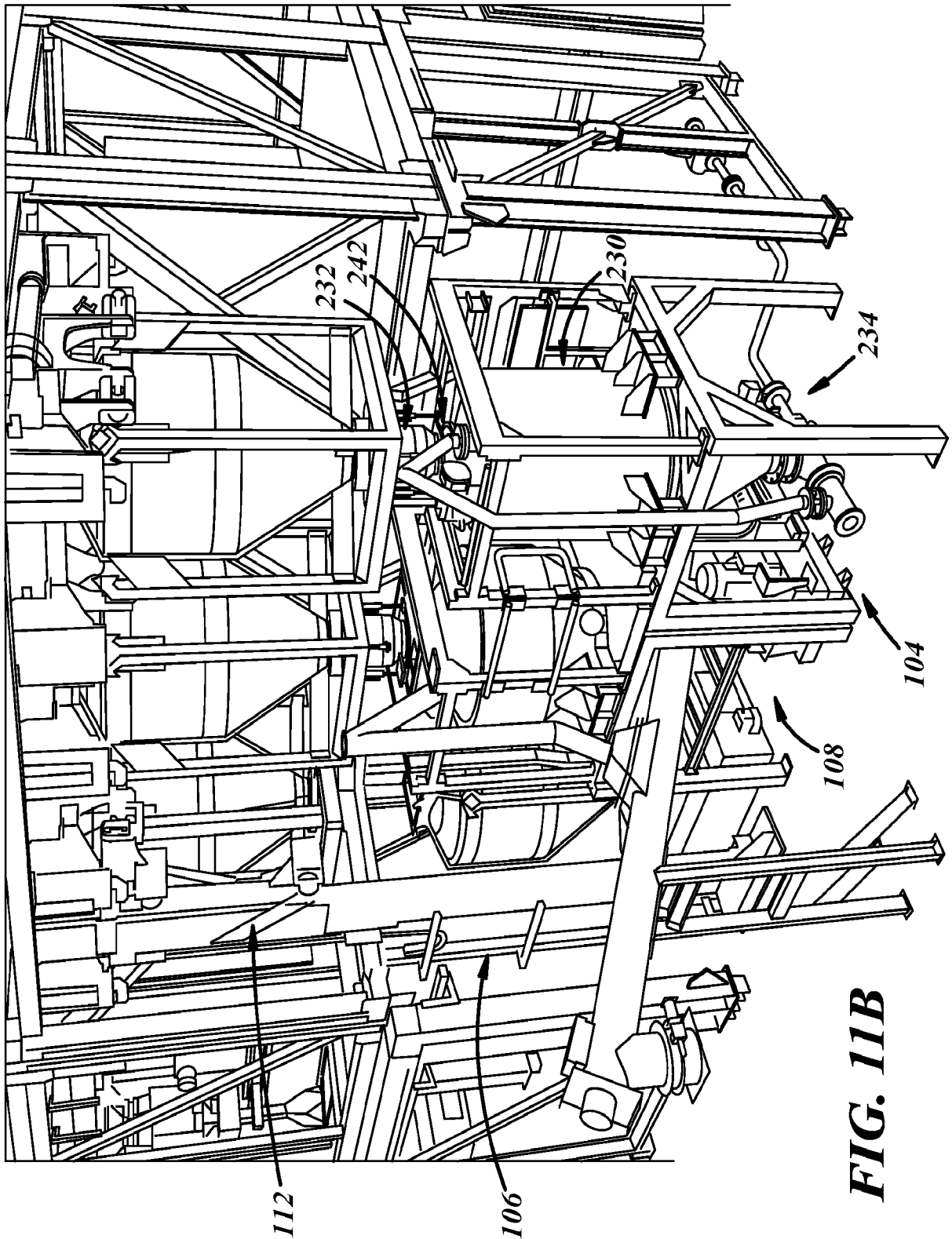


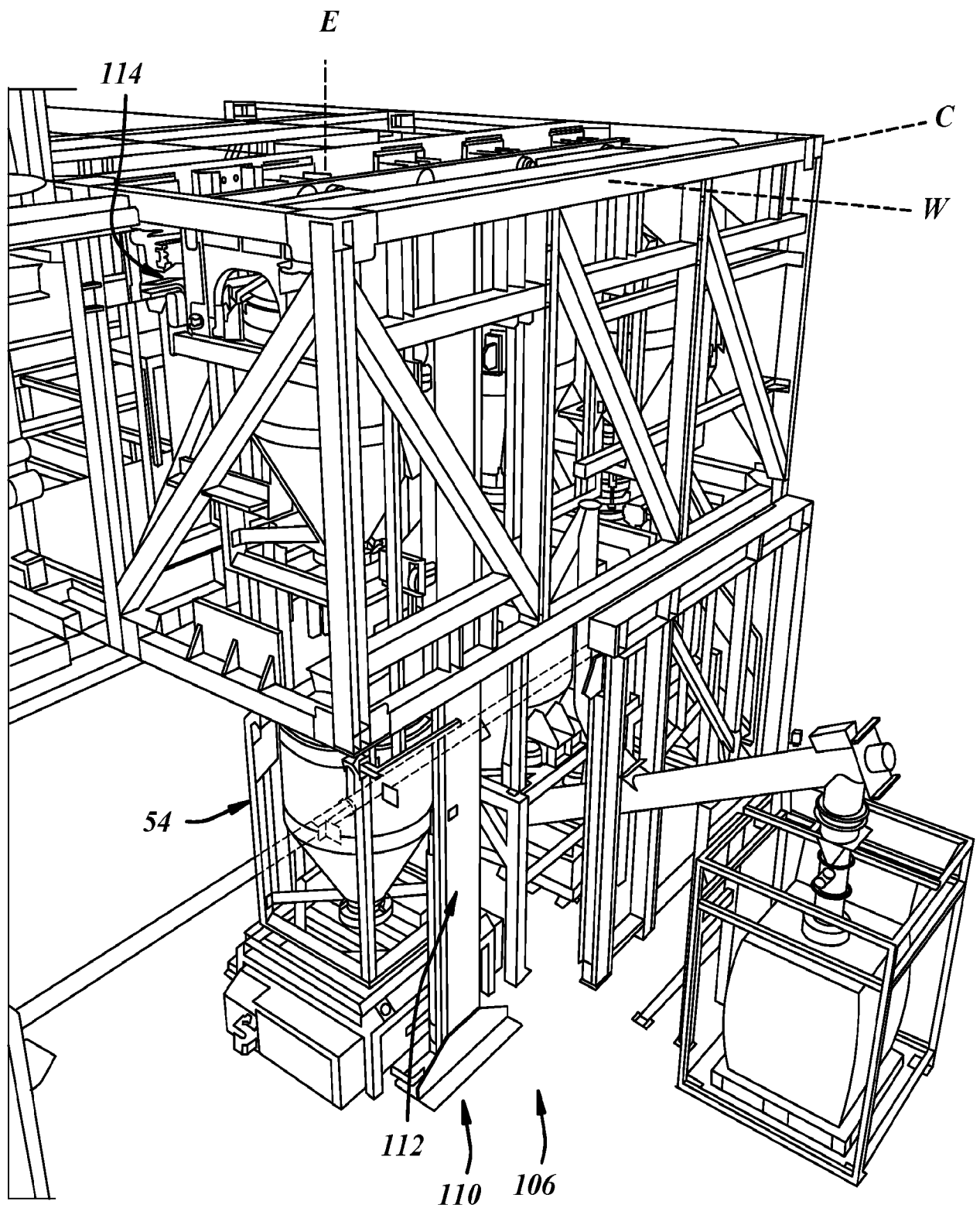
FIG. 9B

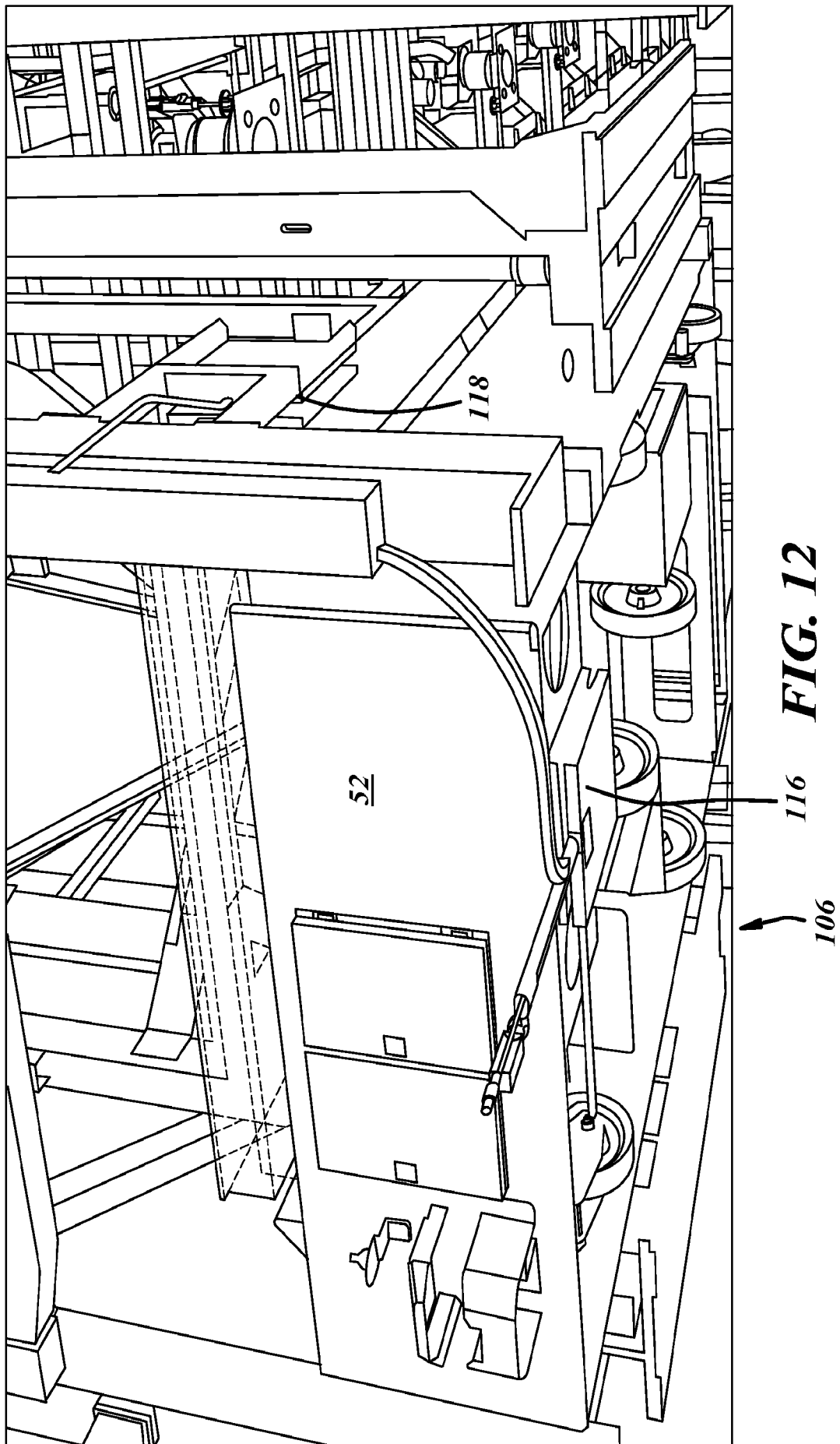
**FIG. 10A**

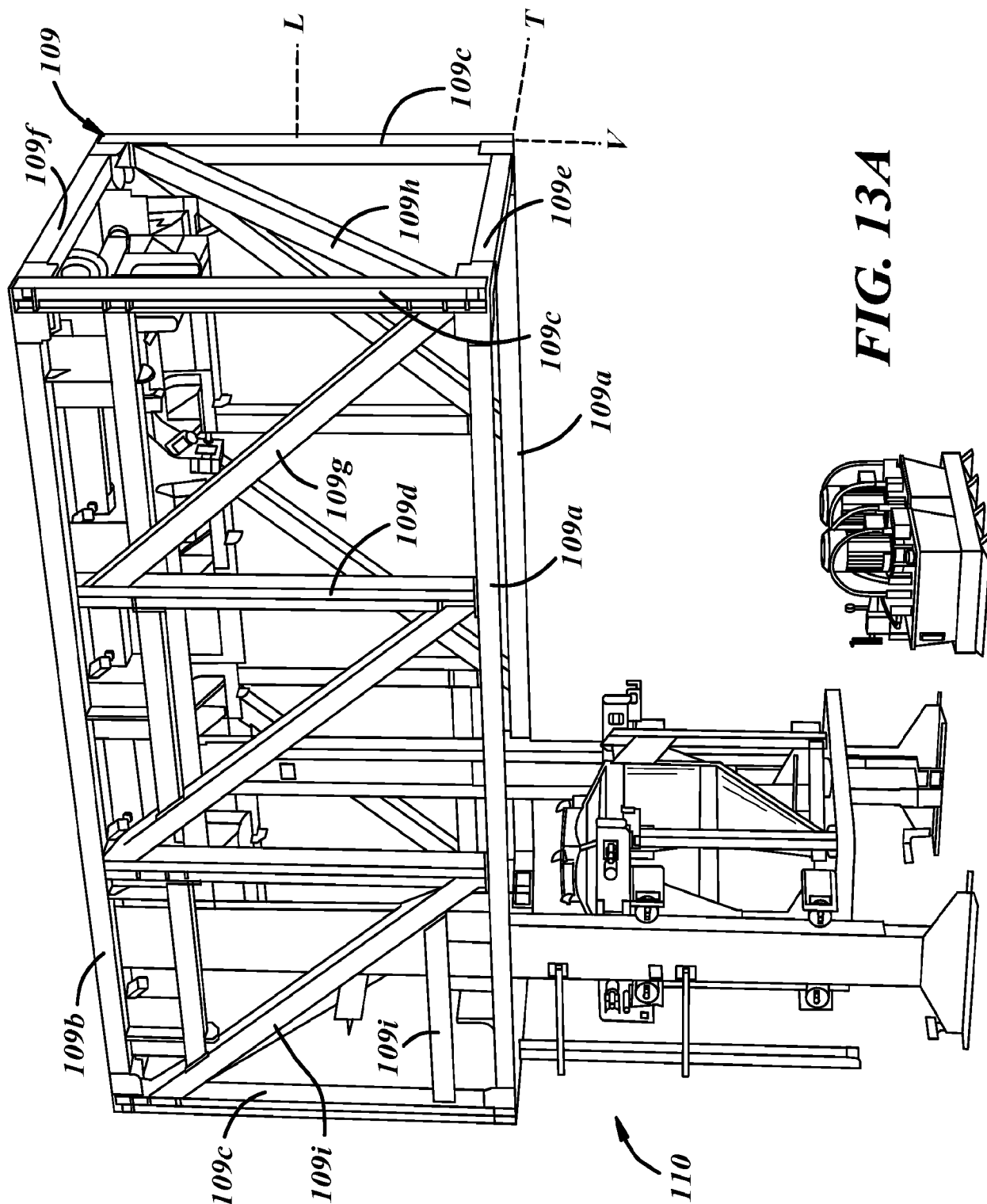


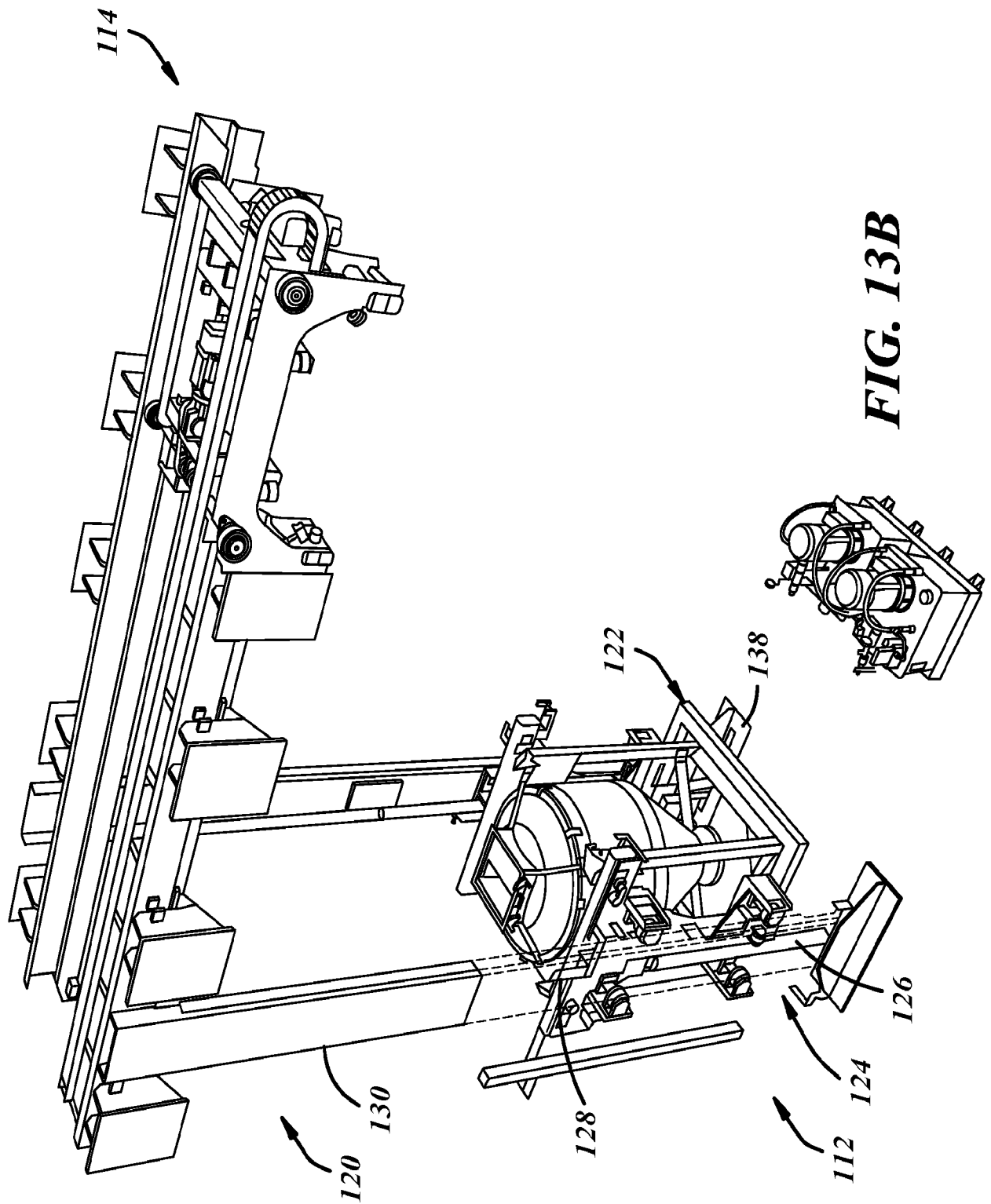


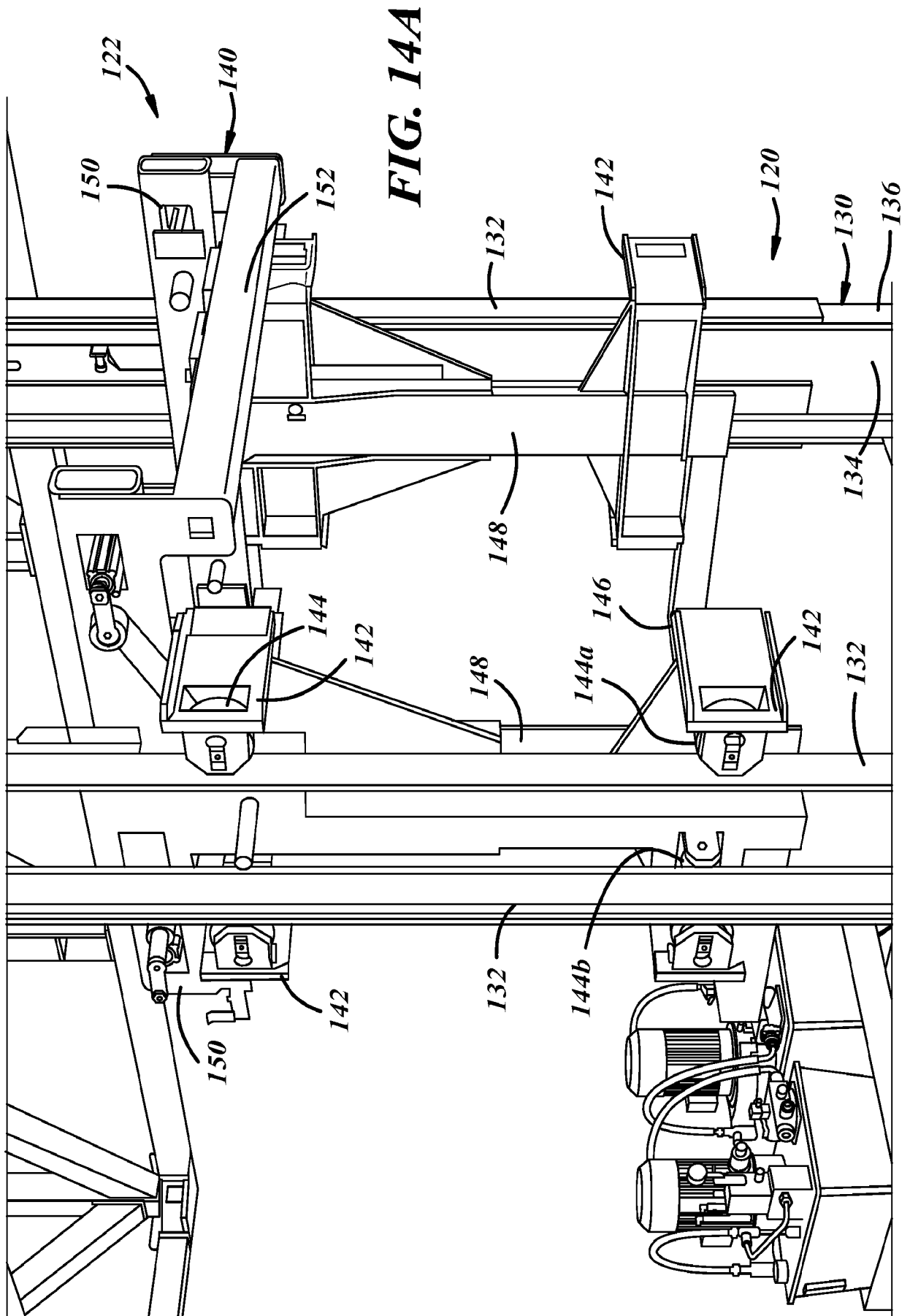


**FIG. 11C**









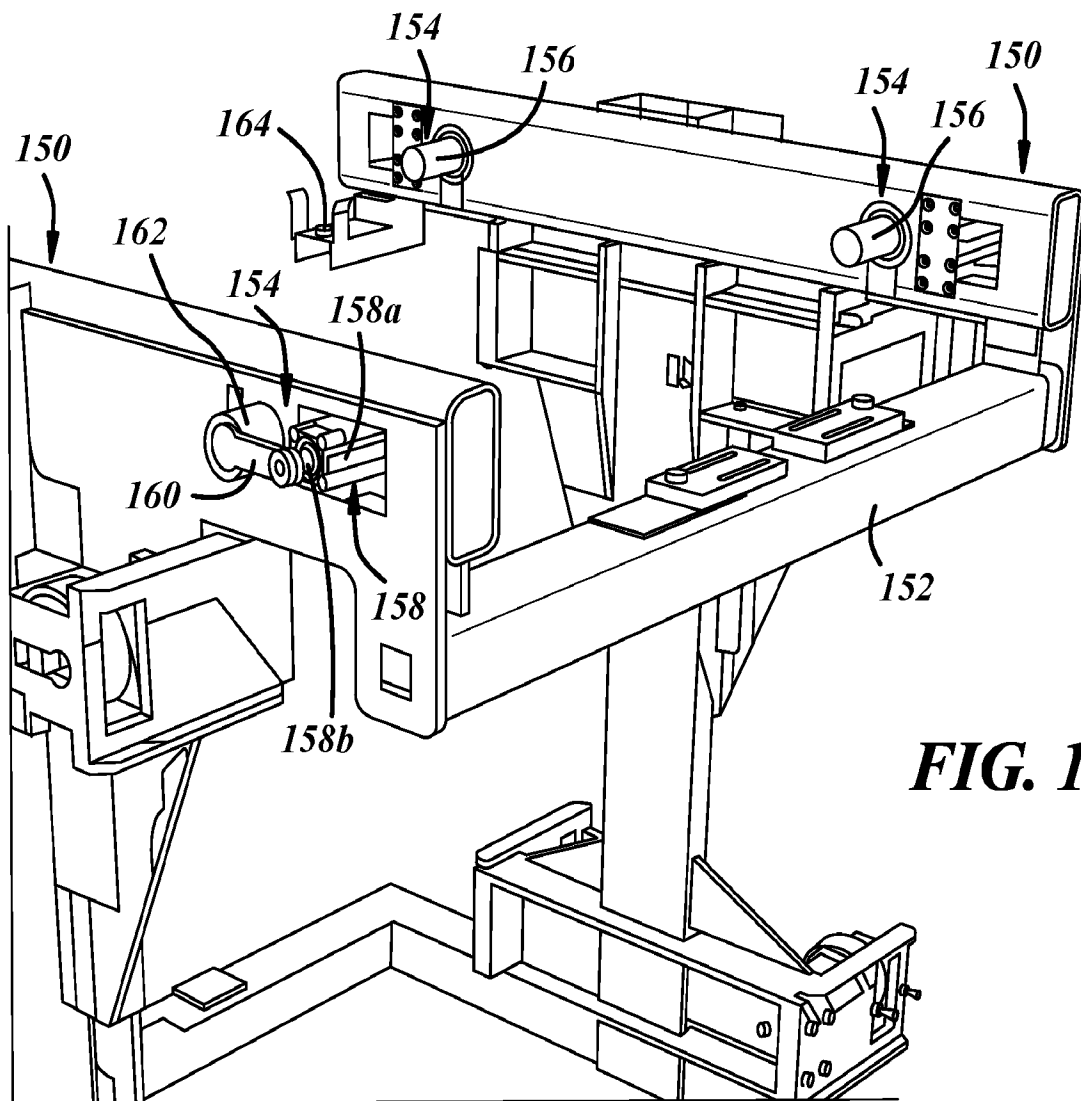


FIG. 14B

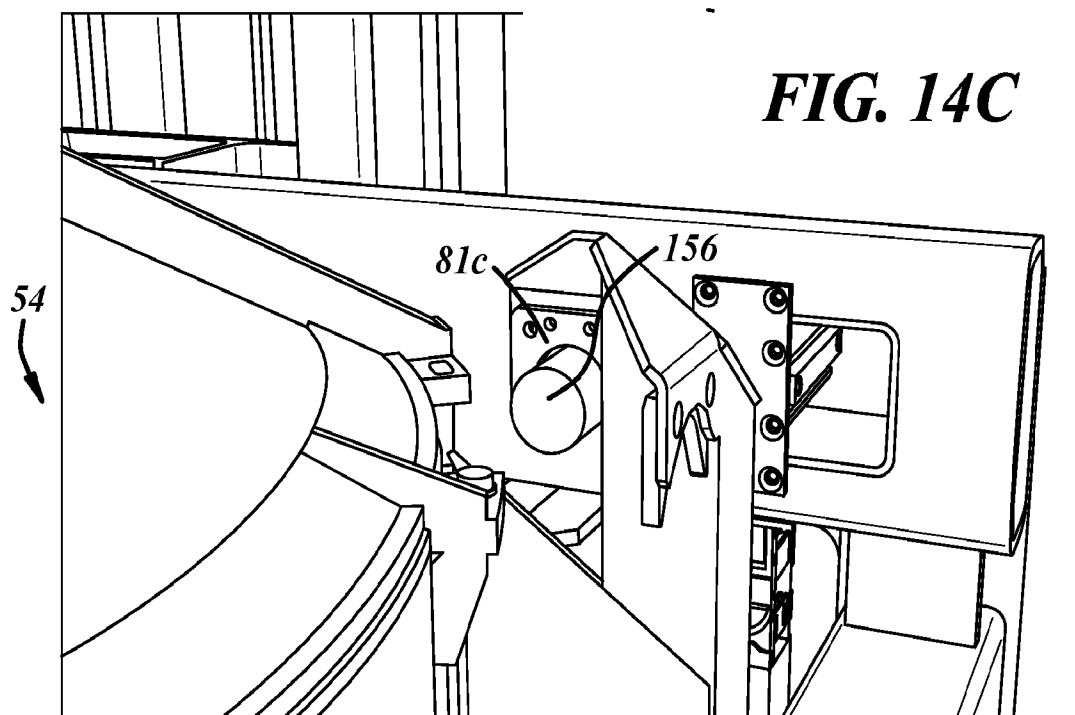


FIG. 14C

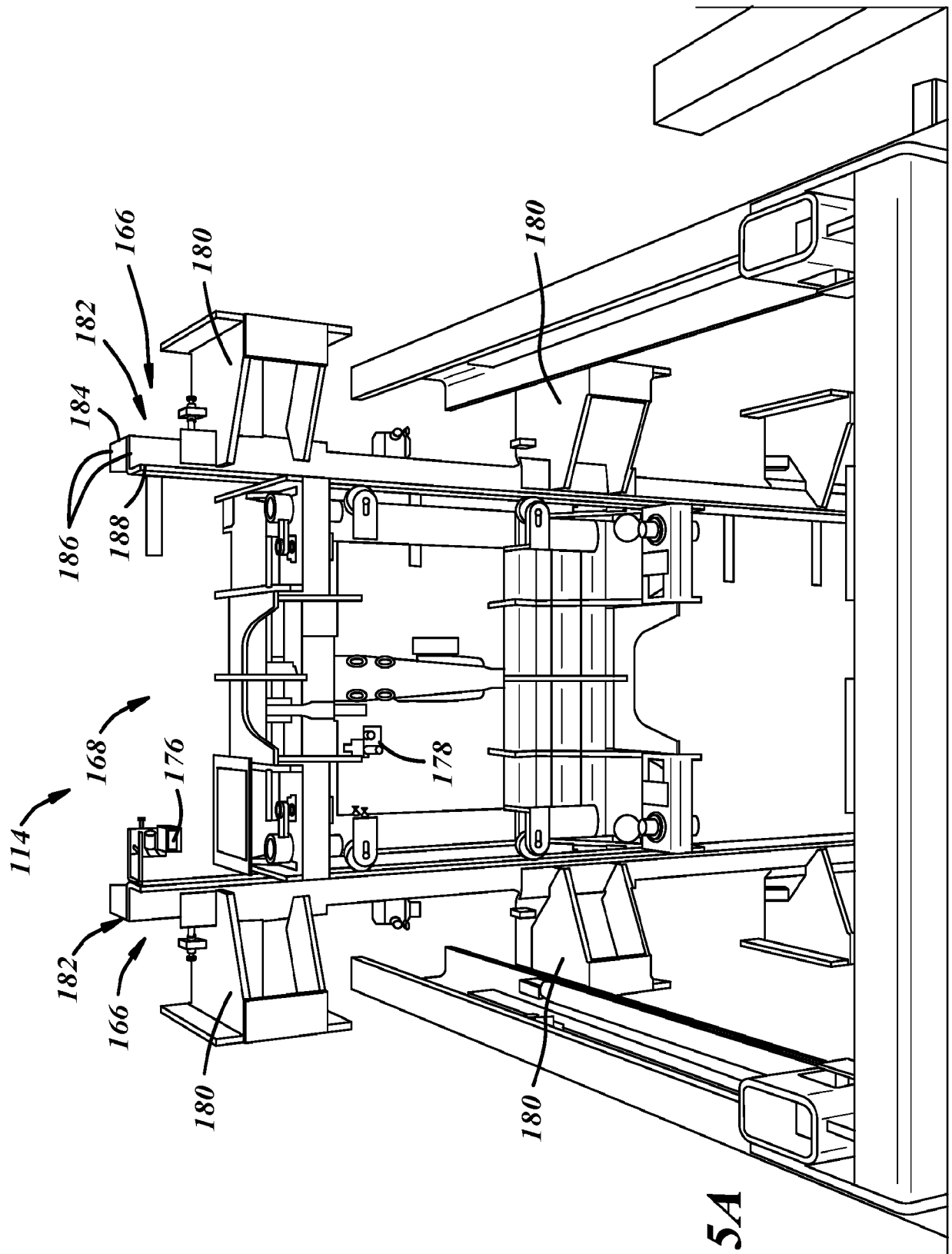


FIG. 15A

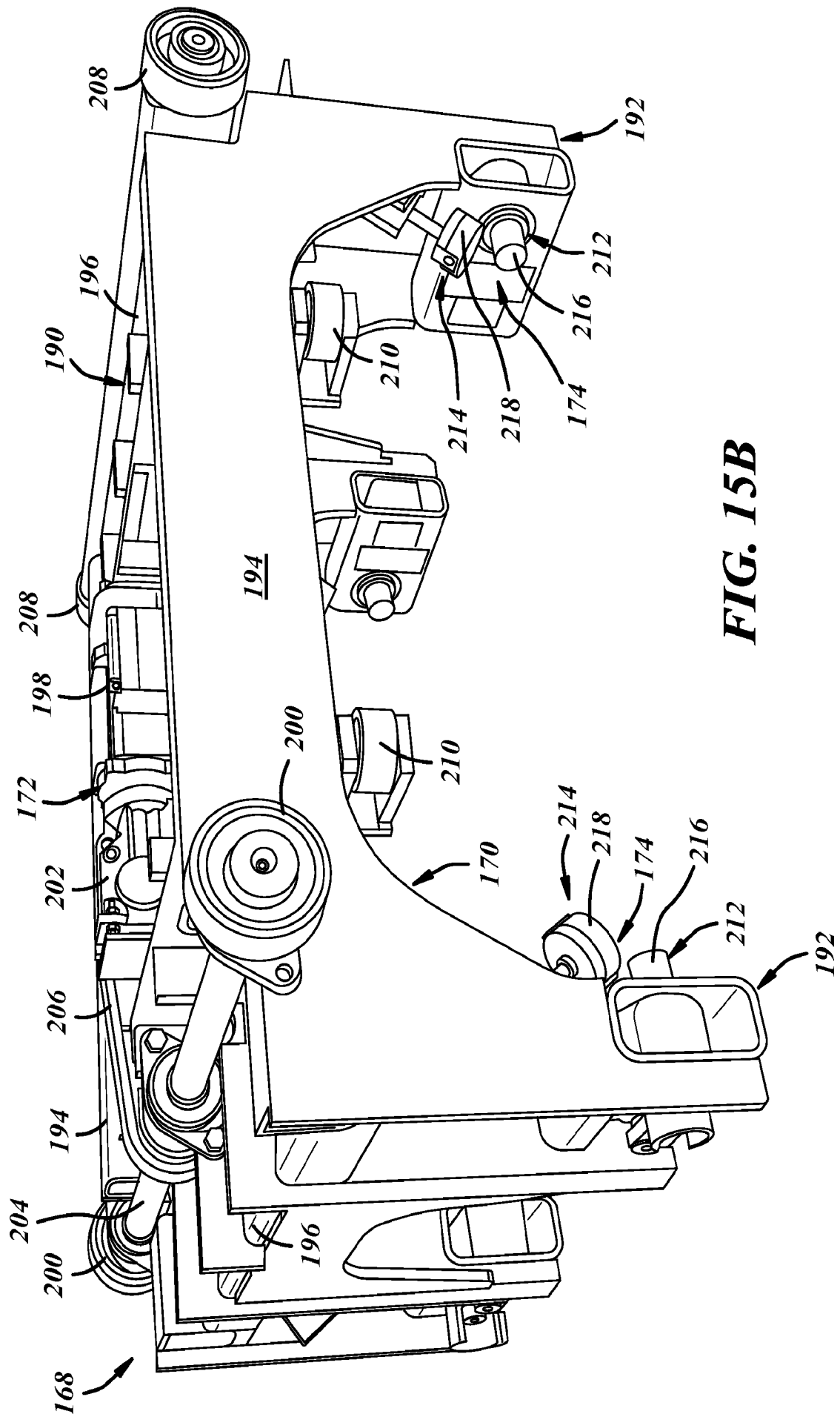


FIG. 15B

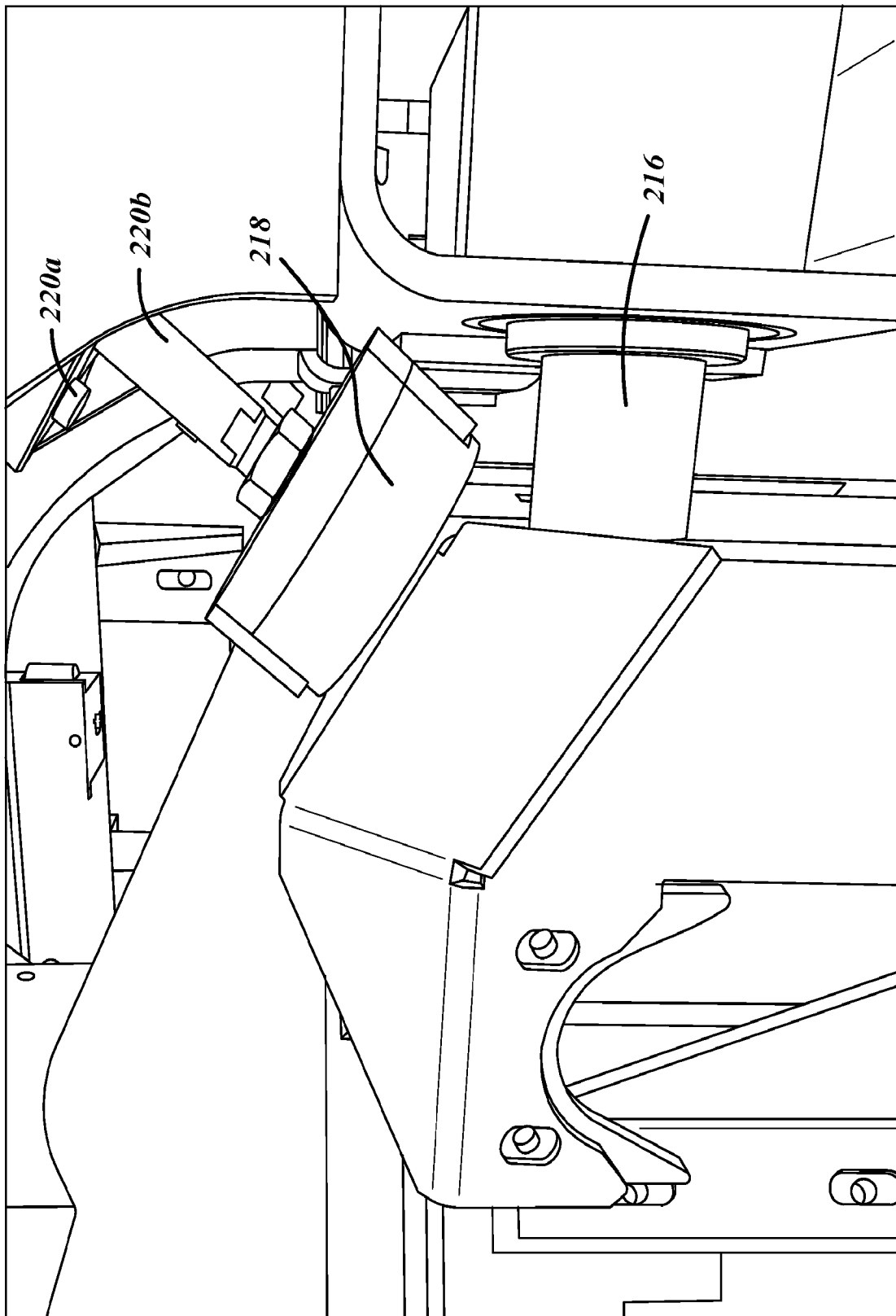


FIG. 15C

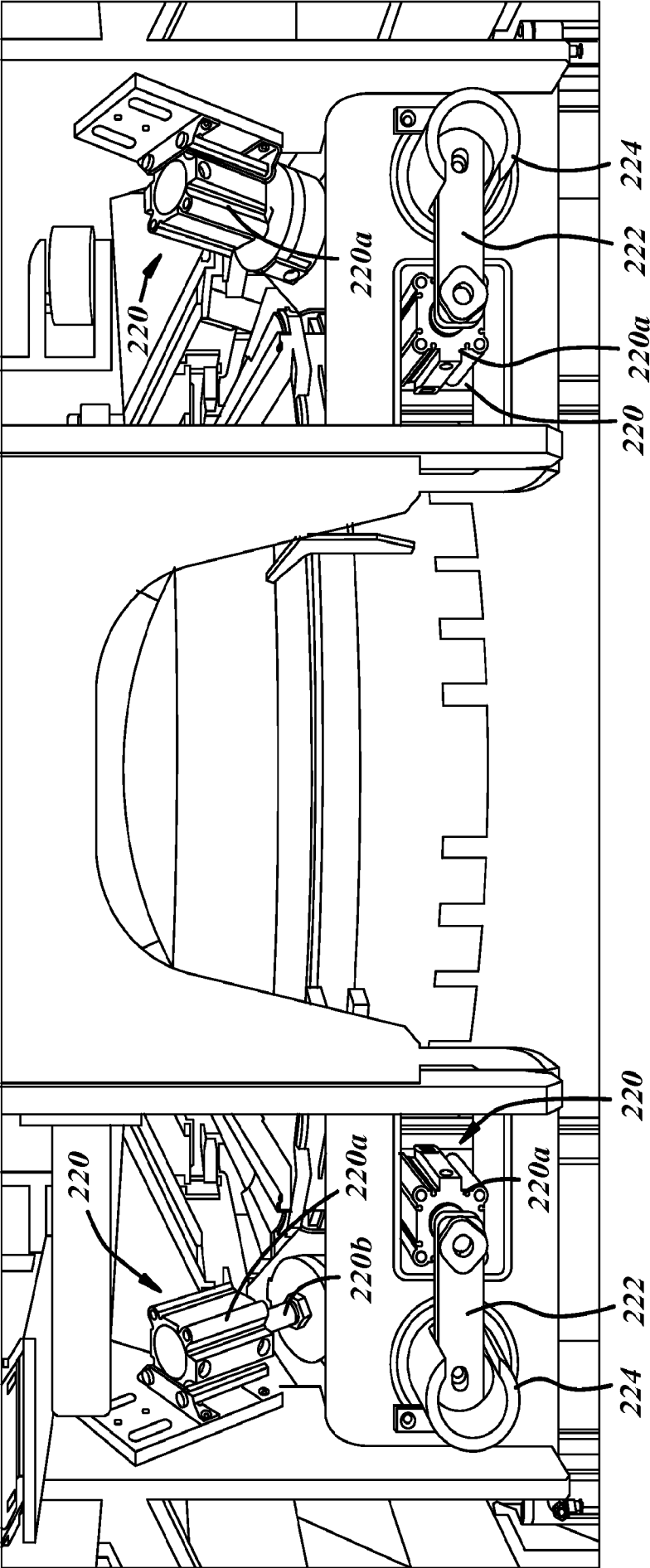


FIG. 15D

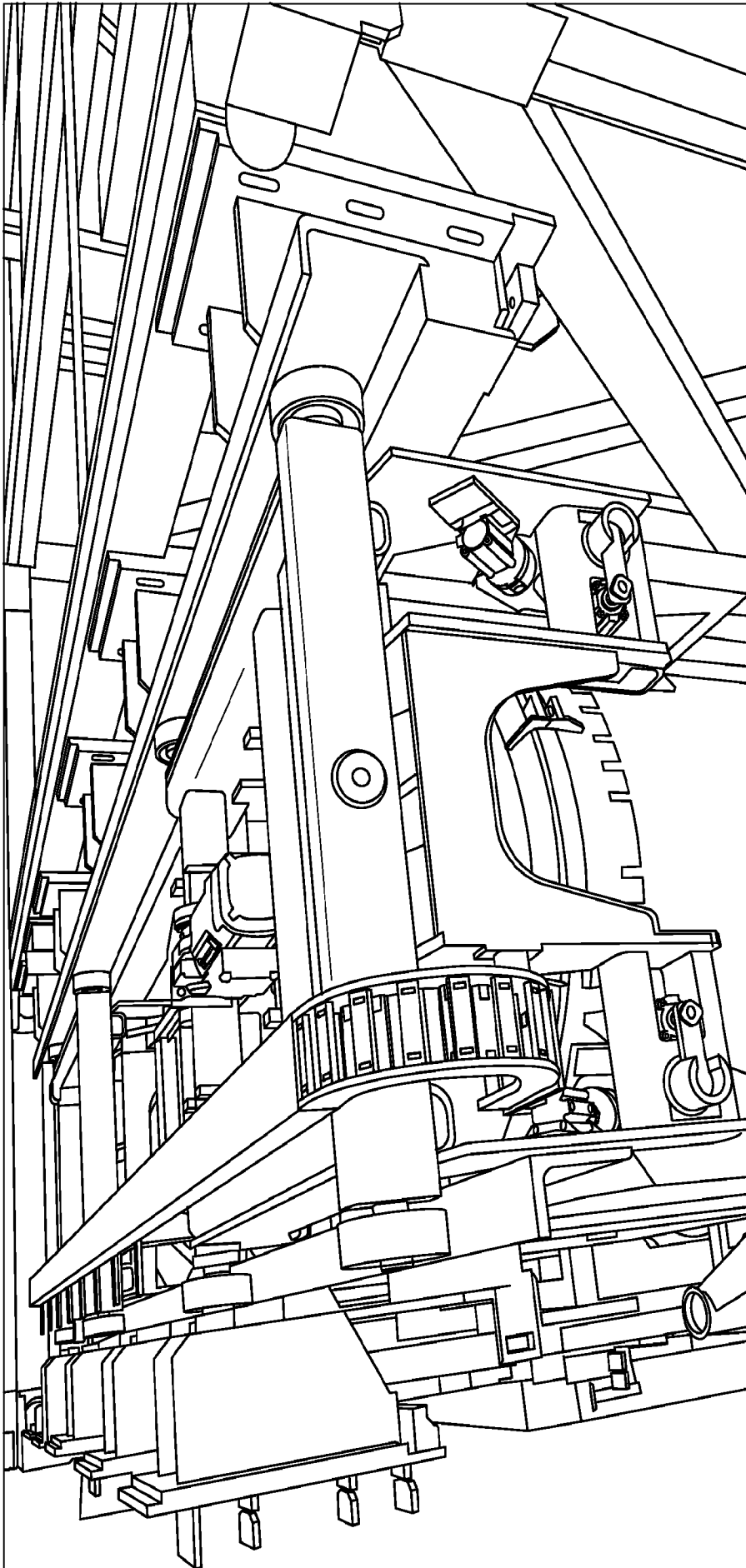
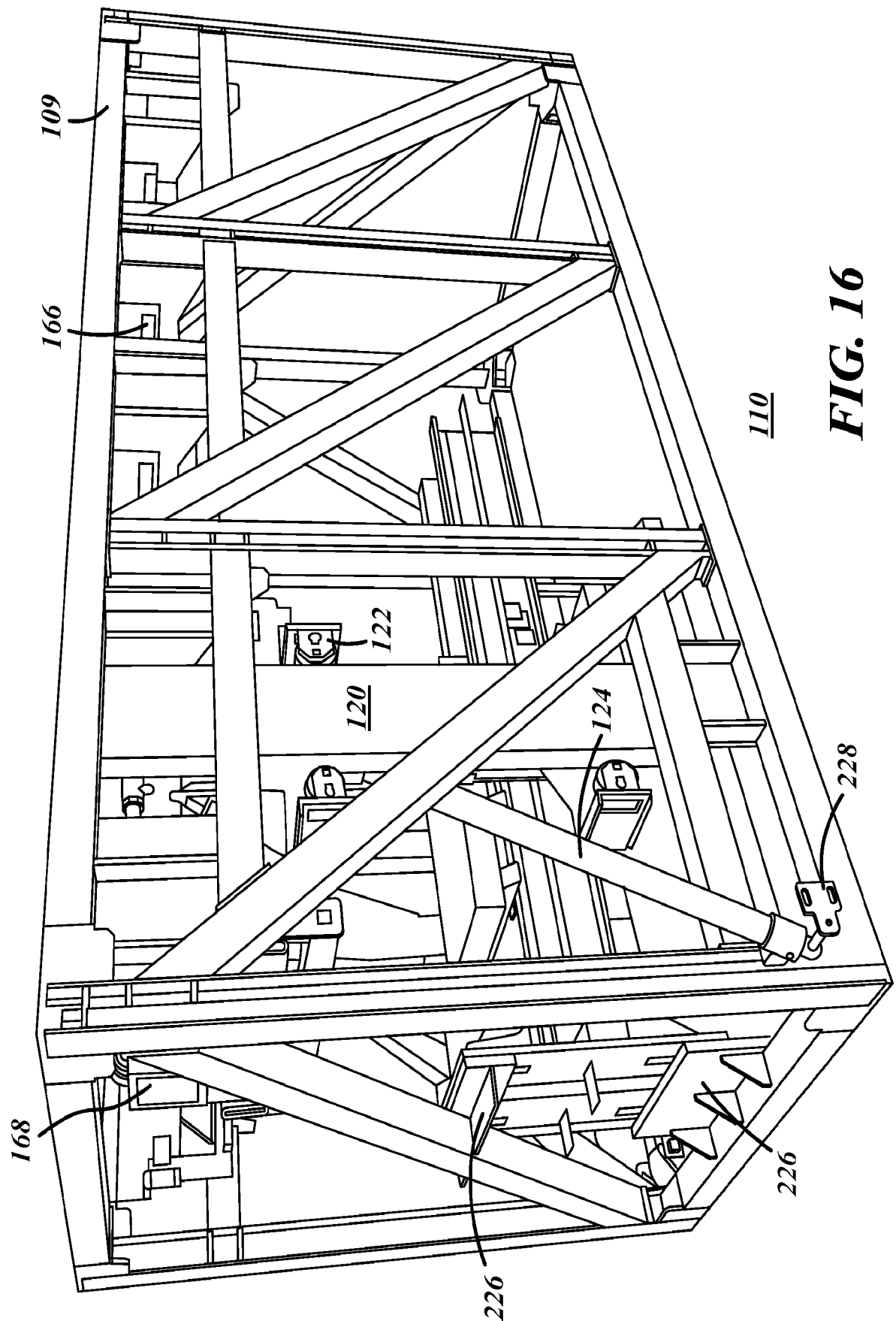
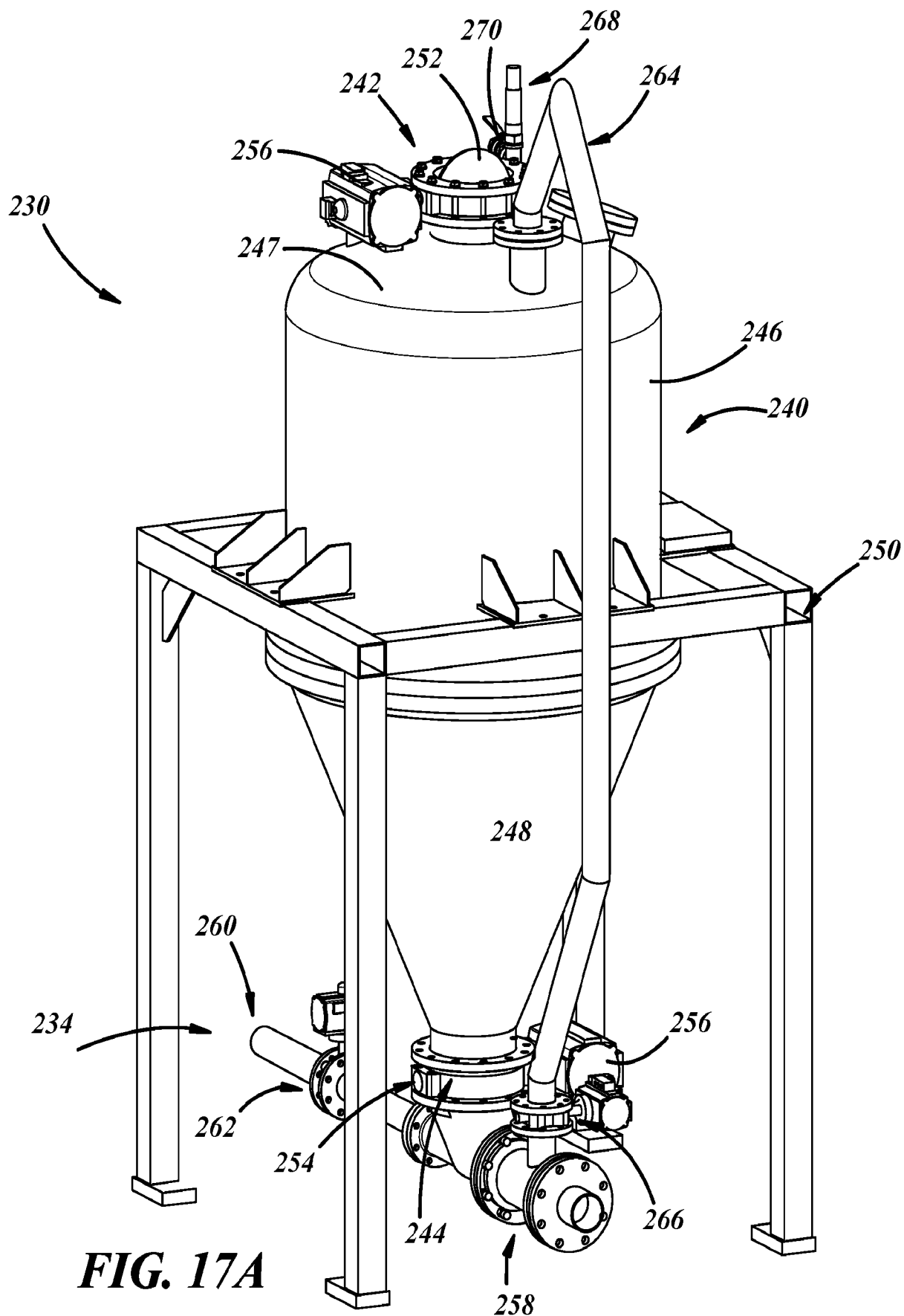


FIG. 15E





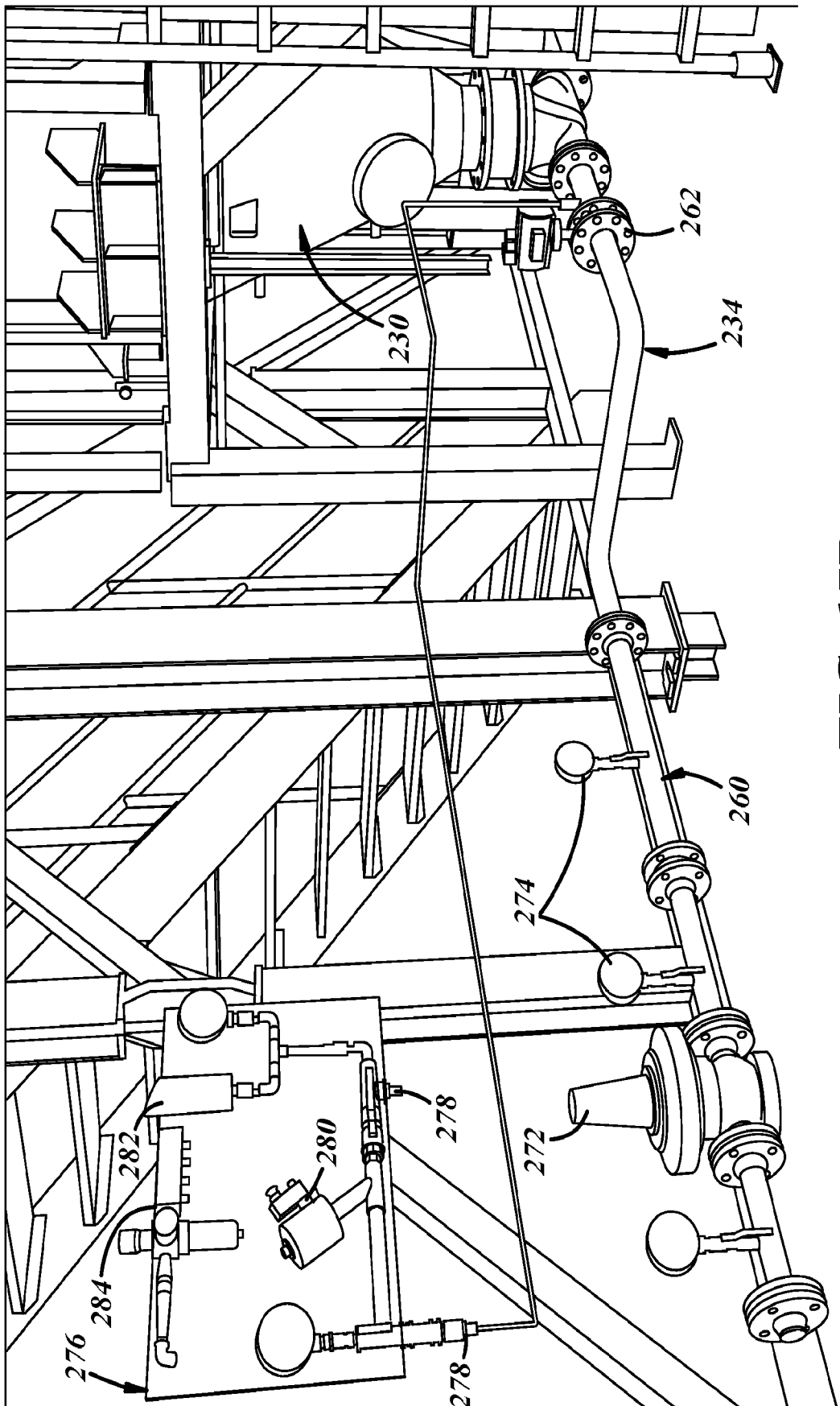


FIG. 17B

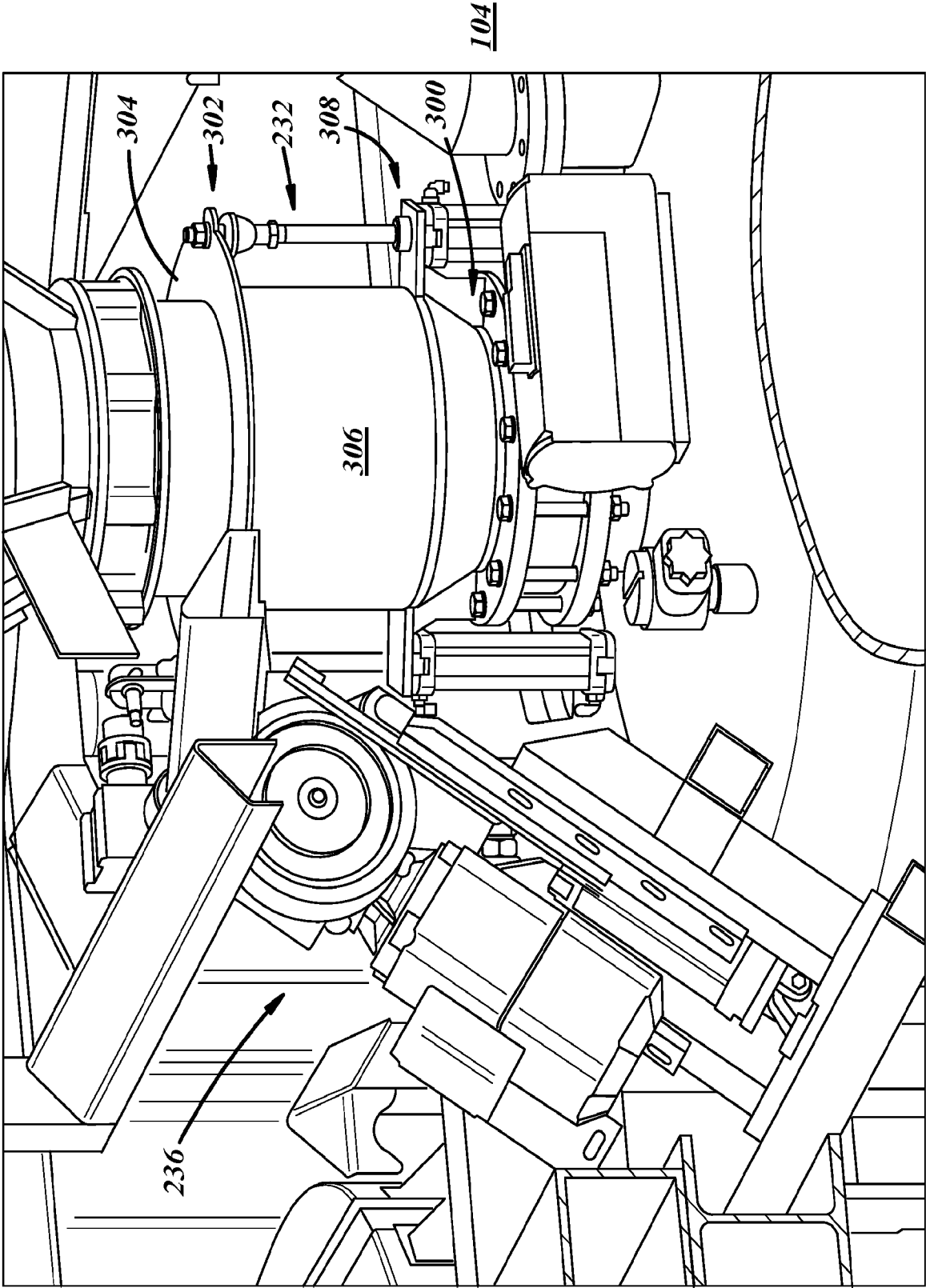


FIG. 18A

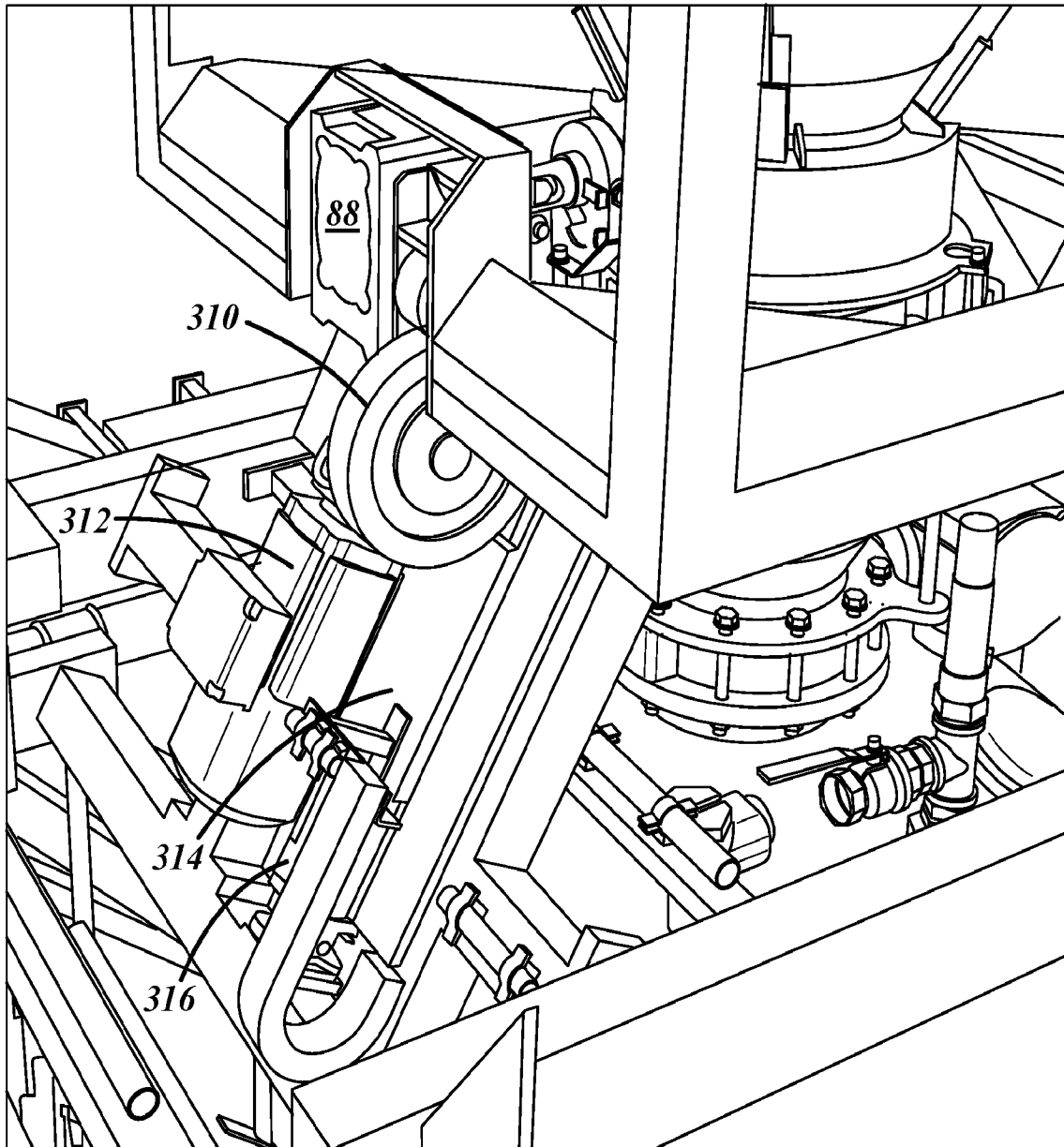
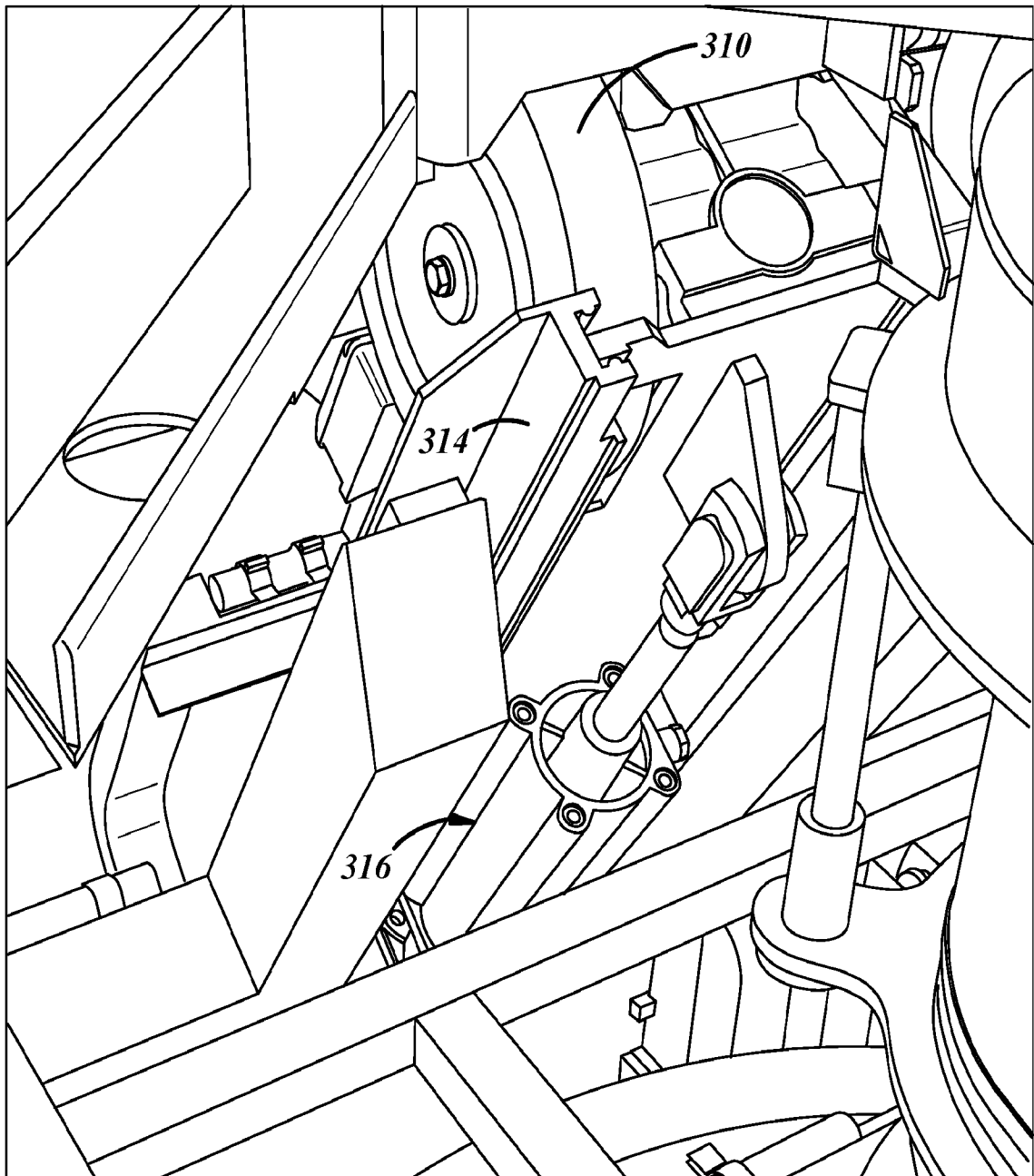


FIG. 18B

***FIG. 18C***

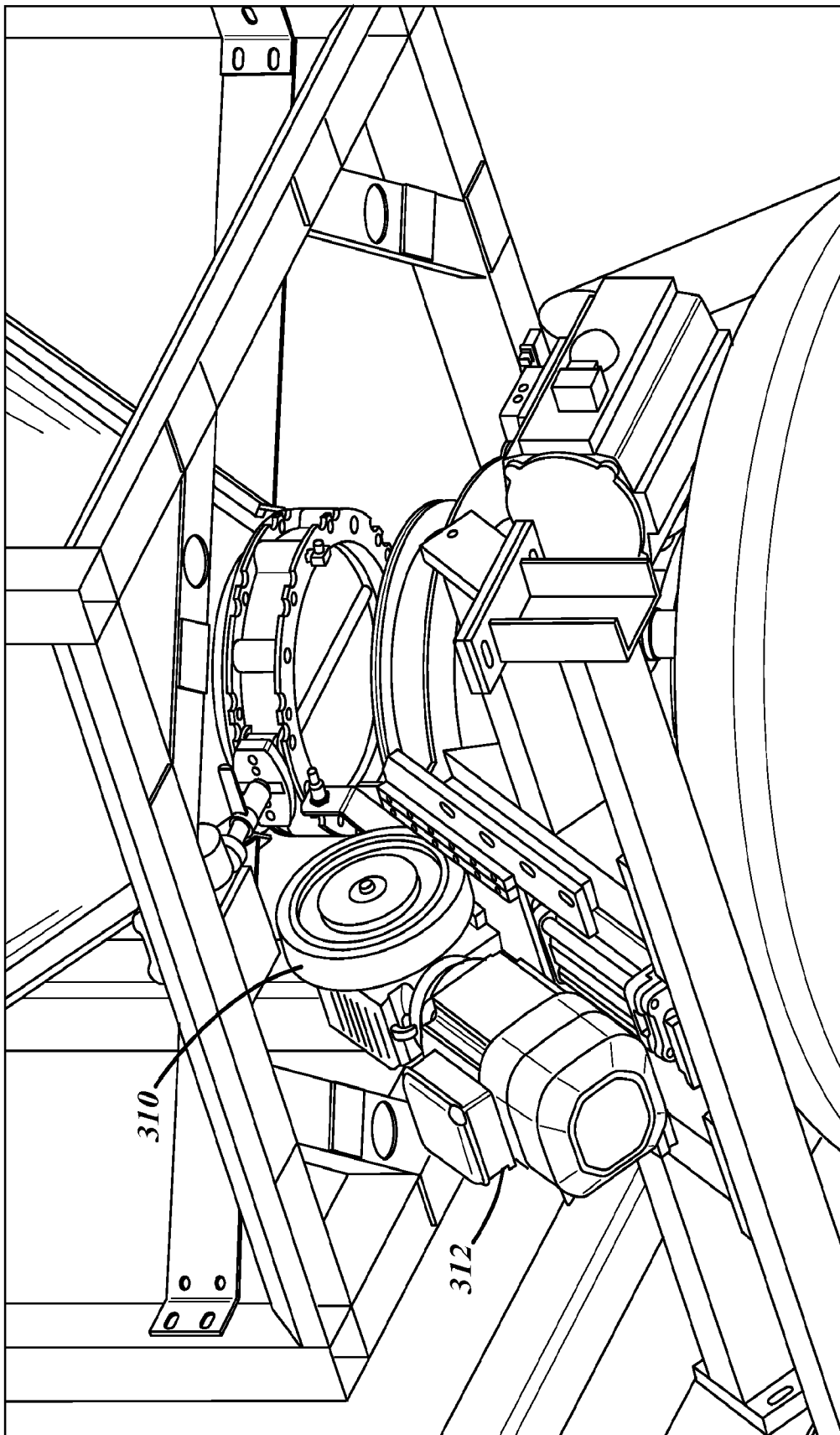


FIG. 18D

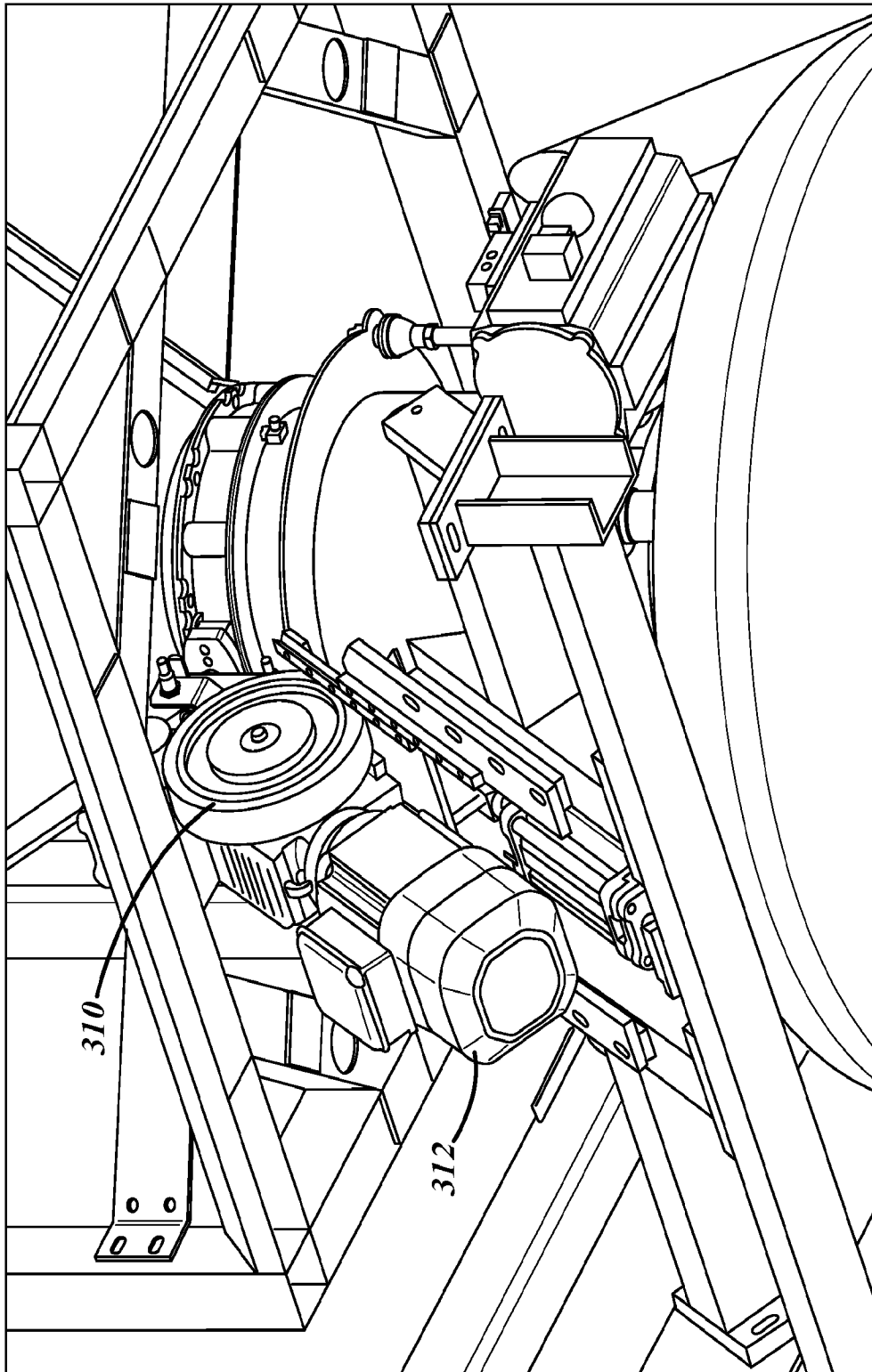


FIG. 18E

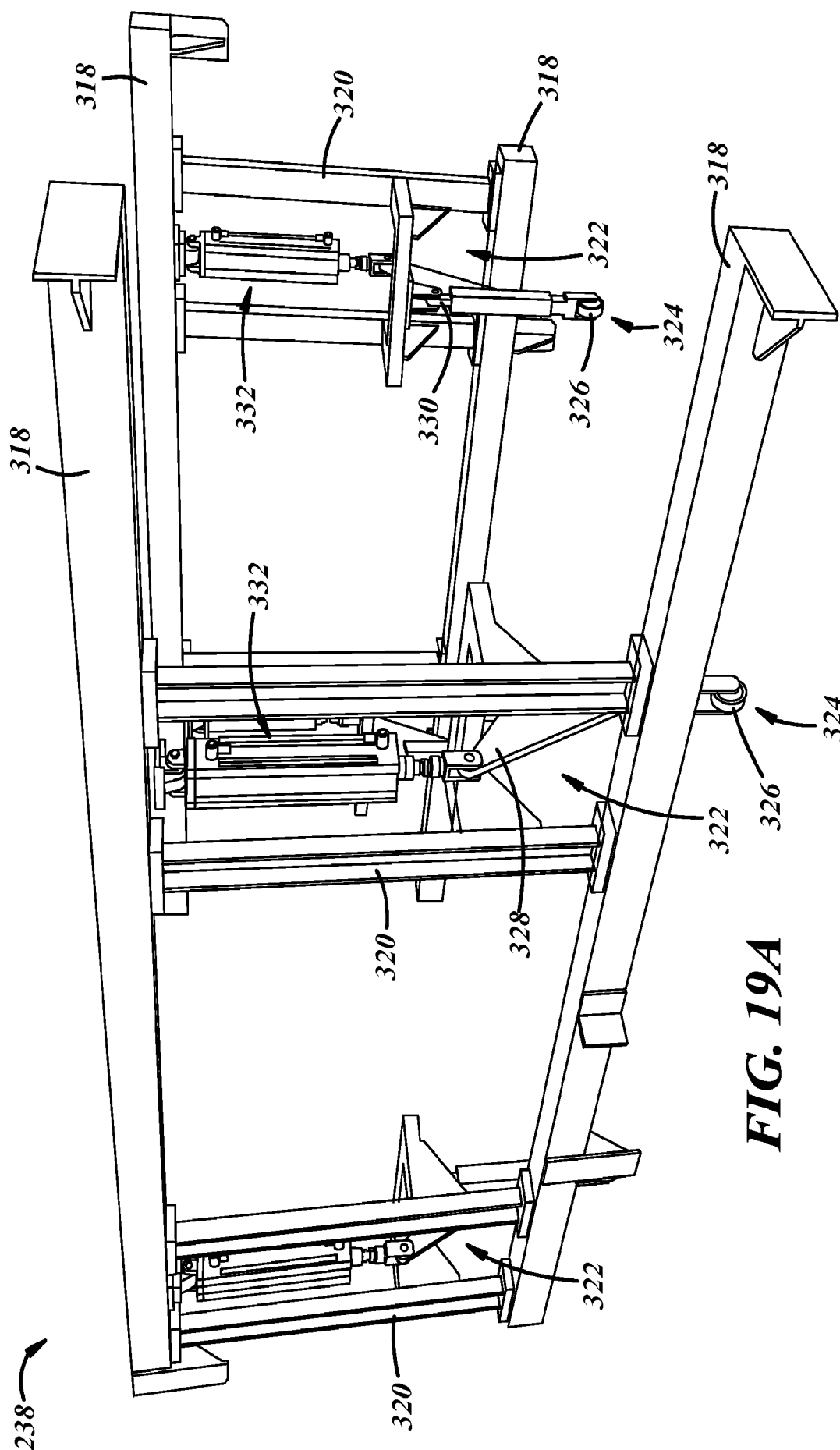


FIG. 19A

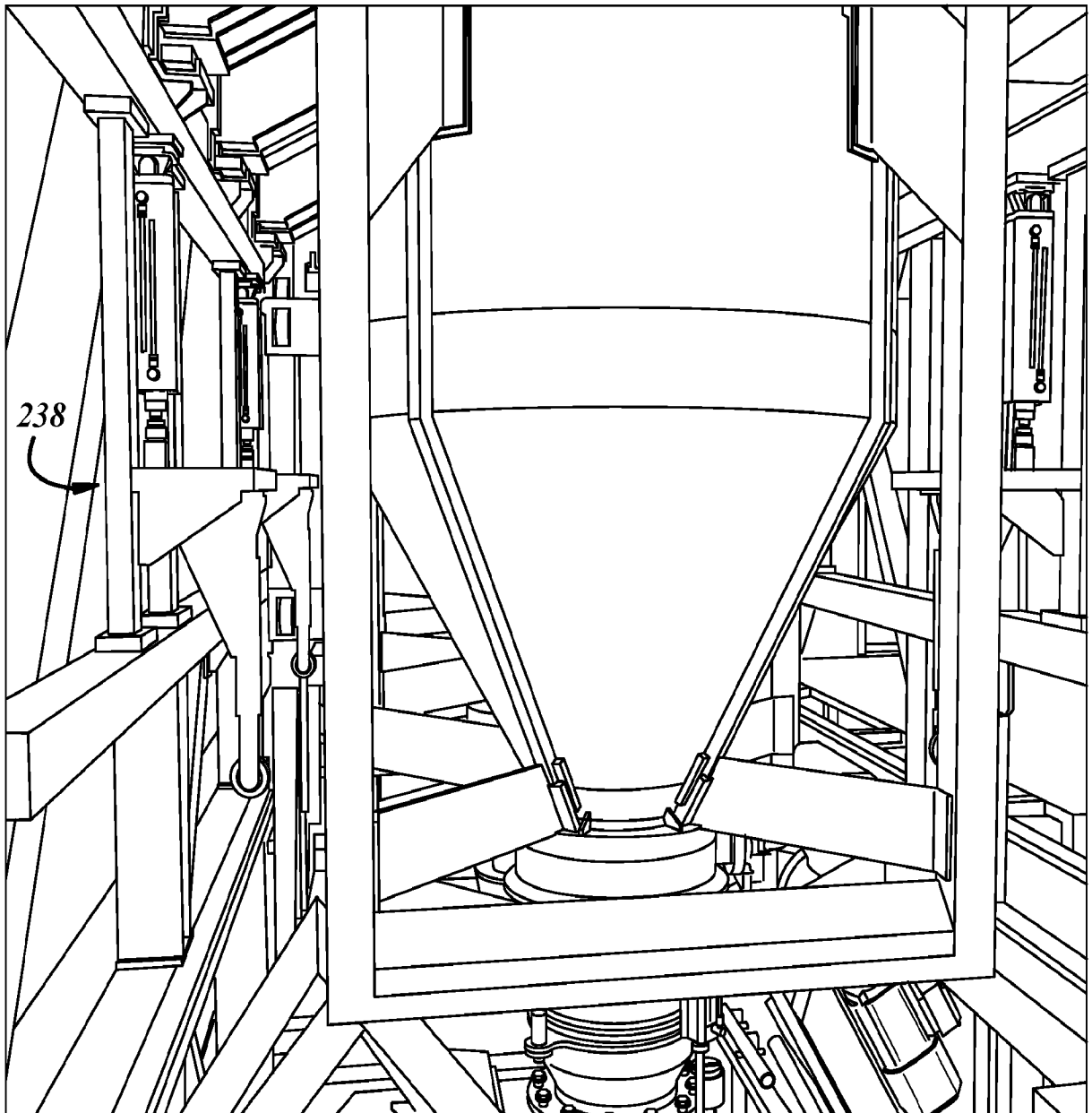


FIG. 19B

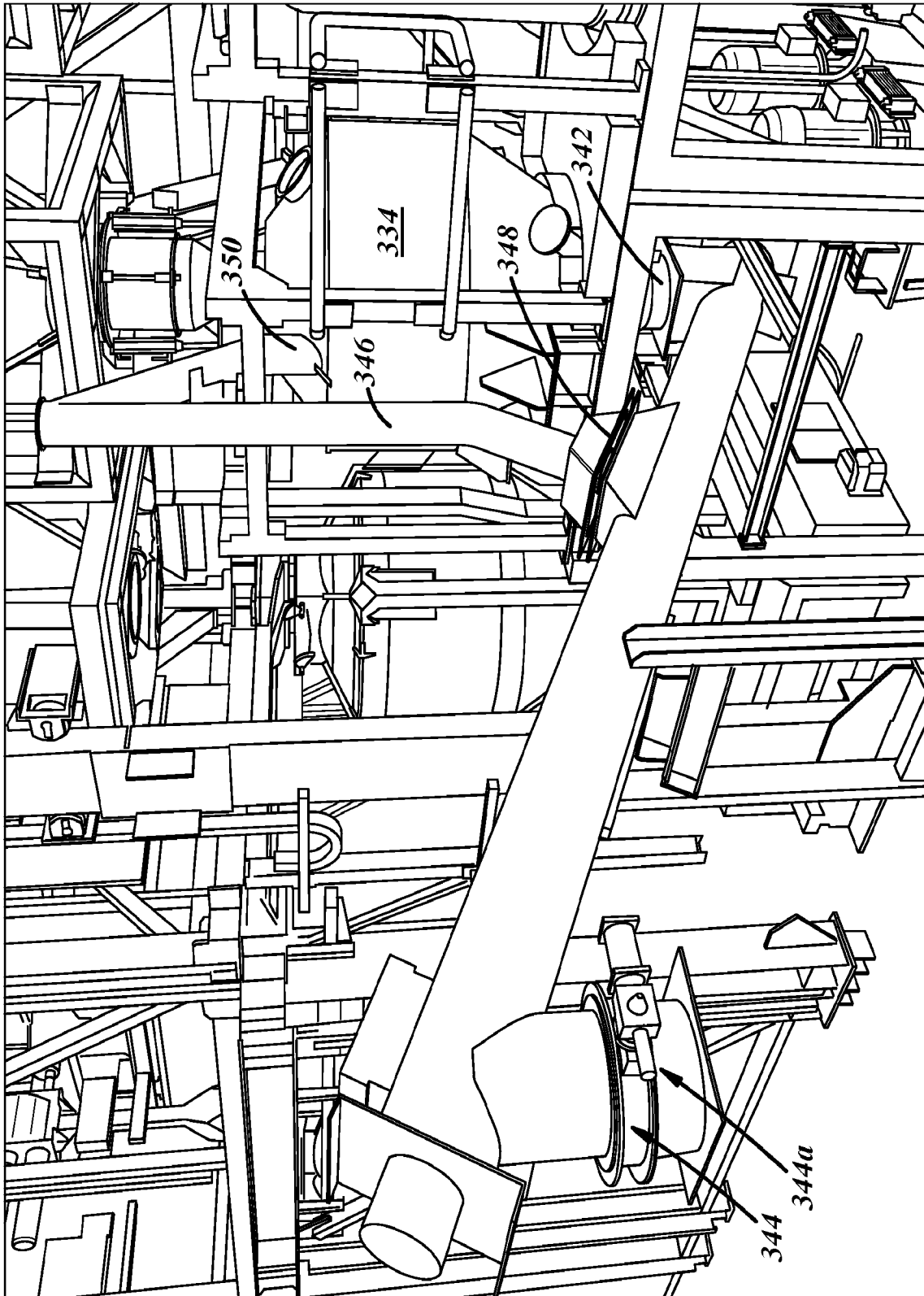
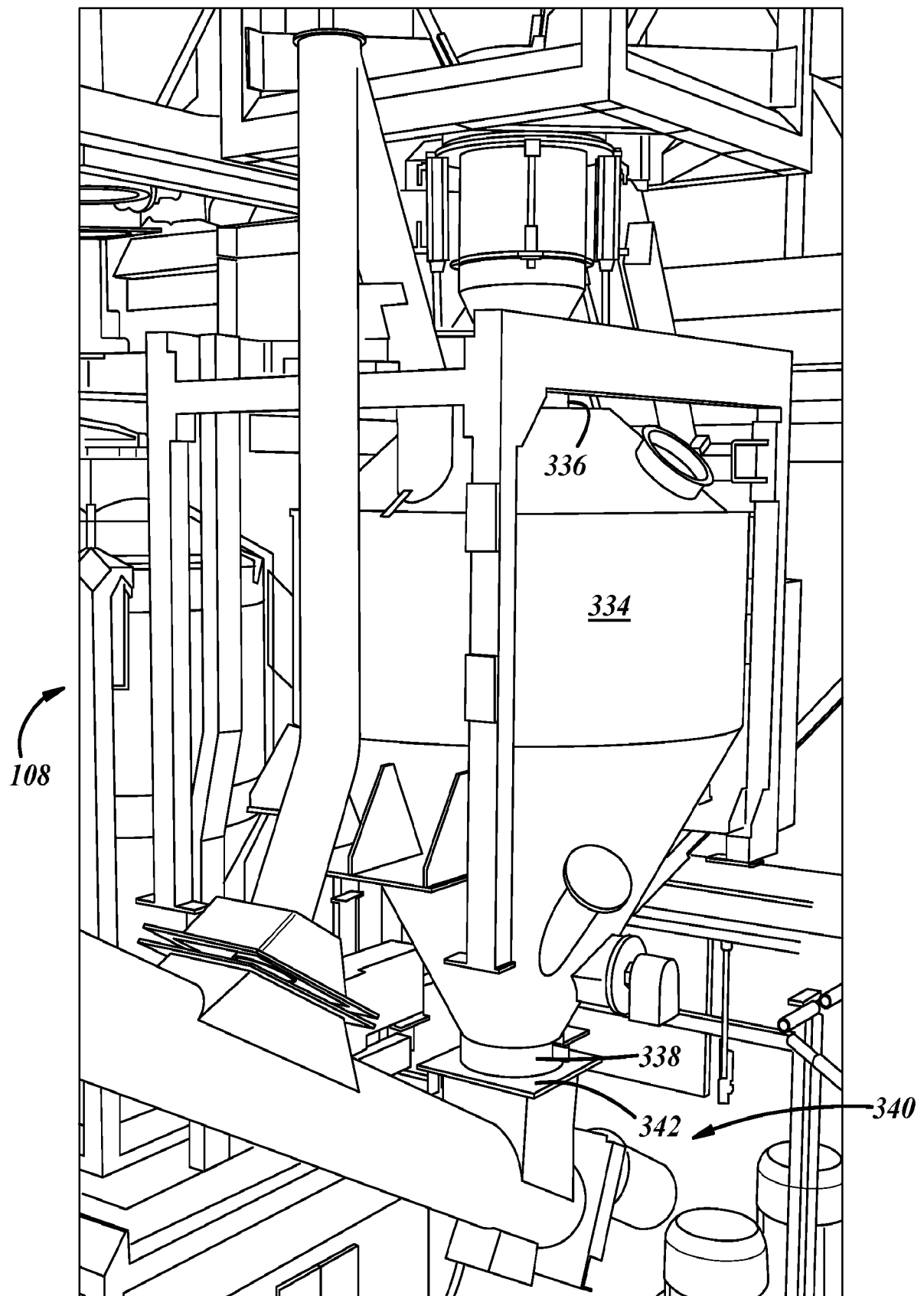


FIG. 20A

**FIG. 20B**

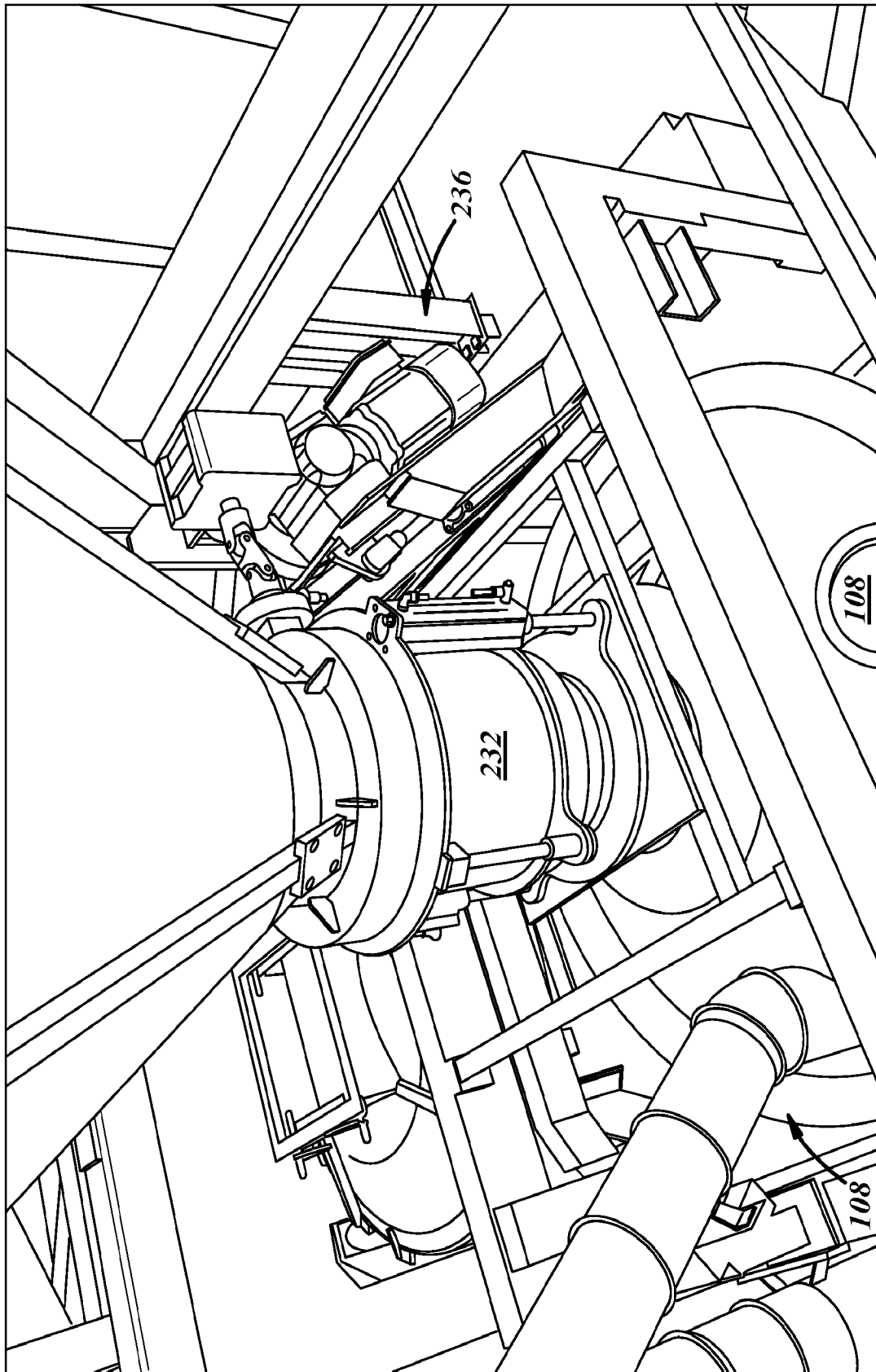


FIG. 20C

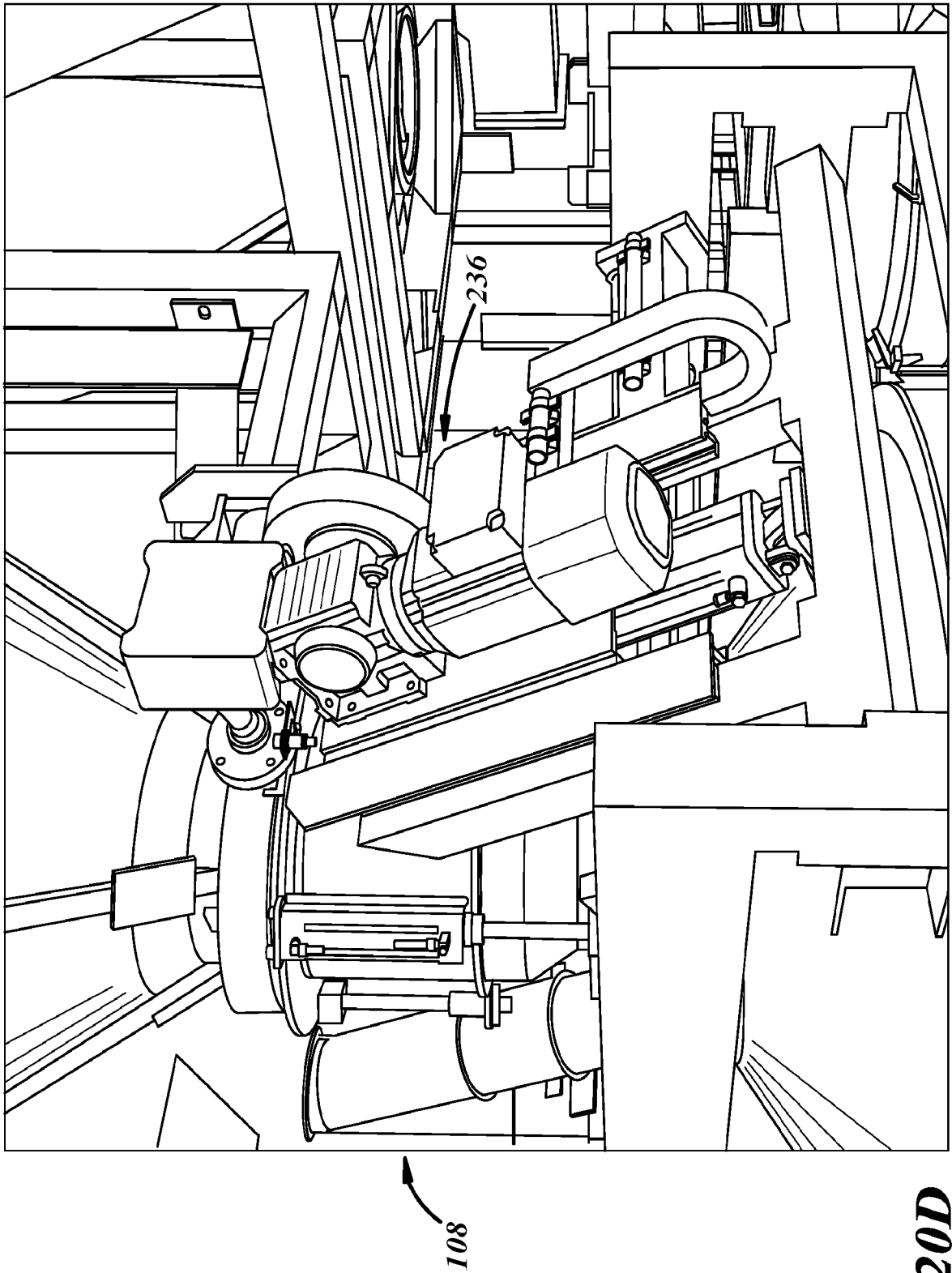


FIG. 20D

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2021/053264

A. CLASSIFICATION OF SUBJECT MATTER INV. B65G53/04 B65G65/32 B65G65/40 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) B65G B65D		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2020/262641 A1 (FRIESEN HENRY [CA]) 20 August 2020 (2020-08-20) figures 1-8 paragraphs [0015], [0087] - [0089], [0094], [0099], [0113], [0115] -----	1-26
Y	US 2020/223648 A1 (HERMAN ALVIN [CA] ET AL) 16 July 2020 (2020-07-16) figures 1, 3 paragraphs [0002], [0004], [0007], [0044], [0083], [0084], [0110] -----	1-26
Y	ES 1 037 414 U (GRUPPO TECNOFERRARI SPA [IT]) 16 February 1998 (1998-02-16) figure 1 column 2, line 39 - line 66 -----	5-8
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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Date of the actual completion of the international search 24 January 2022		Date of mailing of the international search report 04/02/2022
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Waldstein, Martin

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2021/053264

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2020262641 A1	20-08-2020	NONE	
US 2020223648 A1	16-07-2020	AR 117817 A1	25-08-2021
		CA 3126843 A1	23-07-2020
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		WO 2020150177 A1	23-07-2020
ES 1037414 U	16-02-1998	ES 1037414 U	16-02-1998
		IT RE960032 U1	23-01-1998