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(54) **STACKABLE MID-RISE STRUCTURES**

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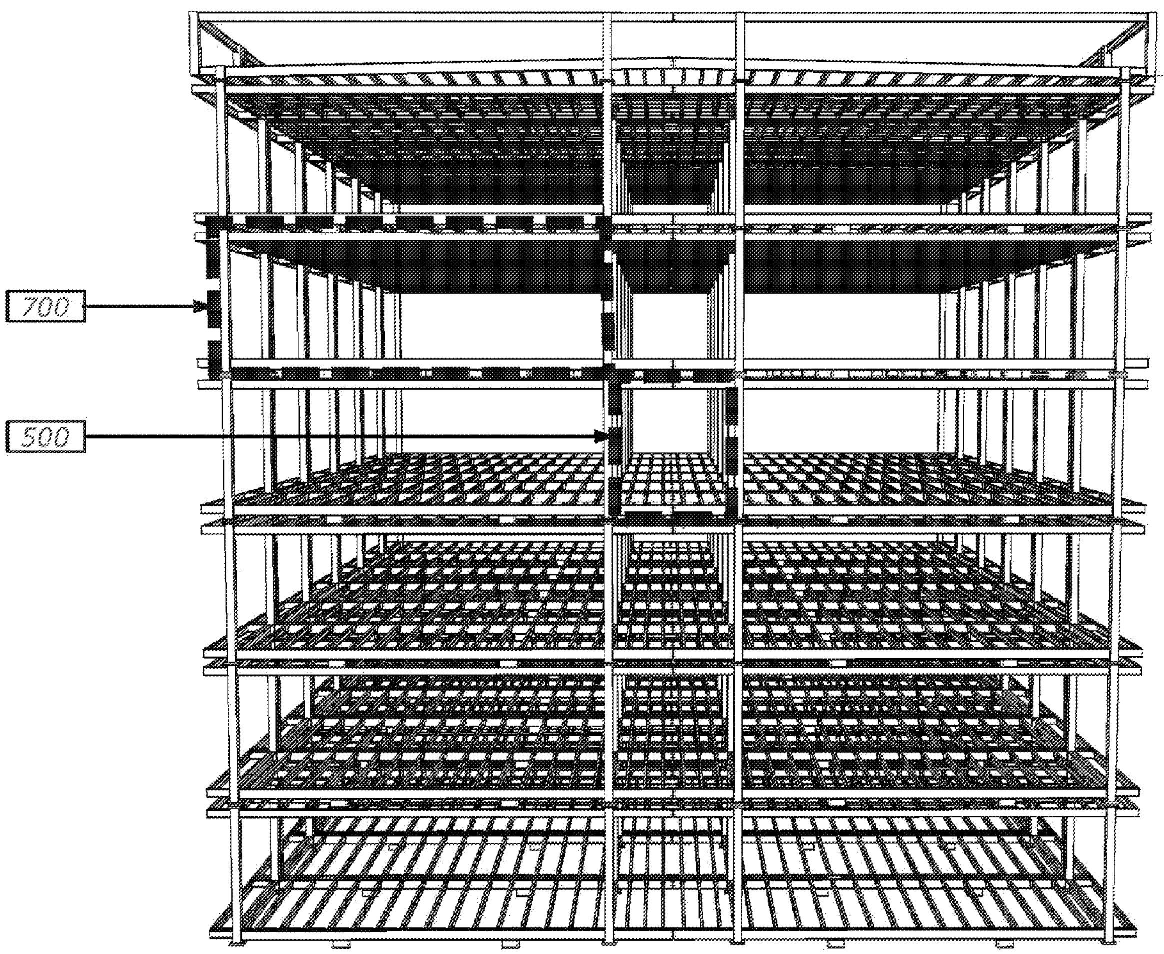
(52) **U.S. Cl.** **52/79.1**; 52/167.1; 52/650.1

(57) **ABSTRACT**

A system of structural steel modular units useful in constructing mid-rise building between 3-8 stories high. Modular units are in the shape of rectangular boxes and the height of the units define a single story of the mid-rise building. Modular units are configured to be stackable onto each other such that they can couple to both modular units positioned directly above and below and also to couple to laterally adjoining modular units. The modular units can include cantilevered extensions to define hallways or other desirable features such as balconies. The systems can also utilize a post tension system that includes a plurality of post tension members anchored to a foundation and are coupled to a damper system positioned on the roof of the building.



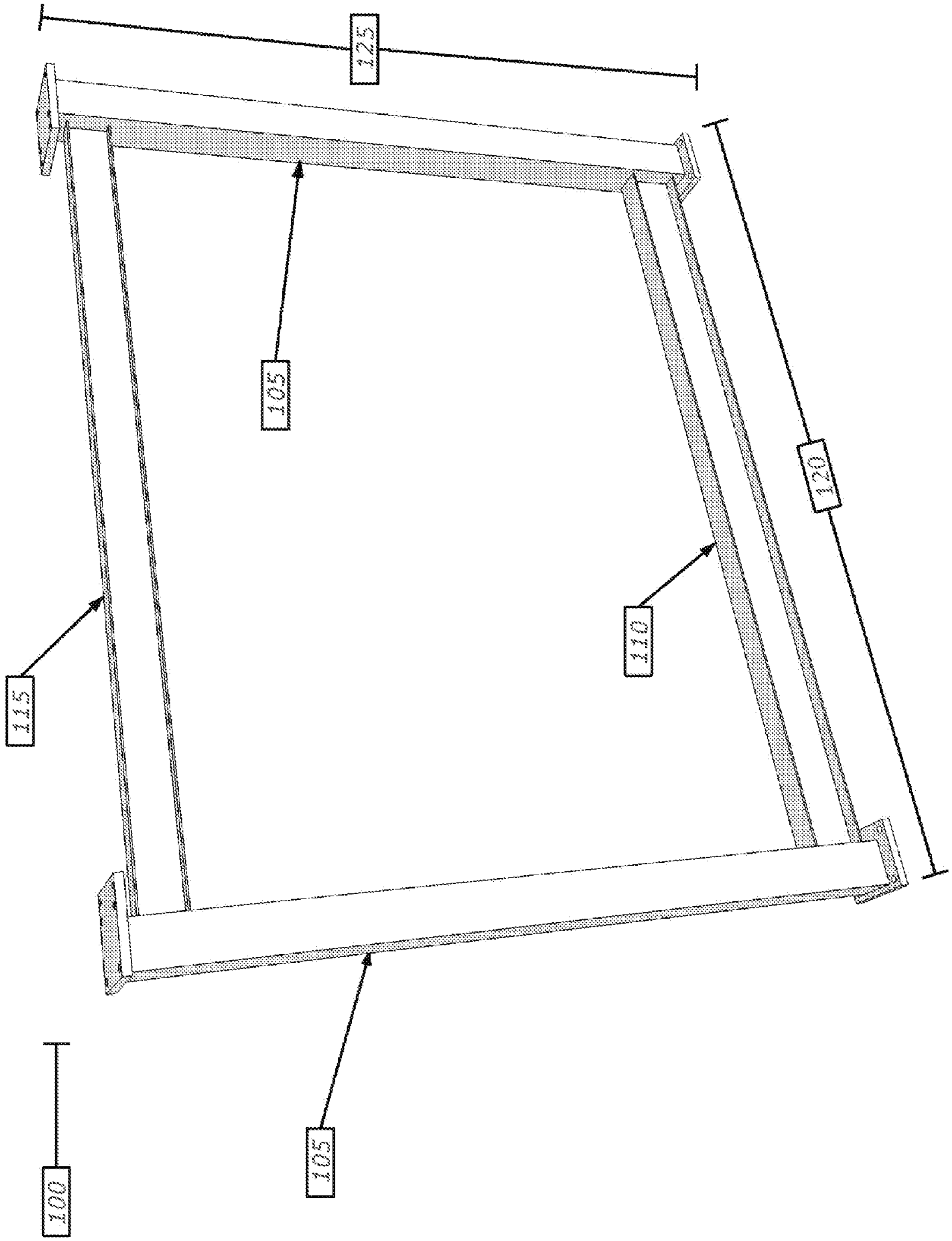


FIG. 1

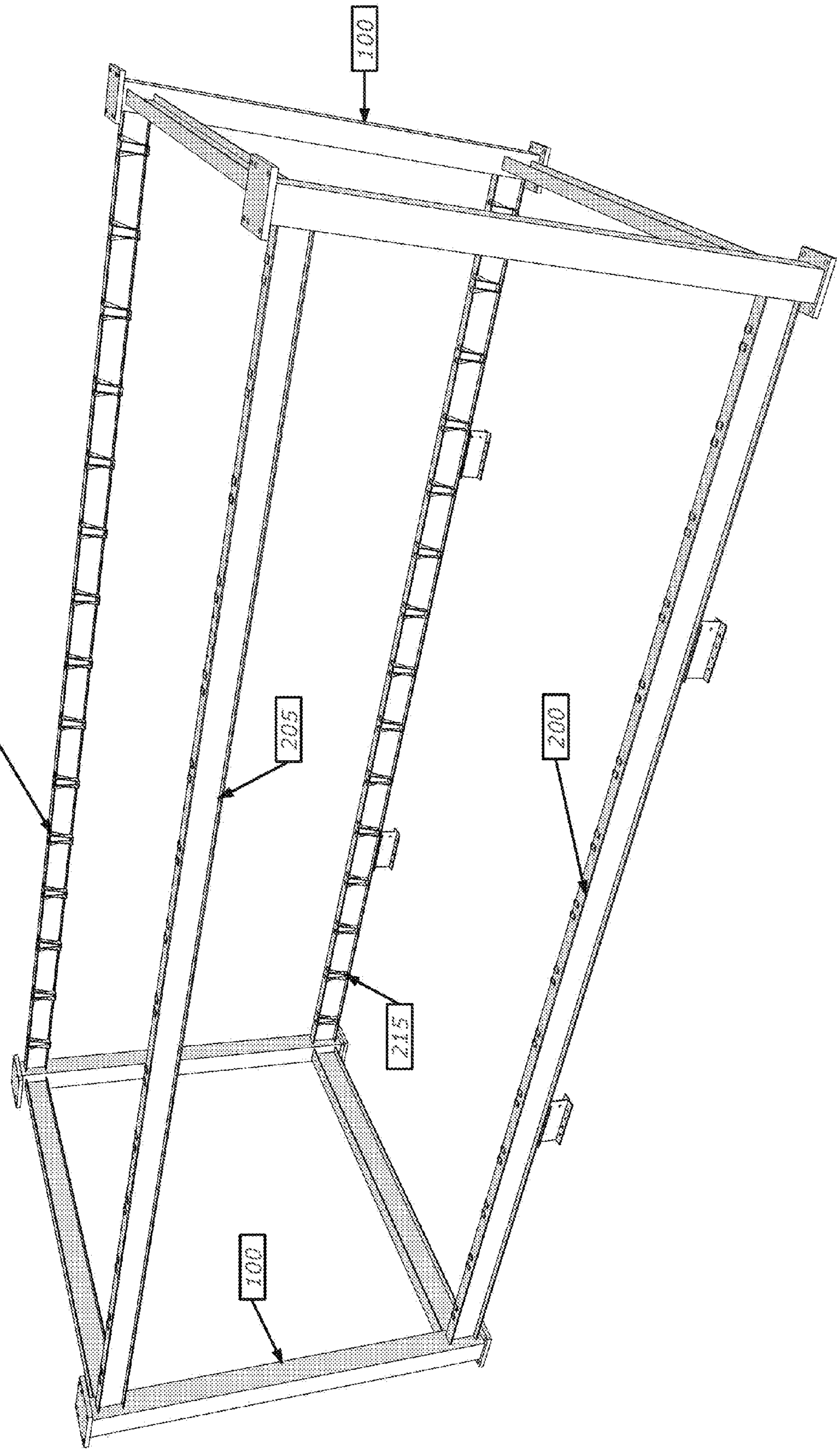


FIG. 2A

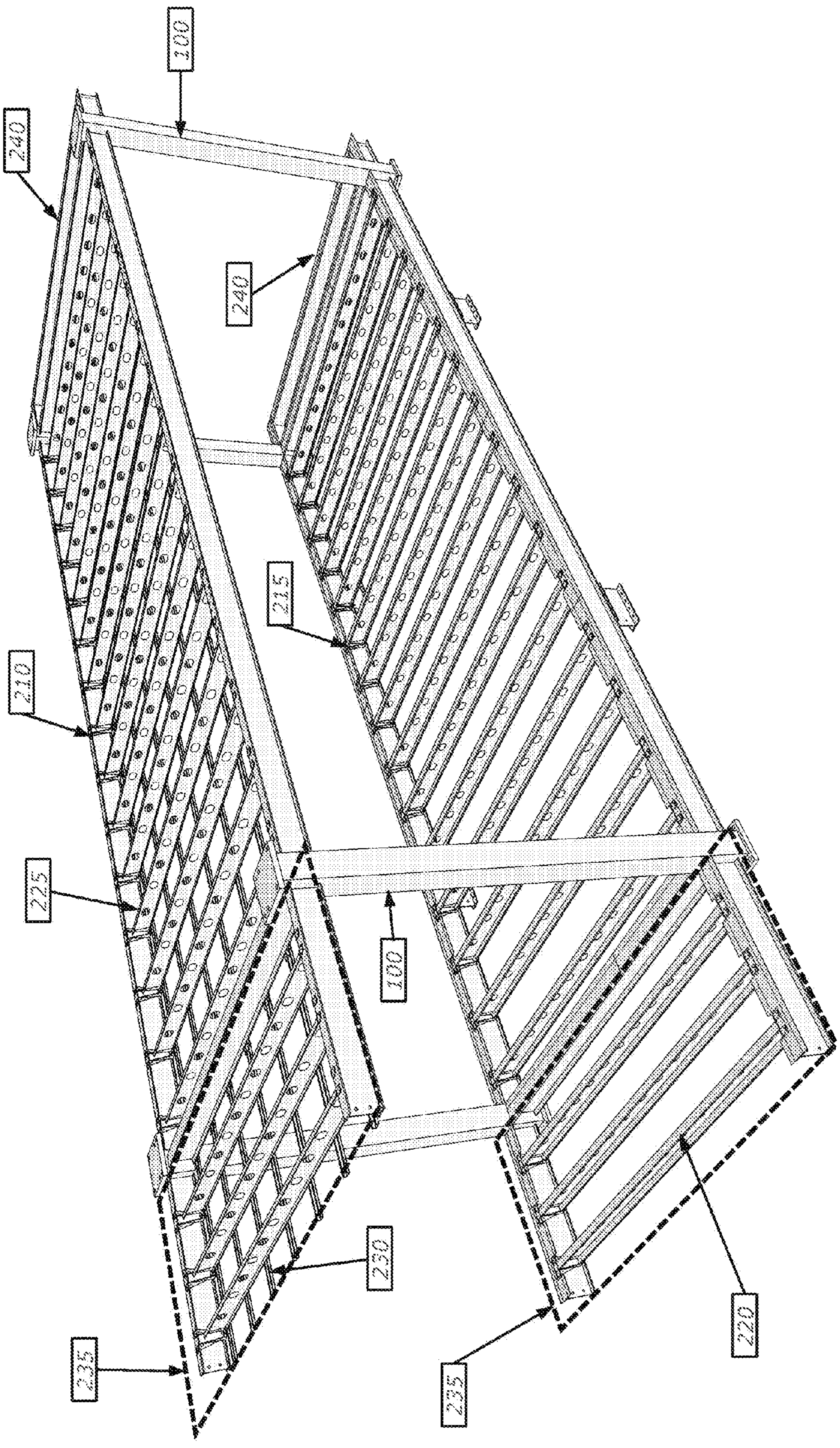


FIG. 2B

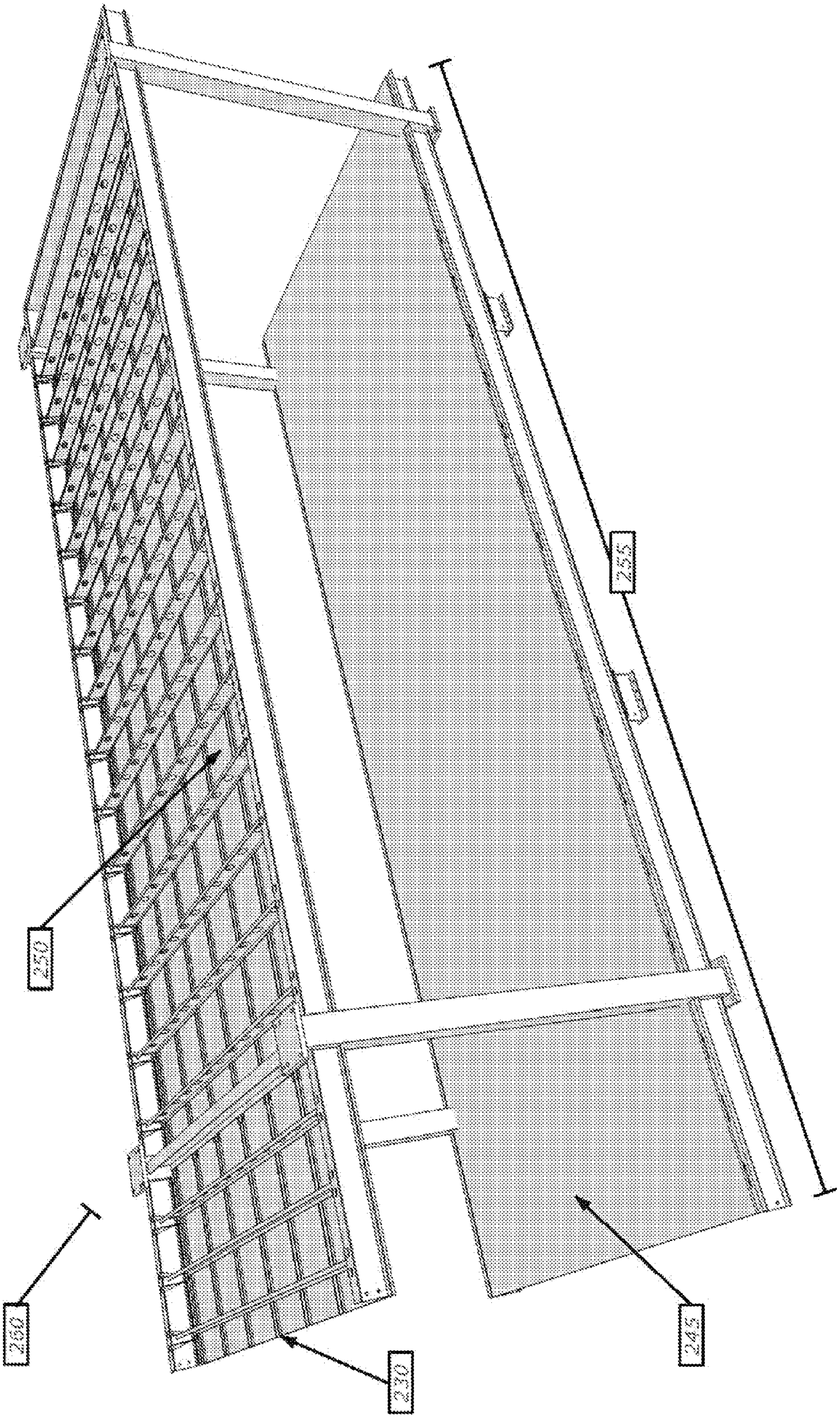


FIG. 2C

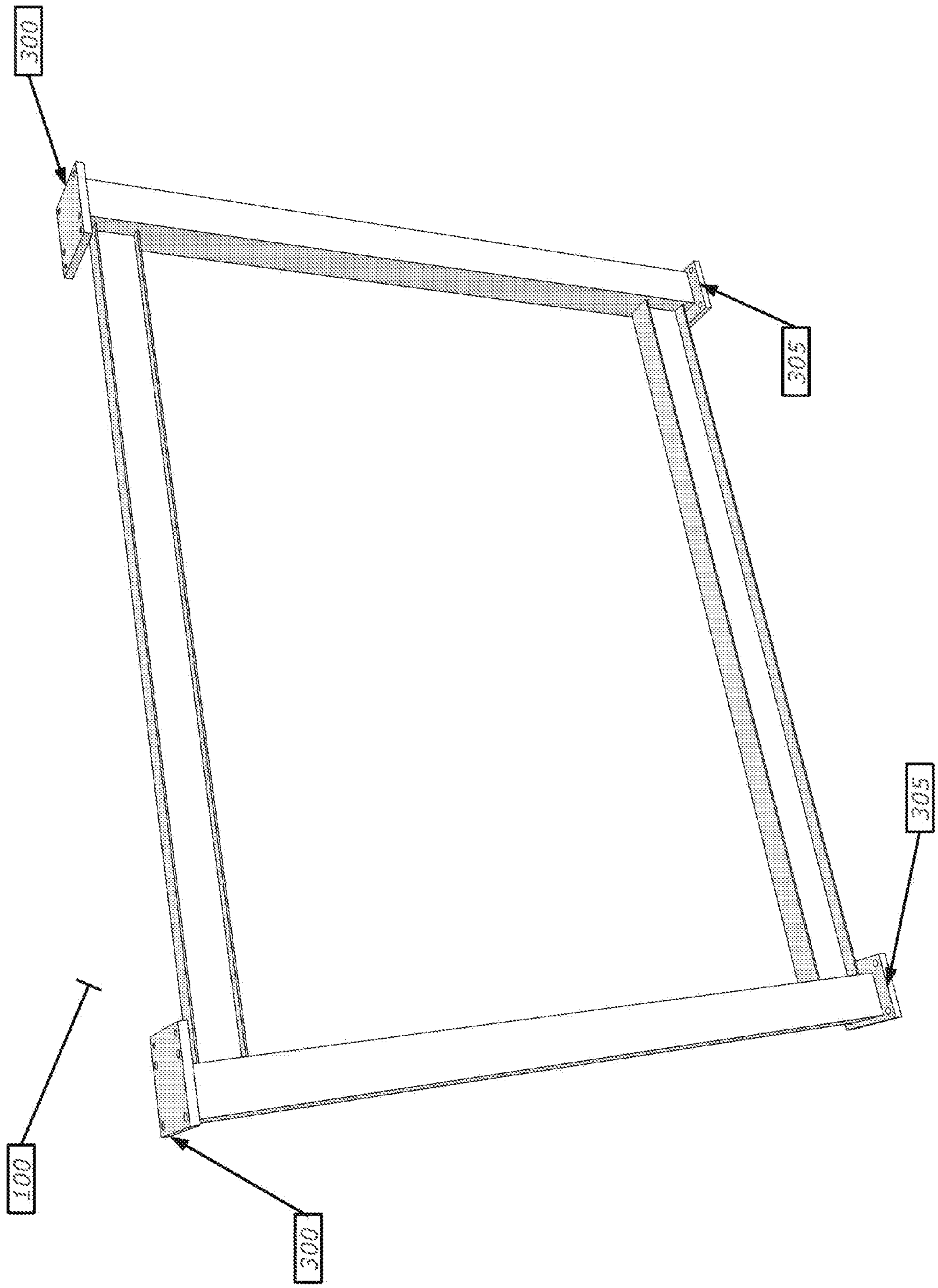


FIG. 3A

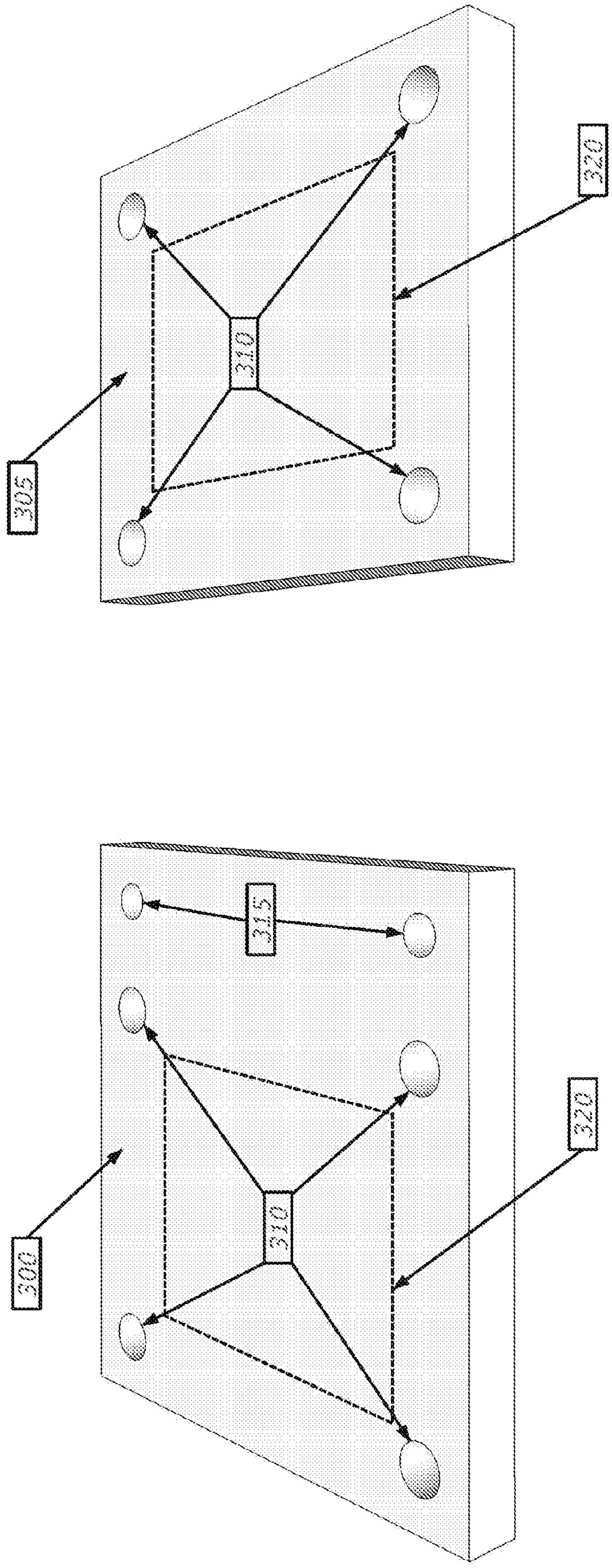


FIG. 3B

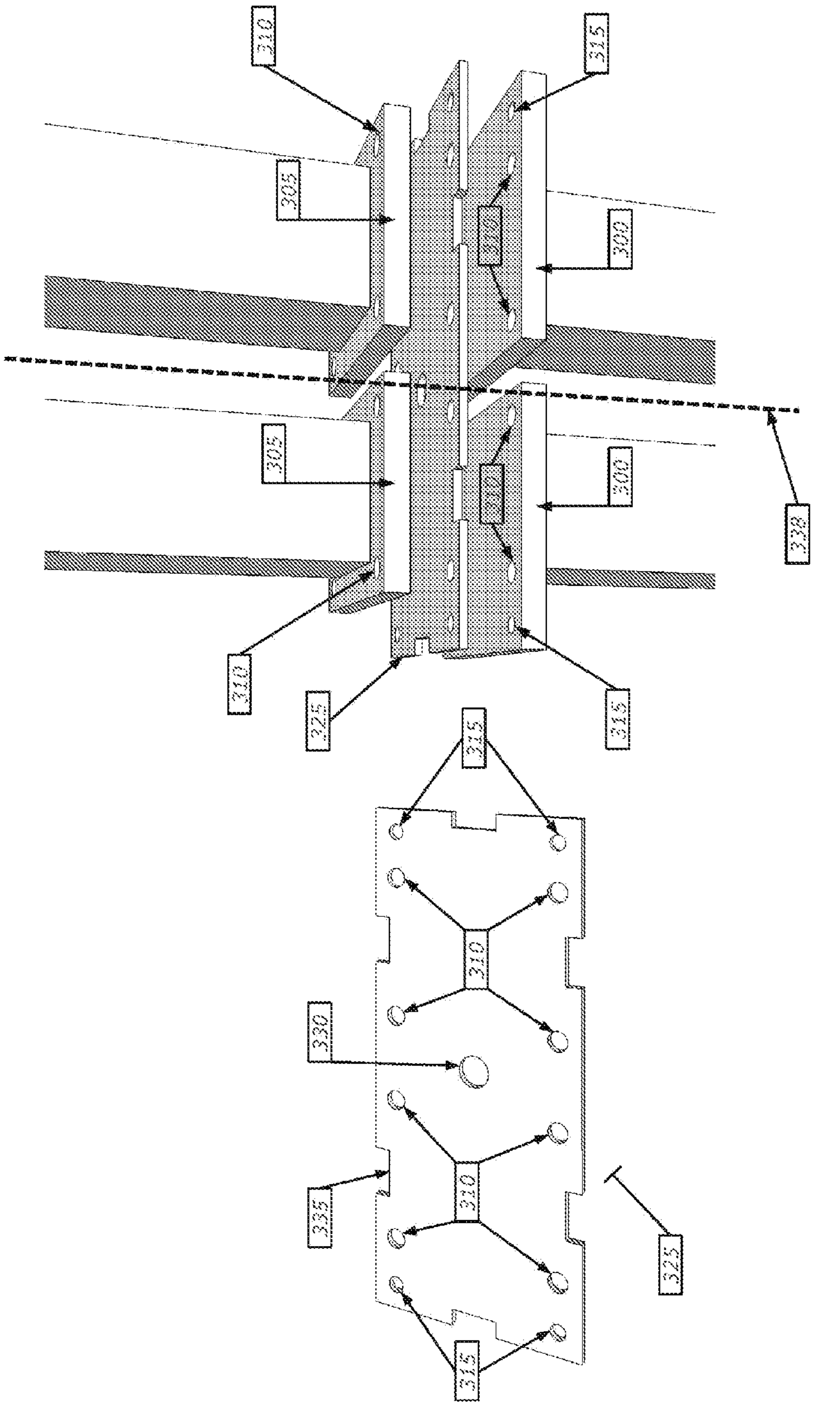

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FIG. 3C

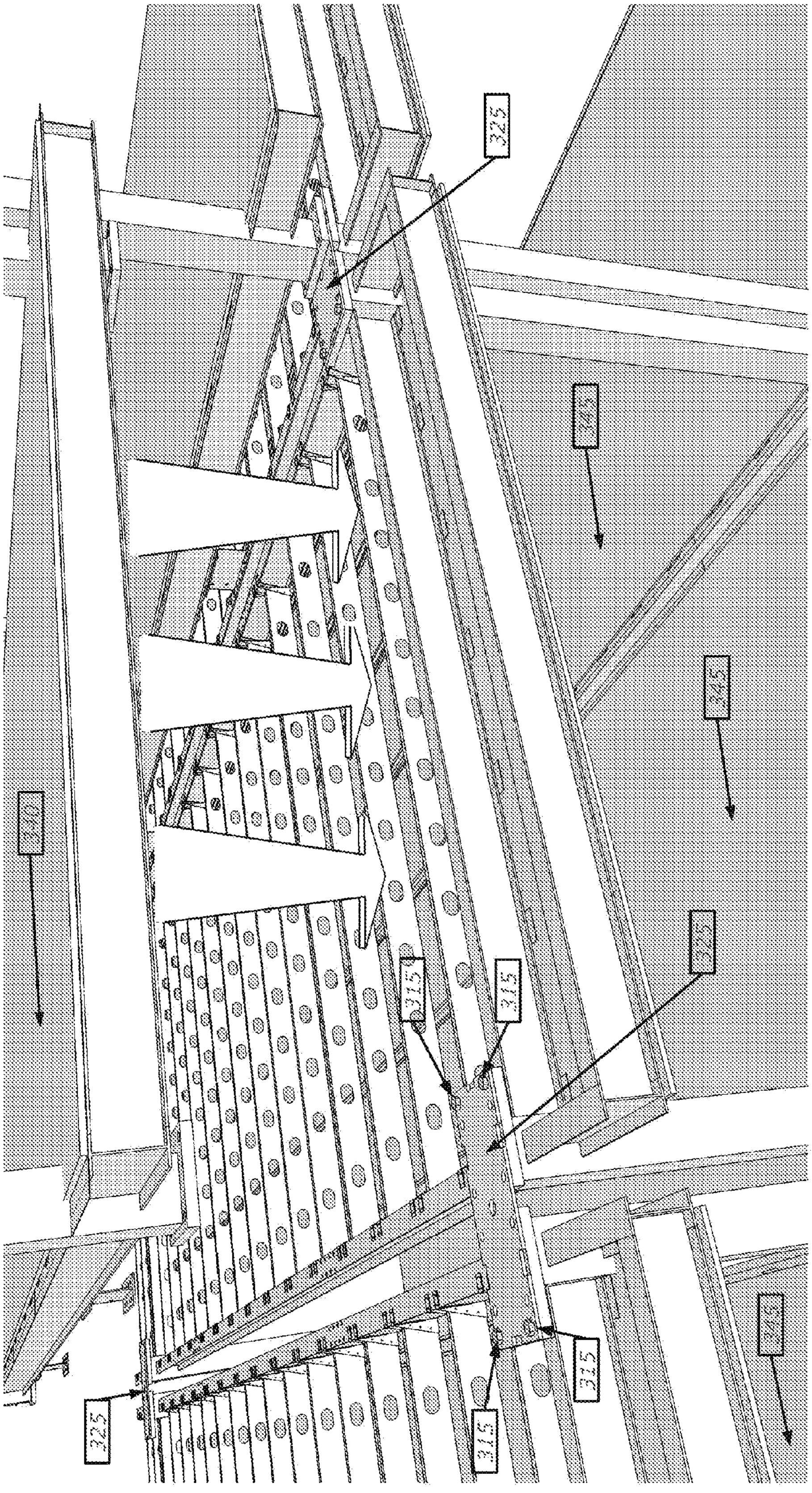

FIG. 3D

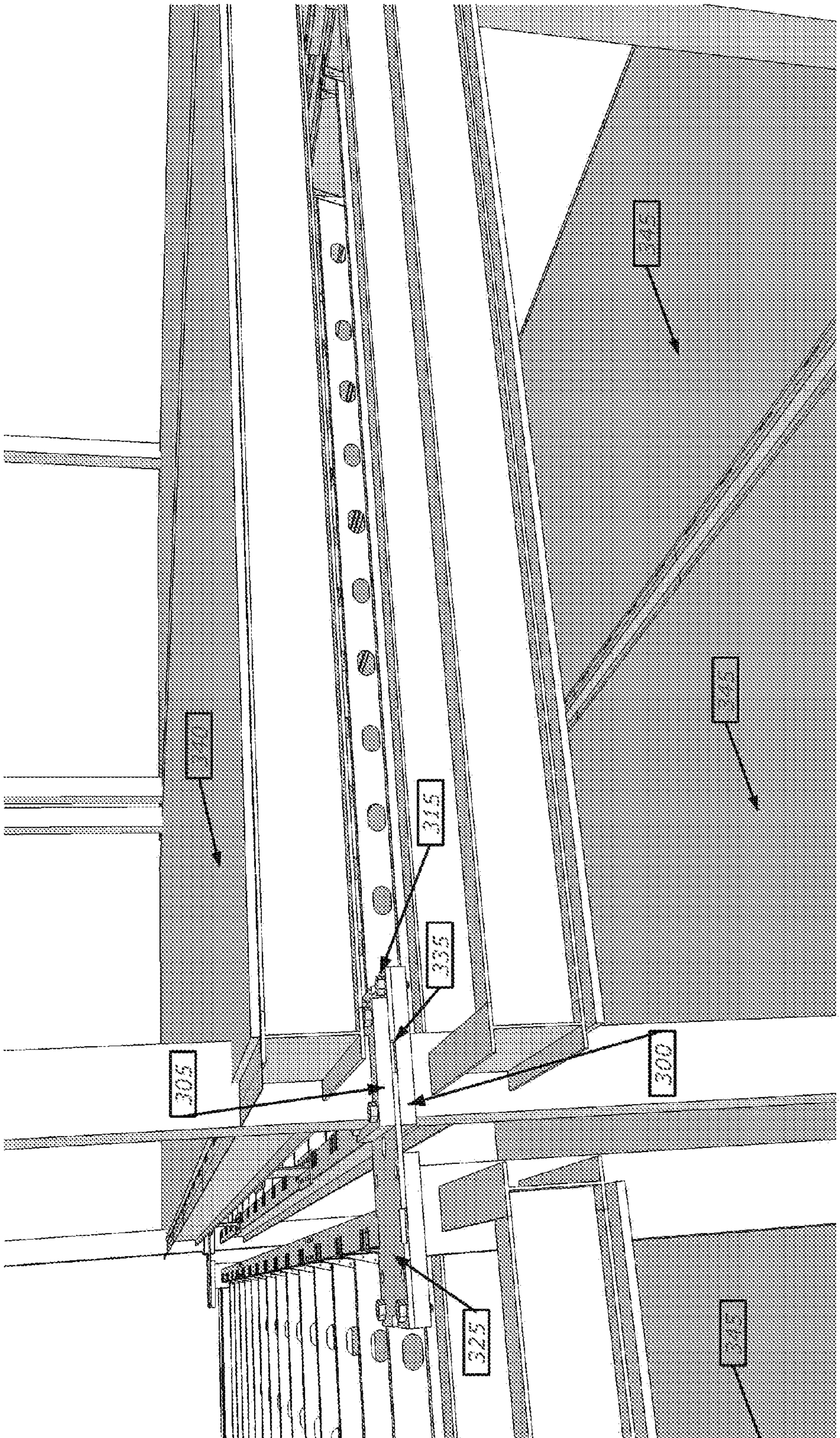

FIG. 3E

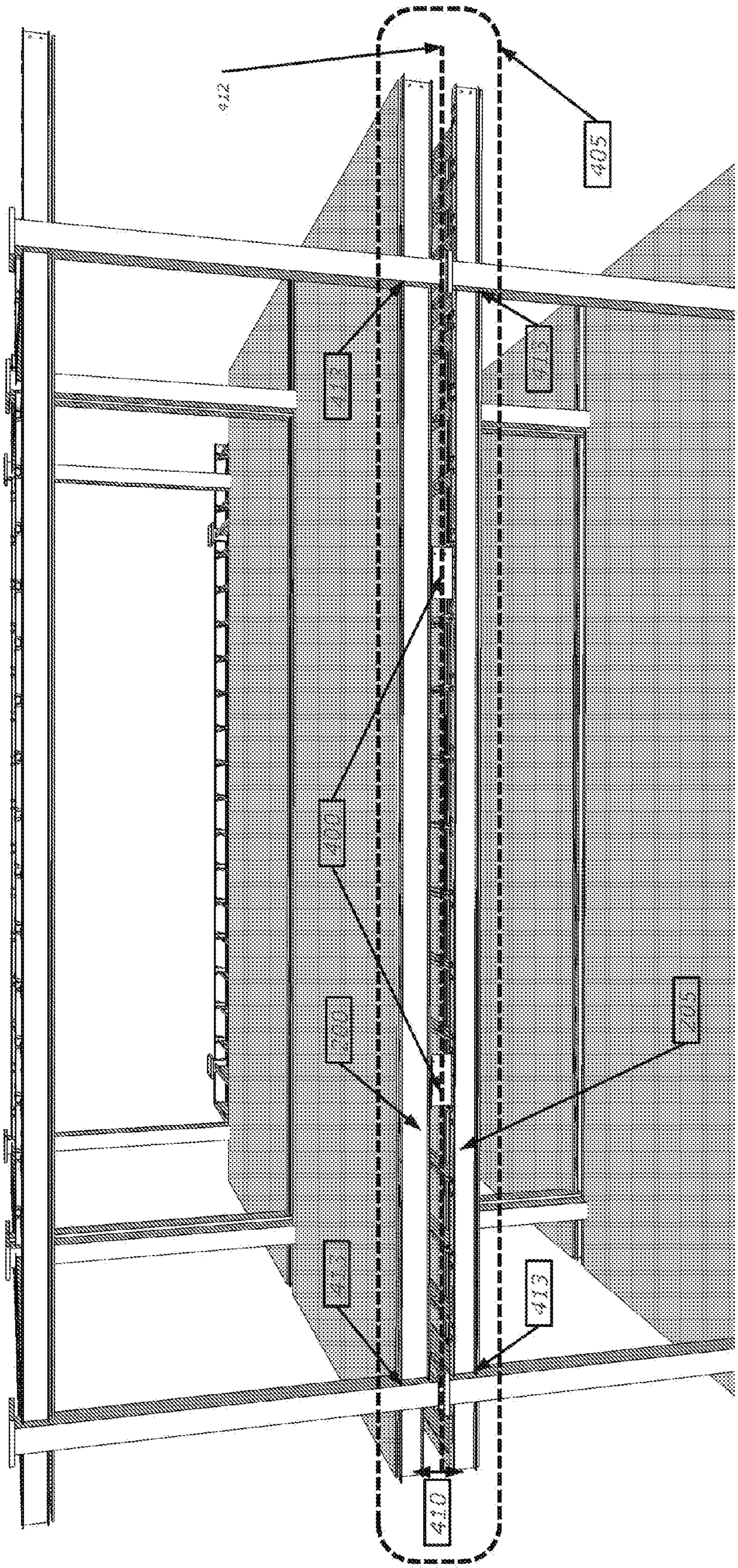

FIG. 4A

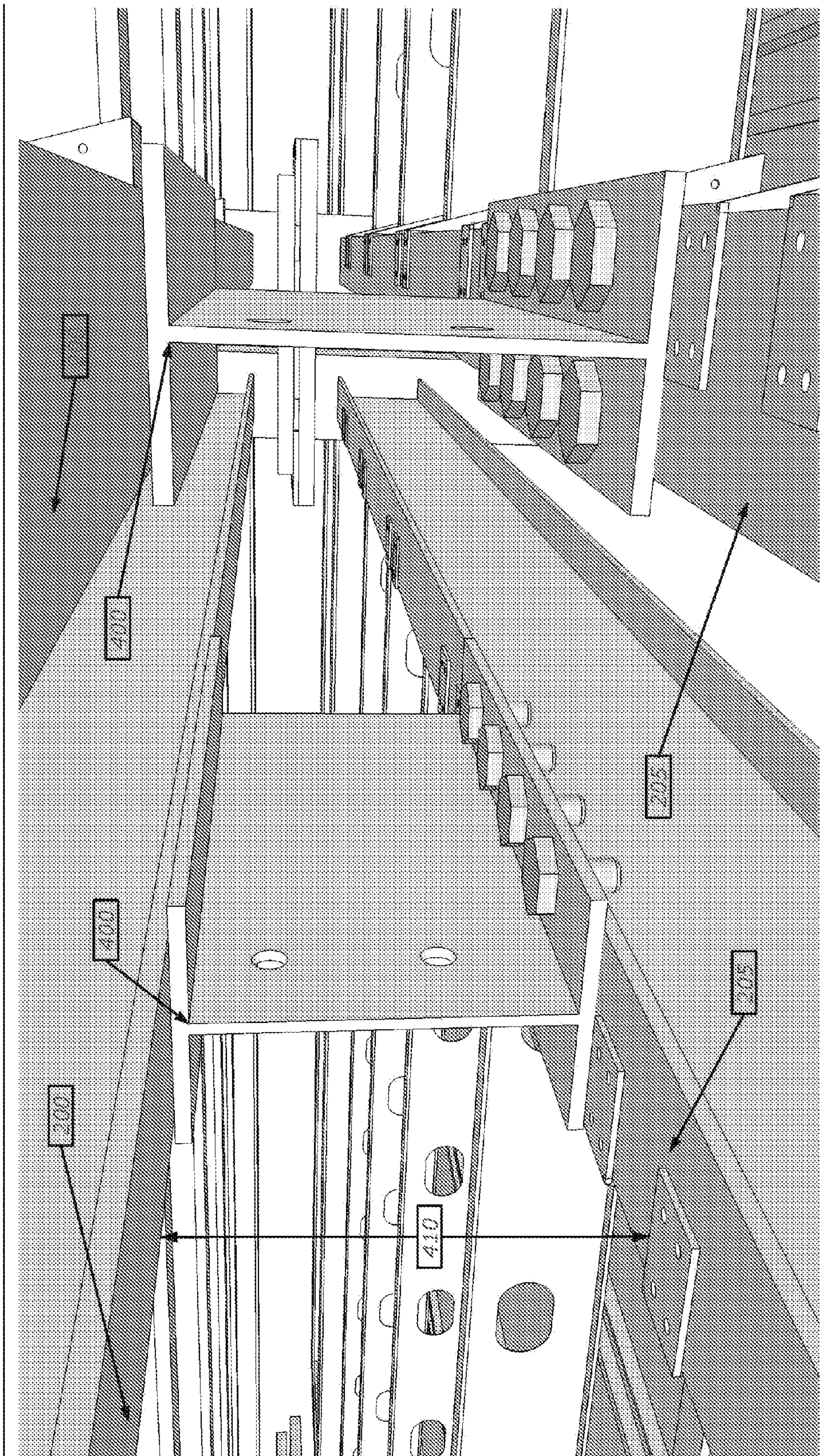

FIG. 4B

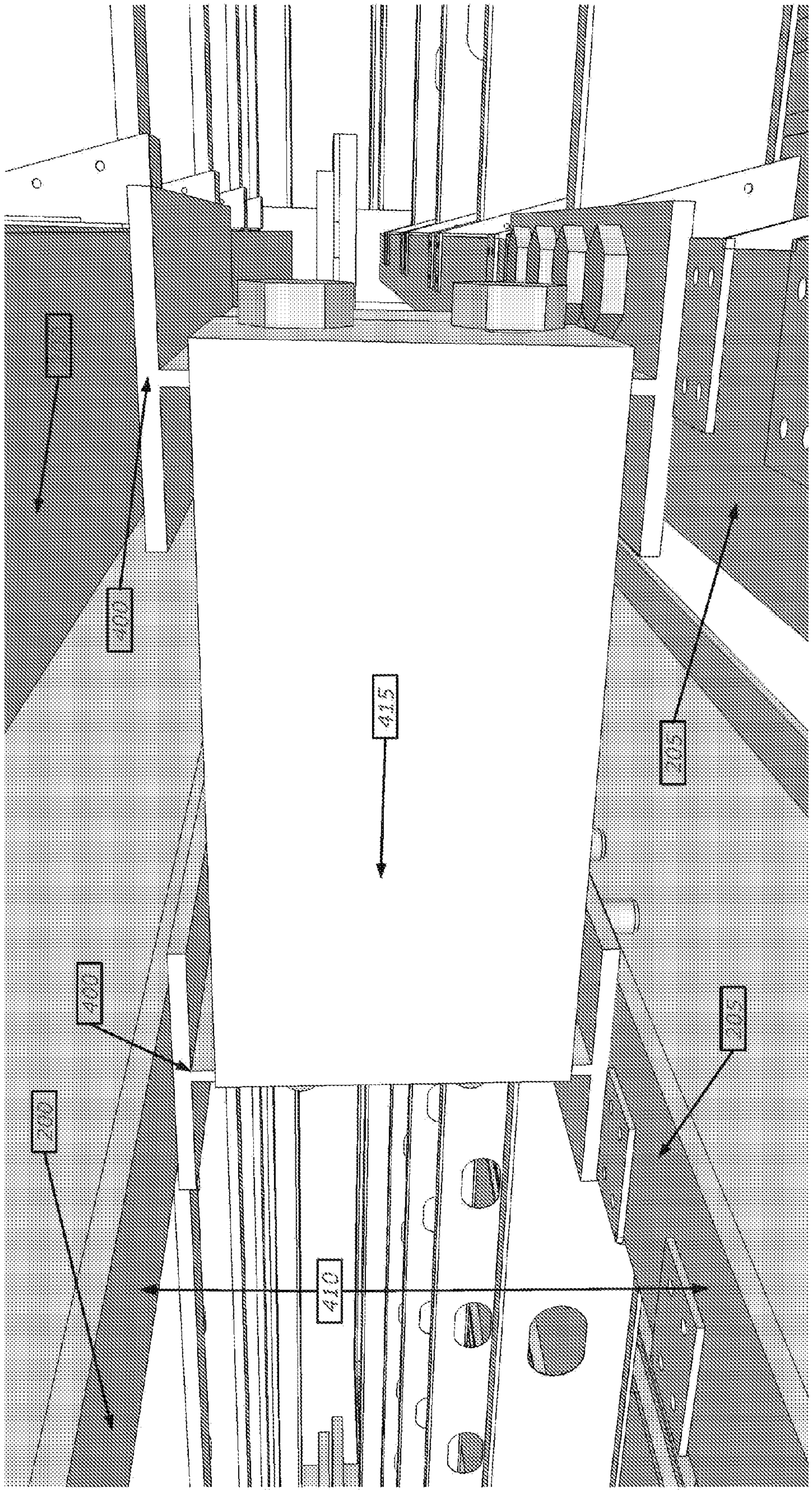

FIG. 4C

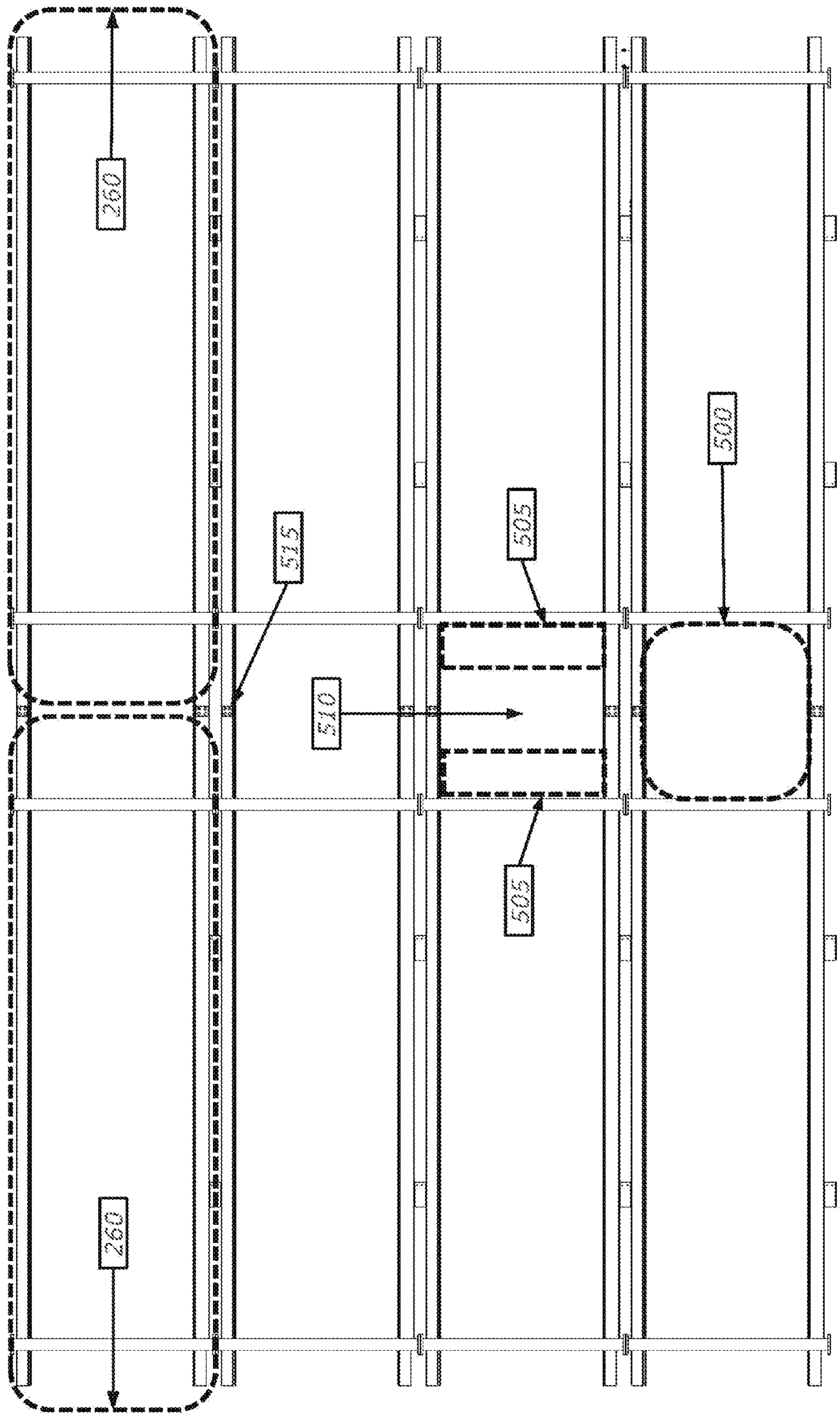

FIG. 5A

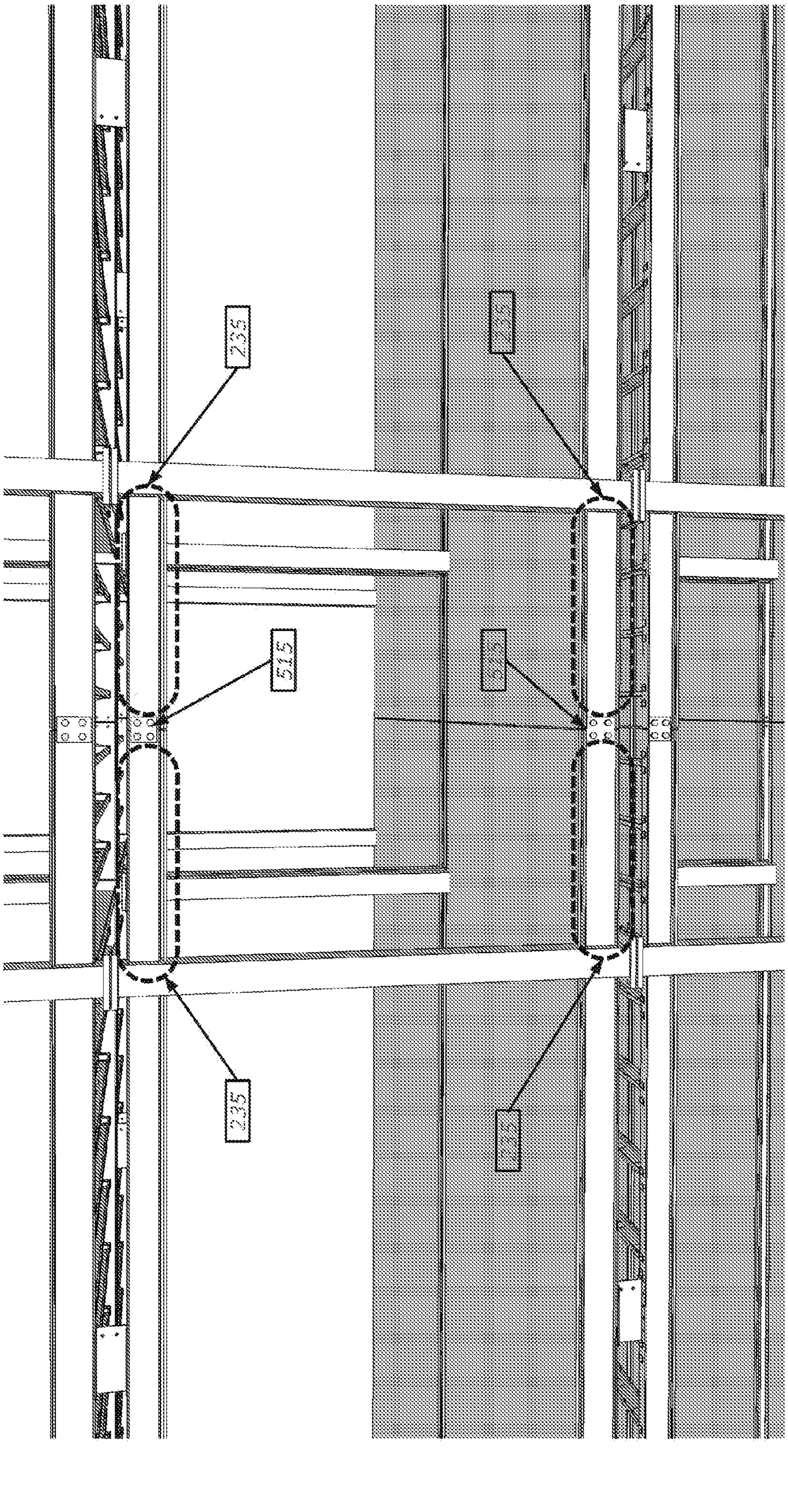

FIG. 5B

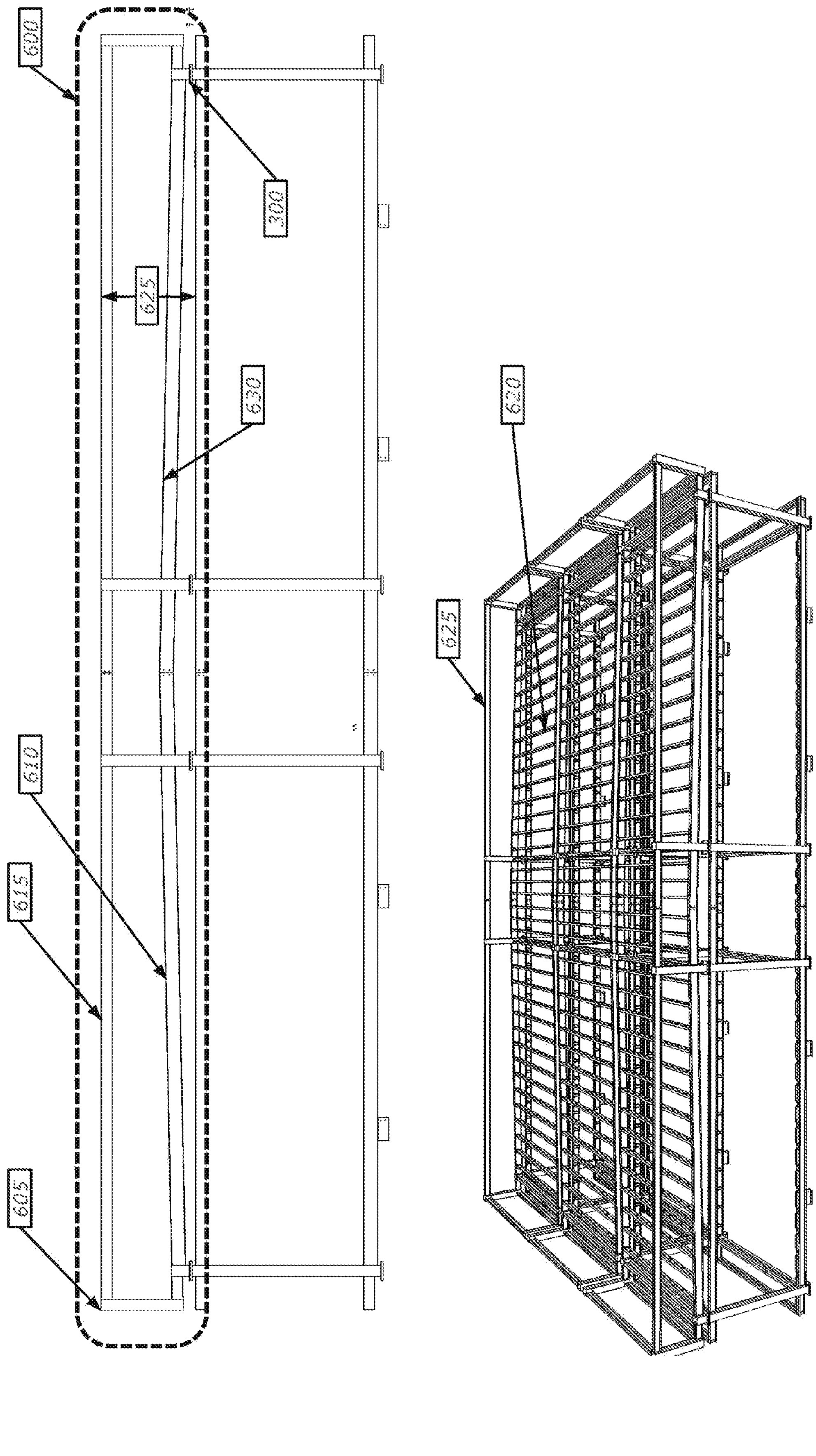

FIG. 6

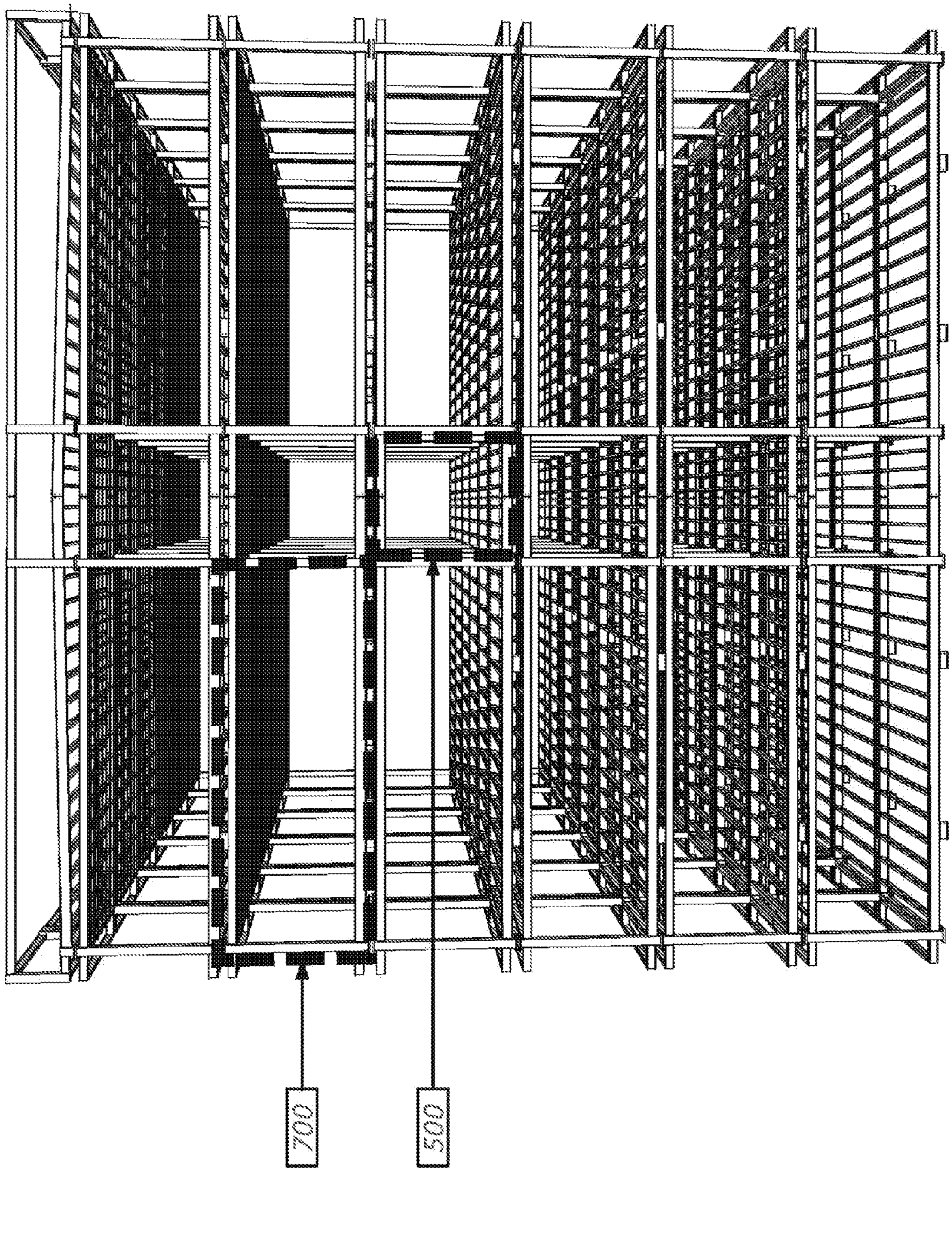

FIG. 7A

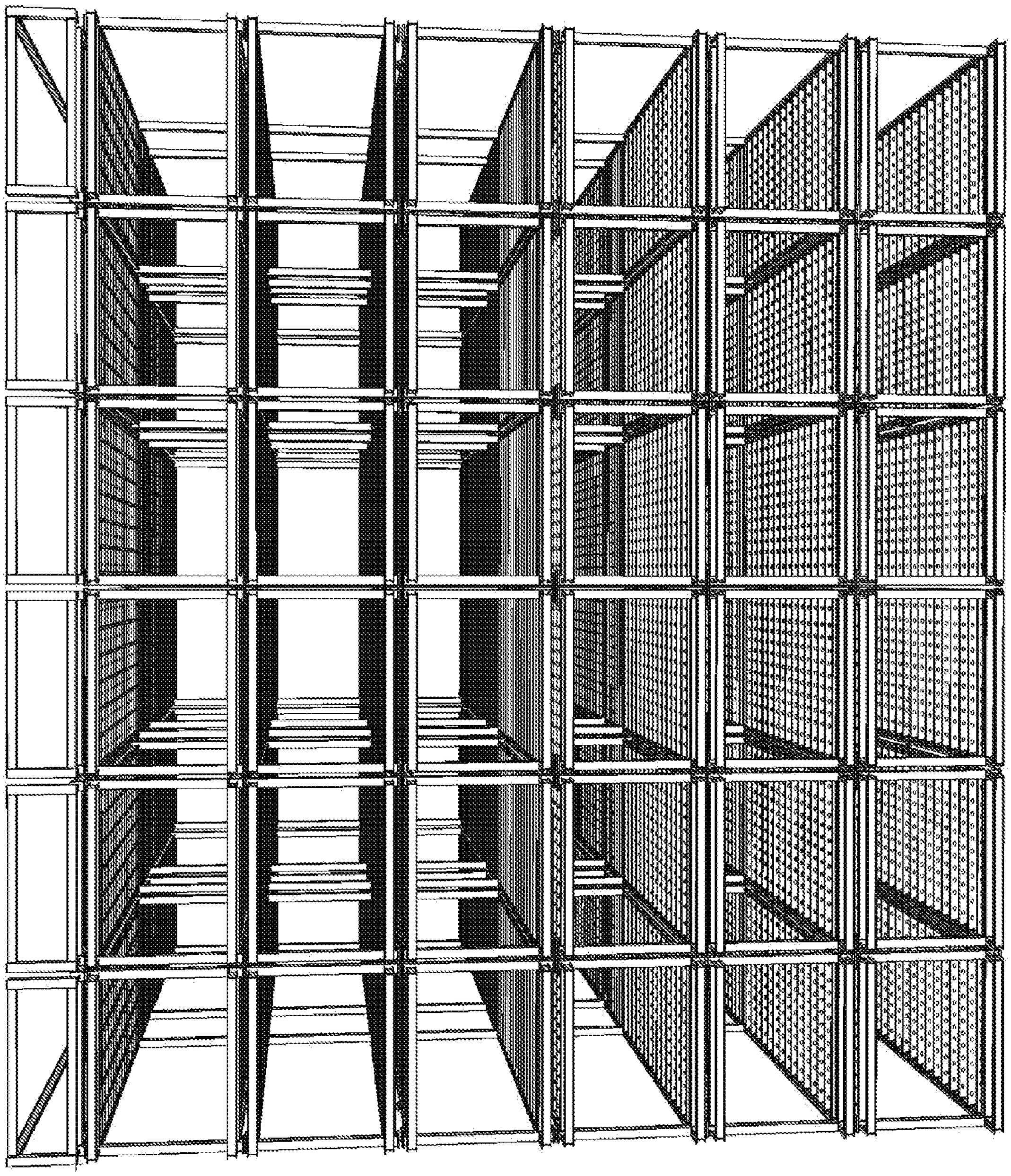

FIG. 7B

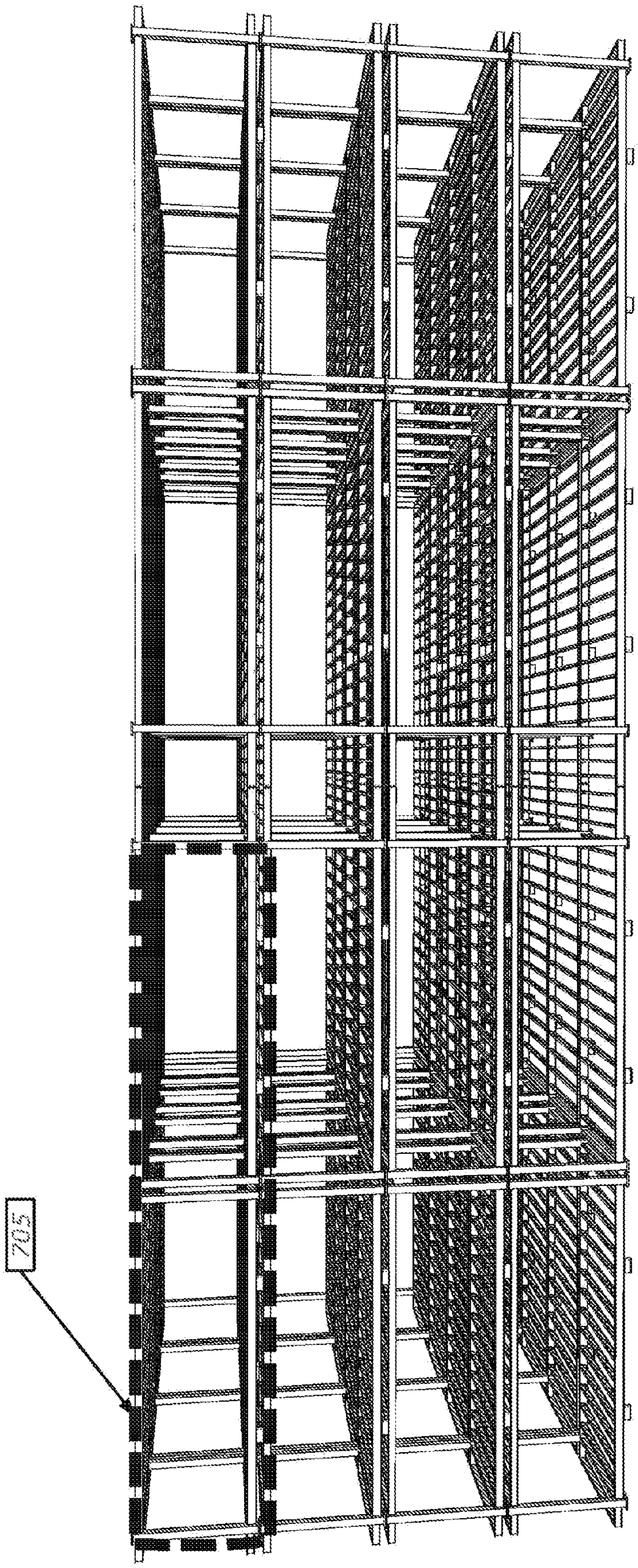

FIG. 7C

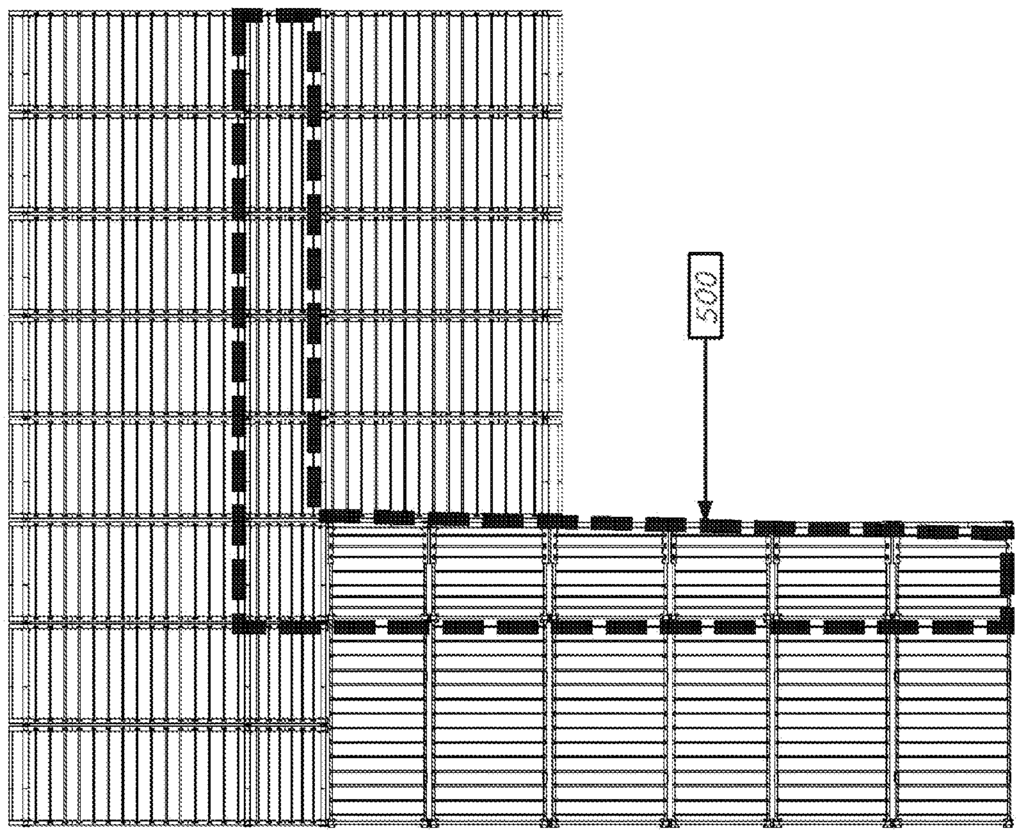

FIG. 7D

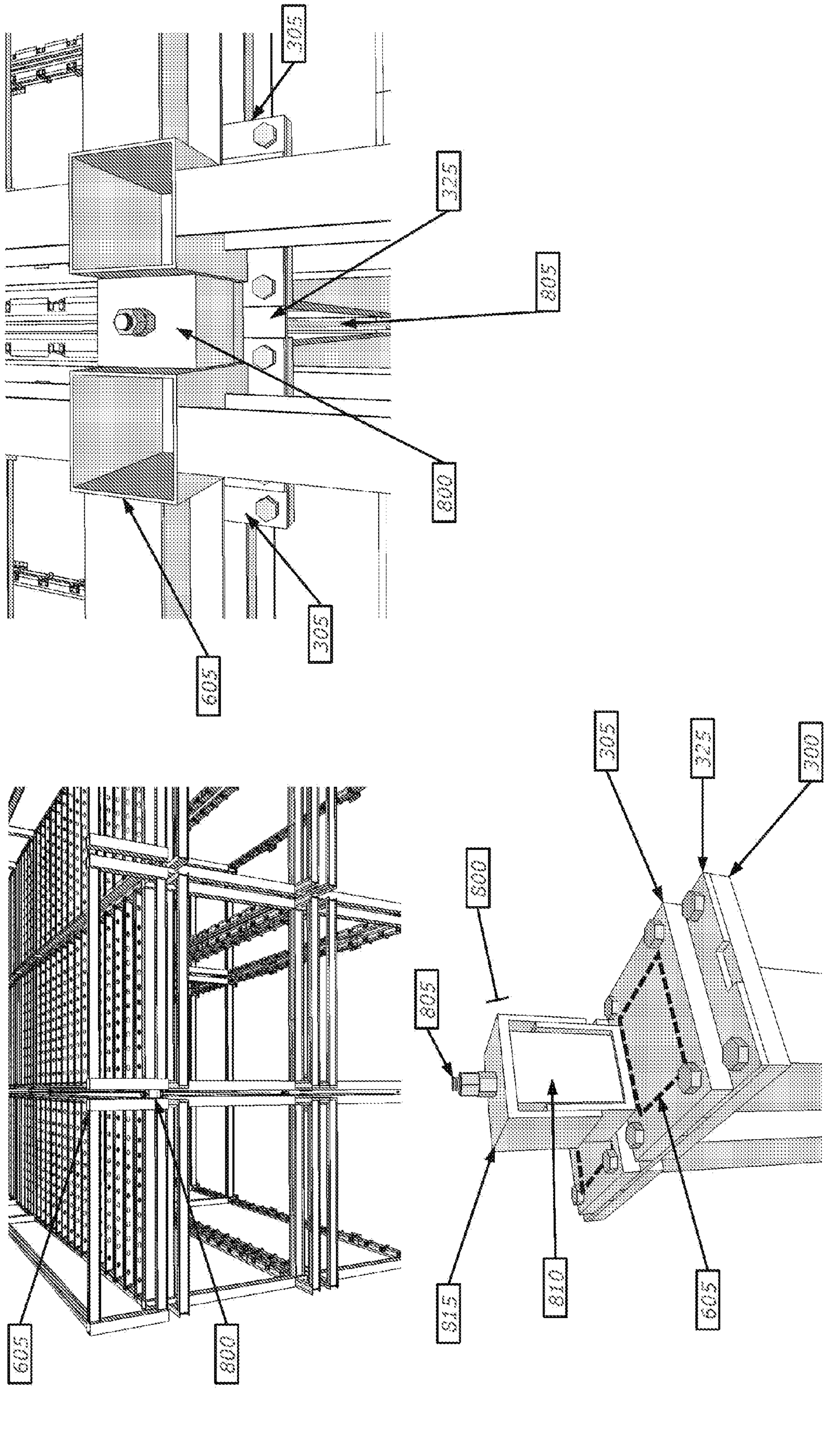

FIG. 8A

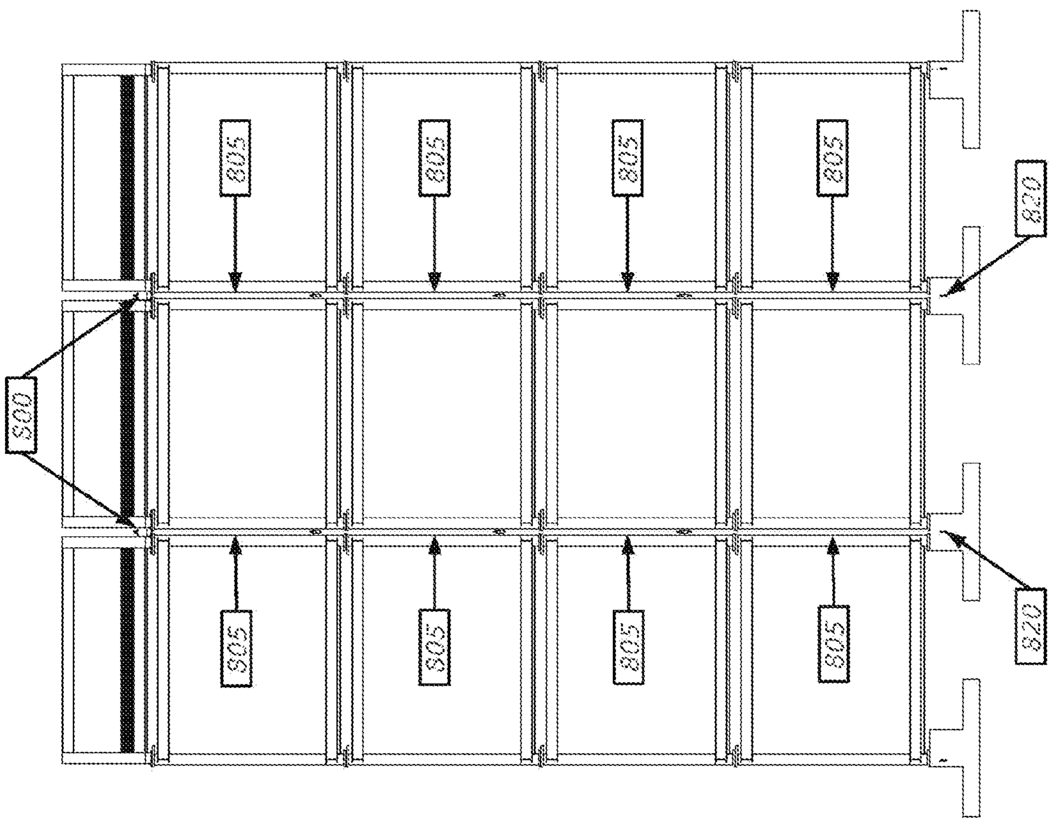

FIG. 8B

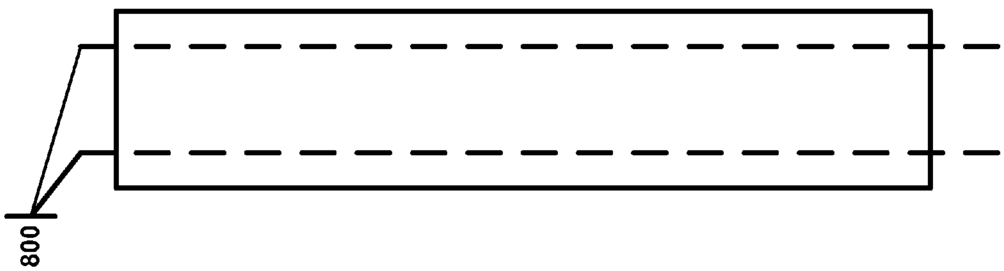

FIG. 9C

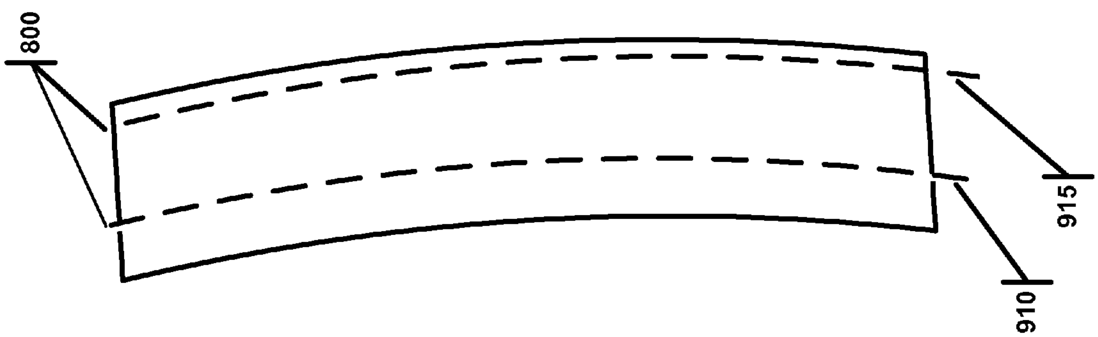

FIG. 9B

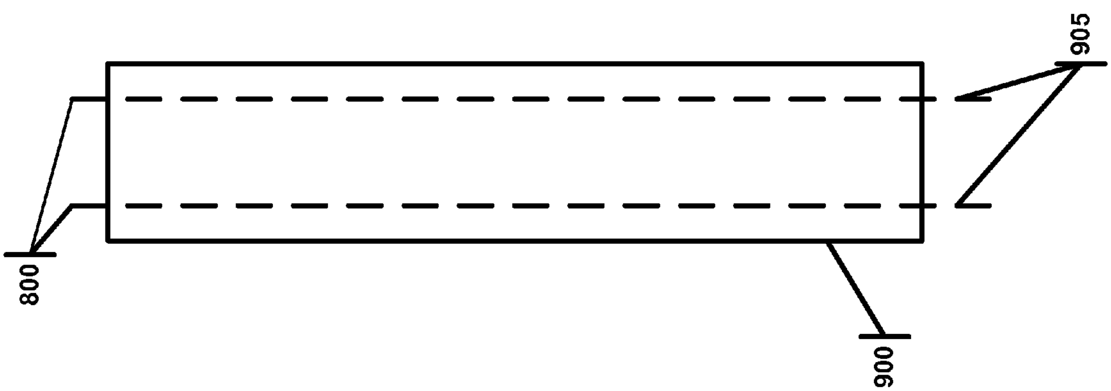

FIG. 9A

STACKABLE MID-RISE STRUCTURES

1.0 BACKGROUND

[0001] America is undergoing a significant shift away from low density suburban sprawl to moderate density urban revitalization in both our major cities and to some extent mid-sized towns. These changes have been brought about by several factors in recent years including:

- **[0002]** The public's awareness of environmental issues such as global warming, efficient utilization of scarce natural resources and a desire to preserve open space.
- **[0003]** The growing trend toward "GREEN" technology in all aspects of our lives including the appropriate types of future development within our cities and towns.
- **[0004]** The desire by both young and old to live, work and play in pedestrian oriented, walkable communities designed around the concept of "Smart Growth."
- **[0005]** The economic realities of today's high energy costs have families rethinking their priorities by considering smaller, denser housing alternatives in centralized locations.
- **[0006]** Many well educated singles, young couples and empty nesters continue to embrace denser, urban living in revitalized areas of many major to mid-sized cities.
- **[0007]** Many City and County planning agencies now mandate higher density future development in order to reduce long term service and maintenance costs.

[0008] The goals and trends discussed above can be realized through concentrating future development within in-fill areas of cities where housing, employment, shopping, recreation and cultural activities are in close proximity. Over the last five years many community leaders have elected to revise their general plans to earmark their community's central core for more moderate-to-high density future development. Most of this "up-zoning" within in-fill areas has focused on moderate density increases from what would be considered low-rise buildings (one to three stories) to mid-rise structures (four to eight stories). This up-zoning within a city's central core is thought to be a paradigm shift in the industry, rather than merely a temporary adjustment. This change from lower density to higher density structures will likely accelerate over the coming years. The question then becomes how to best produce new mid-rise structures that are appropriately sized and cost effective within these infill areas.

[0009] Stackable Mid-Rise (SMR) Structures is a steel modular building system designed to meet the needs of a changing industry. As an entirely new method of construction, SMR Structures makes use of cutting edge technology to deliver a high quality, efficient structural building system. SMR modular units are pre-engineered, factory produced, structural steel modular units that are transported to the building site and craned into place to construct 3 to 8 story buildings.

[0010] Although multi-story modular construction is unique, some foreign and domestic developers have stacked refurbished cargo containers or other types of structures to form utilitarian multi-story apartments, condos, or offices. Most of these factory built, stacked modular projects have occurred in Western Europe and Asia, but few have been done well. In most cases, the end product emphasizes the modular aspects of the structure resulting in very unappealing architecture. There have also been companies that produce factory built light gauge steel floor trusses, wall panels and roof trusses which are trucked to the job site and assembled in the field to form a base structural framework for multi-story buildings. Light gauge steel buildings over three stories high may also require costly structural masonry core or steel brace frame system in order to meet wind and seismic requirements. In addition these light gauge steel structures are not modular, so the end result is basically a prefabricated structural framework. The balance of construction activities including exterior windows, doors, and cladding as well as all work interior to the unit still needs to be accomplished in the field conventionally, so any time saving in the construction process is minimal compared to the modular building system which will be discussed below.

[0011] Therefore, what is needed is a modular or componentized building system that is largely pre-built off site, wherein the components can be stacked and connected to each other at the jobsite. Moreover, the building system must be sufficiently strong to resist seismic and wind loads, while also reducing the amount of material needed.

2.0 SUMMARY OF THE INVENTION

[0012] The teachings herein are directed to modular systems for constructing mid-rise buildings and comprising: a plurality of structural steel, modular units configured to be stackable upon each other such that the height of a modular unit defines a single story in the mid-rise building, wherein the plurality of modular units are individually comprised of first and second moment frames and each moment frame includes two vertical columns coupled to a floor beam and a ceiling beam such as to define a right-angled quadrilateral, and wherein the first and second moment frames are coupled to each other by two long span floor beams and two long span ceiling beams to define a rectangular-box shape.

[0013] Further embodiments herein are directed to modular systems for constructing a mid-rise building having a roof and a foundation comprising: a plurality of structural steel, rectangular-box-shaped, modular units configured to be stackable upon each other such that the height of a modular unit defines a single story in the mid-rise building; a damper system coupled to the roof of the mid-rise building; and a plurality of post tension members selected from the group consisting of: post tension rods and post tension cables, wherein the post tension members are anchored to the foundation and are coupled to the damper system.

3.0 DESCRIPTION OF THE DRAWINGS

[0014] FIG. **1** illustrates a typical SMR moment frame.

[0015] FIG. **2**A shows a SMR modular unit.

[0016] FIG. **2**B illustrates a SMR modular unit with structural framework.

[0017] FIG. **2**C shows a SMR modular unit with floor and ceiling systems.

[0018] FIG. **3**A depicts a SMR column connection with a column cap and base plate attached to the top and bottom of each moment frame column.

[0019] FIG. **3**B illustrates the column cap and base plate detail.

[0020] FIGS. **3**C, **3**D and **3**E show a column connection that connects modular units together horizontally and vertically.

[0021] FIG. **4**A illustrates a truss stitch plate connecting units vertically.

[0022] FIG. **4**B shows a truss stitch plate viewed from air space between floor and ceiling systems.

[0023] FIG. **4**C depicts truss stitch plates connected together horizontally using floor truss stitch plate couplers.

[0024] FIG. **5**A shows hallways created by adjoining SMR modular units back to back including mechanical/utility chases.

[0025] FIG. **5**B illustrates SMR modular units adjoined using hallway connector plates to form a full size hallway

[0026] FIG. **6** depicts the roof structure unit that may be connected to SMR modular units below using the typical column and hallway connection.

[0027] FIGS. **7**A and **7**B illustrate a completed 6-story building comprised of 72 SMR modular units.

[0028] FIG. **7**C depicts a completed 4-story building comprised of SMR modular units with extended bay depths.

[0029] FIG. **7**D is a plan view of a completed building comprised of SMR modular units to create an "L" shaped building.

[0030] FIGS. **8**A and **8**B depict a post tension system that may be used within SMR's structural system.

[0031] FIGS. **9**A-C are representations of the deflection that an SMR modular building experiences from a seismic event, and the correction of the deflection by the post-tension system.

4.0 DETAILED DESCRIPTION

[0032] SMR modular units are pre-engineered, factory produced, structural steel modular units that are transported to the building site and craned into place to construct 3 to 8 story buildings. Each modular unit may be comprised of various sized structural steel members that are robotically welded together in the factory via an assembly line process, similar to that of an automobile plant. During the assembly process each unit may move through a series of work stations and exit the assembly line complete with exterior and interior walls in place; plumbing, electrical and mechanical equipment roughed in and most interior finishes either in place or packaged and ready for final installation in the field. Once completed, SMR modular units are trucked to the building site, lifted into place by crane, secured with high strength slip critical bolts and then finished on-site to form 3 to 8 story mid-rise buildings. Uses include Residential (condominiums, apartments and single occupancy residences); Commercial (offices, medical suites and hotel rooms); Educational/Institutional (school classrooms, dormitories and hospital rooms); Government/Military (offices, temporary quarters and permanent barracks) and potentially other uses such as multistory urban infill storage facilities.

[0033] Fabrication of SMR units may be compatible with a wide range of environmentally sustainable materials and techniques through the system's use of state of the art manufacturing technology. These design considerations may help developers obtain Leadership in Energy and Environmental Design (LEED) certification from the U.S. Green Building Council in recognition of green building practices for their projects.

[0034] The fabrication of SMR units may start concurrently with a project's site work. Unlike conventional construction, this parallel process allows for a building's structural elements, as well as a substantial portion of the building's finish work, to occur at the same time as grading, under-grounding of utilities, and pouring of foundations. Through this expedited process, SMR's modular units can be onsite and ready to be craned into place upon the completion of a project's site work, representing considerable cost and time savings when compared to conventional construction methods.

[0035] 4.1 SMR Modular Unit Construction

[0036] Each modular unit may be constructed of a series of moment frames that resist lateral loads in the event of seismic/wind activity. Moment frames in SMR's structural system consist of two tube steel columns and two wide flange steel beams as can be seen in FIG. **1**. Moment frame floor and ceiling beams (**110**, **115**) are affixed to two square tube steel columns (**105**), preferably using complete joint penetration (CJP) welds to form a structural square (or rectangle). The width and height of each individual moment frame (**120**, **125**) will depend on the type of building (residential, office, school, etc.) and the design parameters selected by the architect. It would be apparent to one of skill in the art that the moment frame's (**100**) size and components may be modified to meet a particular purpose.

[0037] Now that the moment frame (**100**) has been described, the base structure of each modular unit will be discussed with reference to FIG. **2**A. Long span floor and ceiling beams (**200**, **205**) are connected to moment frames (**100**) at each end to create a structural steel rectangular box. These long span wide flange beams are attached to each moment frame (**100**) at the column using CJP welds. Joist hangers (**210**, **215**) are then spot welded to each long span beam's flange for the attachment of floor/ceiling joists. It should be noted that the size of long span floor and ceiling beams will be determined based on design requirements specific to each project (seismic/wind loads, soil conditions, building size, etc).

[0038] This basic SMR modular unit has significant advantages over conventional construction. Conventionally constructed mid-rise buildings typically have either brace frames, moment frames or concrete core/shear walls to handle lateral forces during seismic or wind events. During seismic/wind events in conventionally constructed mid-rise buildings, lateral loads from those events generally are transferred to these frames or shear walls. If any of these moment frames, brace frames or shear walls fail due to seismic/wind events or through faulty construction, the failure could be catastrophic effecting loss of life not to mention damage, possibly beyond repair, to the building. The SMR modular unit construction, however, contains at least two moment frames per unit with several modular units joined together and stacked to form buildings with many moment frames creating structural redundancy which bolsters the structural integrity of the entire building. Should any one of these moment frames fail, the failure may be very localized minimizing damage to the building and loss of life. If the damage is only localized, the building can be effectively repaired.

[0039] FIG. **2**B builds on the base structure depicted in FIG. **2**A by adding outlooker extensions (**240**), hallway extensions (**235**), floor joists (**220**), ceiling joists (**225**), and resilient channels (**230**) completing the structural framework of an SMR modular unit. Outlooker extensions (**240**) are composed of steel wide flange beams and are attached to moment frame columns (**100**), preferably using CJP welds. Aside from their primary function of providing a surface for attaching sheathing and facade, outlookers can also be lengthened to extend the depth of a module creating additional interior space or may also be used to create cantilevered balconies or architectural undulations in the building. Hallway extensions (**235**), like outlooker extensions, are composed of steel wide flange beams and are attached to moment frame columns (**100**), preferably using CJP welds. Hallway extensions provide a key connection point between modular units where two units can be connected back-to-back to form a full hallway thereby providing additional structural strength as adjoining modular units behave as one. As an integral part of SMR's structural system, the hallway connection will be discussed later in greater detail. Floor joists (**220**) and ceiling joists (**225**), as well as resilient channels (**230**), are screwed to joist hangers (**210**, **215**) in order to provide a surface for affixing each unit's floor and ceiling system.

[0040] FIG. **2**C is the same modular unit seen in FIG. **2**B, but now with floor and ceiling systems (**245**, **250**) in place. The floor system (**245**) may be composed of a cementitious panelized product called Fortocrete®, manufactured by USG Corporation (see http://www.usg.com/usg-fortocrete-structural-panels.html). Fortocrete structural panels are non-combustible, high-strength, fiberglass reinforced cement panels designed for use in load bearing cold-formed steel construction applications. This panelized floor system is significantly lighter than conventional cast in place concrete systems and can reduce the seismic design forces of each floor of a building by as much as 20%. Unlike conventional sub-flooring systems, like poured in place concrete or light weight concrete over metal pan decking, Fortocrete has no cure or set time. The structural panels become the structural sub-floor as soon as they are fastened. Another feature of Fortocrete panels is that they cut like wood and fasten to floor joists with conventional tools (self tapping screws and a screw gun) which significantly expedites the process of installing SMR's floor system in the factory. While all of these benefits, as well as a one- and two-hour fire resistant design, make Fortocrete an ideal product for SMR's floor system, SMR modular units are also designed to work with other sub-flooring materials including light weight concrete over metal pan decking. The ceiling system (**250**) of each modular unit may be clad in conventional drywall attached to sound attenuating resilient channels (**230**) as needed. Alternatively, drop down T-bar ceilings with acoustical tile may be used in place of drywall and resilient channels in certain circumstances.

[0041] 4.2 SMR Modular Unit Connections

[0042] For speed and ease of construction SMR modular units have been designed to be stacked into place on the job site and connected without the use of field welding. In place of field welds, high strength slip critical bolts and a series of connection plates may be used to attach modular units both vertically and horizontally. At the end of a conventional mid-rise building's life cycle, buildings are typically either imploded or demolished, but SMR's bolted connection plate system allows modular units to be disassembled for relocation, re-use, or recycling.

[0043] FIG. **3**A shows a moment frame (**100**) with a column cap plate (**300**) and a column base plate (**305**) fillet welded to the top and bottom of each of its columns. The column cap plate (**300**) and column base plate (**305**) are used as points of connection for adjoining two or more SMR modular units together at the column. FIG. **3**B illustrates the positioning of the moment frame column (**320**) within the cap and base plate as well as the location of each plate's bolt and alignment holes (**310**, **315**). The function of the bolt and alignment holes is to create points of access where moment frame columns may be bolted together at adjoining corners using a column connector plate. FIG. **3**C shows a detailed depiction of the column connector plate (**325**) and illustrates how the connector plate's holes match up with the holes of the cap and base plate (**300**,**305**) of each column. The connector plate also includes a hole (**330**) through which a post tension rod/cable may be inserted to provide even more strength in high seismic and wind areas; the post tension system will be described below. This figure also illustrates that two columns joined with the column connector plate, in effect, form one integral column where the neutral axis (**338**) is centered between the columns reducing stress on the column connection plates. FIGS. **3**D and **3**E illustrate the use of the column connector plate by showing a modular unit being lowered into place (**340**) and connected at adjoining columns to a row of completed units below (**345**). In FIG. **3**D column connector plates (**325**) and column cap plates of completed units below have been bolted together through their alignment holes (**315**). This prevents the column connector plate from slipping during the installation of the next floor's modular units. In FIG. **3**E the modular unit being lowered into place (**340**) from FIG. **3**D is now attached and has a set of slip critical bolts sandwiching together the column connector plate (**325**), the column cap plate (**300**) of the unit below, and the column base plate (**305**) of the unit being lowered into place (**345**). Welding tabs (**335**) on the column connector plate (**325**) may also be utilized to provide additional strength if necessary.

[0044] Another type of connection plate that may be utilized by SMR's structural system is the floor truss stitch plate. FIG. **4**A illustrates the use of the floor truss stitch plate (**400**) in connecting the long span beams of two adjoining units together vertically thereby creating a strong and efficient floor truss system (**405**). Floor truss stitch plates (**400**) are factory welded to the bottom of each modular unit's long span floor beams (**200**) at intermediate locations. At the jobsite, modular units are lowered into place and floor truss stitch plates (**400**) are attached to the long span ceiling beams (**205**) of units below, that connection may use high strength slip critical bolts. With long span floor and ceiling beams (**200**, **205**) fused together in this manner a truss system (**405**) is created. The long span floor and ceiling beams (**200**, **205**) of each unit act as the truss chords and the floor truss stitch plates (**400**) act as the truss webs, creating a floor truss system with a structural strength that is far greater than the sum of its parts. With this floor truss system in place, the physical stress points (**413**) are shifted from the column connection points which now lie along the neutral axis (**412**) to points at the top and bottom of the truss system away from the neutral axis.

[0045] Another function of a floor truss stitch plate is to create air space between floor and ceiling systems (**410**) of stacked units allowing for ducting and conduit to be run between modular units. FIG. **4**B illustrates two adjacent floor truss stitch plates (**400**) viewed from the airspace between floor and ceiling systems (**410**). As previously discussed, floor truss stitch plates (**400**) are welded to the flange of long span floor beams (**200**) and bolted to the flange of long span ceiling beams (**205**). FIG. **4**C is an identical view of the two floor truss stitch plates depicted in FIG. **4**B but now with a floor truss stitch plate coupler (**415**) holding together the two adjacent floor truss stitch plates horizontally with, preferably, high strength slip critical bolts. With the floor truss system now held together vertically by floor truss stitch plates (**400**), and horizontally by floor truss stitch plate couplers (**415**), the size of the floor truss system's individual members can be significantly reduced. The floor truss stitch plate couplers also help properly align the floor surfaces of adjoining modular units, creating a level surface to install SMR's Fortocrete floor system.

[0046] FIG. 5A illustrates yet another unique aspect of SMR's structural system, the hallway connection. As was discussed earlier, a hallway extension is included in the structural framework of each SMR modular unit (see FIG. 2B). A full hallway (500) is formed when completed SMR modular units (260) are placed back-to-back with hallway connector plates (515) bonding together adjacent unit's hallway extensions. The length of hallway extensions, and thus the width of a full hallway, will depend on the building type and end user. It should also be noted, that a hallway may be formed by connecting a modular unit with the hallway extension, to an adjacent modular unit without such an extension. Not only can this hallway be used for ingress and egress (510), but it can also be used to provide services to the building through mechanical/utility chases (505). FIG. 5B illustrates a detailed view of the hallway connection described above. In this depiction, a full hallway has been formed by connecting multiple hallway extensions (235) together using hallway connector plates (515) and high strength slip critical bolts. The hallway structure also acts as a moment frame in a perpendicular direction from those moment frames that form individual SMR units.

[0047] 4.3 SMR Roof System

[0048] Once a building's modular units have been stacked into place and connected using the various methods previously described, the column cap plates (300) of the building's top floor receive SMR's roof system. FIG. 6 illustrates multiple angles of a building's top floor with SMR's roof system (600) attached. The roof system is attached to the top floor's modular units using the typical column and hallway connections previously discussed (see FIGS. 3A-3E & FIGS. 5A-5B for connection detail). The structural members that make up SMR's roof system (600) are similar to those of SMR modular units. The roof system has vertical square tube steel parapet columns (605) connected to horizontal wide flange beams (610, 615) creating a parapet wall (625) that surrounds the perimeter of the building. The roof system's diaphragm is also similar to that of a typical modular unit in that it is composed of Fortocrete panels (not shown) over steel roof joists (620), the main difference is that the roof system's floor is sloped toward the parapet wall for drainage (630).

[0049] 4.4 SMR Structures Completed Building

[0050] SMR modular units, when paired with the various connections and systems described above, give architects and developers a tool kit of pre-engineered building blocks that can be pieced together to form a multitude of building configurations. FIGS. 7A and 7B show two different views of a standard 6-story building composed of 72 modular units and a roof system. As shown in FIG. 7A, once completed, buildings constructed using SMR structures form hallways (500) with large open bays (700), absent of any interior columns on either side. The absence of interior columns provides building owners/designers tremendous flexibility as open bays can be designed for any conceivable use or configuration. Interior walls would be constructed with light gauge steel framing and drywall just like conventional mid-rise buildings; however, most of his interior work could be done in the factory before SMR modular units are shipped to the jobsite. FIGS. 7A and 7B also illustrate the web-like series of moment frames that are created on all 4 sides of a building constructed using SMR structures. Once connected, the moment frames in SMR's system are able to act in unison to resist lateral loads allowing member sizes of individual modular units to be significantly reduced. This web-like series of moment frames also gives buildings constructed using the SMR system a significant amount of structural redundancy. This means that if one or more of the building's beams fail during a seismic/wind event, there are many other support beams in close proximity that can carry the load of the failed beams. This redundancy in having many moment frames in an SMR structure makes it significantly more advantageous over conventional construction designs from a seismic/wind load standpoint.

[0051] Although FIGS. 7A and 7B show buildings with only two units connected back-to-back at the hallway, it should be noted as shown in FIG. 7C that extended bay depths (705) can be achieved by simply adding another row of modular units to either side of the structure. FIG. 7D shows "L" shaped building may also be achieved by reconfiguring the placement of modular units and using the systems and connections described herein. It would be apparent that other building shapes can be achieved including "T", "O" and "C".

[0052] 4.5 SMR Post Tension System (High Seismic/Wind)

[0053] In high seismic/wind regions, or as determined by structural engineers, SMR's post tension system may be utilized to provide additional structural strength. FIG. 8A illustrates the installation of SMR's post tension system where a post tension rod (or cable) (805) has been bolted from the roof to the foundation (820) as shown in FIG. 8B. Turning back to FIG. 8A, the rod (805) has been threaded through holes (330—FIG. 3C) in column connector plates (325) on each floor, attached to an energy dampening device on the roof (800) and bolted to a connection plate at the foundation (820). From the foundation to the roof, the building is now tied down vertically and compressed by with tension rods (or cables) at various load points throughout the building. In between each set of parapet columns (605) on the roof, a post tension energy dampening device (800) is used to create tension and pre-load the building. The energy dampening device consists of a post tension rod (or cable) strung through an upper and lower damper sleeve (815) which encases a rubber (or spring) dampening mechanism (810). As nuts are tightened on the threaded portion of the post tension rod (or cable) (805) atop the post tension energy dampening system (800), the upper and lower damper sleeves (815) compress around the rubber dampening mechanism (810) and pre-load the building to a pre-engineered compression. It would be apparent to one skilled in the art that other damping materials/structures may be employed including high tension springs for example.

[0054] This energy dampening device will be placed between pairs of columns as determined by the structural engineer. Some or all columns may require the dampening system depending on a buildings site conditions. From the foundation to the roof, the building is now vertically connected with post tension rods (or cables) to dampen energy from lateral forces on the structure resulting from seismic activity or high winds. The post tension system is engineered so that in a strong seismic/wind event the entire structure will flex, then return to the neutral position after the event as a result of the post tension energy dampening system.

[0055] FIGS. 9A-C show a representation of an SMR building (900) with a typical post-tension rod and energy dampening device in place (905). FIG. 9A shows the building in the neutral or rest position where each post-tension rod or cable (905) throughout the building experiences approximately the same amount of pre-engineered tension, thus the structure is in equilibrium. However, when a wind load or seismic event causes the building (i.e., the columns) to deflect as shown in

FIG. 9B, the post-tension rods or cables (**910** & **915**) are pulled compressing the rubber or spring mechanism in the energy dampening device. After the event, the energy dampening device pulls the building back into the neutral or at rest position as shown in FIG. 9C. The benefit of the post-tension rods or cables to bring the structure back into equilibrium adds structural stability in the event of seismic and extreme wind loads. The energy absorbing feature of the SMR post tension system helps return a building back to normal or equilibrium position with little if any structural damage.

[0056] Other seismic stability systems are concerned with maintaining the building's structural integrity only to the point of allowing the inhabitants to escape unharmed; however, the building is often too damaged afterwards to be repaired and must be razed. The SMR system using post-tension rods or cables and energy dampening device automatically brings the building back into the neutral position such that after a seismic event the building, while experiencing some cosmetic damage, would be structurally sound and could be repaired.

[0057] While particular embodiments of SMR structures have been disclosed, various modifications and extensions of the above described technology may be implemented using the teachings described above. All such modifications and extensions are intended to be included within the true spirit and scope of this patent application.

1. A modular system for constructing a mid-rise building comprising:

a plurality of structural steel, modular units configured to be stackable upon each other such that the height of a modular unit defines a single story in the mid-rise building,

wherein the plurality of modular units individually comprise first and second moment frames each individually including two vertical columns coupled to a floor beam and a ceiling beam such as to define a right-angled quadrilateral, and

wherein the first and second moment frames are coupled to each other by two long span floor beams and two long span ceiling beams to define a rectangular box.

2. The modular system of claim **1**, wherein a first modular unit, selected from the plurality of modular units, further comprises:

a first upper extension comprising steel wide flange beams cantilevered outward from the vertical columns of the first modular frame such that they are substantially aligned with the two long span ceiling beams, and

a first lower extension cantilevered outward from the vertical columns of the first modular frame such that they are substantially aligned with the two long span floor beams, and

wherein the first upper and lower extensions define an extension selected from the group consisting of: a first outlooker extension and a first hallway extension.

3. The modular system of claim **2**, wherein the first upper and lower extension define a first hallway extension, and the modular system further comprises a second modular unit, selected from the plurality of modular units, having a second upper extension and a second lower extension that define a second hallway extension configured to couple to the first hallway extension of the first modular steel unit to define a hallway in the mid-rise building.

4. The modular system of claim **1**, wherein the plurality of modular units individually comprise multiple floor truss stitch plates positioned on the underside of the long span floor beams on upper modular units that are configured to couple to the topside of long span ceiling beams of vertically adjoining, modular units stacked below the upper modular units to create a truss system where the physical stress points are shifted from the coupling points of the vertical columns along a neutral horizontal axis to positions at the top and bottom of the truss system further along the vertical columns.

5. The modular system of claim **4**, further comprising:

a plurality of floor truss stitch plate couplers that are configured to secure a first floor truss stitch plate positioned on a first modular unit to a second floor truss stitch plate positioned on a laterally adjacent second modular unit.

6. The modular system of claim **1**, further comprising:

a plurality of column connector plates, wherein the plurality of modular units individually comprise cap plates on top of the vertical columns, and base plates on the bottom of the vertical columns, and

wherein the cap plates and base plates are configured to attach to the column connector plates such that a cap plate positioned on top of a vertical column on a lower modular unit, can be coupled to a base plate on the bottom of a vertical column of an upper modular unit that is stacked on top of the lower modular unit.

7. The modular system of claim **6**, wherein the plurality of column connector plates are configured to allow attachment of four separate modular units including: the cap plates of two vertical columns, each from two separate horizontally adjacent lower modular units and the base plates of two vertical columns, each from two separate horizontally adjacent upper modular units stacked on top of the two lower modular units.

8. The modular system of claim **7**, further comprising:

a roof comprising a damper system positioned on top of the mid-rise building, a foundation beneath the mid-rise building, and a plurality of post tension members selected from the group consisting of: post tension rods and post tension cables,

wherein the post tension members are anchored to the foundation and are coupled to the damper system.

9. The modular system of claim **8**, wherein the plurality of column connector plates further comprise centrally positioned, vertical apertures configured to allow the post tension members to pass through.

10. The modular system of claim **8**, wherein the post tension members are individually strung through an upper and lower damper sleeve that encase and are configured to compress a rubber dampening mechanism such as to pre-load the mid-rise building to a pre-engineered compression.

11. A modular system for constructing a mid-rise building having a roof and a foundation comprising:

a plurality of structural steel, rectangular-box-shaped, modular units configured to be stackable upon each other such that the height of a modular unit defines a single story in the mid-rise building;

a damper system coupled to the roof of the mid-rise building;

and a plurality of post tension members selected from the group consisting of: post tension rods and post tension cables, wherein the post tension members are anchored to the foundation and are coupled to the damper system.

12. The modular system of claim **11**, wherein each post tension member of the plurality of post tension members is configured, in the absence of an external force, to experience approximately the same amount of tension such that the mid-rise building is in a state of equilibrium.

13. The modular system of claim **12** wherein the plurality of modular units individually comprise first and second moment frames each individually including two vertical columns coupled to a floor beam and a ceiling beam such as to define a right-angled quadrilateral, and wherein the first and second moment frames are coupled to each other by two long span floor beams and two long span ceiling beams to define a rectangular box shape.

14. The modular system of claim **13**, wherein a first modular unit, selected from the plurality of modular units, further comprises:

a first upper extension comprising steel wide flange beams cantilevered outward from the vertical columns of the first modular frame such that they are substantially aligned with the two long span ceiling beams, and

a first lower extension cantilevered outward from the vertical columns of the first modular frame such that they are substantially aligned with the two long span floor beams, and

wherein the first upper and lower extensions define an extension selected from the group consisting of: a first outlooker extension and a first hallway extension.

15. The modular system of claim **14**, wherein the first upper and lower extension define a first hallway extension, and the modular system further comprises a second modular unit, selected from the plurality of modular units, having a second upper extension and a second lower extension that define a second hallway extension configured to couple to the first hallway extension of the first modular steel unit to define a hallway in the mid-rise building.

16. The modular system of claim **13**, wherein the plurality of modular units individually comprise multiple floor truss stitch plates positioned on the underside of the long span floor beams on upper modular units that are configured to couple to the topside of long span ceiling beams of vertically adjoining, modular units stacked below the upper modular units to create a truss system where the physical stress points are shifted from the coupling points of the vertical columns along a neutral horizontal axis to positions at the top and bottom of the truss system further along the vertical columns.

17. The modular system of claim **16**, further comprising:

a plurality of floor truss stitch plate couplers that are configured to secure a first floor truss stitch plate positioned on a first modular unit to a second floor truss stitch plate positioned on a laterally adjacent second modular unit.

18. The modular system of claim **13**, further comprising:

a plurality of column connector plates, wherein the plurality of modular units individually comprise cap plates on top of the vertical columns, and base plates on the bottom of the vertical columns, and

wherein the cap plates and base plates are configured to attach to the column connector plates such that a cap plate positioned on top of a vertical column on a lower modular unit, can be coupled to a base plate on the bottom of a vertical column of an upper modular unit that is stacked on top of the lower modular unit.

19. The modular system of claim **18**, wherein the plurality of column connector plates are configured to allow attachment of four separate modular units including: the cap plates of two vertical columns, each from two separate horizontally adjacent lower modular units and the base plates of two vertical columns, each from two separate horizontally adjacent upper modular units stacked on top of the two lower modular units.

20. A damper system for use in a multistory building with a foundation, the system comprising:

a damper coupled to the building;

a plurality of post tension members selected from the group consisting of: post tension rods and post tension cables, the post tension members coupled to the foundation and to the damper;

wherein the post tension members are configured to transfer energy to the damper when the building experiences deflection event and wherein the damper elastically stores the energy during the event and releases the energy after the event, restoring the building to a substantially neutral equilibrium.

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