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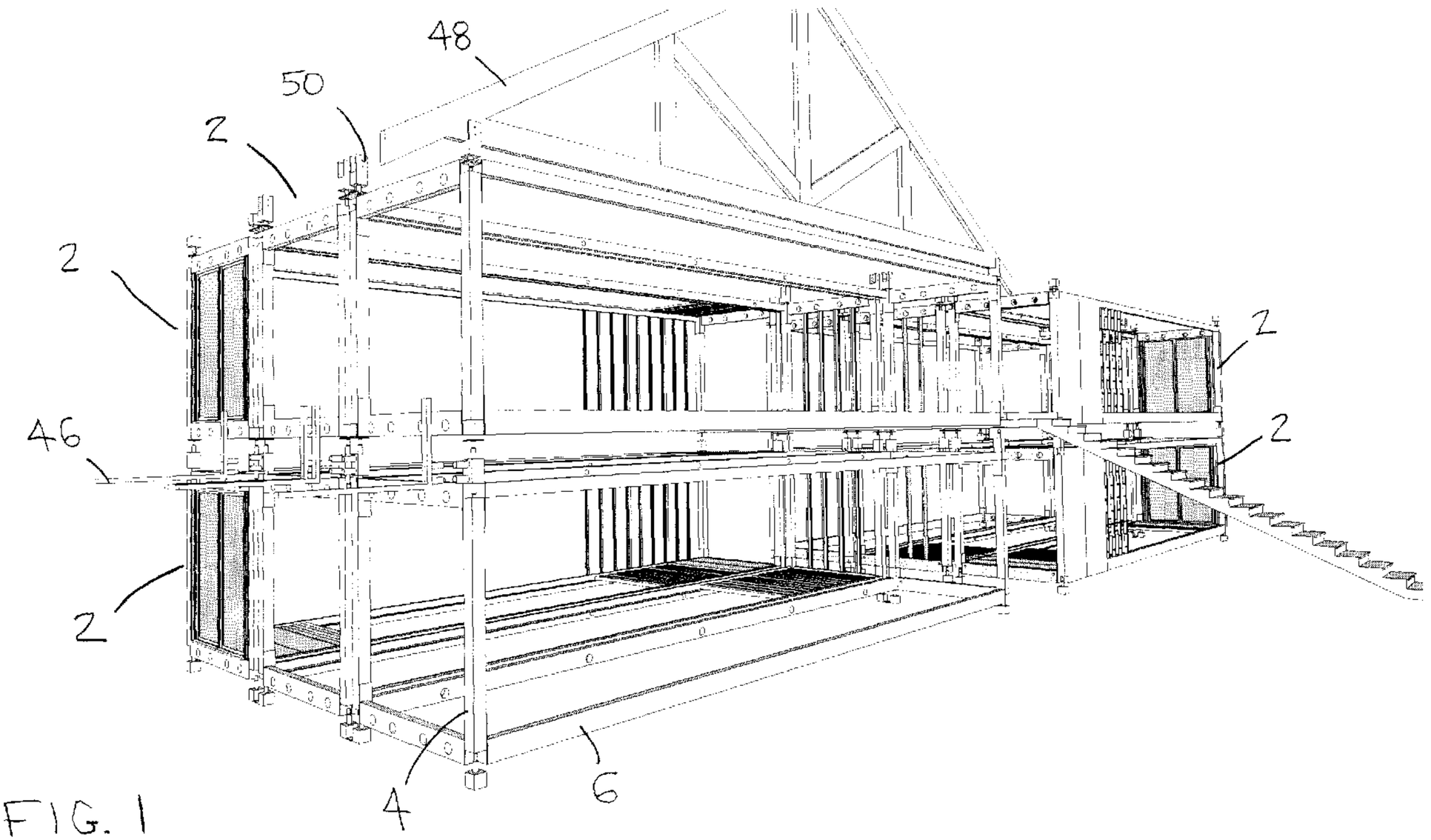



FIG. 1

(57) Abrégé/Abstract:
A modular building system in which individual cuboid modules are assembled at a manufacturing facility, optimized for transportation, and transported to a building site by conventional delivery systems. On site, the modules may be modularly assembled into multi-modular buildings. Buildings may be assembled by attaching together a plurality of the structurally self-supporting modules. The modules may be attached horizontally adjacent or vertically adjacent one another using a variety of specialized, interchangeable adaptors. The modules may also be offset horizontally, vertically or perpendicularly to one another.

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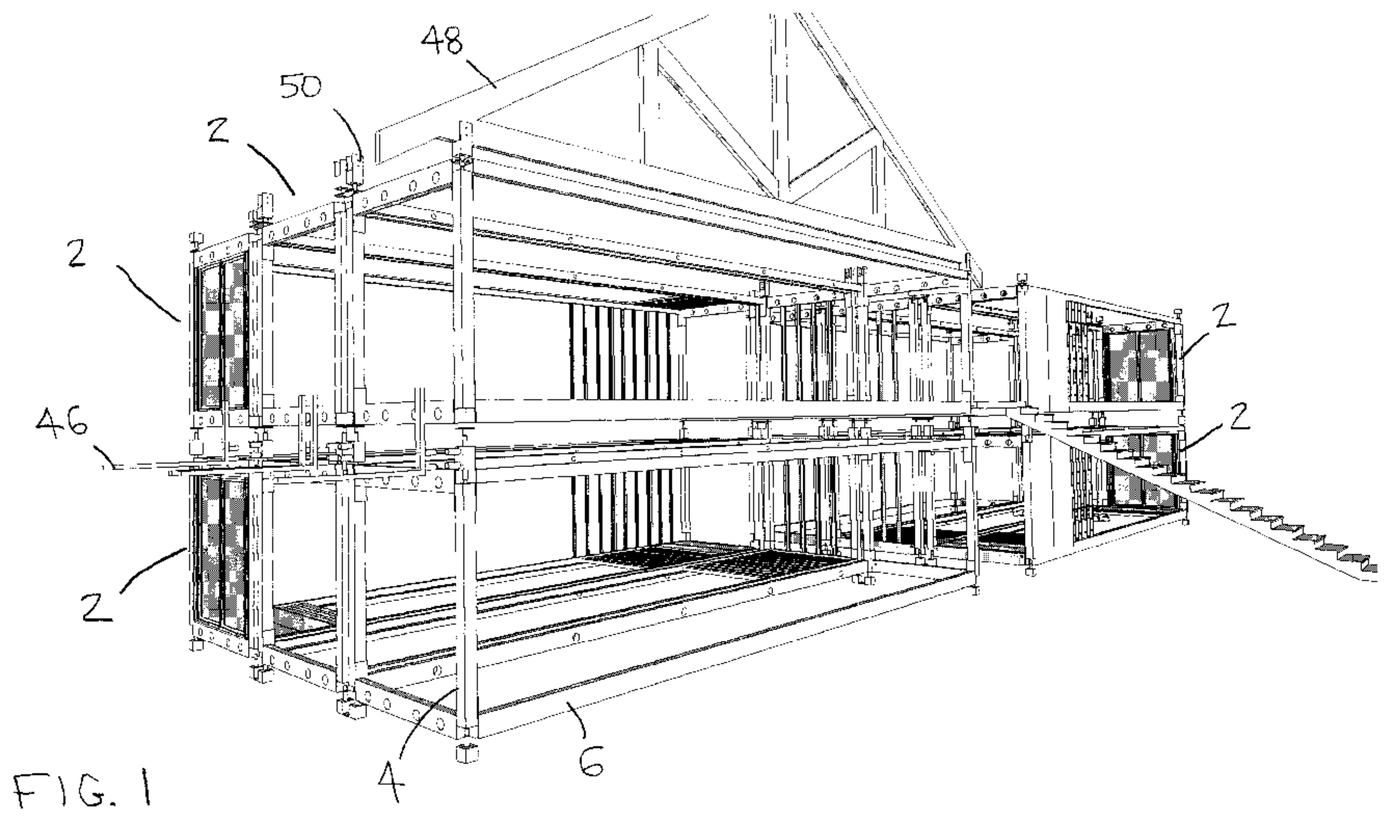



FIG. 1

**(57) Abstract**: A modular building system in which individual cuboid modules are assembled at a manufacturing facility, optimized for transportation, and transported to a building site by conventional delivery systems. On site, the modules may be modularly assembled into multi-modular buildings. Buildings may be assembled by attaching together a plurality of the structurally self-supporting modules. The modules may be attached horizontally adjacent or vertically adjacent one another using a variety of specialized, interchangeable adaptors. The modules may also be offset horizontally, vertically or perpendicularly to one another.

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# MODULAR BUILDING SYSTEM

## TECHNICAL FIELD OF THE INVENTION

The present invention relates to buildings. In particular, the invention relates to a modular building system.

## BACKGROUND OF THE INVENTION

In order to optimize building design flexibility, cost, and adaptability, modular building systems have been developed for residential, commercial and industrial application. However, existing prior art modular building systems have several drawbacks, which the present invention seeks to overcome.

Current prior art construction methods generally require the majority of construction work to be performed at the building site. There exist some prefabrication methods that seek to reduce the amount of on-site work, thereby realizing some cost savings. Significantly increasing the ratio of factory-based assembly to on-site work further reduces construction costs and improves the quality of construction. This efficiency is achieved by delivering to a building site finished modules which may be very quickly assembled on-site.

According to prior art prefabrication technologies, building components are transported to building sites as panels and are erected and finished on-site. Some prior art prefab systems offer limited interior finishing, but these typically are self-contained small, closed units. Other prior art prefabricated systems may deliver parts of a building by wide-load trucking, which is inefficient and expensive when shipped a considerable distance from the factory. Some prior art prefab buildings are container-based and cannot offer the flexibility of open space design, finish and precision due to the structural constraints imposed by the container.

## BRIEF DESCRIPTION OF THE DRAWINGS

The embodiments of the present invention are described below, with reference to the attached drawings in which:

FIG. 1 is an exploded front left view of a two-storey modular building structure, according to the invention;

FIG. 2 is an exploded rear left view of the two-storey modular building of FIG. 1, according to the invention;

FIG. 3 is an exploded left view of the inside under the corridor of the two-storey modular building of FIG. 1, according to the invention;

FIG. 4 is an exploded front left view of the two-storey modular building of FIG. 1, according to the invention;

FIG. 5 is an exploded view of adjacent stacked modules and adjacent lateral adaptors of the two-storey building of FIG. 1, according to the invention;

FIG. 6 depicts an exploded view of adjacent modules and lateral foundation adaptors, according to the invention;

FIG. 7 shows two adjacent modules from inside, with partial floor, according to the invention;

FIG. 8 shows two adjacent modules from inside, with partial floor, according to the invention;

FIG. 9 is an external view of two adjacent modules and a lateral foundation adaptor, according to the invention;

FIG. 10 is an interior view of the bottom floor of the two-storey building of FIG. 1, according to the invention;

FIG. 11 is an exterior view of the bottom floor of the two-storey building of FIG. 1, according to the invention;

FIG. 12 is a perspective view of seismic supports within the corridor/walkway structure between modules of a two-storey modular building, according to the invention;

FIG. 13 is a perspective view of seismic supports within the corridor/walkway structure between modules of a two-storey modular building also showing stairs, according to the invention;

FIG. 14 is an exploded top view of the two-storey modular building of FIG. 1, according to the invention;

FIG. 15 is an exploded side view of the two-storey modular building of FIG. 1, according to the invention;

FIG. 16 depicts corner adaptors, stacking adaptors, a lateral spacing adaptor and a balcony adaptor in the two-storey modular building of FIG. 1, according to the invention;

FIG. 17 depicts lateral spacing adaptors, corner adaptors, stacking adaptors, and balcony adaptors in the two-storey modular building of FIG. 1, according to the invention;

FIG. 18 depicts a corner adaptor, stacking adaptors, a roof adaptor, balcony adaptors, and lateral spacing adaptors in the two-storey modular building of FIG. 1, according to the invention;

FIG. 19 depicts corner adaptors, stacking adaptors, lateral spacing adaptors, roof adaptors, and balcony adaptors in the two-storey modular building of FIG. 1, according to the invention;

FIG. 20 depicts foundation adaptors, corner adaptors, stacking adaptors, lateral spacing adaptors, and balcony adaptors in the two-storey modular building of FIG. 1, according to the invention;

FIG. 21 is an exploded view showing a balcony adaptor and balcony support, connected to a standard stacking adaptor using a lateral spacing adaptor, according to the invention;

FIG. 22 depicts the upper storey of the two-storey building of FIG. 1, showing steel decking and partial concrete surface on the upper floor, according to the invention;

FIG. 23 depicts a roof truss connected by a roof adaptor to the two-storey building of FIG. 1, according to the invention;

FIG. 24 depicts a floor frame showing partial flooring;

FIG. 25 depicts a multiple-storey modular building and a truck delivering a module with removable ISO corner adaptors, for installation into the building, according to the invention;

FIG. 26 depicts the multiple-storey modular building of FIG. 35 and truck delivering a module for installation into the building, according to the invention;

FIG. 27 depicts the multiple-storey modular building of FIG. 35 with cross-bracing, according to the invention;

FIG. 28 depicts the multiple-storey modular building of FIG. 35 with cross-bracing and seismic bracing in the corridors, according to the invention;

FIG. 29 shows a second storey in which the modules are oriented perpendicular and cantilevered to those of the first storey, according to the invention;

FIG. 30 also shows a second storey in which the modules are oriented perpendicular and cantilevered to those of the first storey, according to the invention;

FIGS. 31-35 depict third-party structures contained within an alternate embodiment of the present invention;

FIG. 36 depicts another embodiment for stacked modules, showing an opening for a corner adaptor, and a stacking adaptor with corridor adaptor, according to the invention;

FIG. 37 depicts another embodiment for a stack of eight modules, showing various adaptors and adaptors, according to the invention;

FIGS. 38-40 show embodiments of a corner receptor at one end of a column;

FIGS. 41-43 show ISO and non-ISO embodiments of a removable transportation adaptor;

FIG. 44 shows a module with removable ISO corner adaptors, loaded on a truck for transportation to a building site, according to the invention;

FIG. 45 shows a module with removable ISO corner adaptors, loaded on a truck for transportation to a building site with cross-bracing for transport, according to the invention;

FIG. 46 shows a module with removable ISO corner adaptors, loaded on a truck for transportation to a building site with cross-bracing for transport and a covering tarp on the open side, according to the invention;

FIG. 47 shows a module with removable ISO corner adaptors, loaded on a truck for transportation to a building site with cross-bracing for transport and exterior sheathing on the roof and closed side, according to the invention;

FIG. 48 shows a module with removable ISO corner adaptors, loaded on a truck for transportation to a building site showing cross-bracing for transport and exterior sheathing on the closed side, according to the invention;

FIG. 49-51 show embodiments of a lateral spacing foundation adaptor;

FIGS. 52-53 show a mid-beam variable width lateral spacing adaptor;

FIG. 54 shows a mid-beam variable width lateral spacing adaptor;

FIG. 55 depicts a shim;

FIG. 56 shows a plug-in mid-beam variable width lateral spacing adaptor;

FIG. 57-58 show embodiments of a corner adaptor;

FIG. 59 depicts a shim;

FIG. 60 shows a shim and corner adaptor; according to the invention;

FIGS. 61-67 depict use of corner adaptors on smaller diameter vertical corner columns, according to one embodiment of the invention.

FIGS. 68-70 show one embodiment of a balcony adaptor

FIG. 70 shows a roof adaptor; according to the invention;

FIG. 71 shows a balcony adaptor; according to the invention;

FIG. 72-73 show balcony assemblies; according to the invention;

FIG. 74-75 shows a seismic spine for a corridor or walkway; according to the invention;

FIGS. 76-78 depict incorporation of in-wall bracing, according to one embodiment of the invention;

FIG. 79 depicts a steel cylinder for use as a conduit for mechanical and electrical services between modules, according to the invention;

FIG. 80 shows an HVAC adaptor between modules; according to the invention;

FIG. 81 shows an H-clip, or mid-beam 4-way adaptor;

FIGS. 82 and 83 show one embodiment of a mid-beam 4-way adaptor for mid-beam stacking and bracing, according to the invention;

FIGS 84-86 depicts various mid-beam adaptors; according to the invention;

FIG. 87 shows a mid-beam lateral stacking adaptor and corner stacking adaptors, according to the invention;

FIG. 88 shows another embodiment for a lateral spacing and mid-beam stacking adaptors, according to the invention;

FIG. 89 depicts a flush corner adaptor, according to the invention;

FIGS. 90-92 depict the transition assembly between adjacent modules, according to the invention;

FIGS. 93-98 depict the modular building envelope, according to the invention;

FIG. 99 depicts use of modules of differing length in the same building, according to the invention; and

FIG. 100 is an exploded view of a modular building, showing a corner window/door and lateral cross bracing embedded inside a wall, according to the invention.

SUMMARY OF THE INVENTION

In one of its aspects, the invention provides a structurally self-supporting cuboid module comprising a cuboid framework of vertical corner columns interconnected by horizontal beams defining a bottom floor frame, a top ceiling frame, and four side wall frames; a floor disposed in the floor frame; a ceiling disposed in the ceiling frame; and receiving means at each end of each column for receiving one of a plurality of adaptors.

The cuboid framework may be 8 feet wide, 40 feet long, and 9.5 feet high. The floor may be manufactured of steel, which may have a concrete layer on its upper surface, or the floor may be manufactured of pre-stressed, pre-cast concrete.

At least one intermediate column may extend between the ceiling frame and the floor frame between adjacent corner columns. There may be a wall disposed in each of the one or more wall frames. Each wall may comprise a plurality of spaced studs and drywall attached to the inner side of the studs and panels attached to the outer side of the studs. Each wall further may comprise at least one window. Each wall may further comprise at least one door.

A building envelope may be connected to the outer side of at least one wall. A roof assembly may be connected to the outer side of the ceiling frame.

One or more components of an electrical distribution system may be disposed within the framework, the electrical components selected from the group of electrical components consisting of electrical breaker panels, light fixtures, switches, dimmers, plugs, fans, appliances, air handlers, heat pump components, furnaces, electric baseboards, electric fireplaces, thermostats and controls.

One or more components of a plumbing system may be disposed within the framework, the plumbing components selected from the group of plumbing components consisting of toilets, sinks, waste disposal units, hot water tanks, washers, dryers, hot and cold water distribution conduits, faucets, baths and showers.

Heating, ventilation and air conditioning units and air distribution ducting may be disposed within the framework.

One or more finishing elements, the finishing elements selected from the group of finishing elements consisting of paint, wallpaper, carpeting, flooring, baseboards, cabinetry, tiling, countertops, trim, and appliances may be disposed within the framework.

A fire-rated drywall membrane may be installed along the inner and outer surfaces of the framework. All elements of the module may be non-combustible.

In another aspect, the invention provides a modular building system comprising a plurality of the structurally self-supporting cuboid modules described herein; and a plurality of adaptors, each adaptor attachable to one end of a column of a module for interconnection of each module to at least one horizontally adjacent or vertically adjacent other module, roof assembly, balcony, foundation or corridor, each adaptor selected from the group of adaptors comprising transportation adaptors, foundation adaptors, corner adaptors, lateral spacing adaptors, roof adaptors, balcony adaptors, corridor adaptors, H-clips, mid-component adaptors, and flush corner adaptors.

The system may include an online planning software tool for designing, modelling and pricing a building.

Each module may have the same dimensions, or a plurality of modules of differing lengths may be interconnected. The system may include a foundation having a plurality of foundation anchors for receiving foundation adaptors connected to the lowermost columns.

The system may include corner adaptors and lateral spacing adaptors to connect horizontally adjacent modules a desired horizontal distance apart. It may also include corner adaptors and spacers to connect vertically adjacent modules a desired vertical distance apart.

The system may include roof assemblies attached to the uppermost columns using roof adaptors.

One or more balconies may be attached between vertically adjacent modules using balcony adaptors. One or more corridors may be attached between horizontally adjacent modules using corridor adaptors.

Seismic bracing may be disposed within at least one corridor or floor structure of one or more modules.

A plurality of conduits may be disposed within one or more beams for interconnection of electrical or mechanical components between adjacent modules. A system of colour coding may be used to distinguish among the plurality of functionally distinct adaptors.

Sheathing may be attached between adjacent modules. Insulation and building envelope may be installed on the exterior of the building. Interlocking, insulated wall panels may be attached to the exterior walls of the outer modules of the building, the wall panels having a flashing having a foam insulation therein, the foam compressible between vertically adjacent modules to form a water resistant and airtight connection between modules.

A foam or rubber strip may be disposed along one or more of the outer sides of the columns, the strip compressible between horizontally adjacent modules to form a water resistant and airtight connection between modules.

The system of the invention may allow a first modular building to be assembled, then disassembled and reassembled into a second modular building of the same or different design at the same or different building site.

In another of its aspects, a method of constructing a building, may comprise the steps of: assembling a plurality of the structurally self-supporting cuboid modules as described herein at a manufacturing facility; transporting the modules to a construction site; assembling the modules into a building on a foundation using a plurality of specialized adaptors for interconnection of modules, each adaptor attachable to one end of a column of a module for interconnection of each module to at least one horizontally adjacent or vertically adjacent other module, roof assembly, balcony, foundation or corridor, each adaptor selected from the group of adaptors comprising transportation adaptors, foundation adaptors, corner adaptors, lateral spacing adaptors, roof adaptors, balcony adaptors, corridor adaptors, H-clips, mid-component adaptors, and flush corner adaptors; interconnecting components of electrical, plumbing, heating, ventilation and other

systems between adjacent modules; applying sheathing to brace adjacent modules; applying waterproof membranes to the exterior walls of the building; applying insulation to the exterior walls of the building; installing flashing on the top of each module, the flashing having a compressible gasket tape for sealing the space between vertically adjacent modules; and installing compressible strips along columns between horizontally adjacent modules.

Transportation adaptors may be installed into the receptors of the columns for use during transportation of the modules to a building site.

## DETAILED DESCRIPTION OF THE INVENTION

According to one embodiment of the present invention, there is provided a modular building system comprising individual building modules manufactured and assembled at a manufacturing facility. The modules and related modular components are optimized for transportation, and are transported to a building site by conventional ocean, rail, air and truck delivery systems using temporarily attached standard ISO shipping adaptors. Once on site, the modules may be modularly assembled into conventional-looking buildings.

The individual modules are the core units of the modular building system of the present invention. Buildings may be assembled by attaching together a plurality of the structurally self-supporting modules. The modules may be attached horizontally adjacent to one another, stacked vertically above and below one another, or both horizontally attached and vertically stacked using a variety of specialized, interchangeable adaptors between adjacent and stacked modules. The modules may also be offset horizontally, vertically or perpendicularly to one another.

In a preferred embodiment of the present invention, each module 2 is manufactured using steel columns 4 and beams 6 welded to form an open framework, as may be seen in Figs. 1-23, which depict a plurality of such modules. Preferably, each module is approximately 8 feet wide by 40 feet long by 9.5 feet high, although other dimensions are also within the scope of the invention. The ceiling preferably is constructed of conventional steel deck. Preferably, the floor 10 is constructed of steel deck 12 and may be covered with concrete 14, as shown in Figs. 5 and 24. Alternatively, pre-cast, pre-stressed concrete may be used for the floor assembly between the steel floor beams. The resulting basic module is an open structure with a ceiling structure, a floor structure parallel to the ceiling structure, and four corner columns, each column joining one corner of the ceiling structure to a corresponding corner of the parallel floor structure. Each of

the corner columns includes receiving means 16 on each end for receiving one of a variety of corner adaptors. Optionally, intermediate columns 18 may be desirable between the corner columns, depending on the structural requirements of the building, including length and load requirements.

Walls 20 may be constructed along the sides of each module between the columns using steel studs, drywall, panels, windows and doors. One or more sides of each module may be left open where multiple modules are to be connected together to form a living space larger than 8 feet by 40 feet, such as an apartment or single family home, or a commercial space such as an office or live-work studio. Further, a plurality of modules may be assembled into a multi-level installation such as a hospital or penal institution. Where fire rating and non-combustible construction are of less importance, for example, single or some forms of multi-family housing, wood beams and other structural wood components may be used in one or more walls, or ceilings, or floors.

Each basic module, comprising a ceiling, a floor, columns and walls may be finished at a factory prior to transportation to a building site. Numerous elements may be installed in each basic module at the factory. These elements include interior and exterior walls, floors, ceilings, building envelope and roof assemblies. These may also include wall coverings, carpeting, flooring and other finishes.

Another element which may be added to each module at the factory is the electrical distribution system, including the electrical breaker panel, lighting and light fixtures, switches, dimmers, plugs, fans, appliances, air handlers, heat pump components, furnaces, electric baseboards and fireplaces, thermostats and controls.

Similarly, the plumbing system may be pre-installed in the factory. Plumbing distribution and connections installed may include all plumbing fixtures including toilets, sinks, waste disposal units, hot water tanks, washers, dryers, hot and cold water distribution conduits, faucets, baths and showers. All of the plumbing components may be connected to hot and cold water mains and risers and drainage, as desired.

The heating, ventilation and air conditioning units and air distribution ducts and associated electrical connections may also be installed in the factory.

Ceiling, floor and wall finishes including paint, wallpaper, floor coverings and baseboards may be pre-installed in the factory, as may all cabinetry including kitchen, bathroom, laundry, and closet or storage cabinetry. Further, any tiles, marble, granite, bathroom and kitchen countertops, and accessories may also be added in the factory, along with doors, windows, trim and other surface finishes. Kitchen, laundry and any other appliances may also be pre-installed in the factory.

Once all structural components have been added in the factory, a fire-rated drywall membrane may be factory installed over all structural components to achieve the required fire rating. The fire rated drywall may be installed prior to the ceiling finish. The perimeter drywall will also contribute to achieving the required fire rating standard between apartments. The ceiling and floor assembly with the drywall on the lower apartment and concrete on the floor of the upper apartment provides vertical fire rated separations between apartments. Fire stops, as required, may be inserted in the walls between apartments where there is a space between adjacent apartments. Electrical wiring may be run internal or external to the fire-rated membrane. A decorative layer such as an additional drywall ceiling finish may be applied over the electrical wiring, plumbing and heating, ventilation and air conditioning equipment. Preferably, all material used in construction of the modules is non-combustible to obtain a non-combustible classification for the modular building system of the present invention. However, combustible materials may also be used if desired.

The modules of the present invention are engineered and designed to comply with Canadian and US building codes, and are manufactured to accept required certification and labels. Modification of the modules to comply with other building codes and required certification and labelling requirements is within the scope of the present invention.

At the building site, the modules may be assembled onto a foundation, laterally spaced and secured, and stacked into desired configurations, as depicted in Figures 1-23 which show a two-story building, Figures 25-28 which show a 6 storey building, Figures 29 and 30 which show a multi-storey building with at least some modules oriented perpendicular to adjacent modules, Figures 31-35 which show a 4-storey building incorporating third-party modular structures, and Figures 36 and 37 which show another embodiment of a 2 storey building.

Modules of the present invention may be designed to be interconnectable to form a wide variety of apartment types using a limited number of module types. For example, the kitchen or bath module of the present invention may be substantially similar for a range of apartment types including a studio apartment, a 1 bedroom apartment, a 2 bedroom 2-storey apartment, a 3 bedroom apartment, or other apartment configurations.

Each module is constructed with corners having corner receptors, as shown in Fig. 38-40, adaptable to specialized corner adaptors. Individual modules may be connected to horizontally adjacent and vertically stacked modules using selected function-specific adaptors.

The corner adaptors are interchangeable and are adapted for a number of potential purposes. For example, transportation adaptors 24, as shown in Figs. 41-43, may be attached to modules for shipping using methods associated with standard ISO handling and transportation, as depicted in Figs. 44-48. Once on a building site, these adaptors may be removed and specialized corner adaptors may be attached to the modules for specific purposes consistent with the function and location of a particular module within the building structure.

One of the specialized adaptors is a foundation adaptor 26, depicted in Figs. 49-51. Foundations are prepared with foundation anchors installed onto the top of the foundation wall. Foundation adaptors are used to connect the columns of the module to the foundation anchors.

Corner adaptors 28 have tapered ends and are designed to self guide themselves to precisely fit into the corner receptors. Foundation adaptors use the corridor components to precisely space and self-align the core modules. Corridor components have precisely located receptor holes into which the foundation adaptors self guide themselves, and are then locked into position.

Corner adaptors and lateral spacing adaptors 30 may be used to connect columns of horizontally adjacent modules. Embodiments of lateral spacing adaptors are depicted in Figs. 52-56.

In addition, corner adaptors, as shown in Figs. 57-58, may be used to connect one module to a vertically adjacent module at the corners of the building. Another component of the system of the present invention is a vertical spacer, as shown in Fig. 59. The vertical spacer may be used to provide a properly vertically spaced connection between columns. Vertical connections may be formed by combining a corner adaptor with a spacer, as shown in Fig. 60, or a corner adaptor

with a lateral adaptor, and may be used to connect columns of vertically and/or horizontally adjacent modules.

In an alternate embodiment, vertical columns which are smaller than ISO corner adaptors 34, preferably 5" by 5", may be used in the corners, in which case the ISO corner adaptors may overlap smaller horizontal beams 36 at each end of the module, as shown in Figures 61-67. The corner adaptors may rest on the steel plate which overlaps the smaller steel beam of this embodiment, as shown in Fig. 63, thereby eliminating the need to provide notches in the end beams for proper placement and alignment of the ISO corner adaptor to ensure it is flush to the exterior of the module. In addition, the use of smaller diameter end beams avoids the need for sleeves in the end beams as there is a substantial space provided between the end beam of the ceiling and the adjacent end beam of the floor in the module above.

Similarly, while modules may be laterally joined with no space between adjacent modules, it is also possible to separate modules a desired distance. A fixed lateral spacing adaptor 30 may be attached between adjacent lateral corner columns to determine precisely the distance between adjacent modules. The lateral spacer is designed to be placed onto the corner adaptors to provide precise spacing and a secure connection between adjacent modules. The space between adjacent modules can be set to custom dimensions to suit particular requirements of each specific building by selecting a spacer of the appropriate length. Shims 40 may be used on the other adaptors to match the vertical alignment of the lateral spacing adaptors.

Balcony adaptors 42 may be used to connect a balcony floor 44 to a corner adaptor between vertically connected modules, as shown in Figs. 68-70. The building envelope is first applied, and then the balcony structure is bolted to the balcony adaptors through holes in the installed exterior finish. A balcony can be extended seamlessly across multiple modules. The balcony adaptor design minimizes thermal bridging between the balcony and the building structure. A modular balcony structure 46 may be bolted directly to the corner columns of a core module, as shown in Figs. 72 and 73. By this method the balcony can be attached to the core module prior to the core modules installation.

Roof parapets or roof trusses 48 may be attached to the modules using roof adaptors 50 connectable to the corner adaptors and beams, as shown in Fig. 71. Alternatively, these may be attached to other parts of the structure.

Interior or exterior corridors 52 and walkways may be attached to the modules using corridor adaptors. A spine 54 for seismic bracing may be constructed for every floor of an apartment building by including bracing in a horizontal fashion within each corridor or walkway floor structure as shown in Fig. 74 and 75. According to one embodiment, bracing may be structural diagonally configured steel bars 56 installed inside of stud walls between columns for lateral bracing where required, as shown in Fig. 76. Other bracing structures may include diagonal sheathing bracing or other bracing. Additional cross-bracing may be custom designed into specific building components, including but not limited to stairway and elevator enclosing walls. Additionally, steel plate sheathing may be welded to the exterior of the module structure to provide a lateral structural support, in place of cross bracing and exterior sheathing. This steel sheathing may also provide structural strength and weather proofing during transportation and erection of a building.

According to one embodiment of the invention, as depicted in Figures 77-78, discreet in-wall bracing may be used whereby a flat steel bar 80 may be permanently welded to an exterior wall of a module in the same plane as the exterior surface of the structural beams and columns. A steel stud wall 82 structure may be assembled directly inside the steel bars, and a panel 84 of equivalent thickness may be attached to the steel studs on the exterior of the module, in the same plane as the steel bars, thereby creating a flat surface on both sides of this wall. The panel may be drywall or other material. The thickness of the flat steel bars and the panel may be 1/4 inch or other thickness.

To provide conduits for mechanical and electrical services, steel cylinders 86 as shown in Fig. 79 may be welded through structural beams and aligned at specific intervals to permit passage of mechanical and electrical services from one module to an adjacent module, as well as to run services to the exterior or to a corridor, as shown in Fig. 80. For example, heating ducts may be passed through floor sleeves between adjacent modules within a given apartment, or air ducts may be run from one module to a common area hallway or to the exterior.

Other adaptor components of the system include H-clips, shown in Figs. 81-83, for connecting four parallel beams; mid-component adaptors shown in Figs. 84-88, for connecting adjacent modules other than at a corner; and flush corner adaptors, shown in Fig. 9, for rendering a corner receptor flush.

A system of colour-coding, or other means, may be employed to associate each adaptor with its corresponding receptors. Such a system is intended to help eliminate misfit errors.

As shown in Figs. 90-92, once the modules have been assembled and set into place using variable width lateral spacers, the resulting open space between modules may be completed and finished using specially designed transition assemblies, including floor, ceiling, wall and exterior transitions. Sheathing is attached between adjacent modules once assembled, and then insulation and the building envelope may be applied on top of the sheathing on the transitions and module exteriors. A building envelope, including exterior walls, weather proofing and insulation, can be installed on the modules, in the factory or on the ground on the building site, prior to the erection/assembly of the modules, as depicted in Figs. 93-98. Interlocking, insulated wall panels are attached to the exterior walls of the modules along with a specially designed flashing 87 that includes a compressible insulating material such as foam attached to the flashing. The flashing may be installed on site (slipped between the wall panel and the module sheathing) or in the factory. Upon installation of one module above another, the flashing at the bottom of the upper module overlaps the lower module, and the foam compresses to create a water resistant and airtight connection between the vertically attached modules. Additionally, a compressible foam or rubber strip may be attached to the side edges of the insulated panels to seal the joints between laterally attached modules.

According to another embodiment of the invention, the waterproof membrane, insulation and building envelope finish on the core modules' exterior faces may be installed at a factory, and on site a continuous flashing to the top of each installed core module may be applied. A compressible gasket tape with peel and stick tape on each side of the gasket may then be applied to the top of the flashing. Another core module may be lowered and assembled onto the lower module having the flashing and gasket, thereby compressing the gasket to form a watertight seal between the vertically assembled core modules. This process may be repeated for each of the exterior core modules of the building.

Main electrical panels are factory installed in one of the modules and this main module is completely wired in the factory. A conduit is brought to an area in the ceiling next to the location of the electrical connections of the adjacent secondary module. Each module has a removable ceiling panel that allows access to the wiring connections in the ceiling. The pre-

wired electrical ends in the secondary module are run through two sets of adjacent sleeves and into an electrical box in the ceiling of the main module. Corresponding wires are run in the conduit to the main electrical panel where circuit breakers are installed. The connections in the ceiling connection box are spliced and the ceiling panels in each of the adjacent modules are replaced. Alternatively, a conduit may not be required, and wires may be brought from breakers in the electrical panel, left loose in the ceiling adjacent the sleeve in the floor or ceiling, and then passed through the sleeve and connected in the junction box of the adjacent module once the modules are assembled next to another. The location of the junction box can be interchanged between modules as desired.

Plumbing drains, vents and water supply risers and sprinkler components are factory installed in each module as designed. Preferably, these are brought to a utility closet where connections to utility mains may be brought for connection to the module. All plumbing fixtures inside the modules have been factory installed and the drains and water supplies have been brought to the utility closet for quick and simple connection. Alternatively plumbing risers can be installed in the space between adjacent apartments and then concealed using modular panels or components.

Although intended to be permanent, the building system is also designed to be dismantled, moved to another location and re-assembled. All structural components are designed to be interconnected on site, rather than welded together. The major part of the building can be dismantled and re-used, including the building envelope. Thus, a building can be amortized over a desired period of time, then removed, and will yield a residual value through reuse or sale of the modules.

In one embodiment, modules of differing lengths may be stacked in a building, as shown in Fig. 99.

In another of its aspects, as illustrated in Figure 31 to 35, the invention comprises a self supporting framework 90 which can be created using the corner columns and adaptors of the present invention to contain third-party manufactured units 92 such as trailers or mobile homes which normally are not designed to be stackable, interconnected, or even to be used as building components. Once the corner columns are securely attached to these units, and properly braced, this self-supporting entity can become a modular, self-supporting component of a building constructed from the modules of the present invention. The building structure incorporating the

third-party units may be finished in the manner previously described for modular buildings not containing third-party units, by attaching modules side by side, and vertically, securing the connections, attaching corridors, walkways, roofing, balconies, insulation, exterior cladding, and the other components described above.

In another aspect, windows 94 may be placed in corners of one or more modules, with adjacent in-wall bracing 96, as shown in Fig. 100.

For transportation, temporary ISO shipping adaptors 96 (or non-ISO shipping adaptors 98) may be added to the corner receptors of the modules. These shipping adaptors are removed at the building site and replaced with a variety of specialized adaptors, each designed for a specific function

As shown in Figs. 44-48, temporary flat steel bracing 100 with optional turnbuckle adjustment may be installed on each side of each module for additional rigidity during transportation, where thick steel sheathing has not been used for lateral bracing and support of intermediate columns. Threaded rods secured with couplings and nuts may be used instead of turnbuckles and flat steel. Optionally, for closed walls, cross bracing may be installed for transportation purposes and left in the wall permanently for the purpose of structural lateral bracing. Temporary steel bracing may also be used for open sides and the ends of modules where doors and windows are installed. Other transportation bracing methods may also be used.

Temporary covering of any openings 102, or the entire core modules, is desirable for transportation and site assembly until the modules have been assembled into a building and the roof has been completed. The preferred embodiment for such covering is use of a customized tarp fastenable to the steel frame of the module using specialized spaced grommets. The edges of the tarp may be inserted under a flashing extending from the roof and sides of the module. A vertical zipper with pull tabs on both sides may be incorporated into the tarp for access to either side of the module for removal of the tarp. Conventional truck tarp material may be used. Other methods of temporarily covering the modules during transportation and installation are also possible, including use of disposable shrink wrap plastic sheets to protect the modules from water infiltration.

Temporary protective coverings may not be required for all walls. These walls may be factory fitted with water proof sheathing and any doors and windows in these walls may be factory sealed.

Buildings constructed with the modular technology of the present invention typically may be installed on conventional concrete foundations, but other foundations are also possible. Once a building has been erected, building utilities may be connected to selected modules as desired. Building components such as balconies, stairs, corridor components, roof or canopies and other components also may be connected to one or more of the modules with the specialized adaptors, or directly to the beams and columns. Each of the modules of the present invention is a factory-finished living space component, completely finished and serviced and ready to be incorporated into the building for which it is designed.

In a preferred embodiment, the modular building system of the present invention is designed for low-rise, mid-rise and high-rise residential and commercial buildings, but other embodiments of the invention may be adapted for use in all kinds of construction, including but not limited to single family housing.

The modular building system of the present invention provides several improvements to prior art construction technologies. One of these is the self-supporting open structure design that allows a flexible arrangement of open space design, window and door placement, and building envelope finish. In addition, the building system of the present invention provides novel, precise, quick and efficient connection means between modules.

The building system of the present invention maximizes the proportion of finishing which is completed at the factory, as opposed to the building site. Specialized production jigs may be designed to achieve economies of scale and to standardize the fabrication of core modules, corner adaptors and other factory assembly processes as required.

Installation tools for quick onsite building assembly, such as self-levelling lifting attachments that quickly attach and release core modules. Other specialized tools may be designed to improve speed of assembly or as otherwise required.

The building system of the present invention is not inherently limited in building height or size as are some prior art technologies.

Transportation of building modules is optimized under the building system of the present invention. The system provides the ability to adapt to the ISO transportation grid at the most cost effective transportation rates. The use of ISO standards renders the system economically feasible for transportation globally across oceans and continents. This ease of transportation permits manufacturing to take place in locations where the cost of manufacturing and labour is lower, thereby reducing manufacturing costs.

For transportation, the entire module may be covered with a tarp or plastic wrap with easy to operate enclosures such as zippers, Velcro or shrink wrap bonding.

Apartment building construction can be completed in a fraction of the time required to build conventional buildings. By reducing on-site time and labour, overall costs may be reduced, and costs and construction time can be more accurately budgeted. The ability for adjustable transitions maximizes the floor area of a building that may be developed. Construction testing has demonstrated erection of one module above a second module may be completed in an average time of 5 minutes.

The present invention also produces a highly precise building with as little as 1/16th of an inch tolerance at each corner.

The system of the present invention is easily adaptable to sustainable technologies, including grey water re-use, geo-thermal, solar technologies and other emerging green building technologies.

In another of its aspects, the building system of the present invention includes an interactive building planning software tool which may be made available online via the Internet. The building planning software offers drag and drop tools for users to assemble building models from a selection of standard building system components. The user may configure a mix of apartment types and floor layouts. The resulting building model may be viewed and rotated in three dimensions.

The user may save the building design by registering and logging into an account created in a client relationship management database. The software will calculate an estimated cost for the building designed, based on the total cost of the required components. Orders may be generated using this software, and the orders may be tracked. All building system components may also be

tracked on site using a bar code scanner, and may be associated with the portion of the building they are designed for.

It is to be expressly understood that variations from the embodiments of the invention as described are within the scope of the invention.

CLAIMS

1. A structurally self-supporting cuboid module comprising:

a cuboid framework of vertical corner columns interconnected by horizontal beams defining a bottom floor frame, a top ceiling frame, and four side wall frames;

a floor disposed in the floor frame;

a ceiling disposed in the ceiling frame; and

receiving means at each end of each column for receiving one of a plurality of adaptors.

2. The module of claim 1, wherein the cuboid framework is 8 feet wide, 40 feet long, and 9.5 feet high.

3. The module of claim 1, wherein the floor is manufactured of steel.

4. The module of claim 3, wherein the steel floor further comprises a concrete layer on its upper surface.

5. The module of claim 1, wherein the floor is manufactured of pre-stressed, pre-cast concrete.

6. The module of claim 1, further comprising at least one intermediate column extending between the ceiling frame and the floor frame between adjacent corner columns.

7. The module of claim 1, further comprising a wall disposed in each of the one or more wall frames.

8. The module of claim 7, wherein each wall comprises a plurality of spaced studs and drywall attached to the inner side of the studs and panels attached to the outer side of the studs.

9. The module of claim 8, wherein each wall further comprises at least one window.

10. The module of claim 8, wherein each wall further comprises at least one door.

11. The module of claim 8, further comprising a building envelope connected to the outer side of at least one wall.

12. The module of claim 8, further comprising a roof assembly connected outer side of the ceiling frame.

13. The module of claim 8, further comprising one or more components of an electrical distribution system disposed within the framework, the electrical components selected from the group of electrical components consisting of electrical breaker panels, light fixtures, switches, dimmers, plugs, fans, appliances, air handlers, heat pump components, furnaces, electric baseboards, electric fireplaces, thermostats and controls.

14. The module of claim 8, further comprising one or more components of a plumbing system disposed within the framework, the plumbing components selected from the group of plumbing components consisting of toilets, sinks, waste disposal units, hot water tanks, washers, dryers, hot and cold water distribution conduits, faucets, baths and showers.

15. The module of claim 8, further comprising heating, ventilation and air conditioning units and air distribution ducting disposed within the framework.

16. The module of claim 8, further comprising one or more finishing elements, the finishing elements selected from the group of finishing elements consisting of paint, wallpaper, carpeting, flooring, baseboards.

17. The module of claim 8, further comprising one or more finishing elements selected from the group of finishing elements comprising cabinetry, tiling, countertops, trim, and appliances.

18. The module of claim 8, further comprising a fire-rated drywall membrane installed along the inner and outer surfaces of the framework.

19. The module of claim 8, wherein all elements are non-combustible.

20. A structurally self-supporting cuboid module comprising:

a cuboid framework 8 feet wide, 40 feet long, and 9.5 feet high of vertical corner columns interconnected by horizontal beams defining a bottom floor frame, a top ceiling frame, and four side wall frames;

receiving means at each end of each column for receiving one of a plurality of adaptors.

a floor disposed in the floor frame;

a ceiling disposed in the ceiling frame;

a wall disposed in each of the one or more wall frames, each wall having a plurality of spaced studs and drywall attached to the inner side of the studs and panels attached to the outer side of the studs;

at least one window in at least one wall;

at least one door in at least one wall;

a building envelope connected to the outer side of at least one wall;

a roof assembly connected to the outer side of the ceiling frame;

one or more components of an electrical distribution system disposed within the framework, the electrical components selected from the group of electrical components consisting of electrical breaker panels, light fixtures, switches, dimmers, plugs, fans, appliances, air handlers, heat pump components, furnaces, electric baseboards, electric fireplaces, thermostats and controls;

one or more components of a plumbing system disposed within the framework, the plumbing components selected from the group of plumbing components consisting of toilets, sinks, waste disposal units, hot water tanks, washers, dryers, hot and cold water distribution conduits, faucets, baths and showers;

heating, ventilation and air conditioning units and air distribution ducting disposed within the framework;

one or more finishing elements, the finishing elements selected from the group of finishing elements consisting of paint, wallpaper, carpeting, flooring, baseboards, cabinetry, tiling, countertops, trim, and appliances; and

a fire-rated drywall membrane installed along the inner and outer surfaces of the framework.

21. A modular building system comprising

a plurality of the structurally self-supporting cuboid modules of any of claims 1 to 20; and

a plurality of adaptors, each adaptor attachable to one end of a column of a module for interconnection of each module to at least one horizontally adjacent or vertically adjacent other

module, roof assembly, balcony, foundation or corridor, each adaptor selected from the group of adaptors comprising transportation adaptors, foundation adaptors, corner adaptors, lateral spacing adaptors, roof adaptors, balcony adaptors, corridor adaptors, H-clips, mid-component adaptors, and flush corner adaptors.

22. The modular building system of claim 21, further comprising an online planning software tool for designing, modelling and pricing a building.

23. The modular building system of claim 21, wherein each module has the same dimensions.

24. The modular building system of claim 21 wherein a plurality of modules of differing length are interconnected.

25. The modular building system of claim 21, further comprising a foundation having a plurality of foundation anchors for receiving foundation adaptors connected to the lowermost columns.

26. The modular building system of claim 21, wherein corner adaptors and lateral spacing adaptors are used to connect horizontally adjacent modules a desired horizontal distance apart.

27. The modular building system of claim 21, wherein corner adaptors and spacers are used to connect vertically adjacent modules a desired vertical distance apart.

28. The modular building system of claim 21, further comprising roof assemblies attached to the uppermost columns using roof adaptors.

29. The modular building system of claim 21, further comprising one or more balconies attached between vertically adjacent modules using balcony adaptors.

30. The modular building system of claim 21, further comprising one or more corridors attached between horizontally adjacent modules using corridor adaptors.

31. The modular building system of claim 31, further comprising seismic bracing disposed within at least one corridor or floor structure of one or more modules.

32. The modular building system of claim 21, further comprising a plurality of conduits disposed within one or more beams for interconnection of electrical or mechanical components between adjacent modules.

33. The modular building system of claim 21, wherein a system of colour coding is used to distinguish among the plurality of functionally distinct adaptors.

34. The modular building system of claim 21, further comprising sheathing attached between adjacent modules.

35. The modular building system of claim 21, further comprising application of insulation and building envelope to the exterior of the building.

36. The modular building of claim 21, further comprising interlocking, insulated wall panels attached to the exterior walls of the outer modules of the building, the wall panels having a flashing having a foam insulation therein, the foam compressible between vertically adjacent modules to form a water resistant and airtight connection between modules.

37. The modular building system of claim 21, further comprising a foam or rubber strip along one or more of the outer sides of the columns, the strip compressible between horizontally adjacent modules to form a water resistant and airtight connection between modules.

38. The modular building system of claim 21, wherein a first modular building may be assembled, then disassembled and reassembled into a second modular building of the same or different design at the same or different building site.

39. A method of constructing a building, comprising the following steps:

assembling a plurality of the structurally self-supporting cuboid modules of any of claims 1 to 20 at a manufacturing facility;

transporting the modules to a construction site;

assembling the modules into a building on a foundation using a plurality of specialized adaptors for interconnection of modules, each adaptor attachable to one end of a column of a module for interconnection of each module to at least one horizontally adjacent or vertically adjacent other module, roof assembly, balcony, foundation or corridor, each adaptor selected from the group of adaptors comprising transportation adaptors, foundation adaptors, corner adaptors, lateral spacing adaptors, roof adaptors, balcony adaptors, corridor adaptors, H-clips, mid-component adaptors, and flush corner adaptors;

interconnecting components of electrical, plumbing, heating, ventilation and other systems between adjacent modules;

applying sheathing to brace adjacent modules;

applying waterproof membranes to the exterior walls of the building;

applying insulation to the exterior walls of the building;

installing flashing on the top of each module, the flashing having a compressible gasket tape for sealing the space between vertically adjacent modules;

installing compressible strips along columns between horizontally adjacent modules;

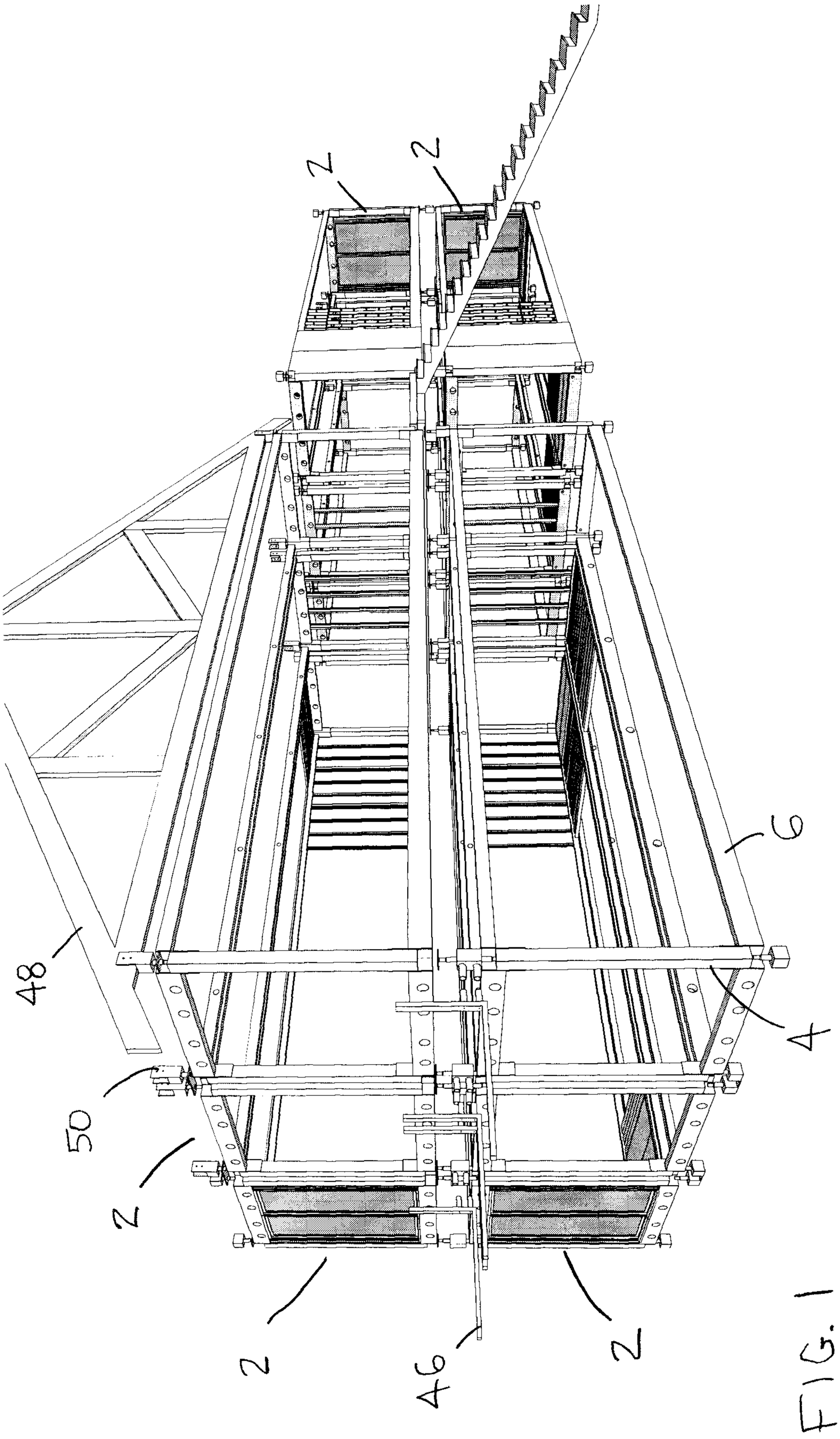
40. The method of claim 39, further comprising insertion of transportation adaptors for use during transportation of the modules to a building site.

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Unscannable items
received with this application
(Request original documents in File Prep. Section on the 10th floor)

Documents reçu avec cette demande ne pouvant être balayés
(Commander les documents originaux dans la section de préparation des dossiers au 10ème étage)


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FIG. 1

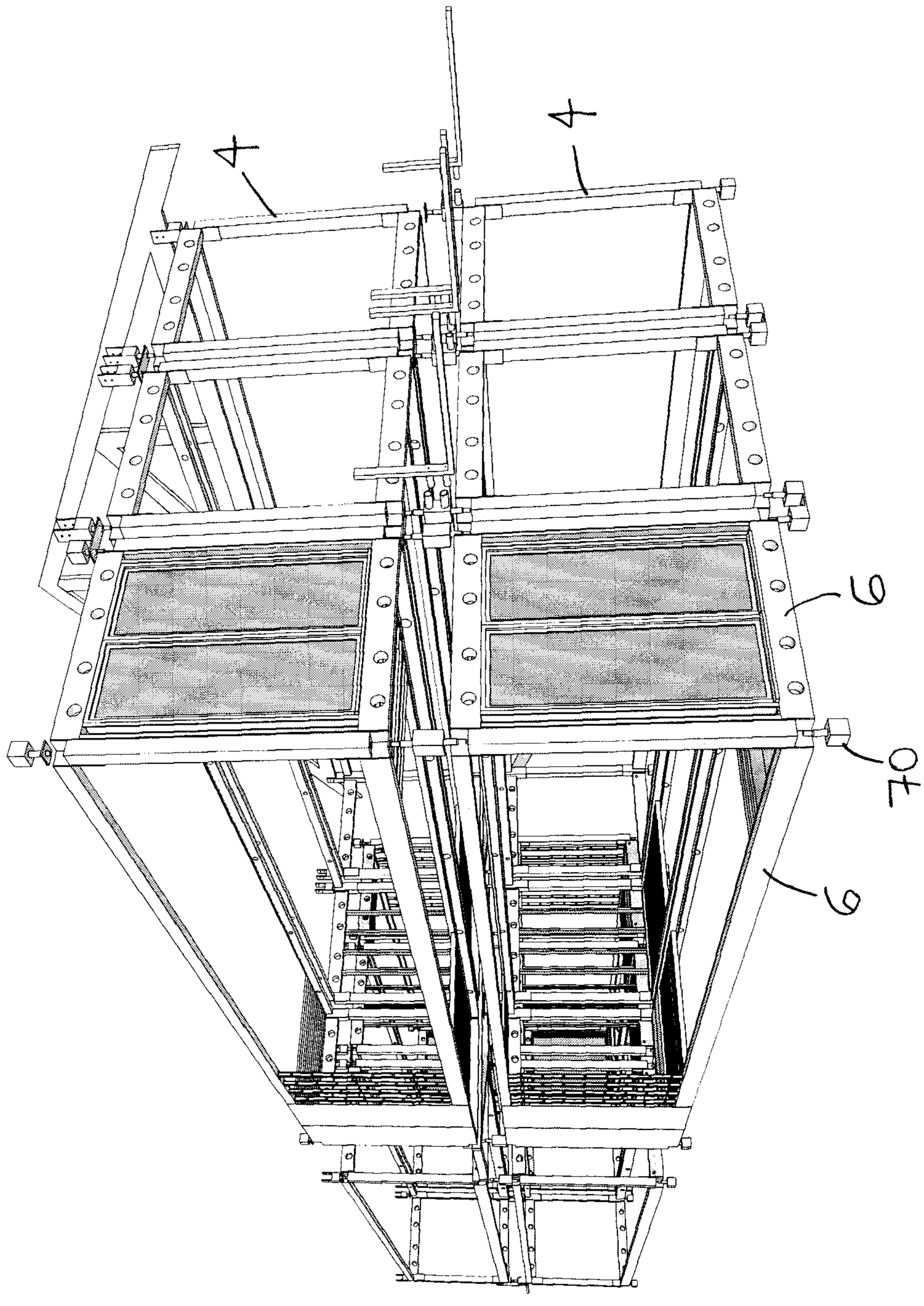



FIG. 2

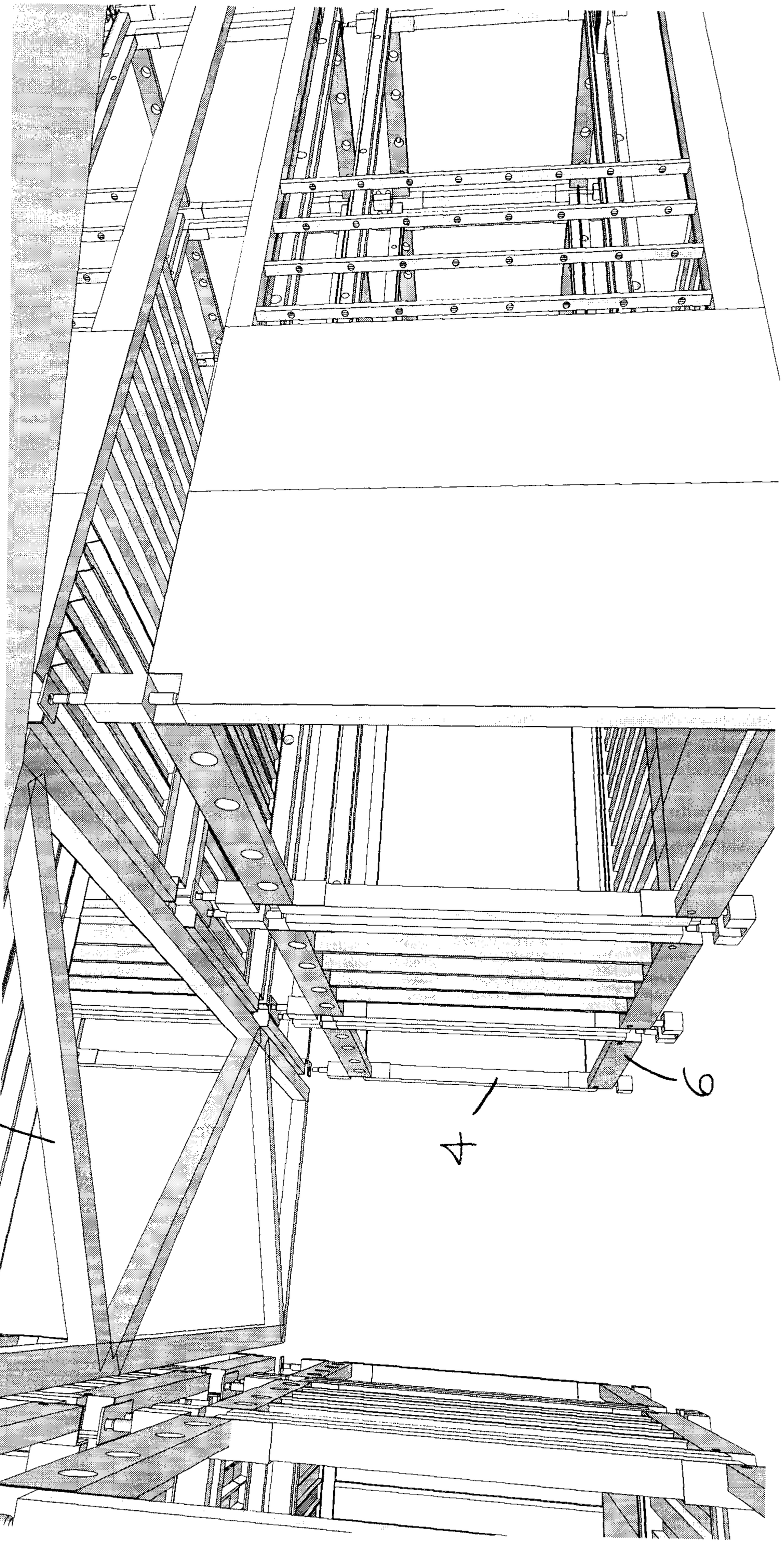



FIG 3

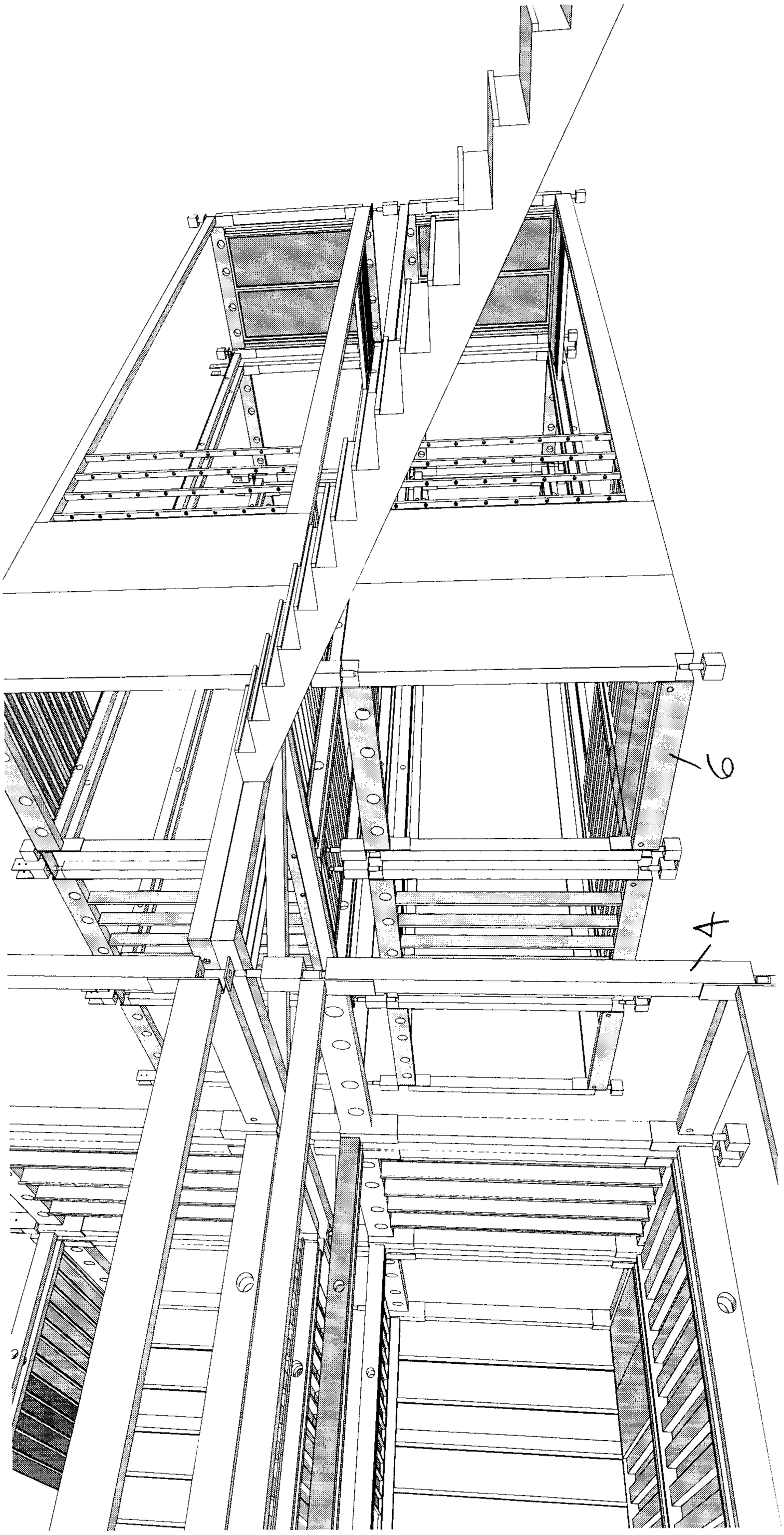
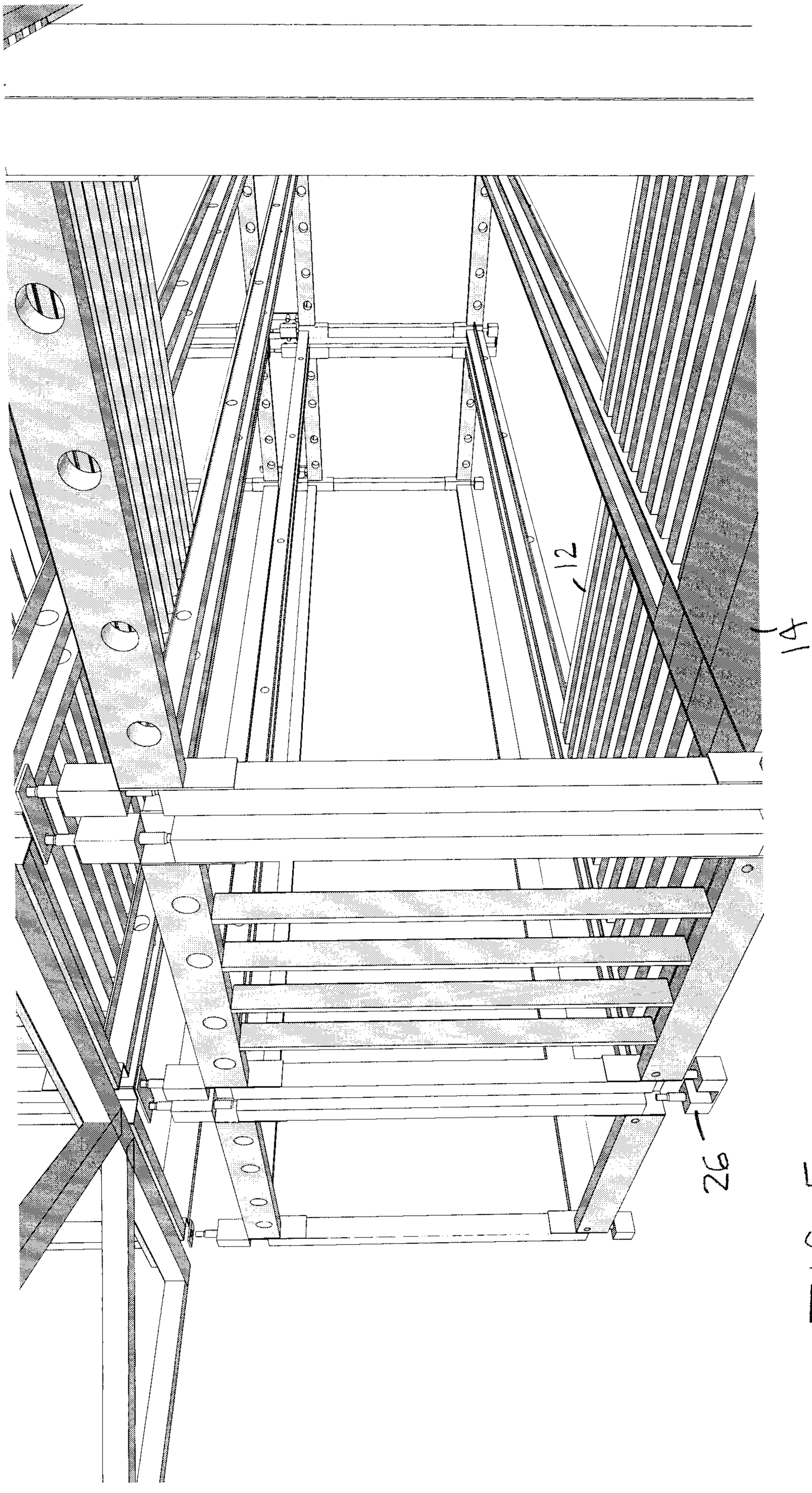



FIG. 4


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FIG. 5

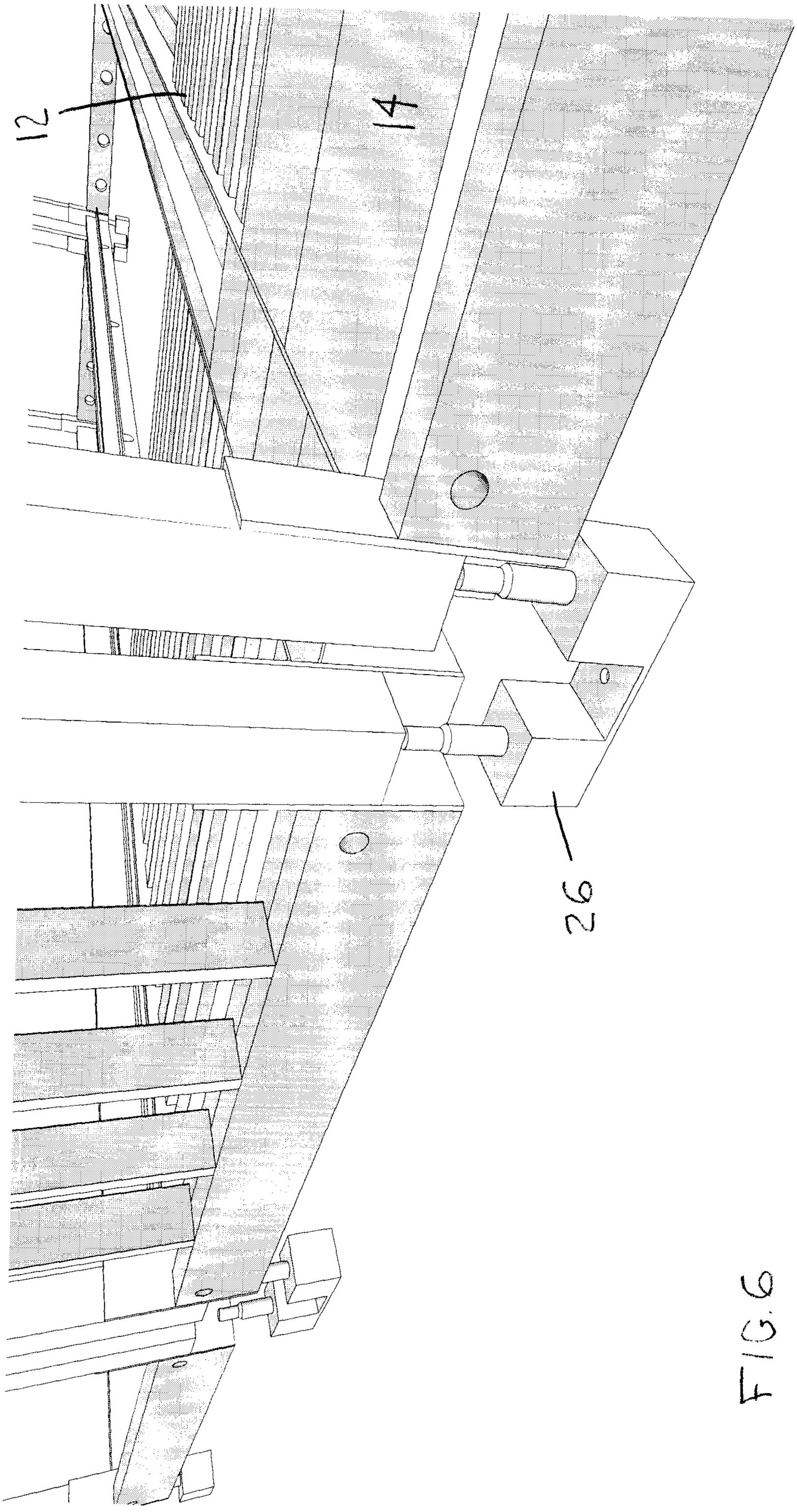
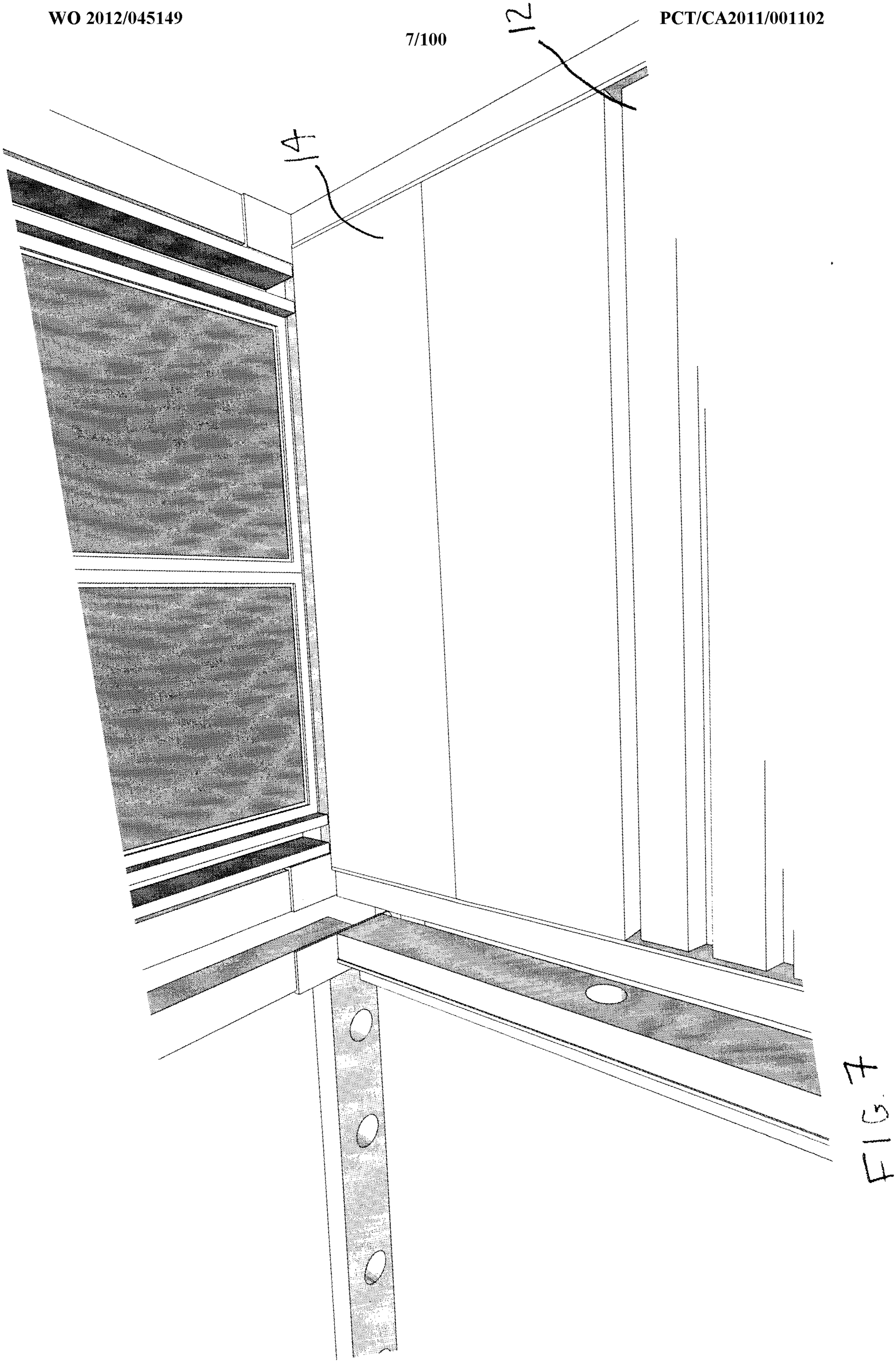



FIG. 6


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FIG 5

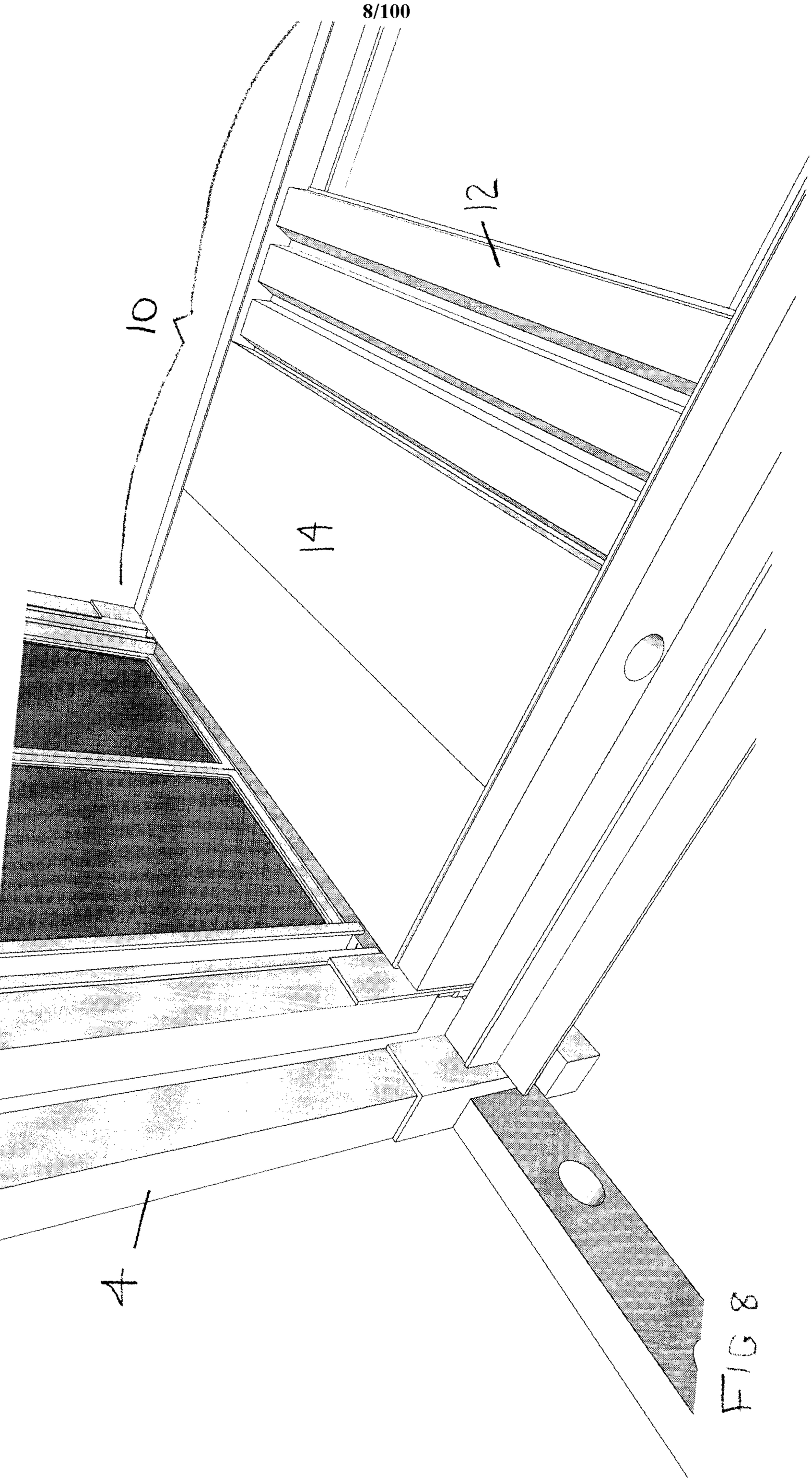



FIG 8

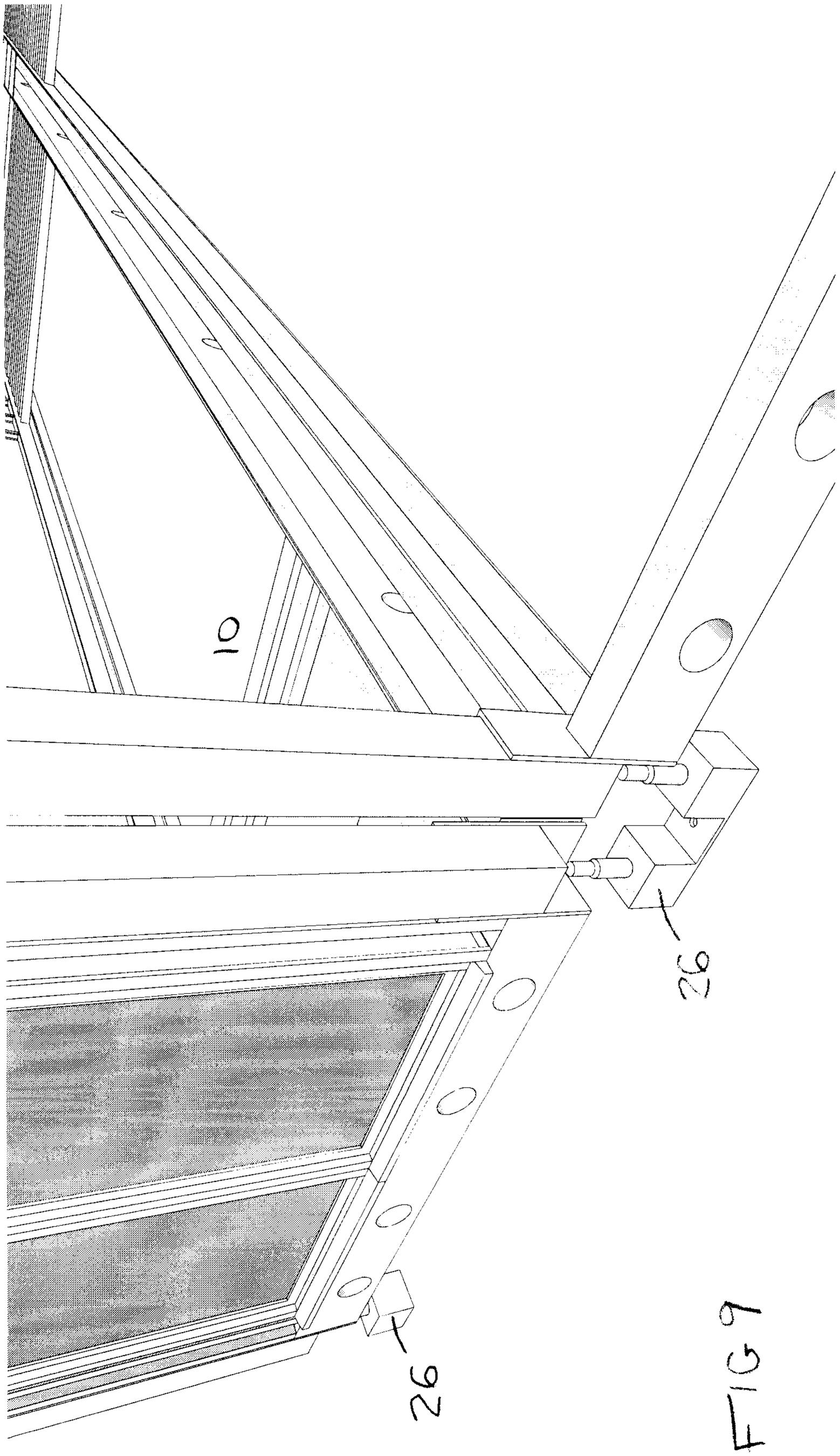



FIG 9

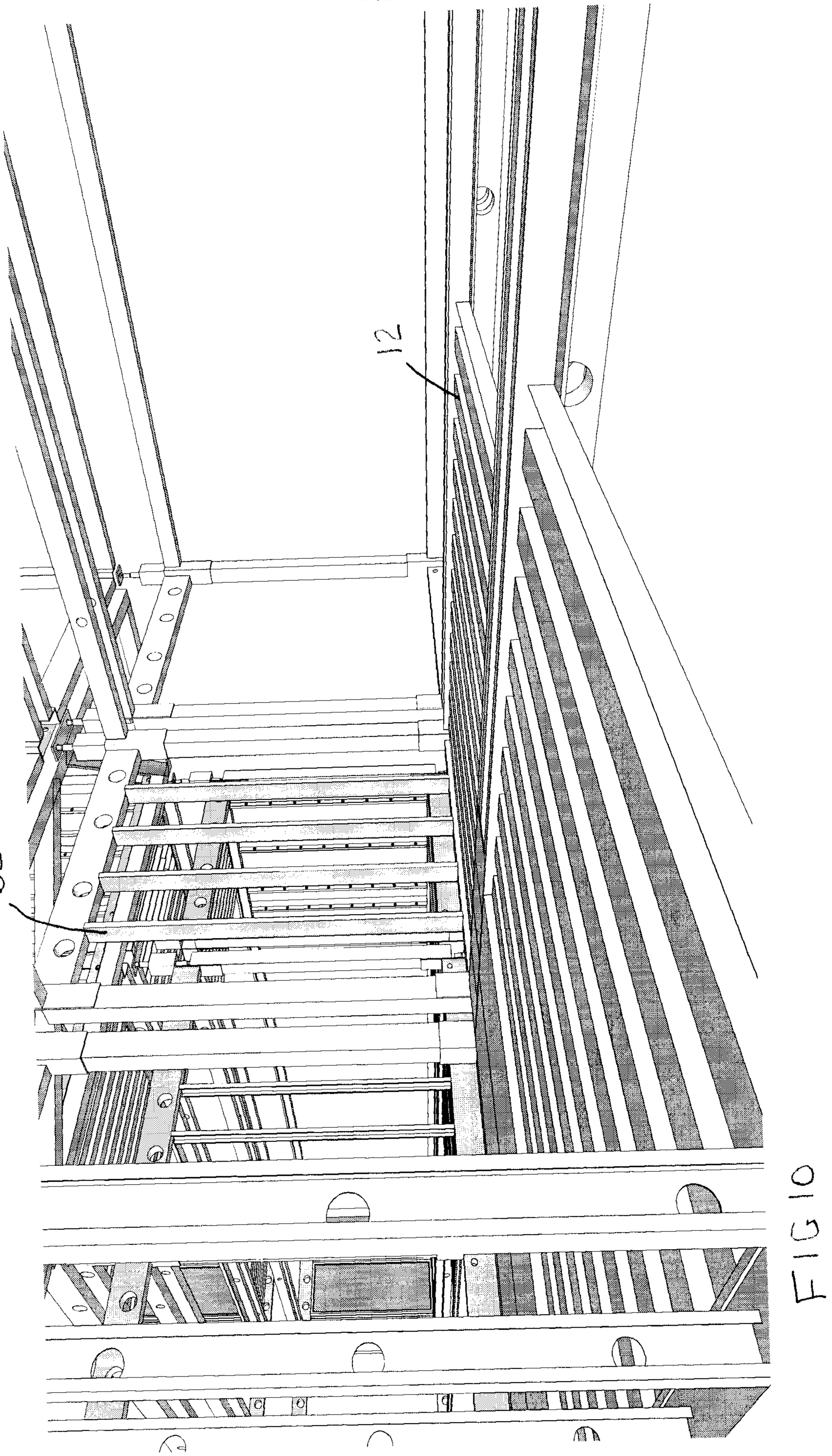



FIG 10

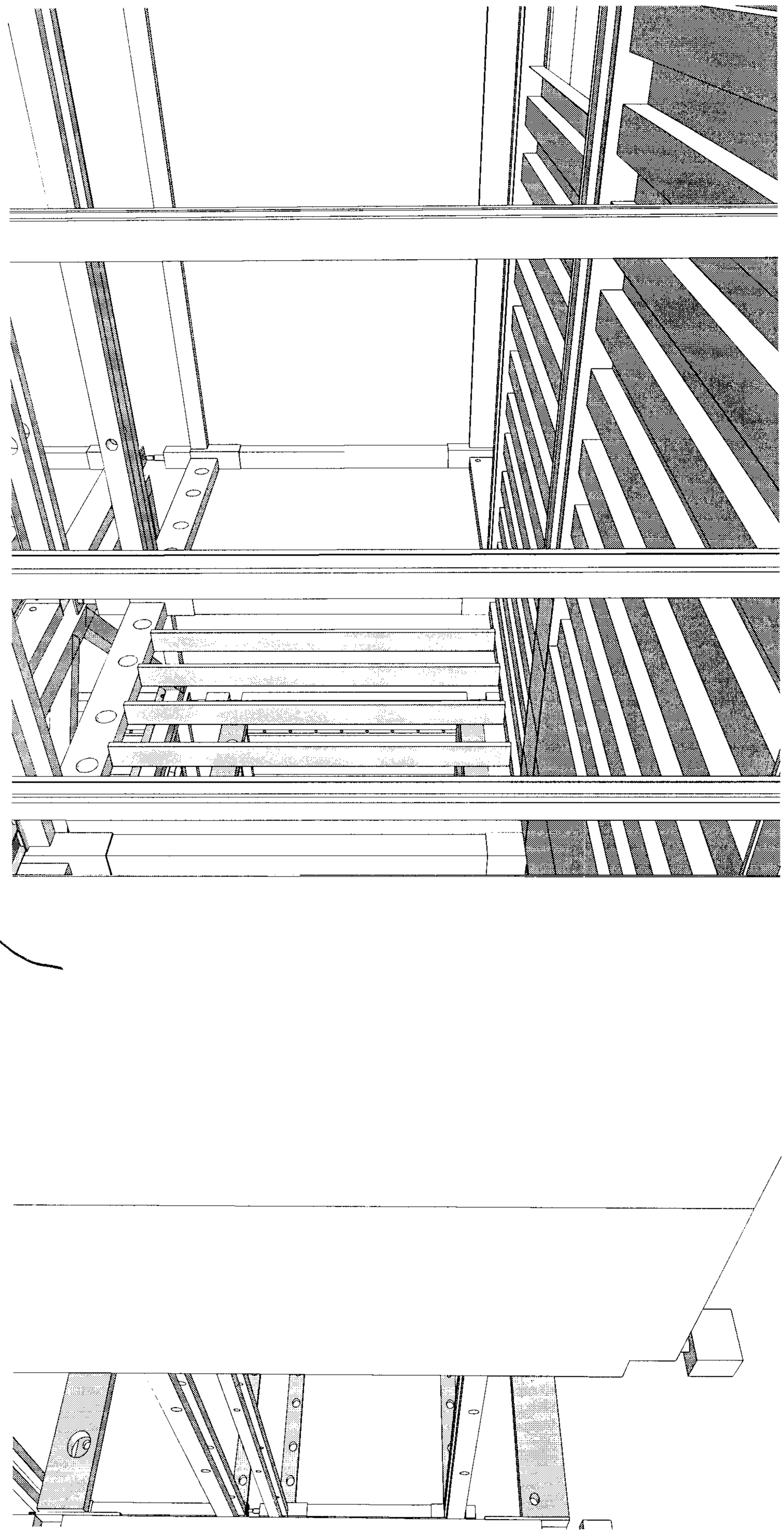



FIG 11

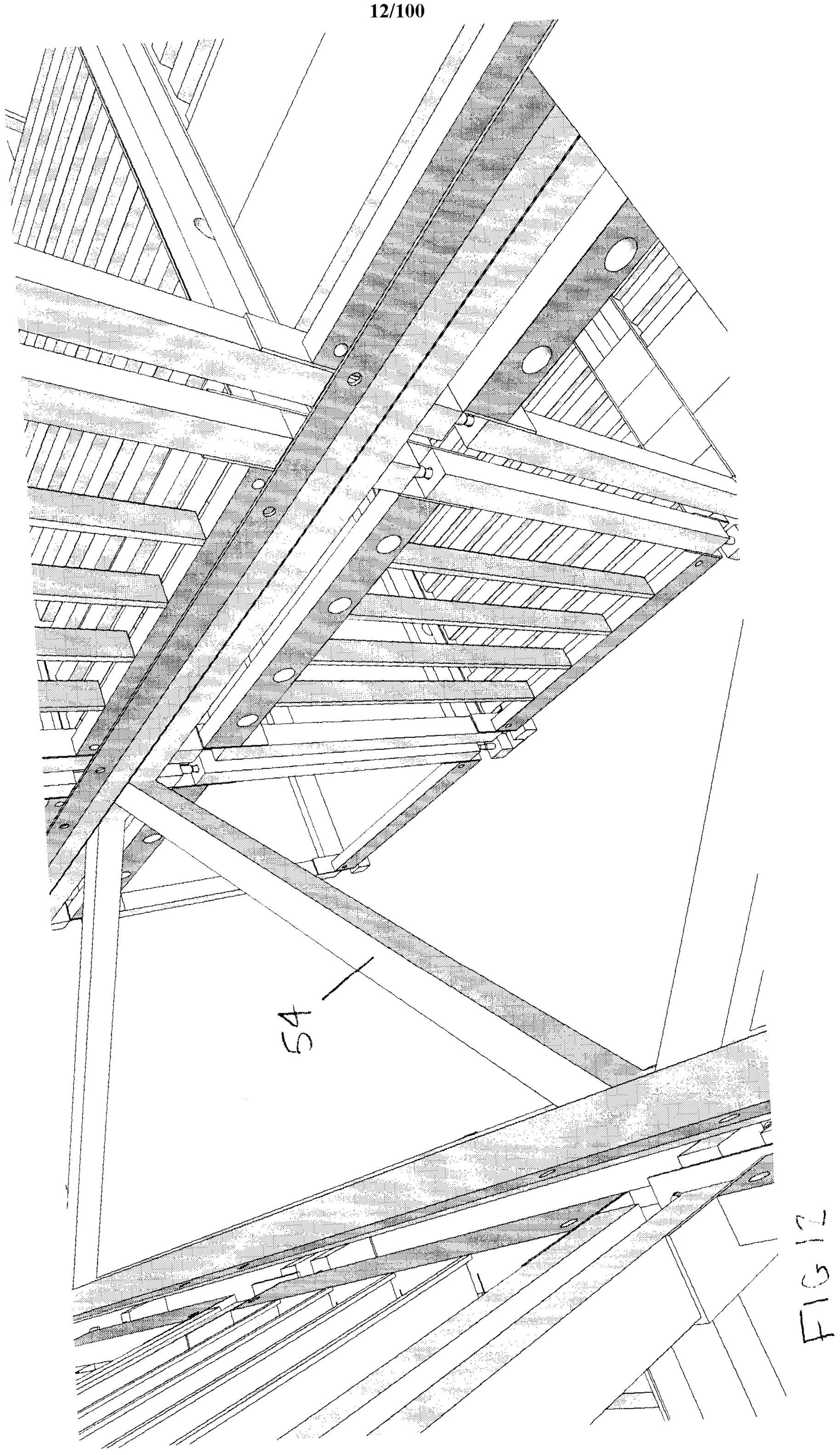



FIG 54

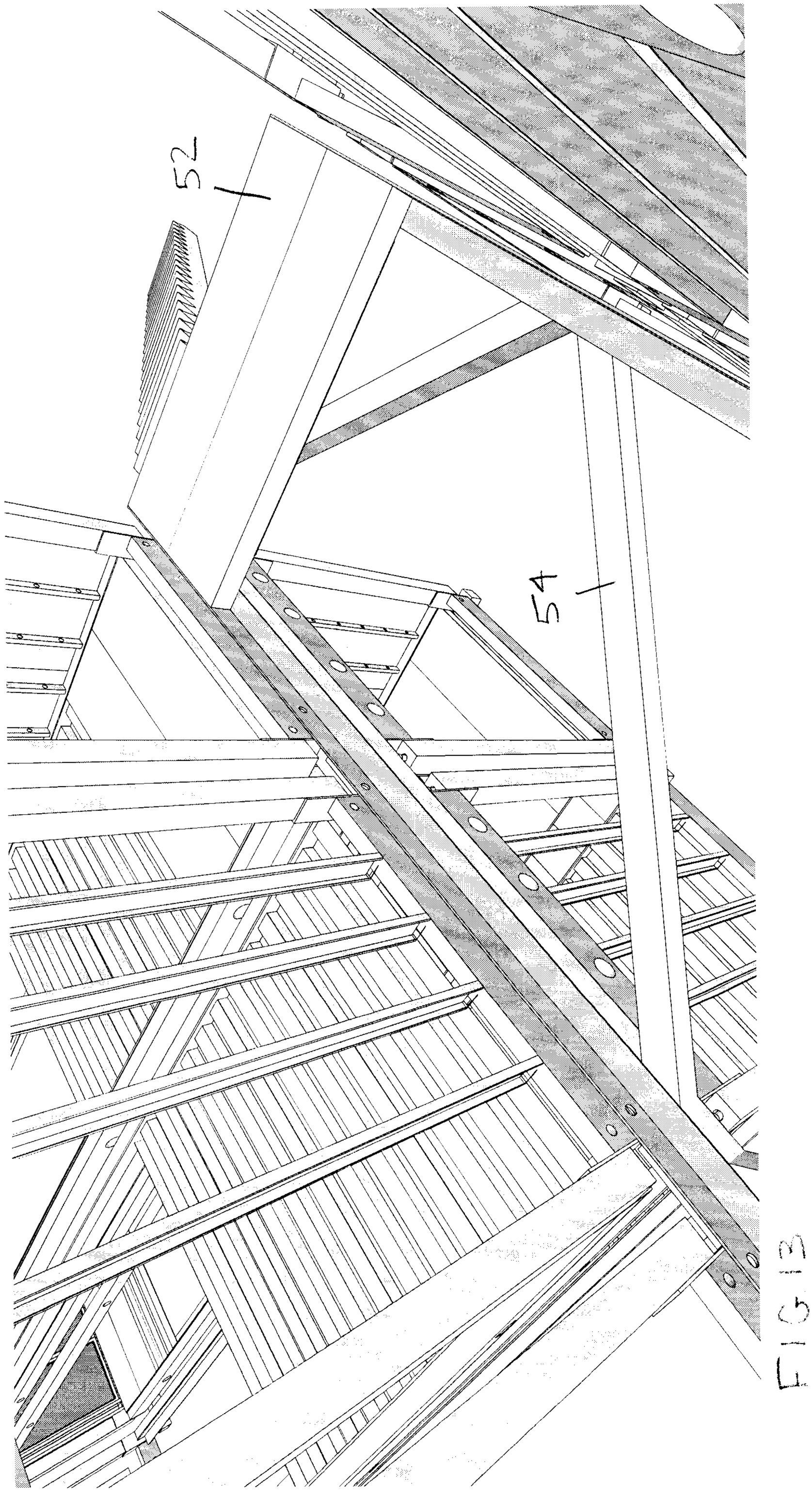



FIG 13

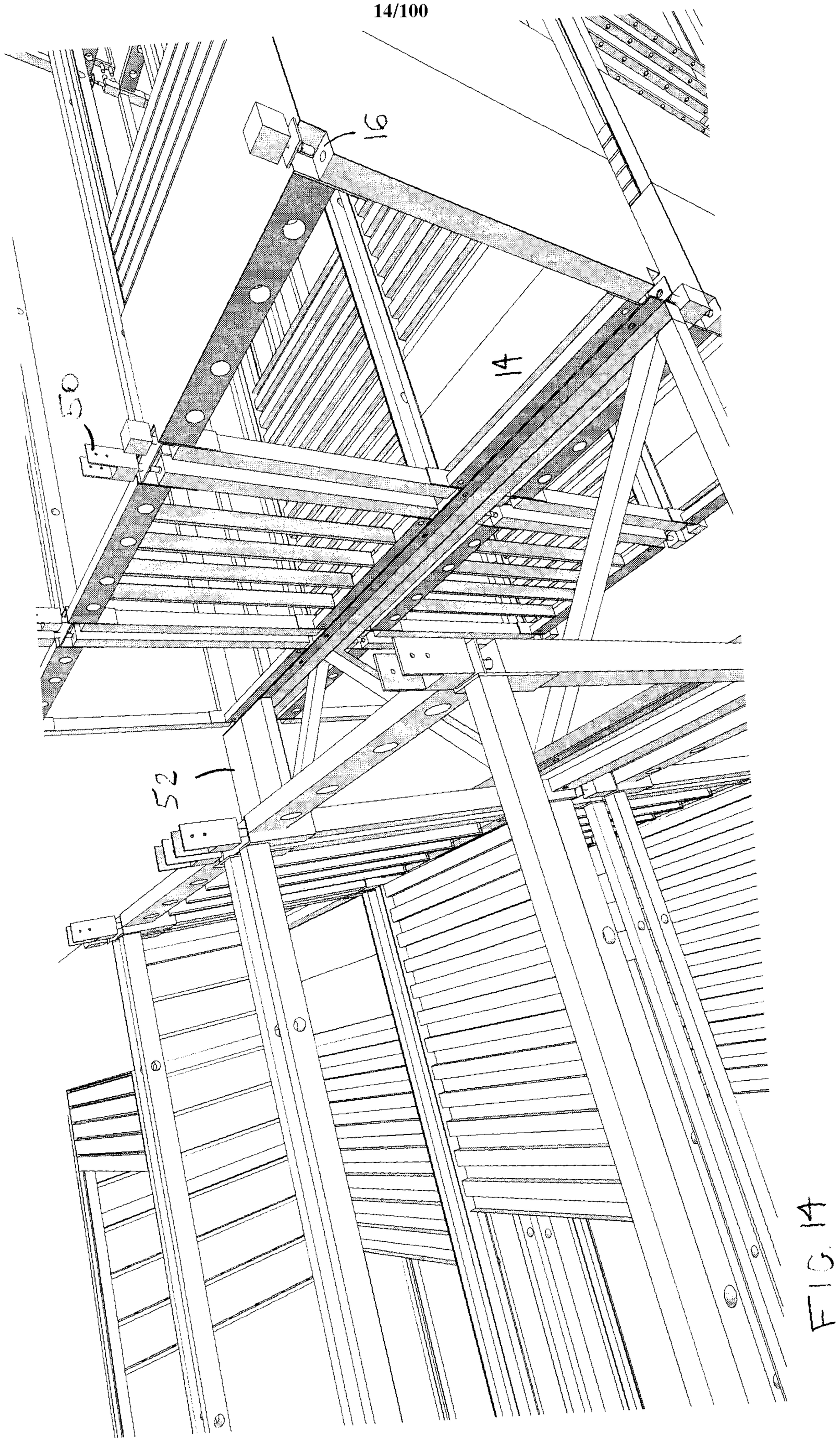



FIG. 14

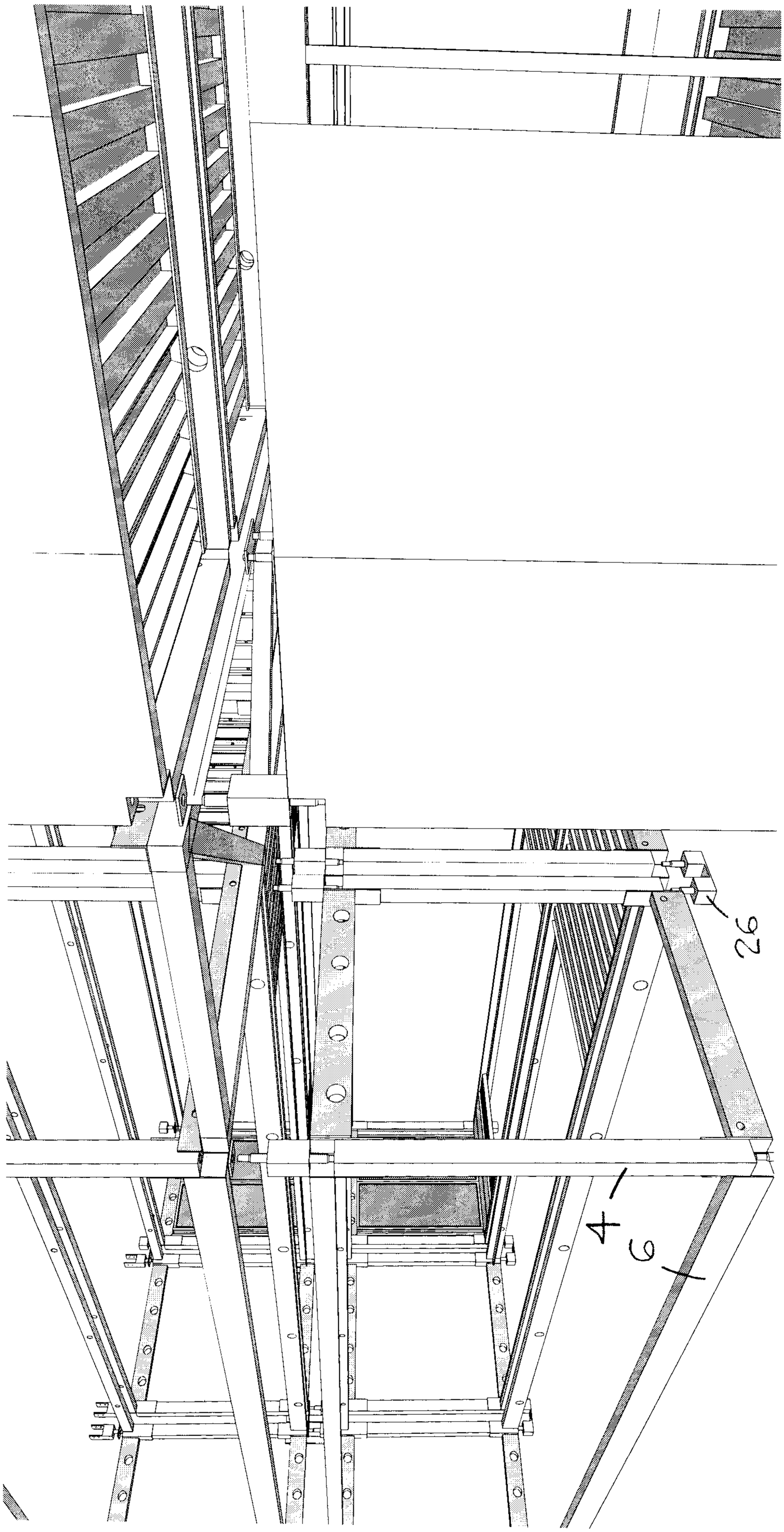
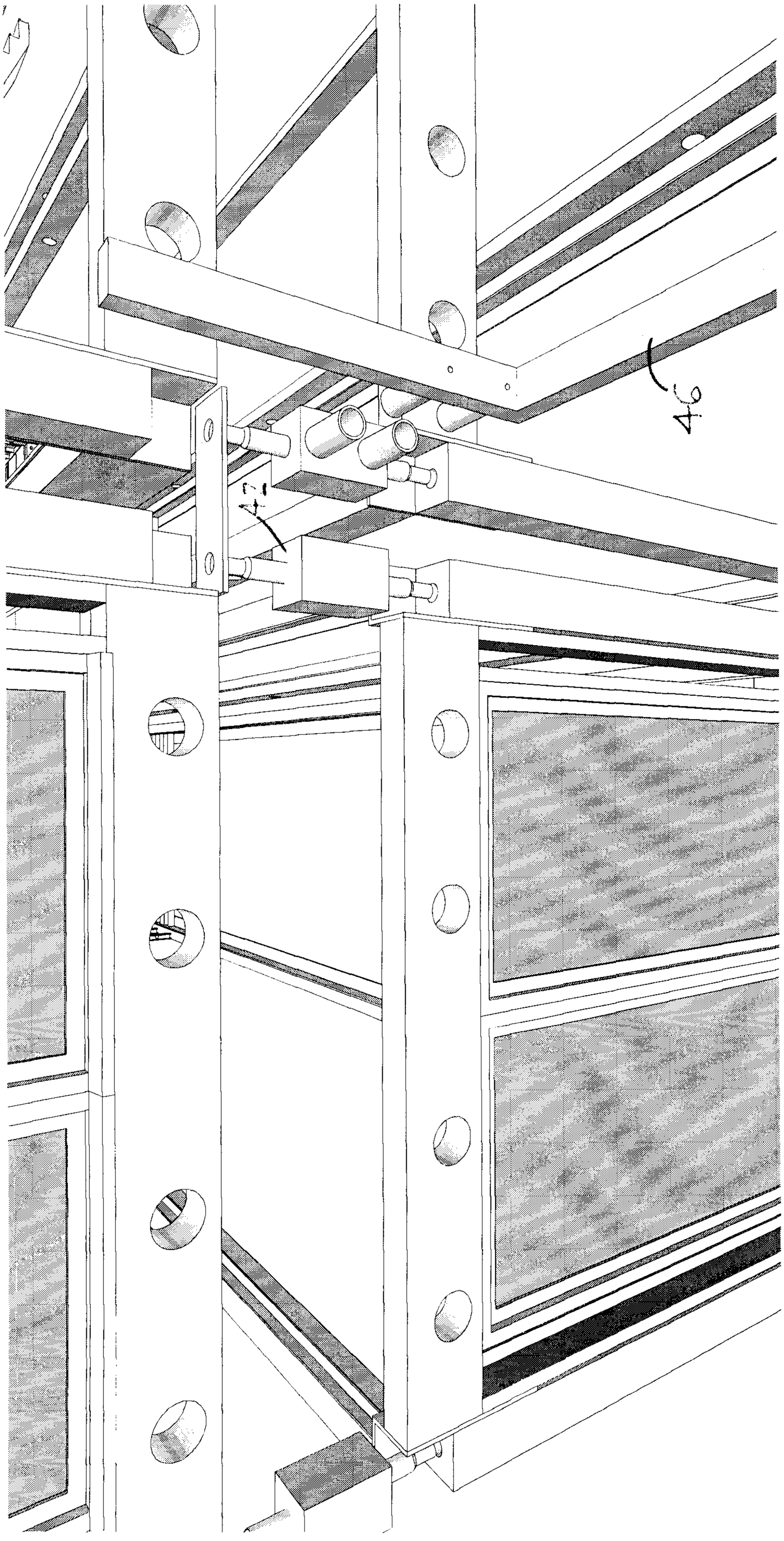
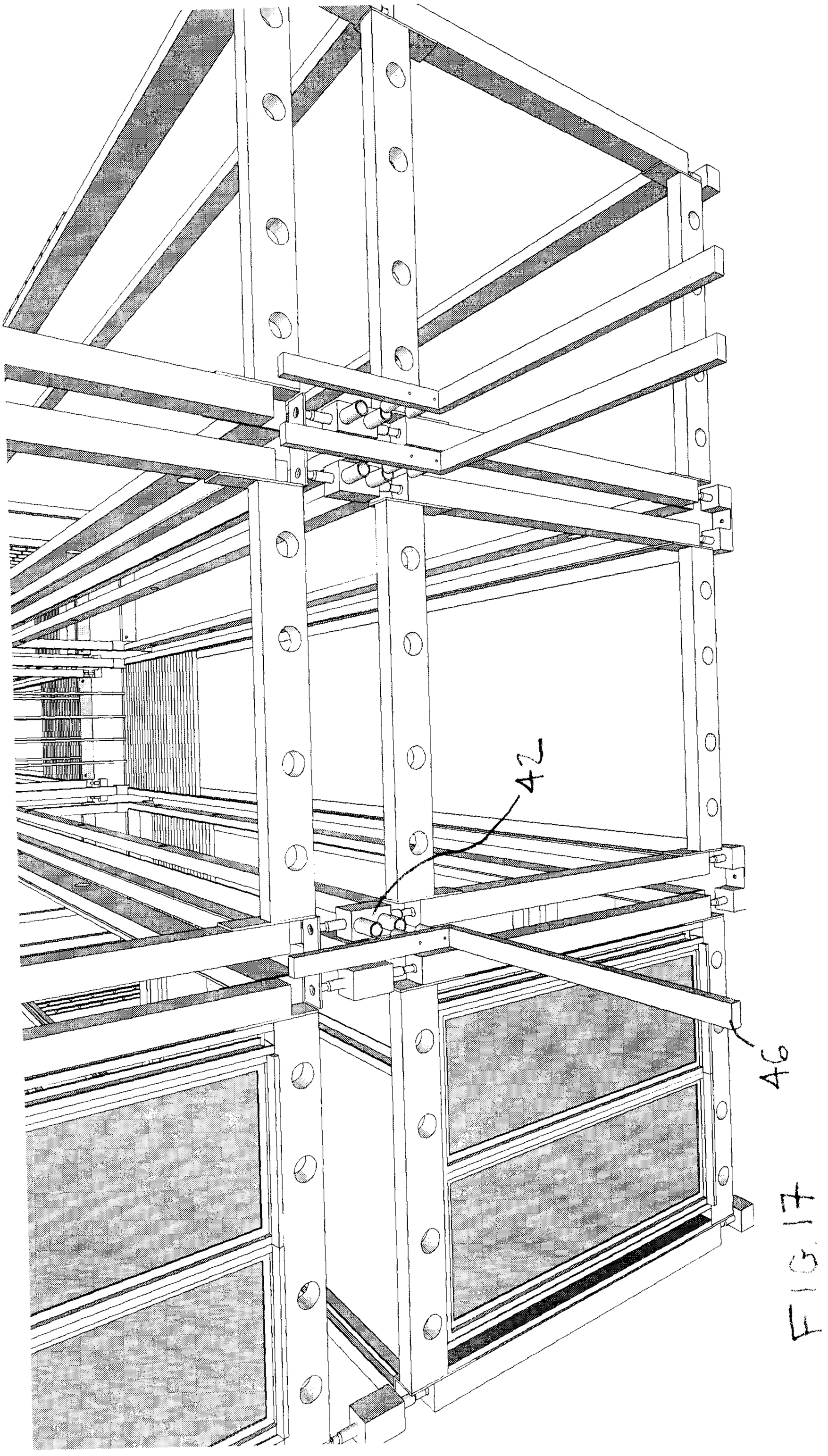
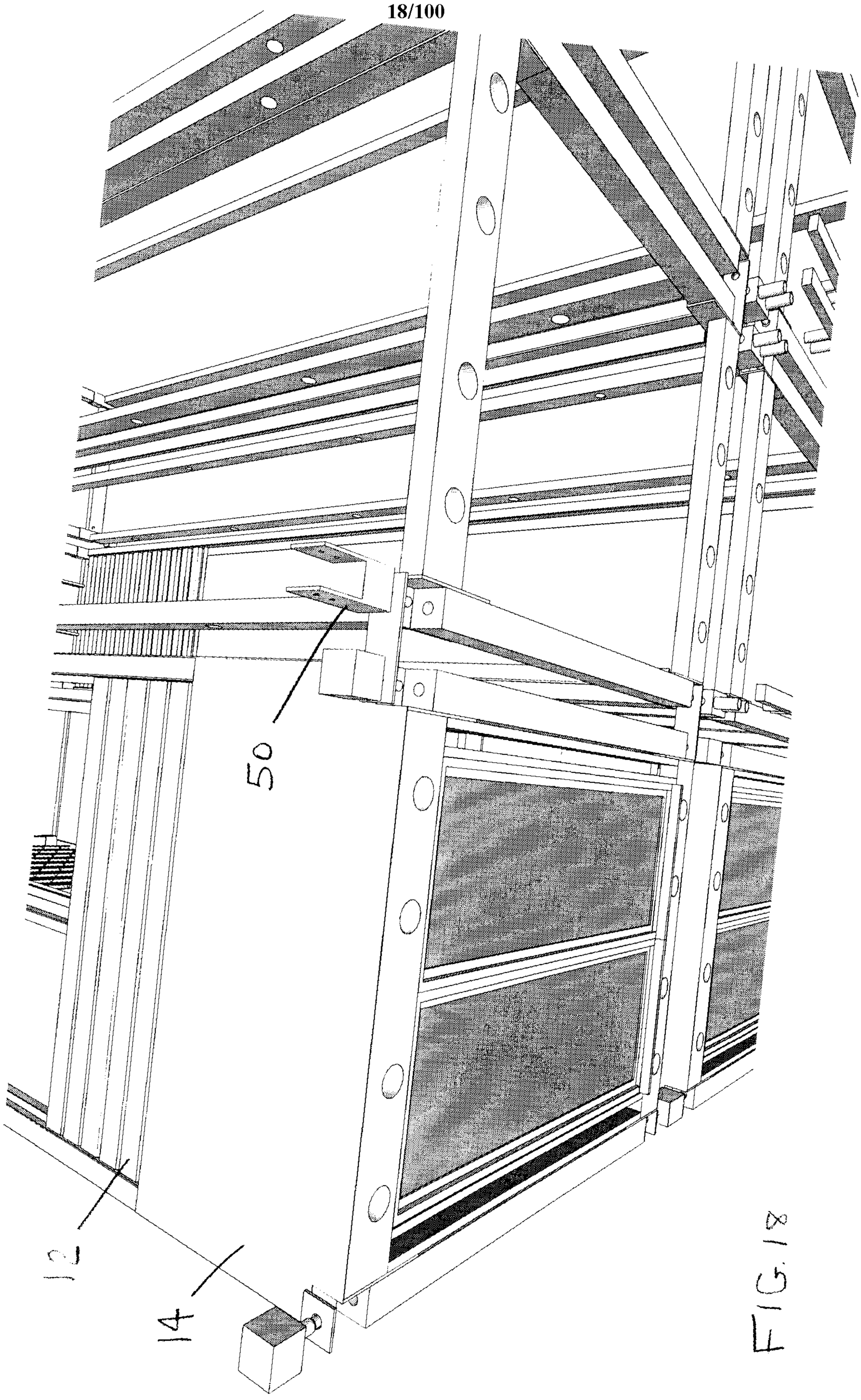



FIG 15


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FIG. 17


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FIG. 18

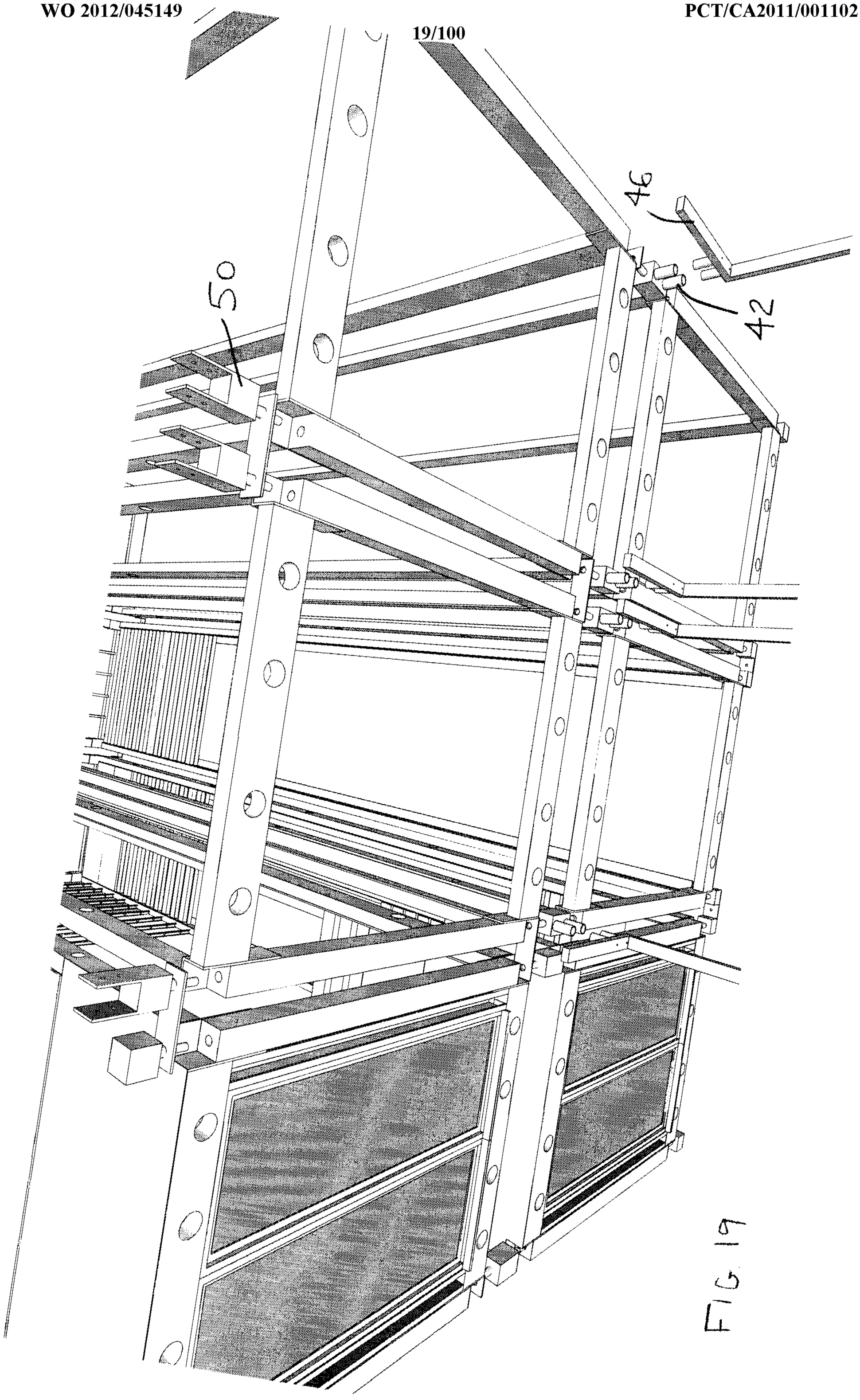



Fig 19

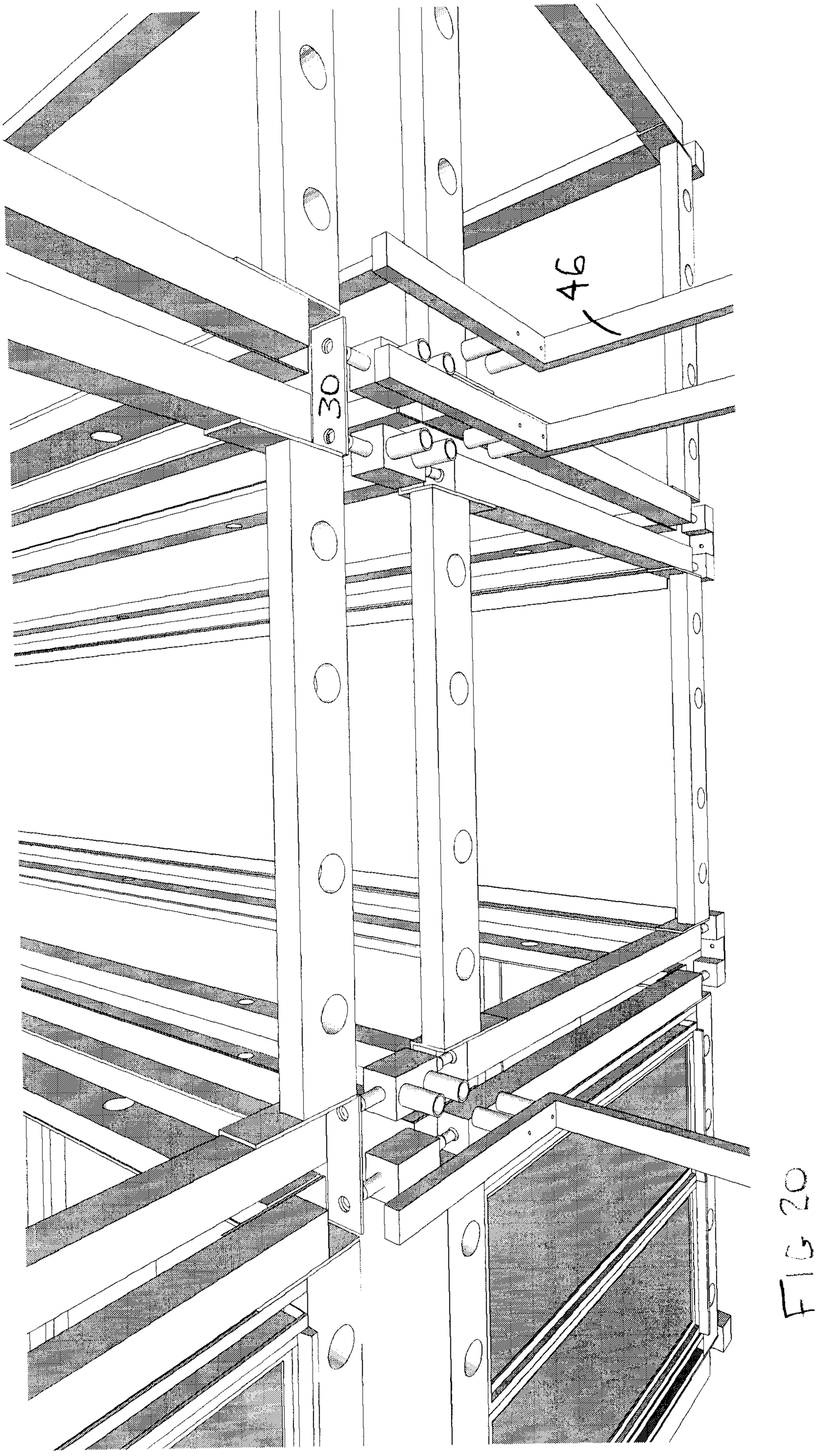



Fig 20

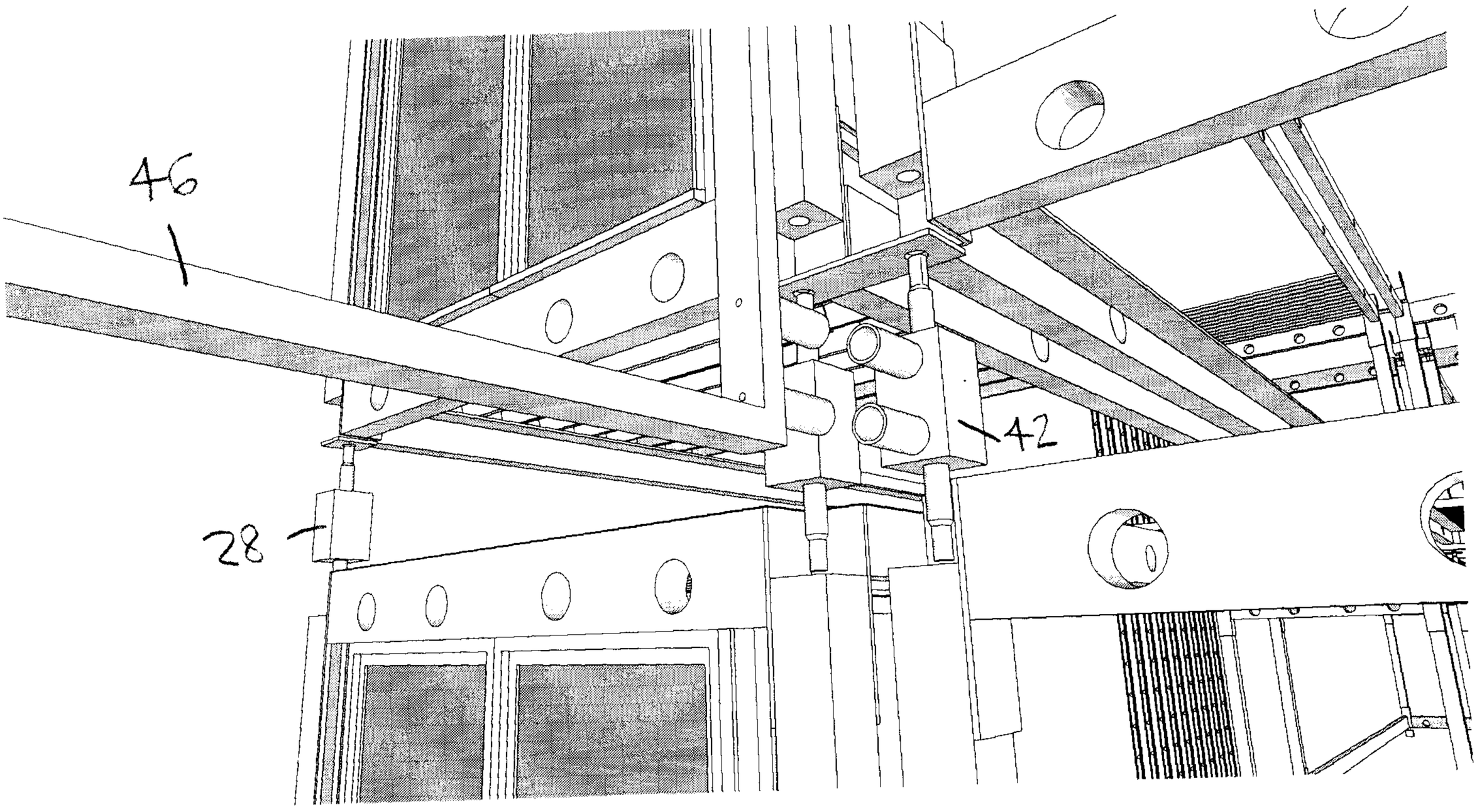



FIG 21

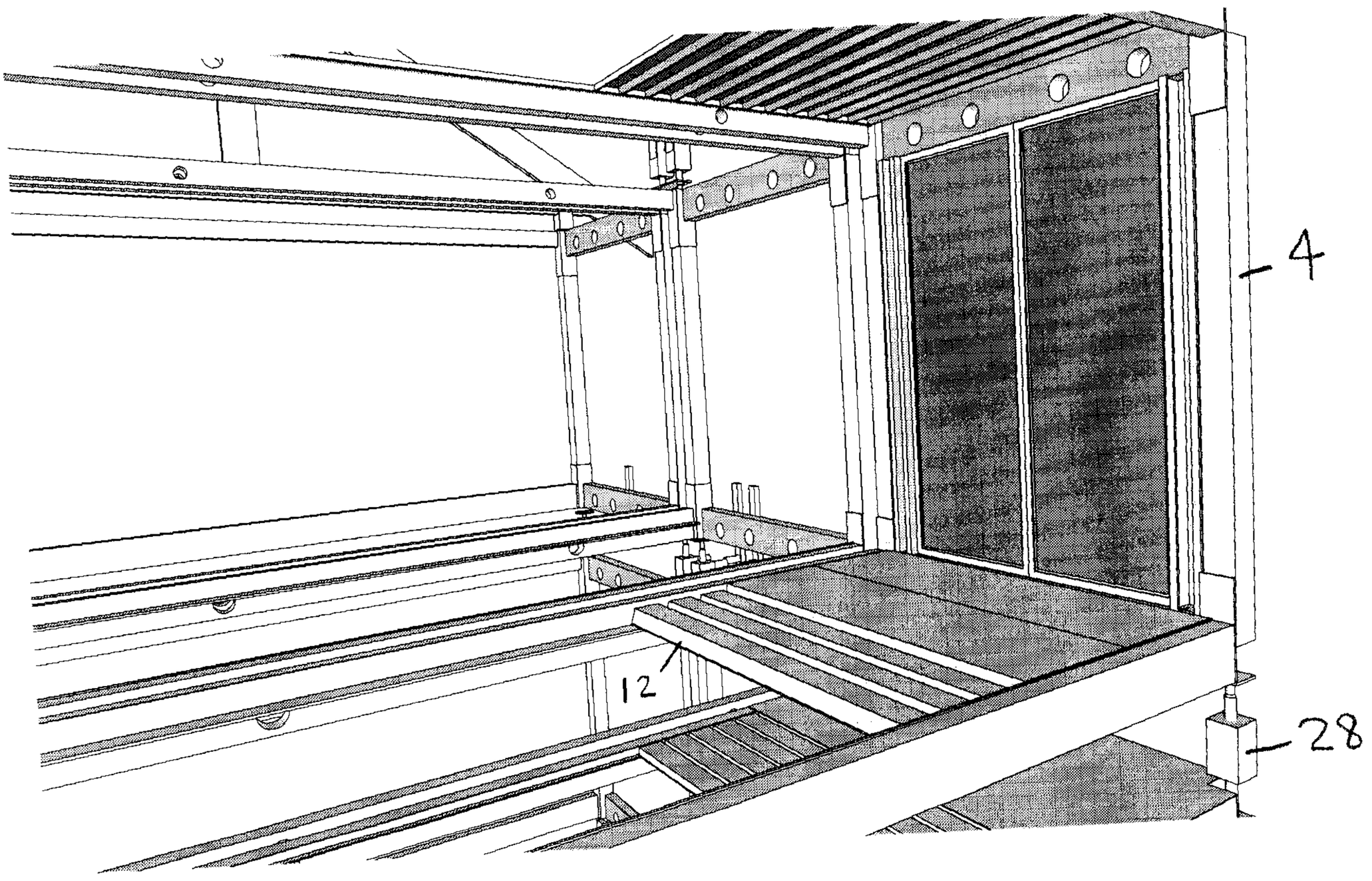



FIG. 22

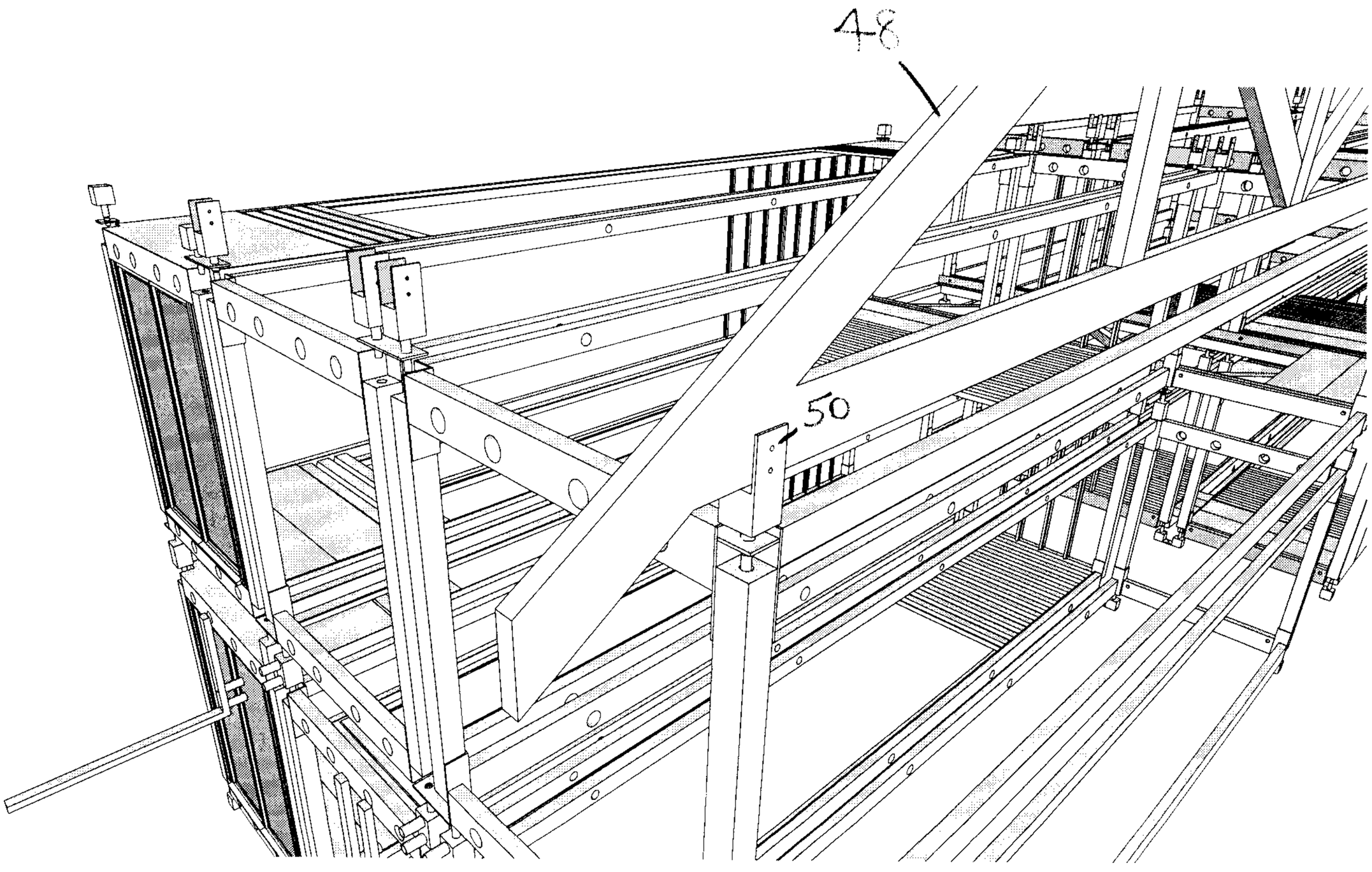



FIG. 23

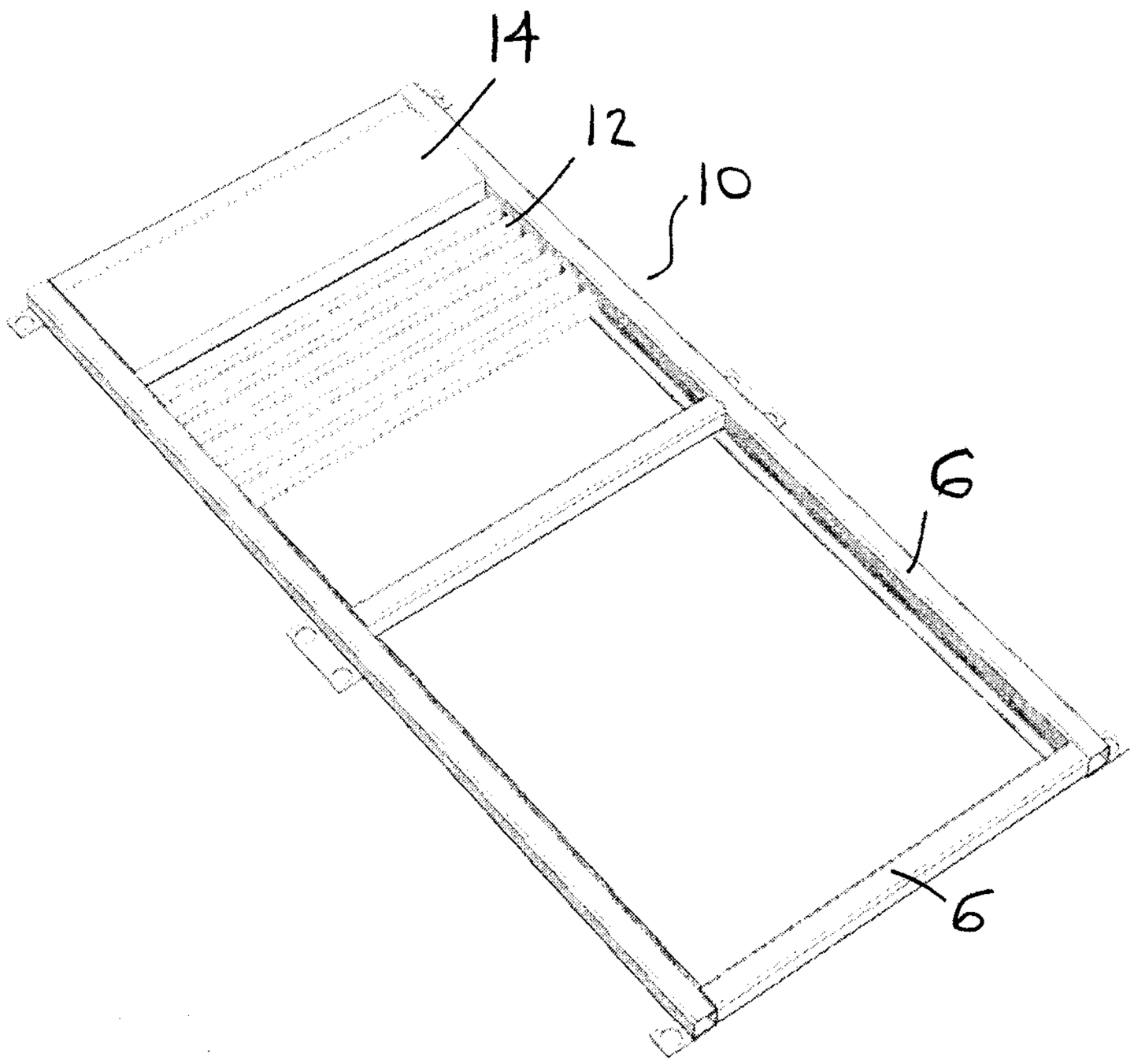



FIG 24

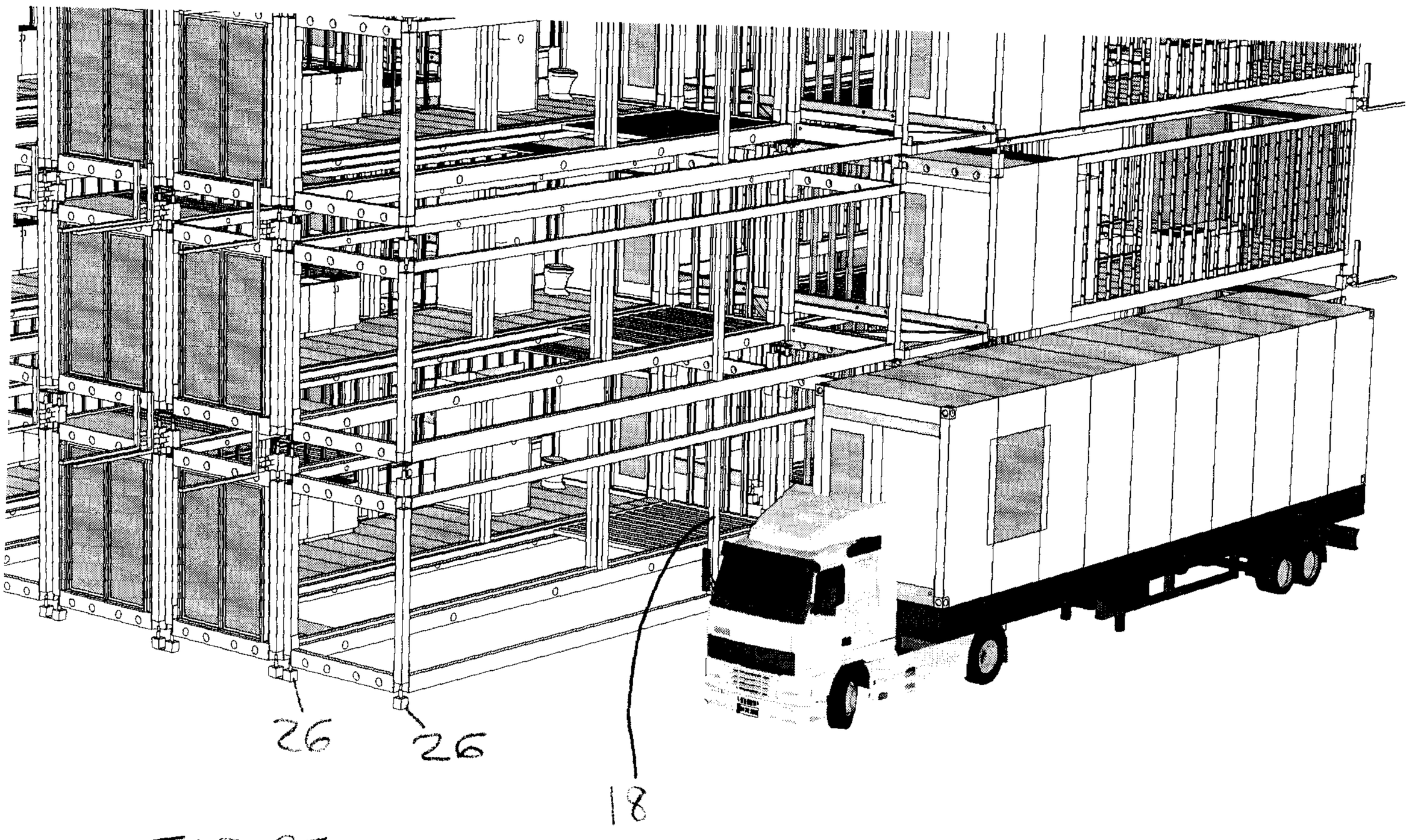



FIG. 25

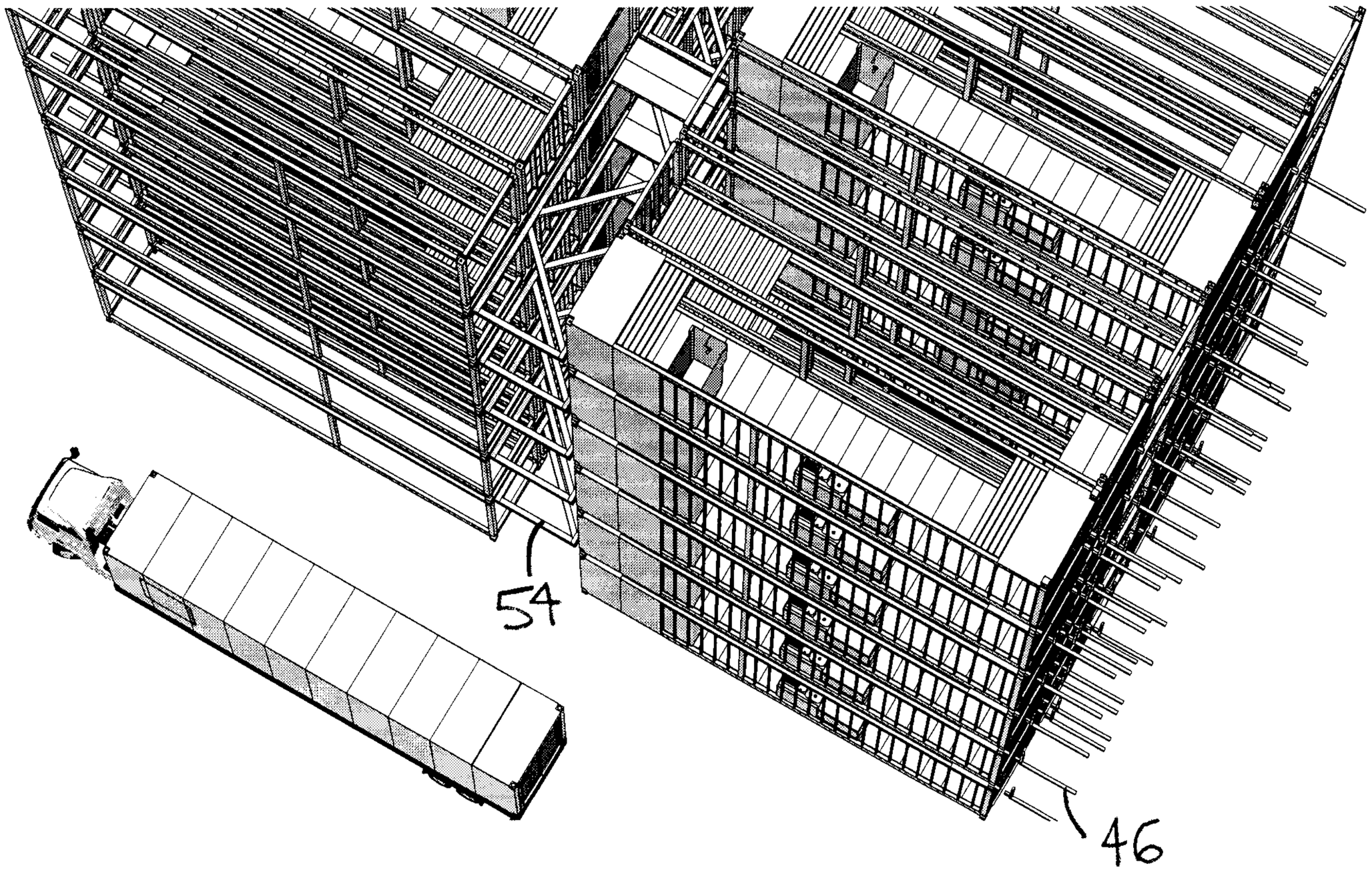



FIG. 26

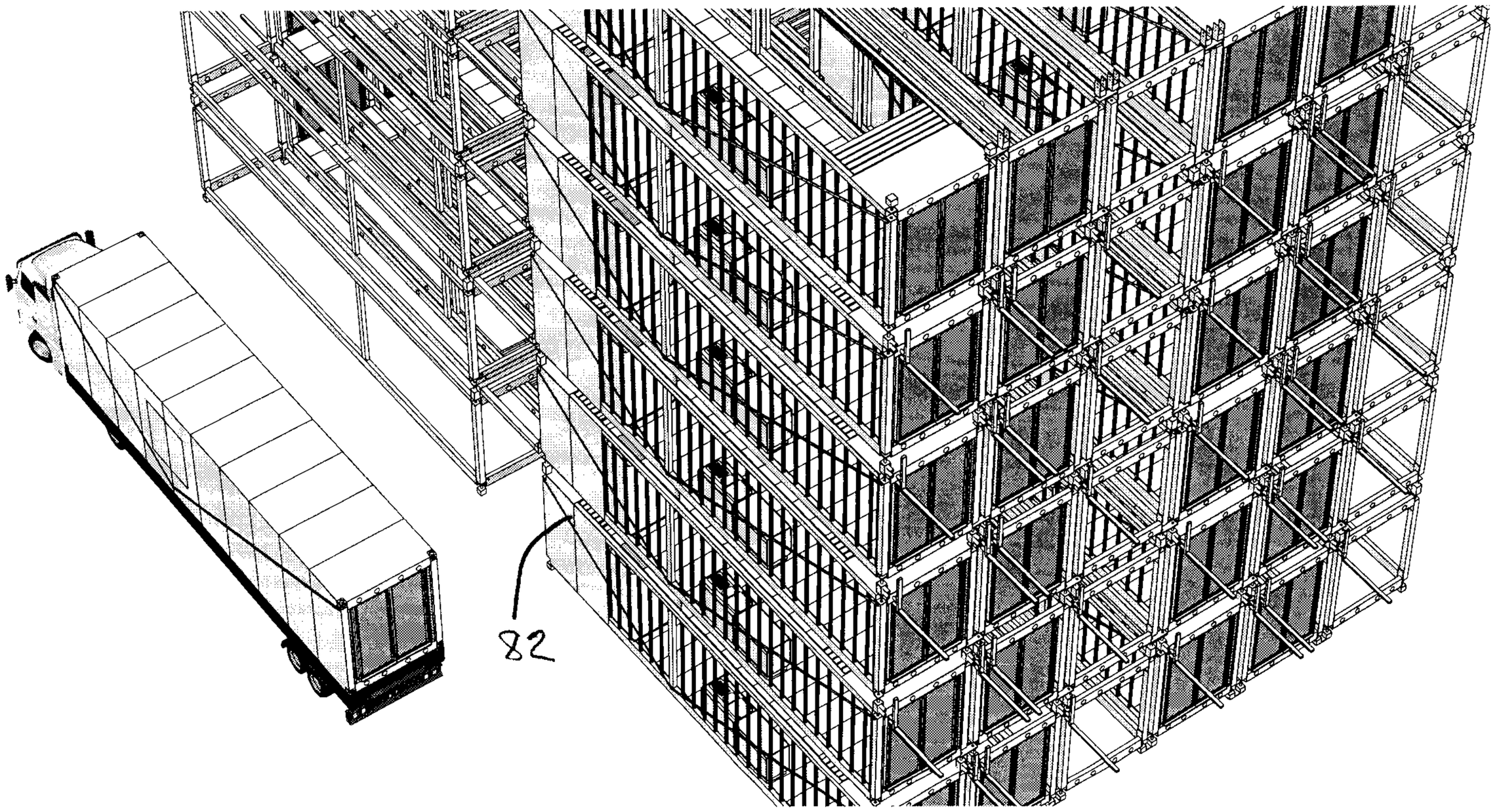



FIG 27

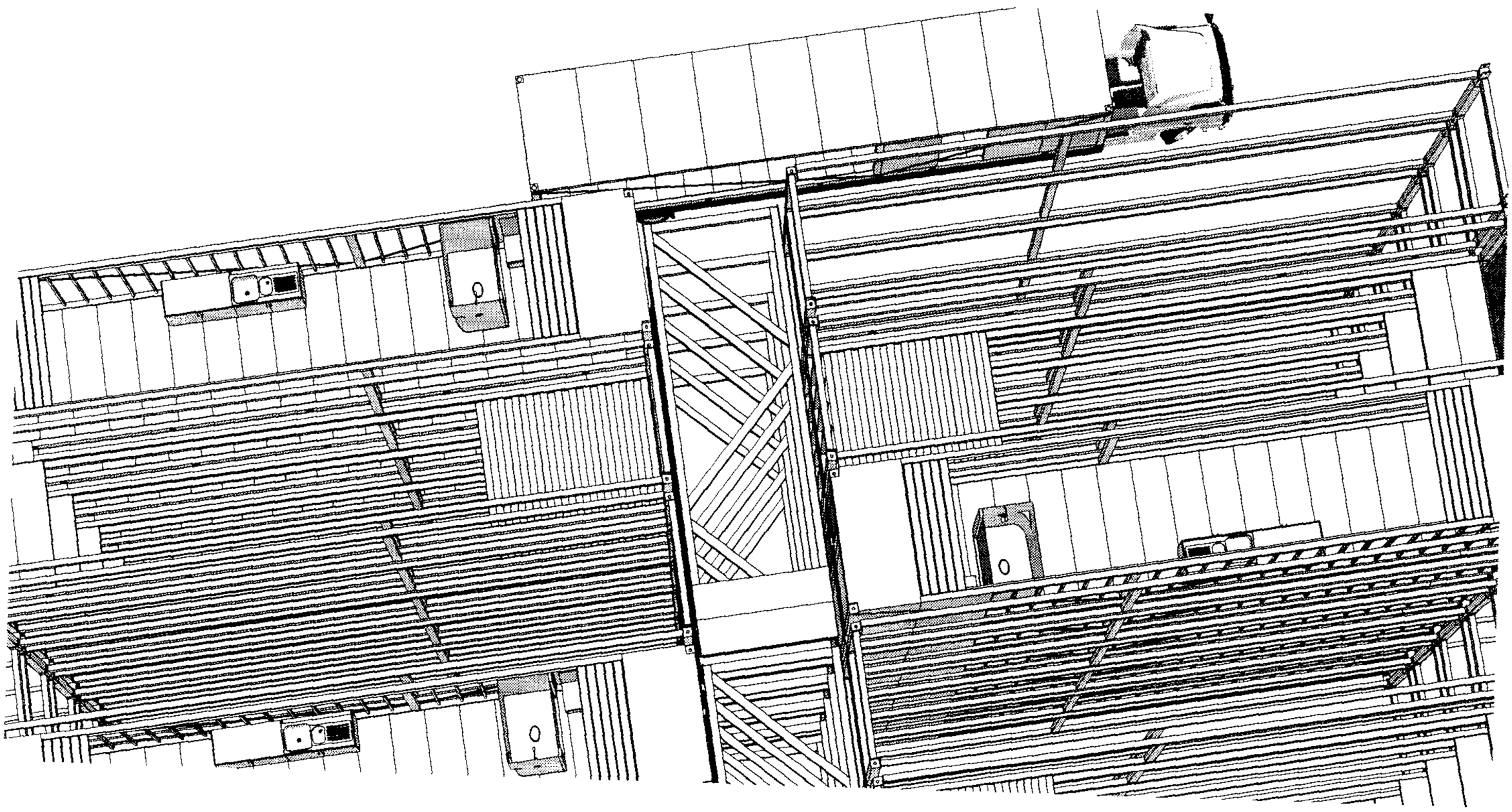


FIG 28

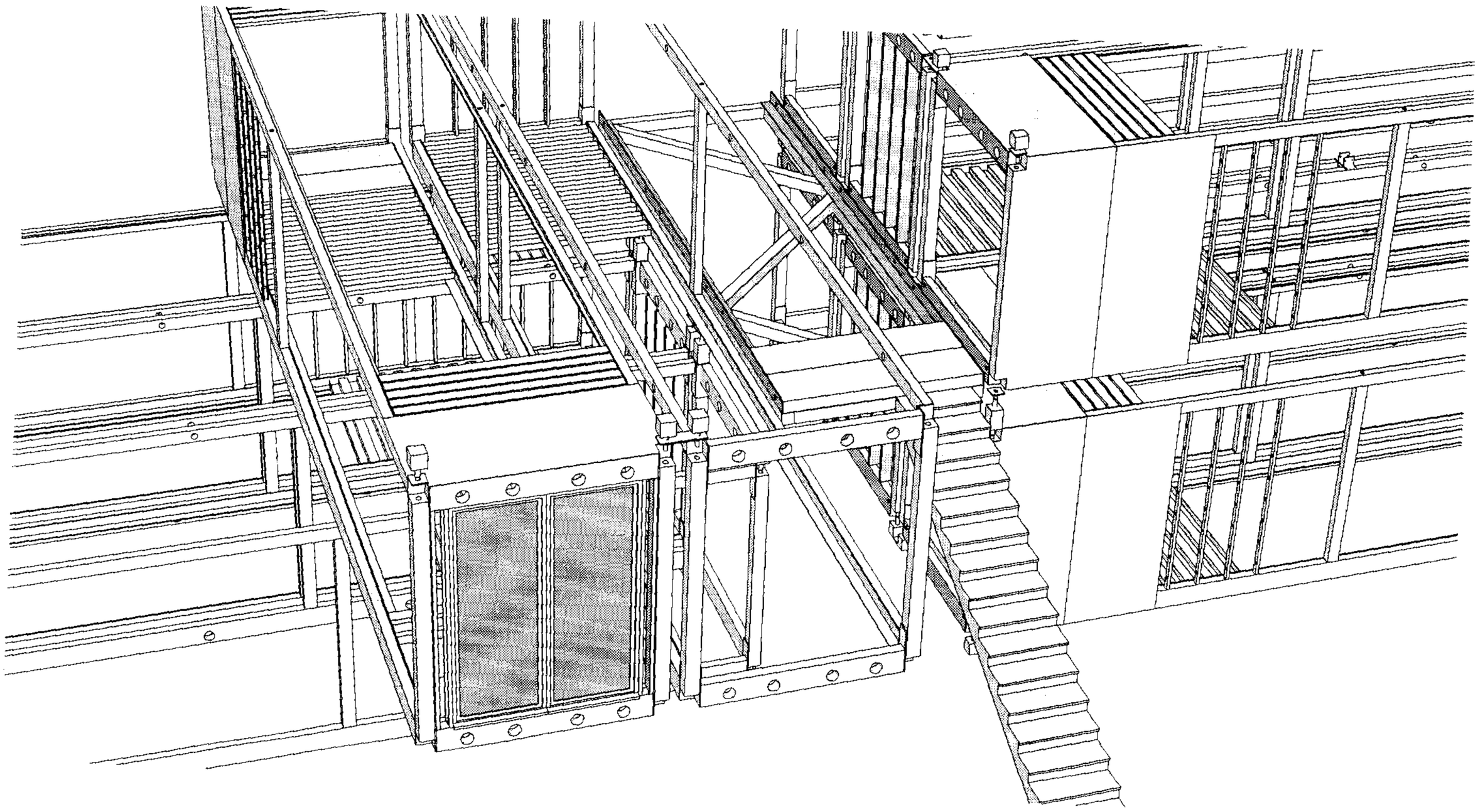


FIG 29

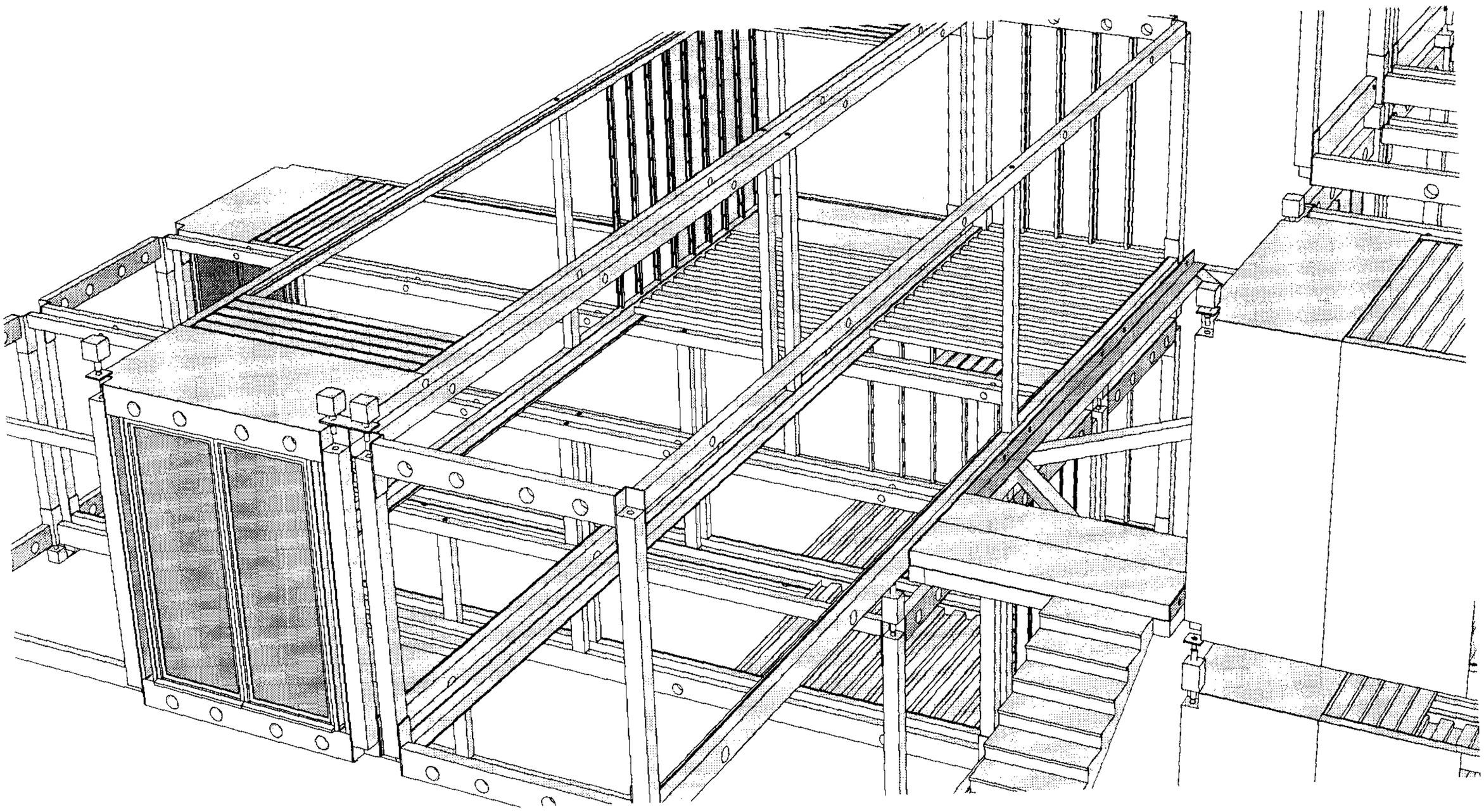


FIG. 30

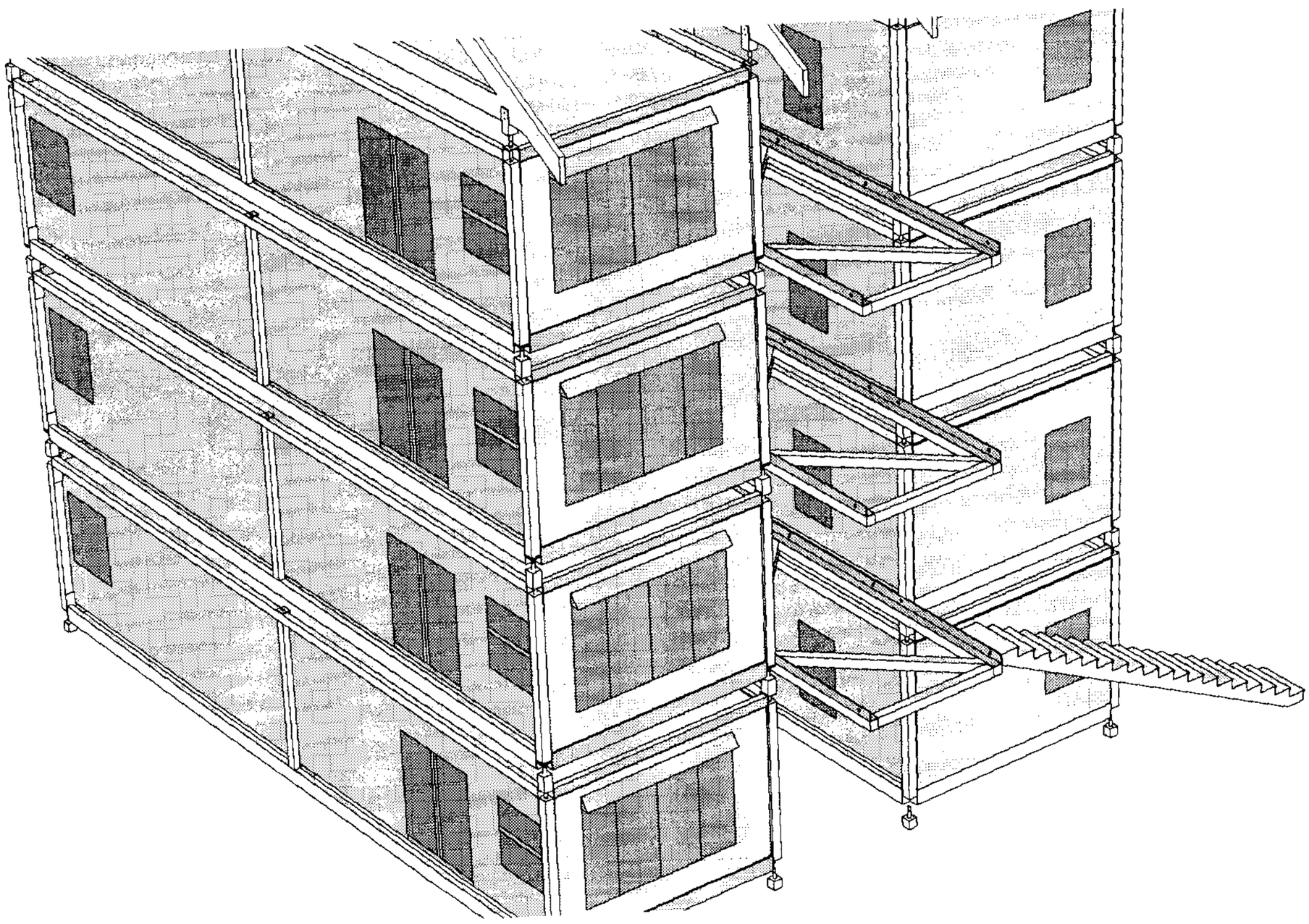


FIG. 31

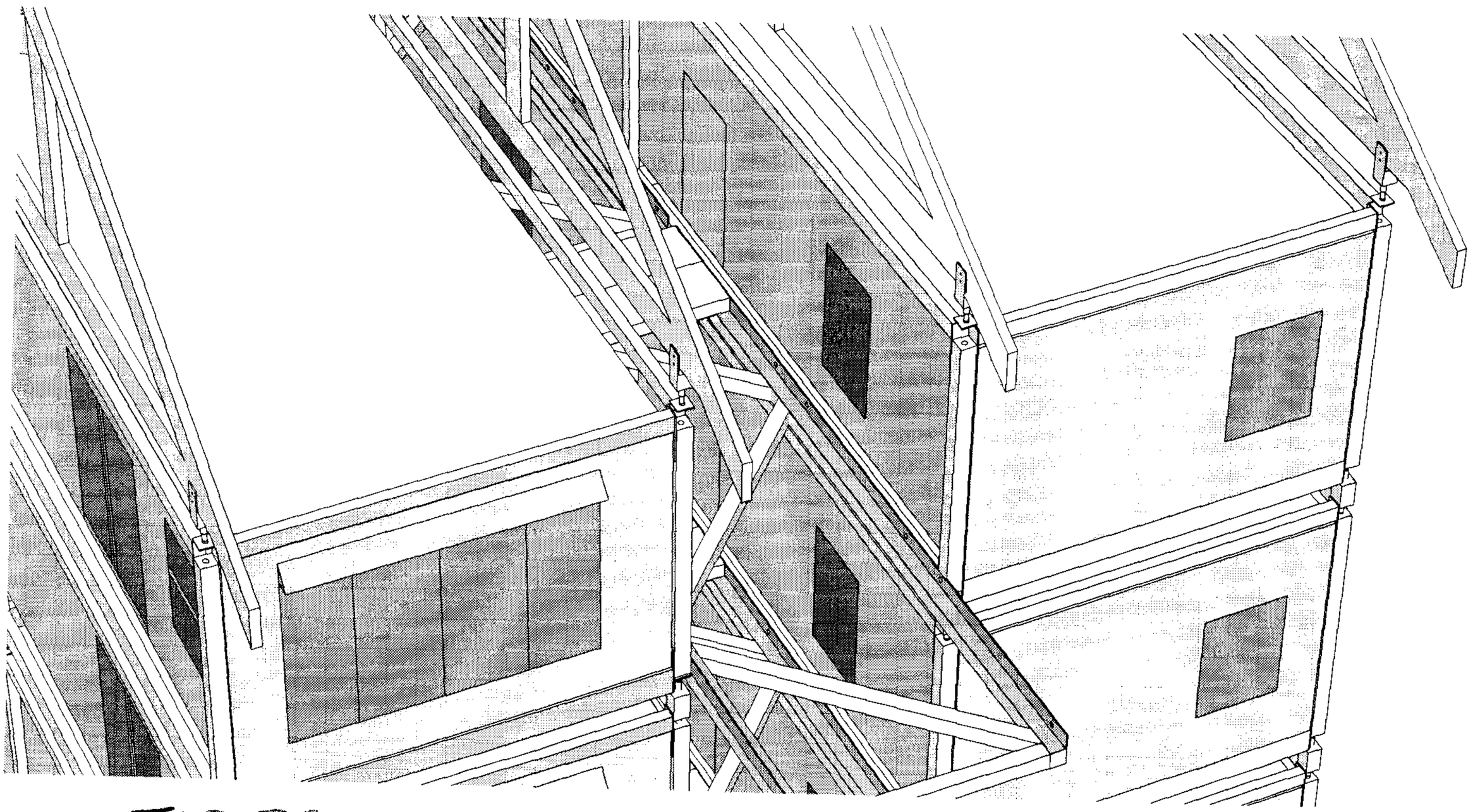


FIG.32

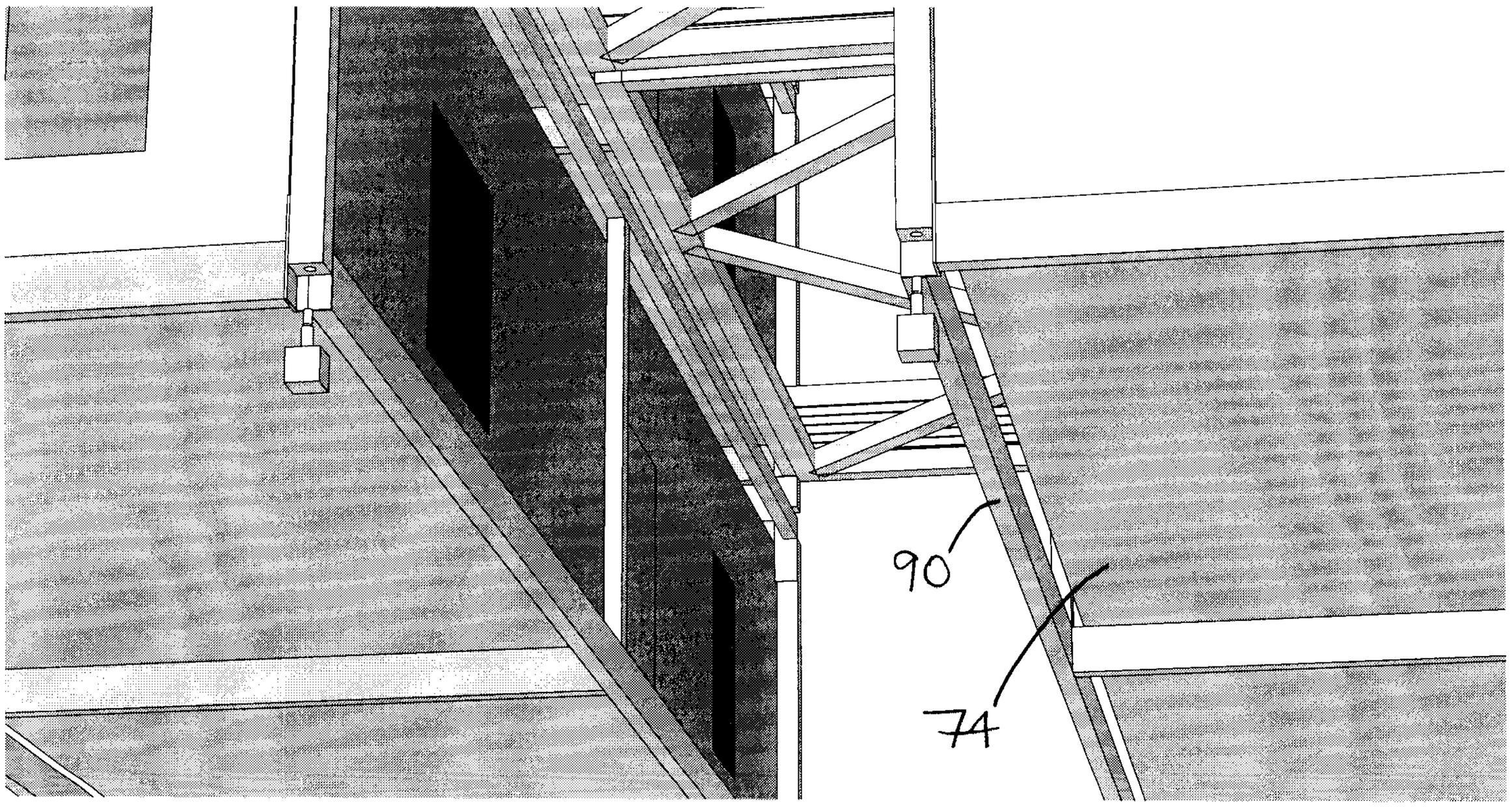



FIG. 33

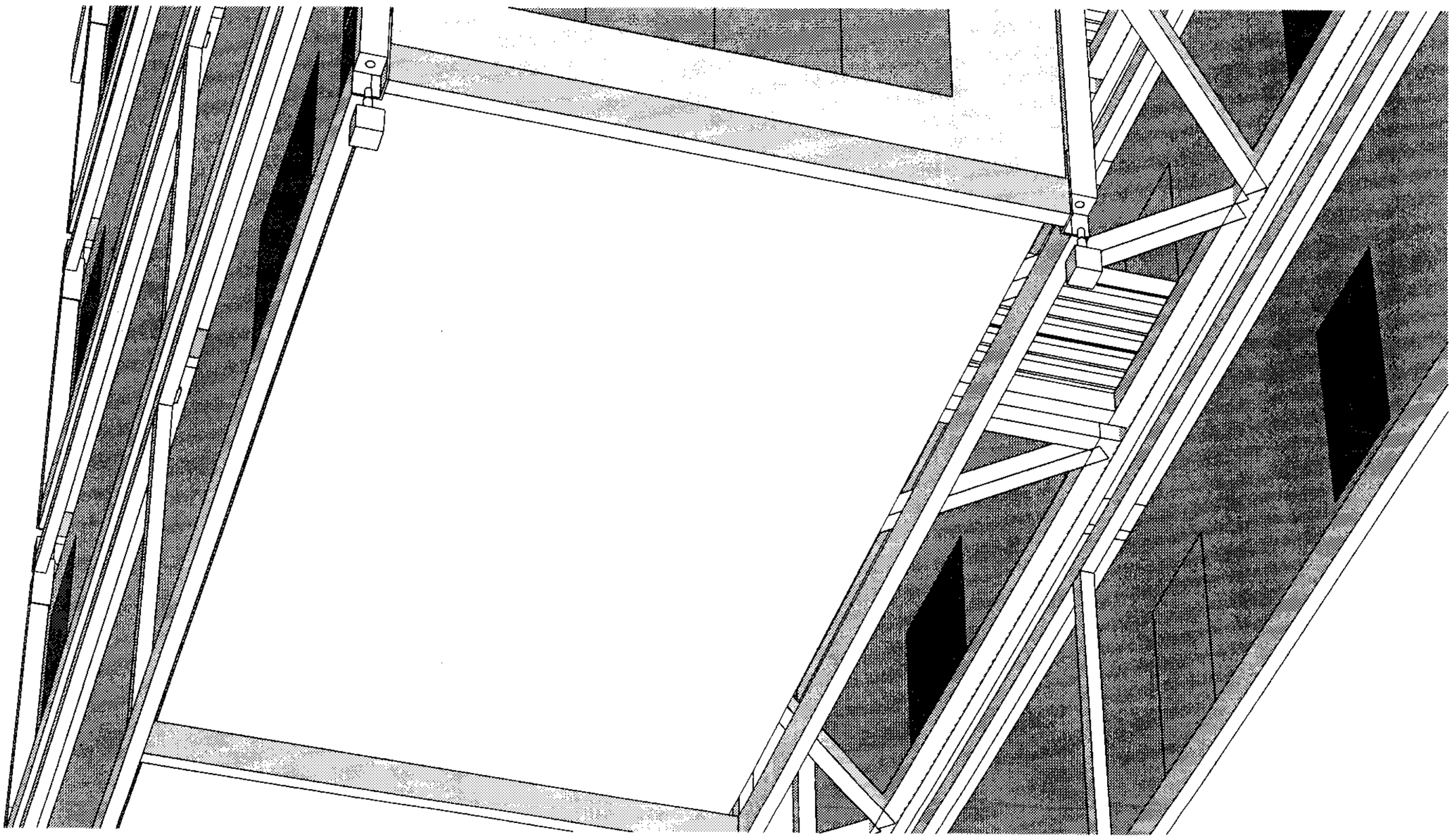


FIG. 34

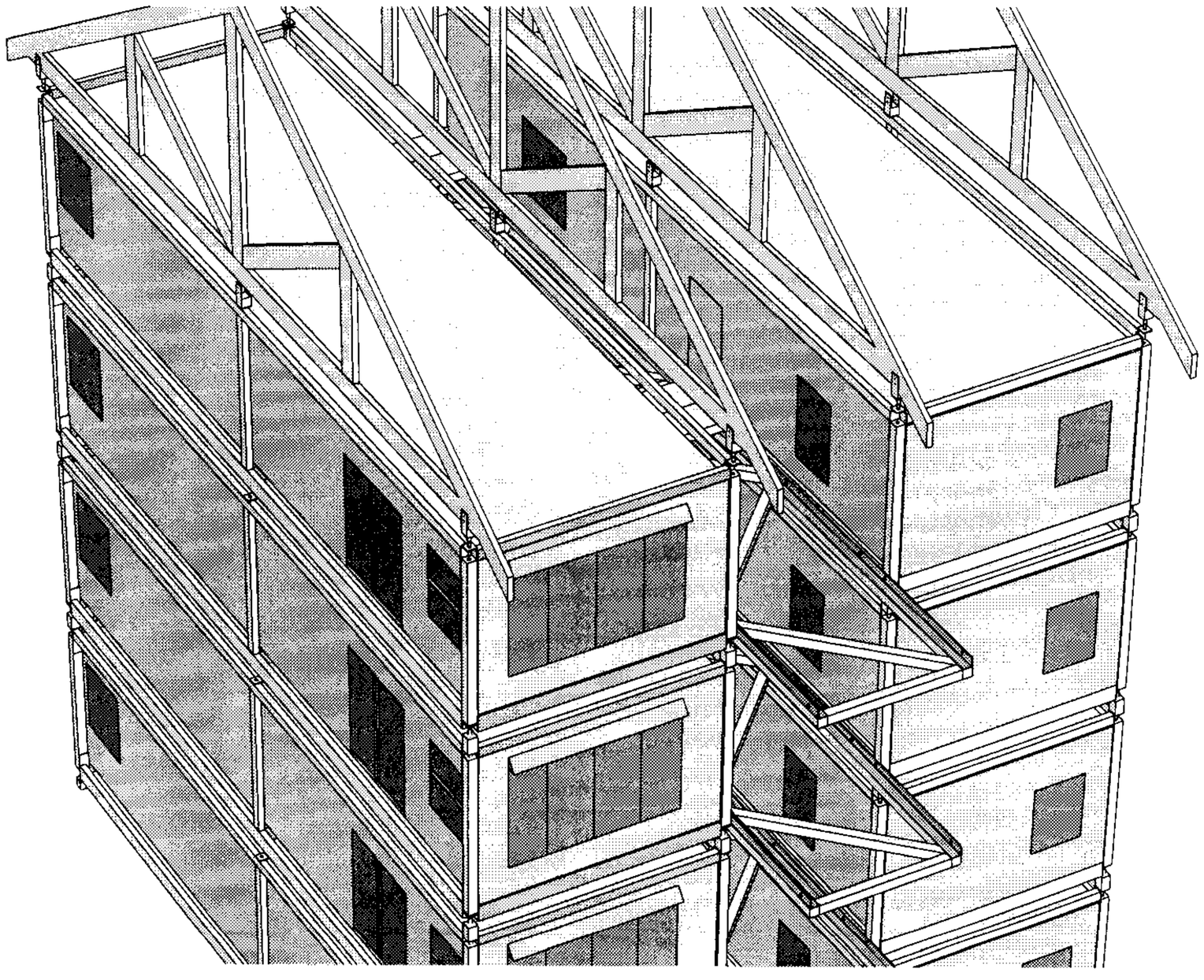


FIG 35

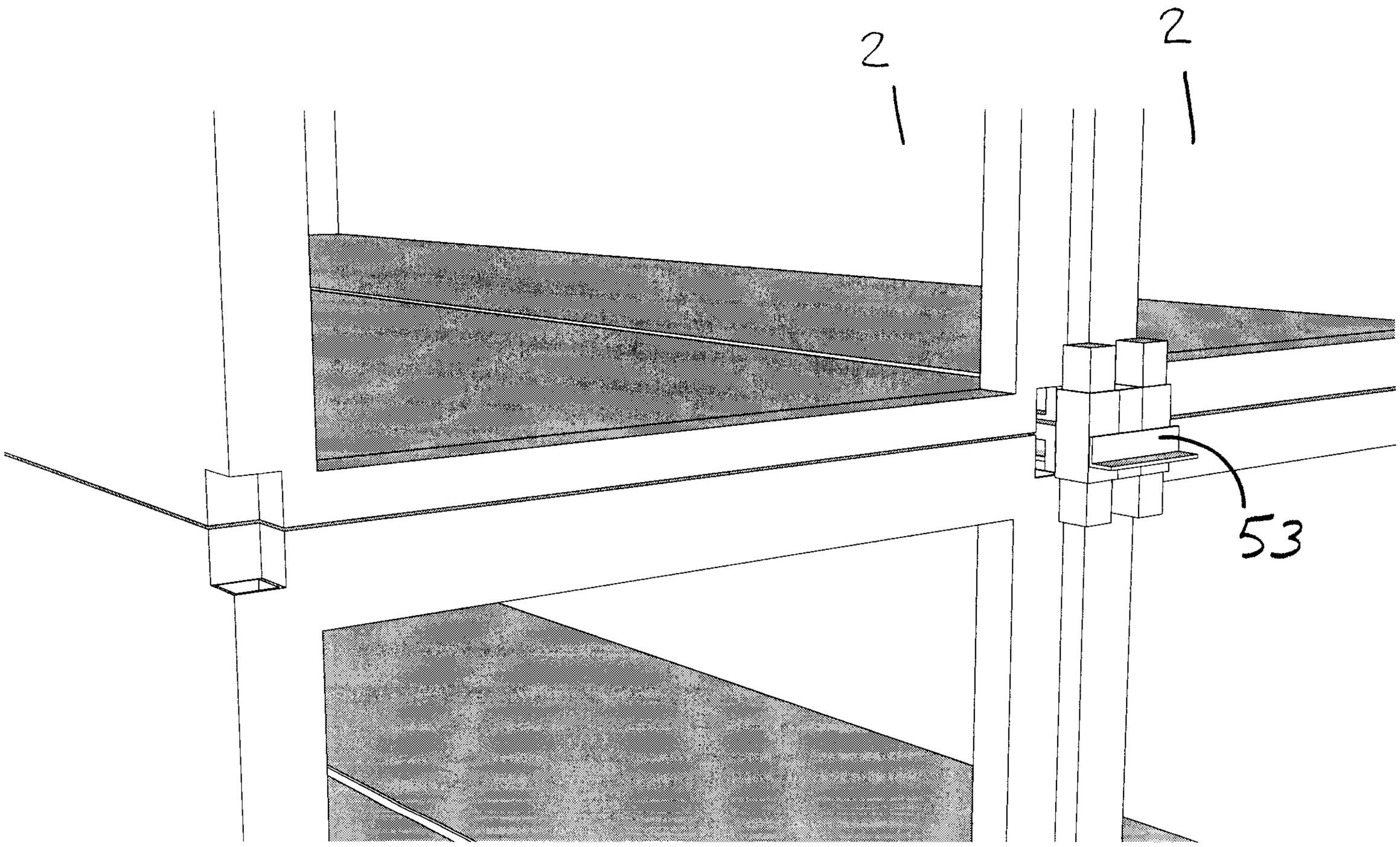



FIG. 36

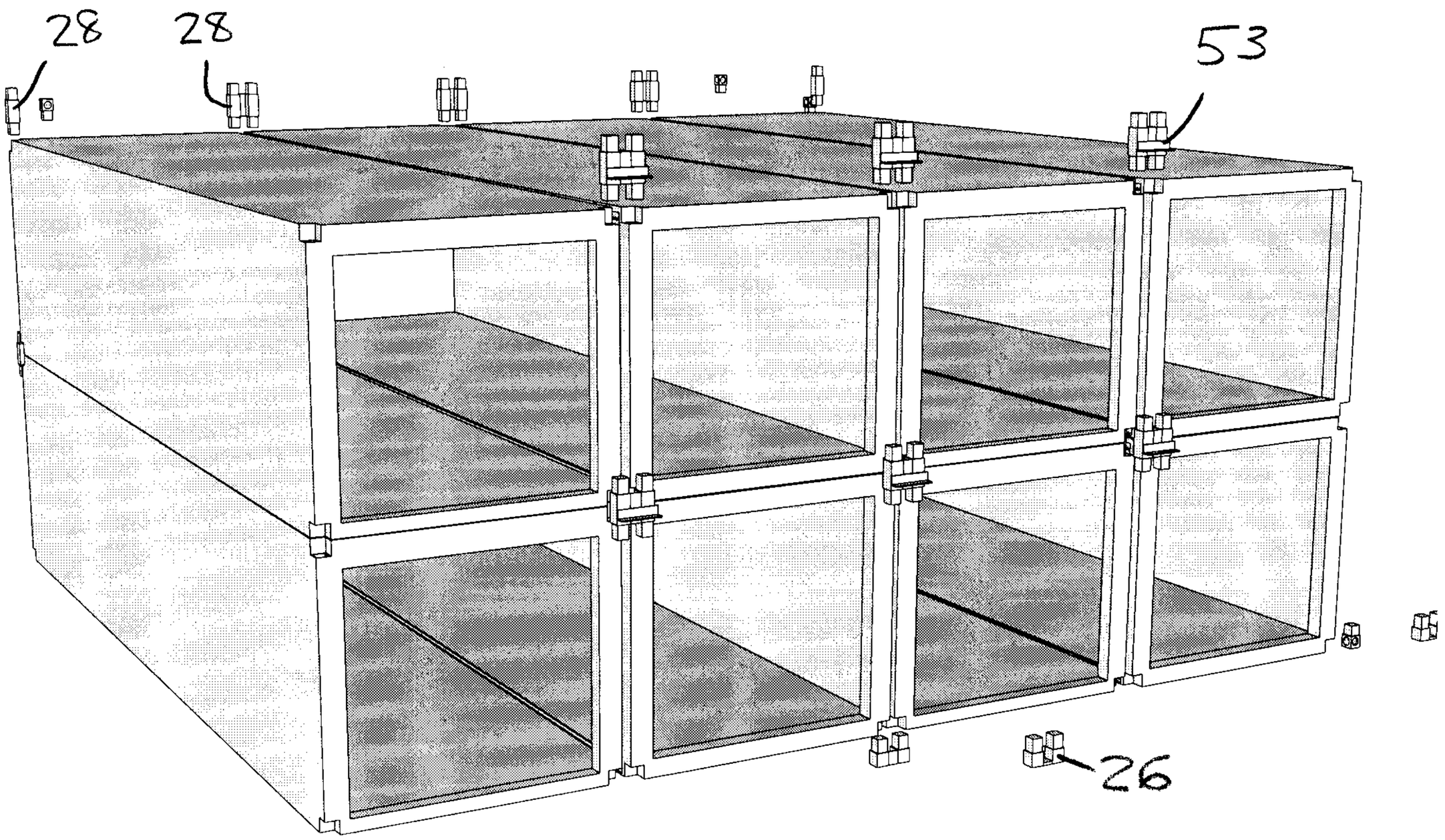



FIG. 37

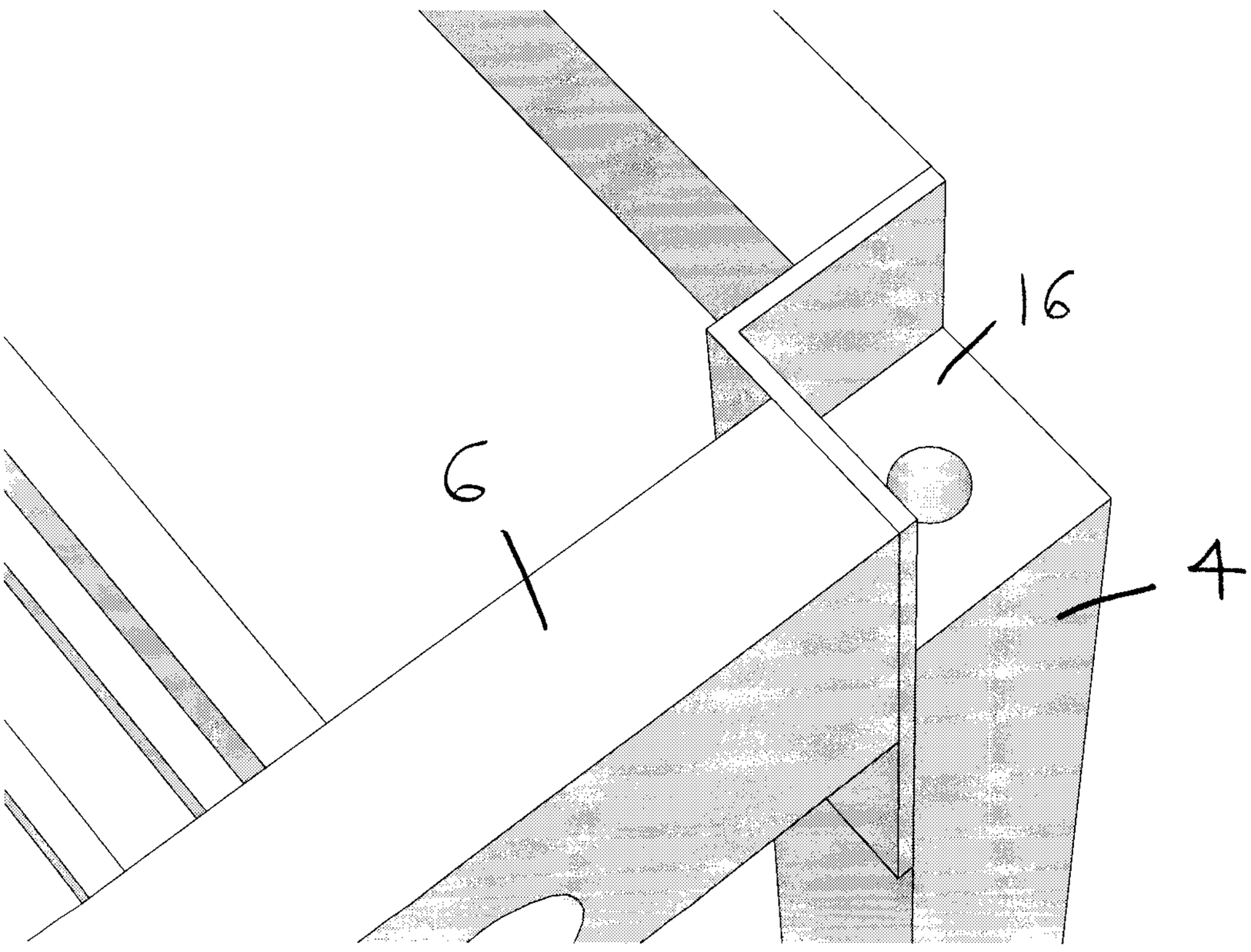



FIG. 38

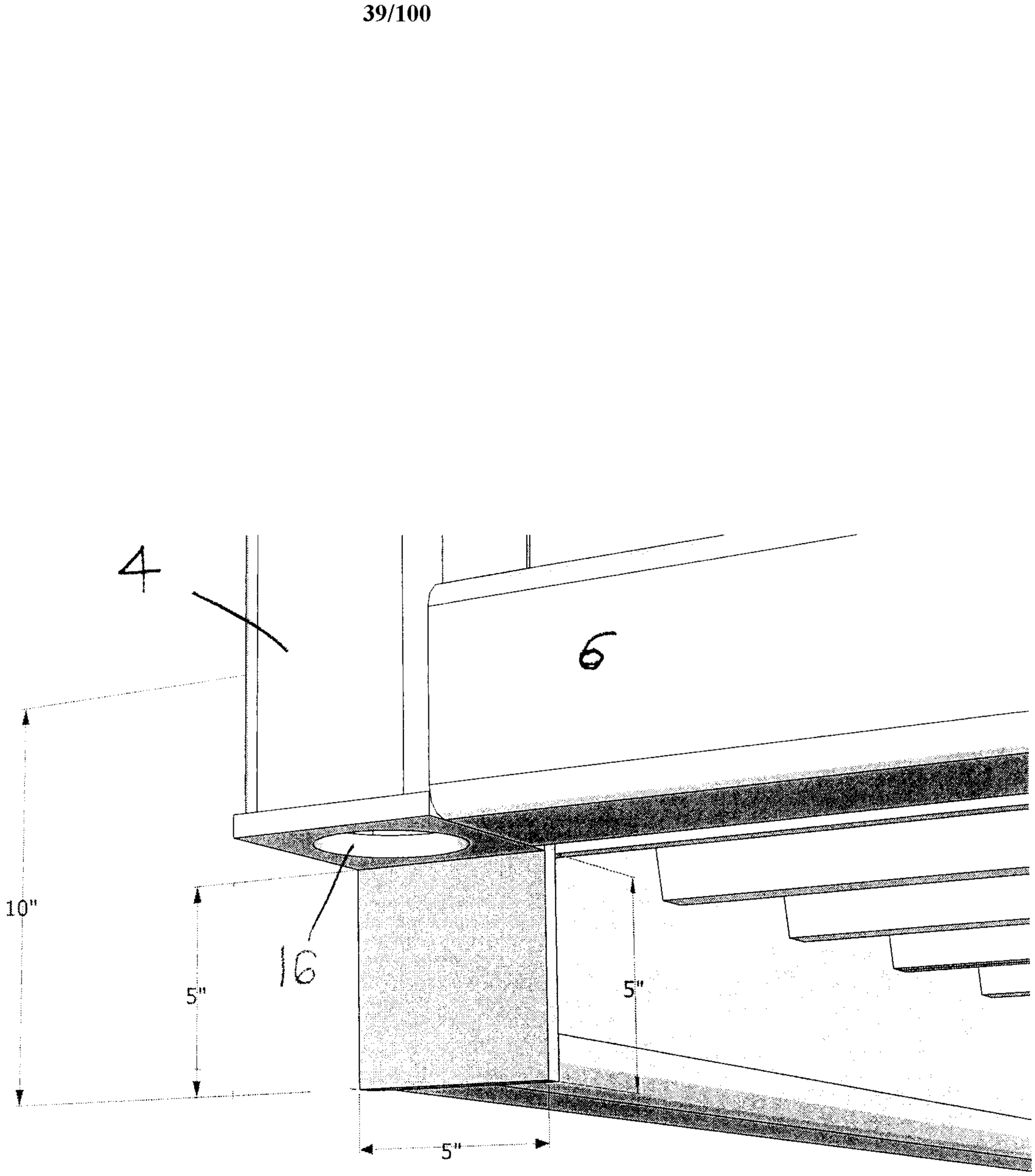



FIG 39

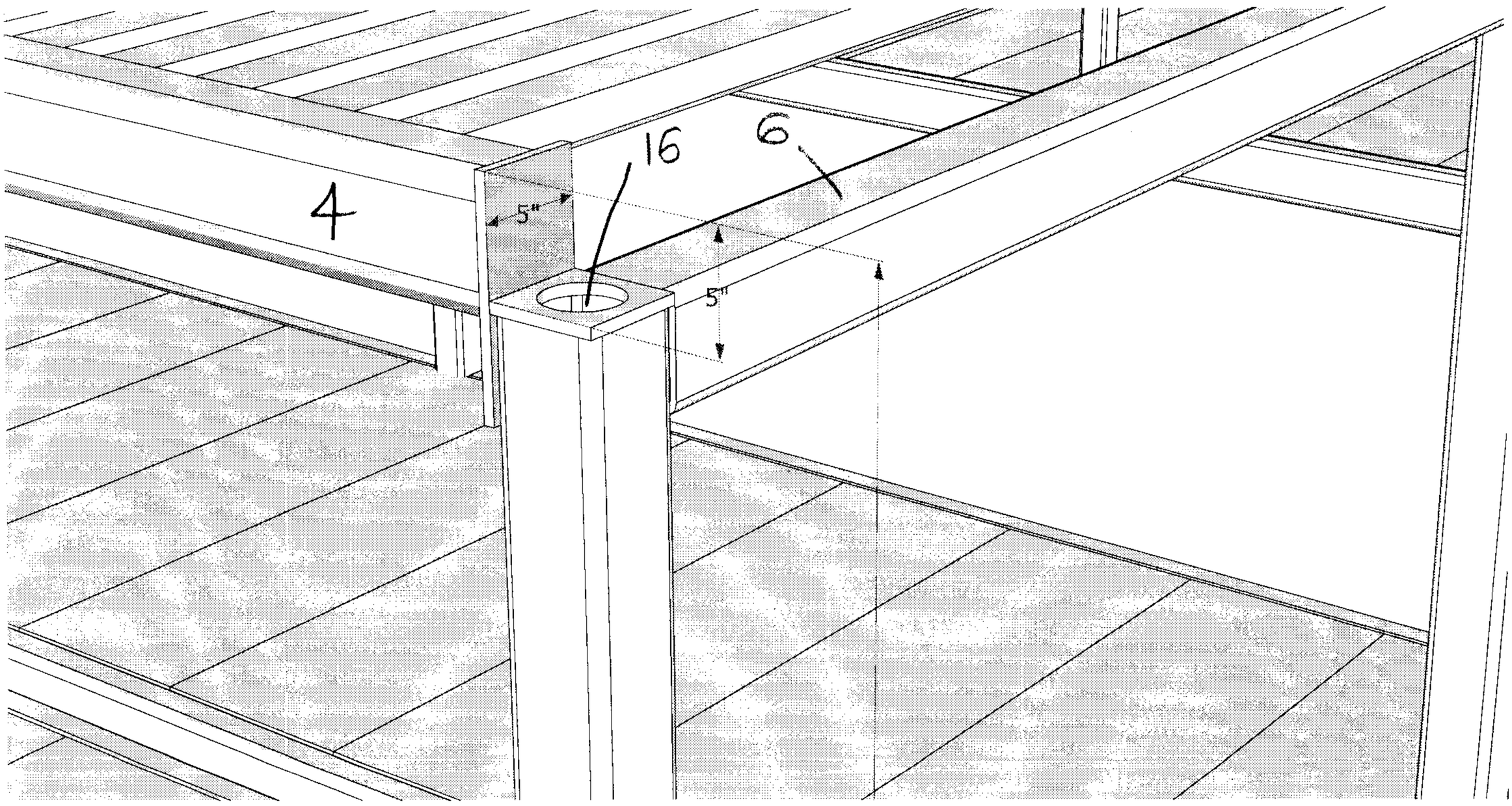



FIG. 40

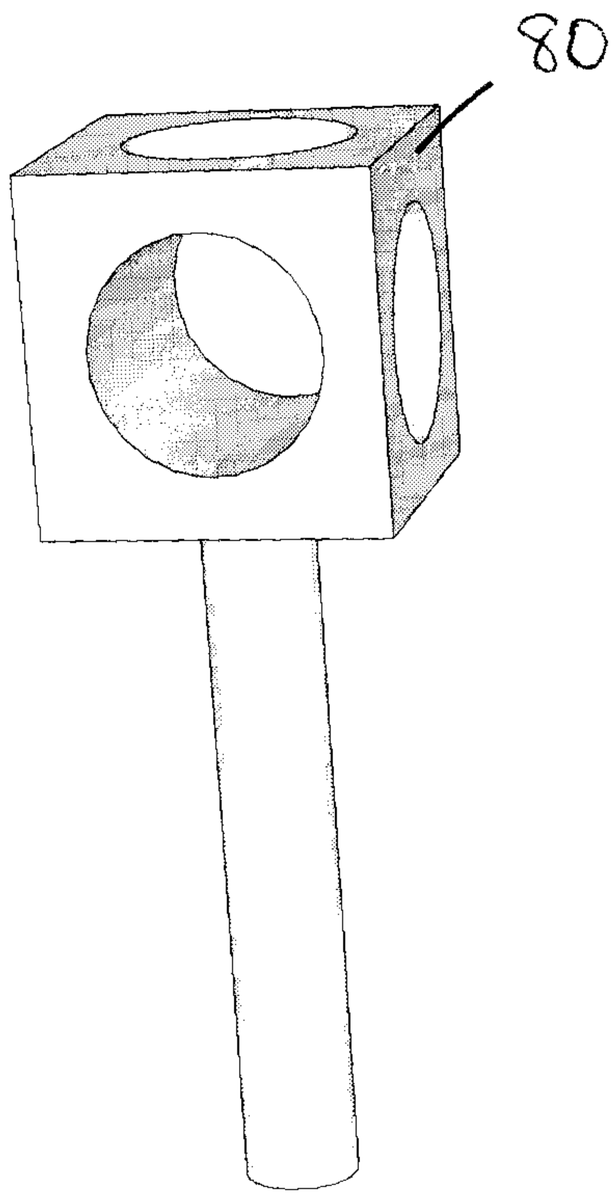



FIG. 41

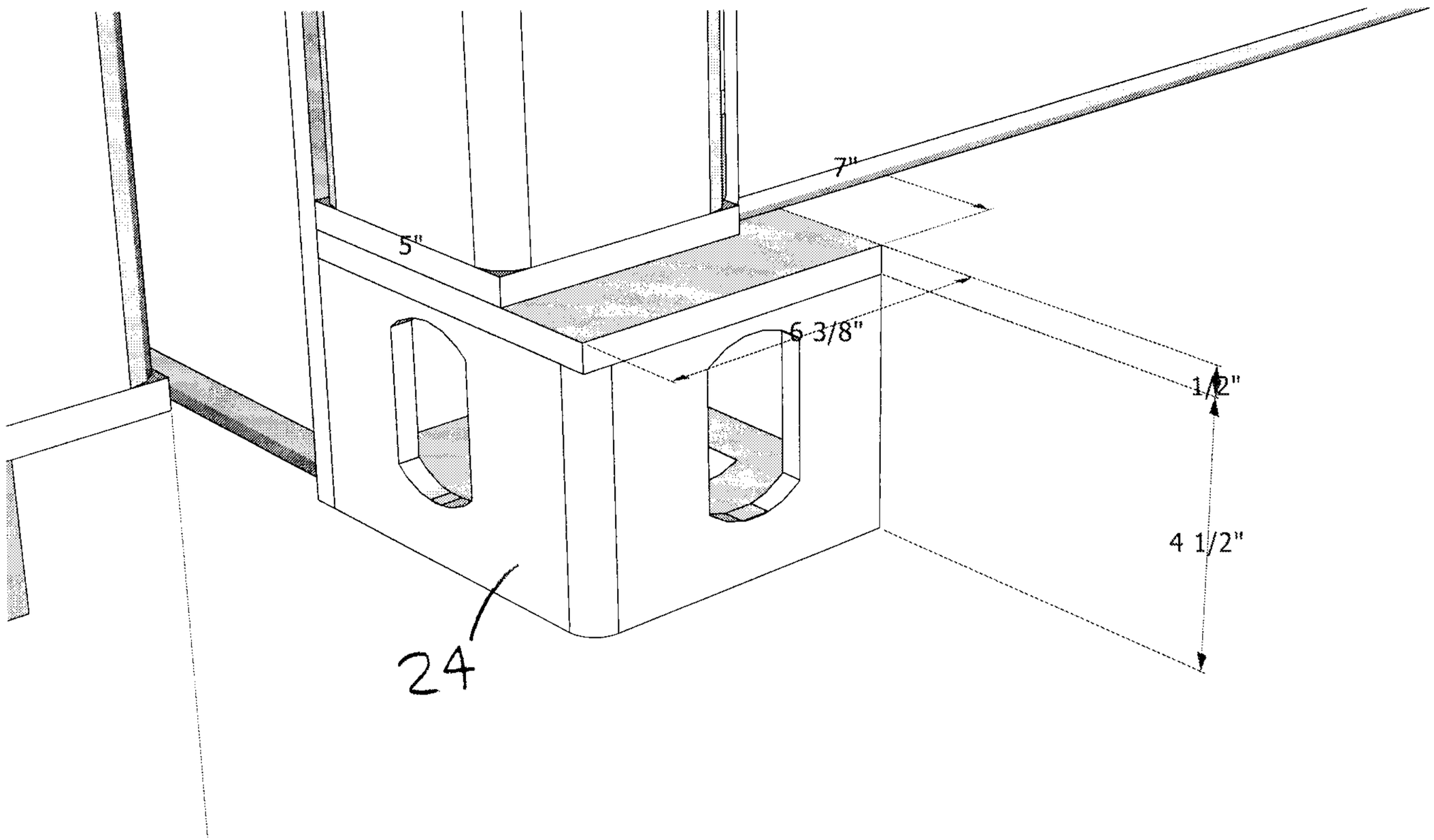



FIG 42

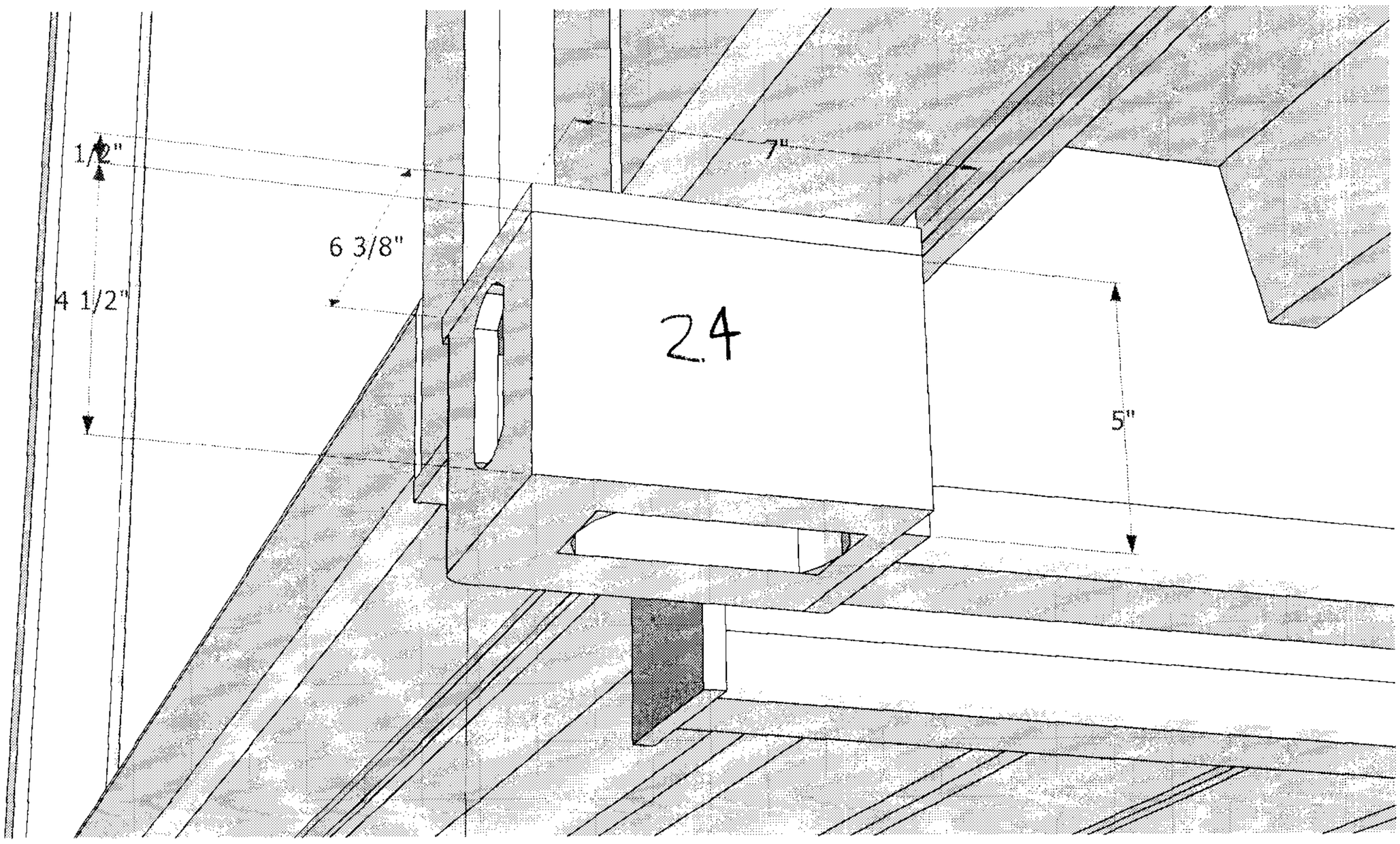



FIG.43

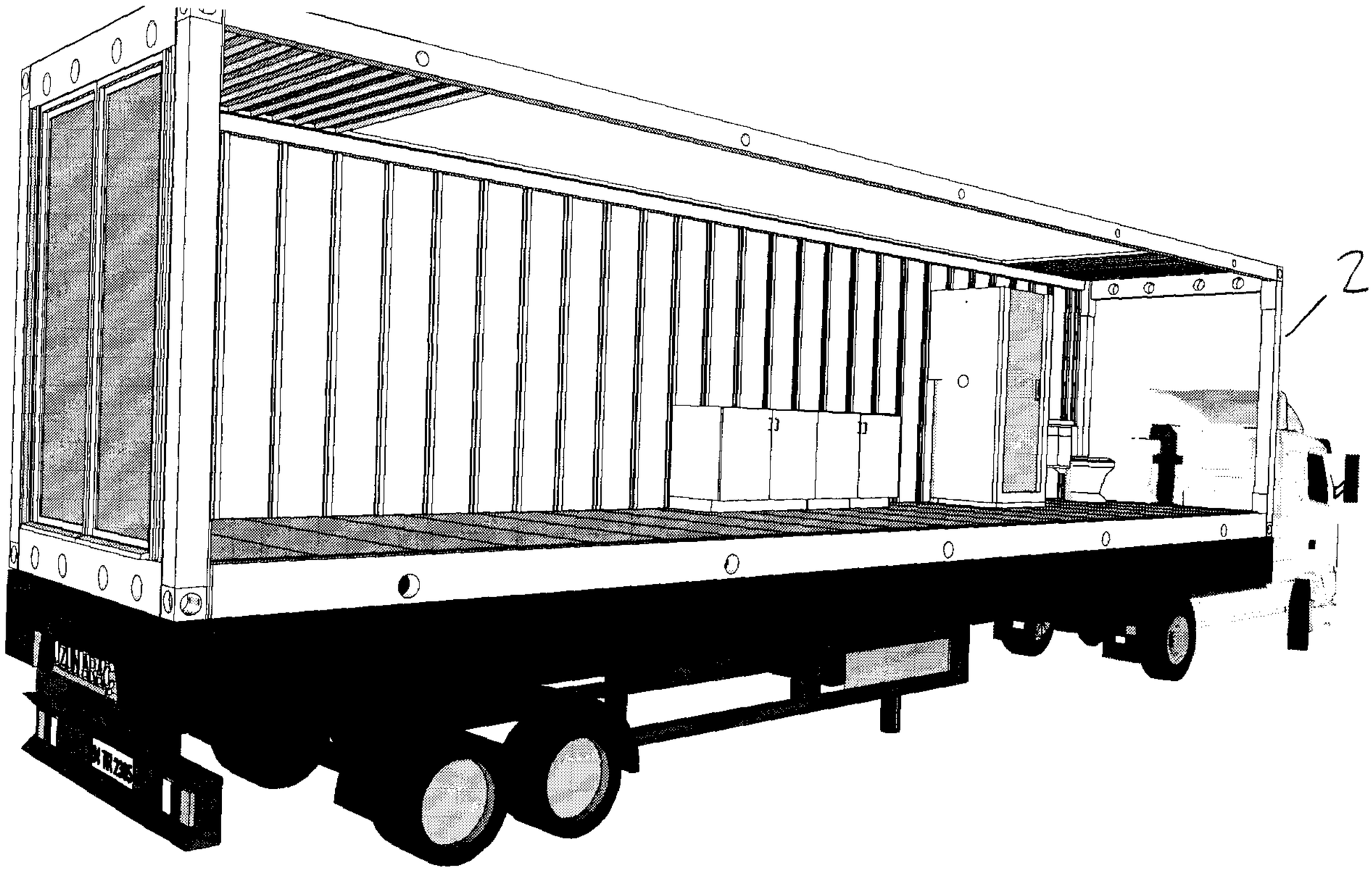



Fig 44

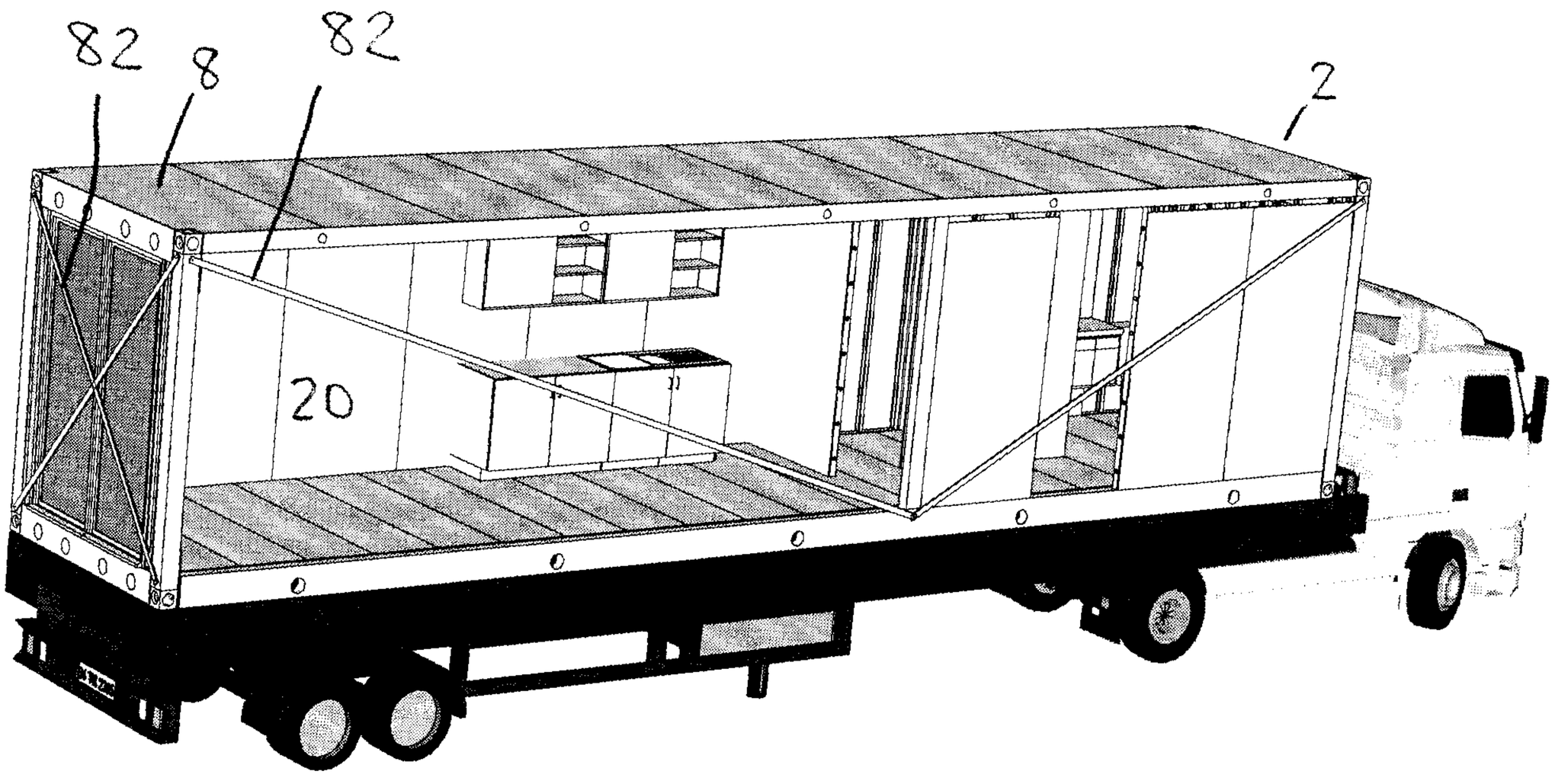



FIG 45

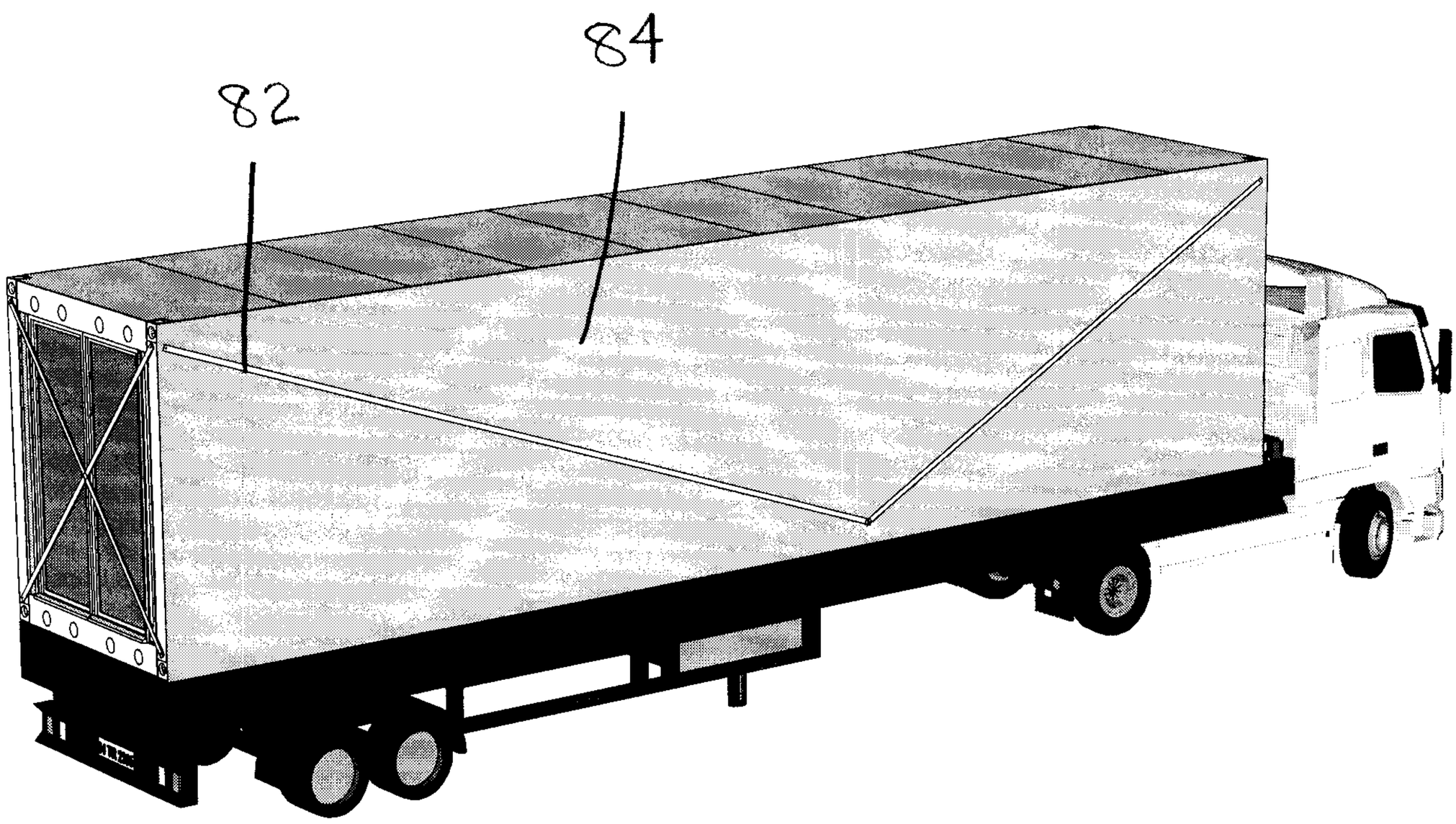



FIG. 46

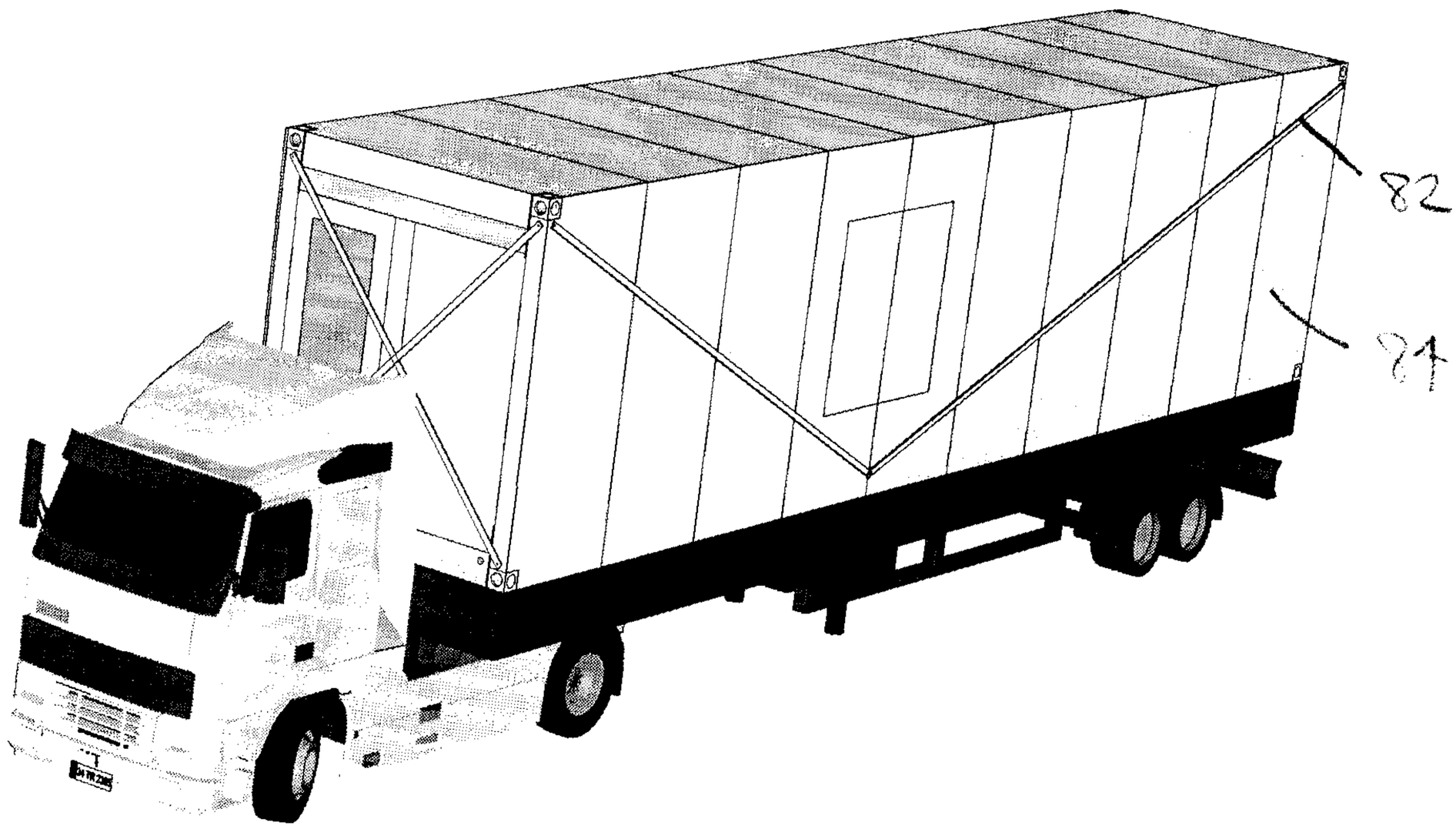



FIG. 47

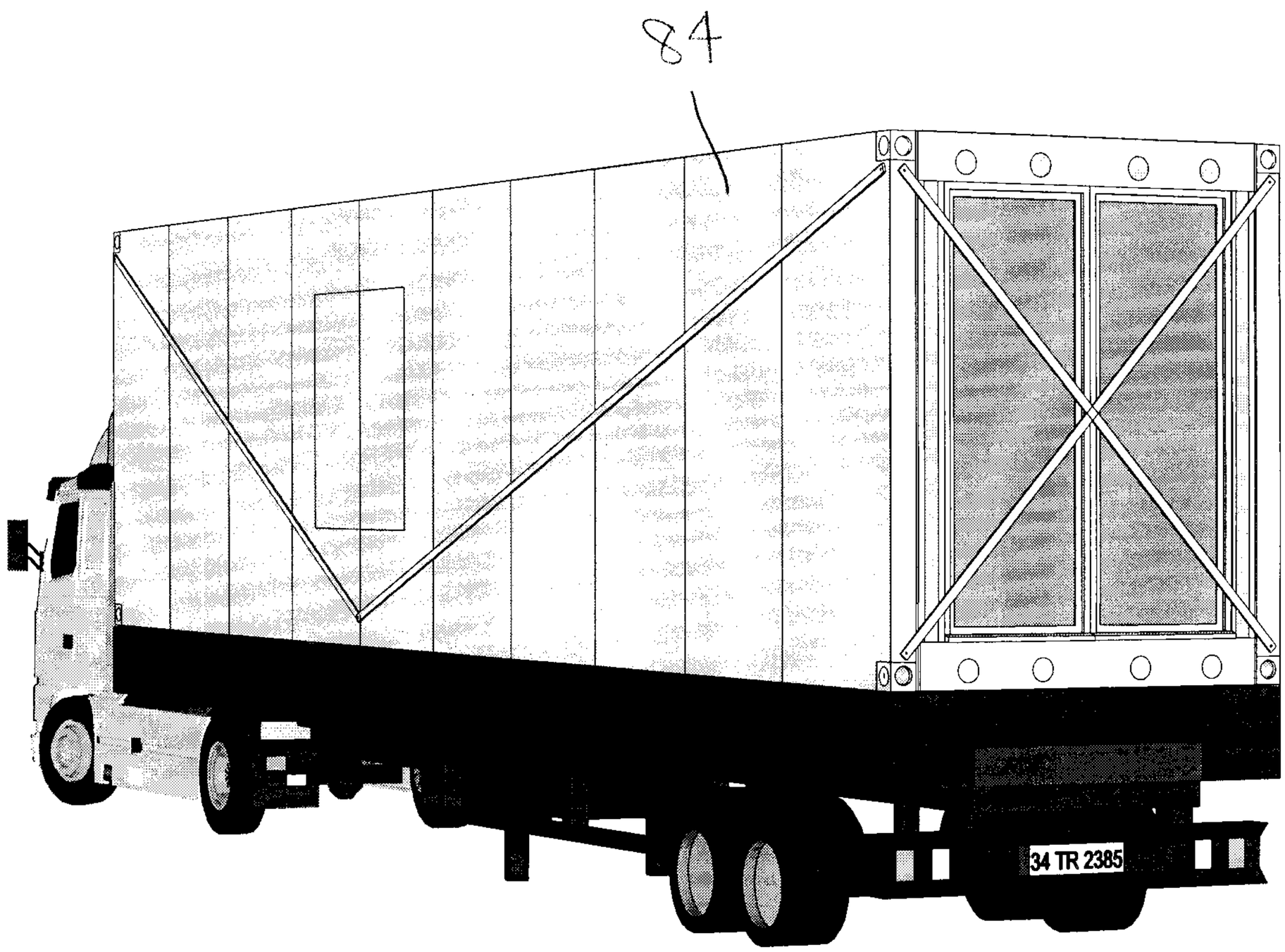



FIG. 48

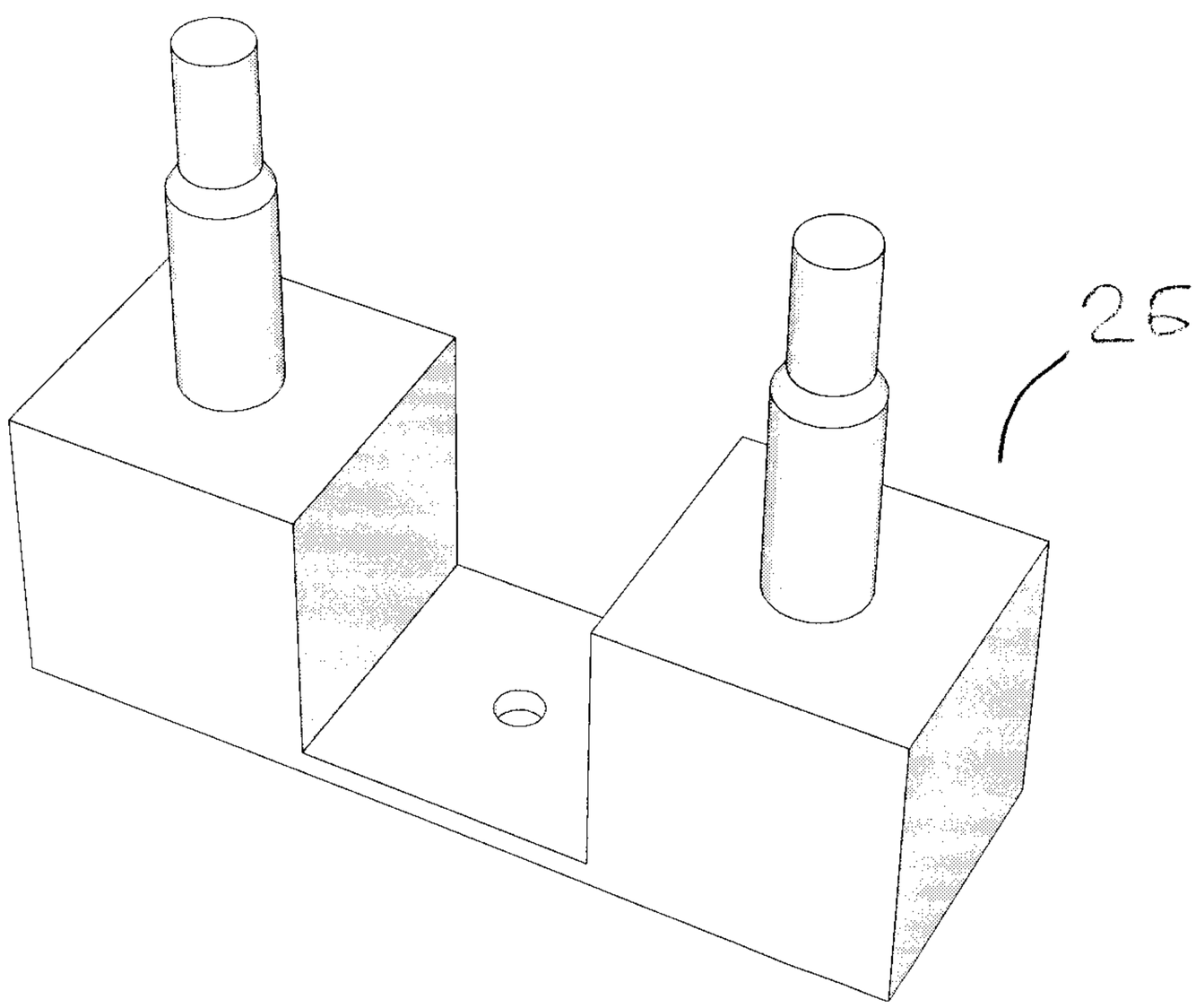



FIG 19

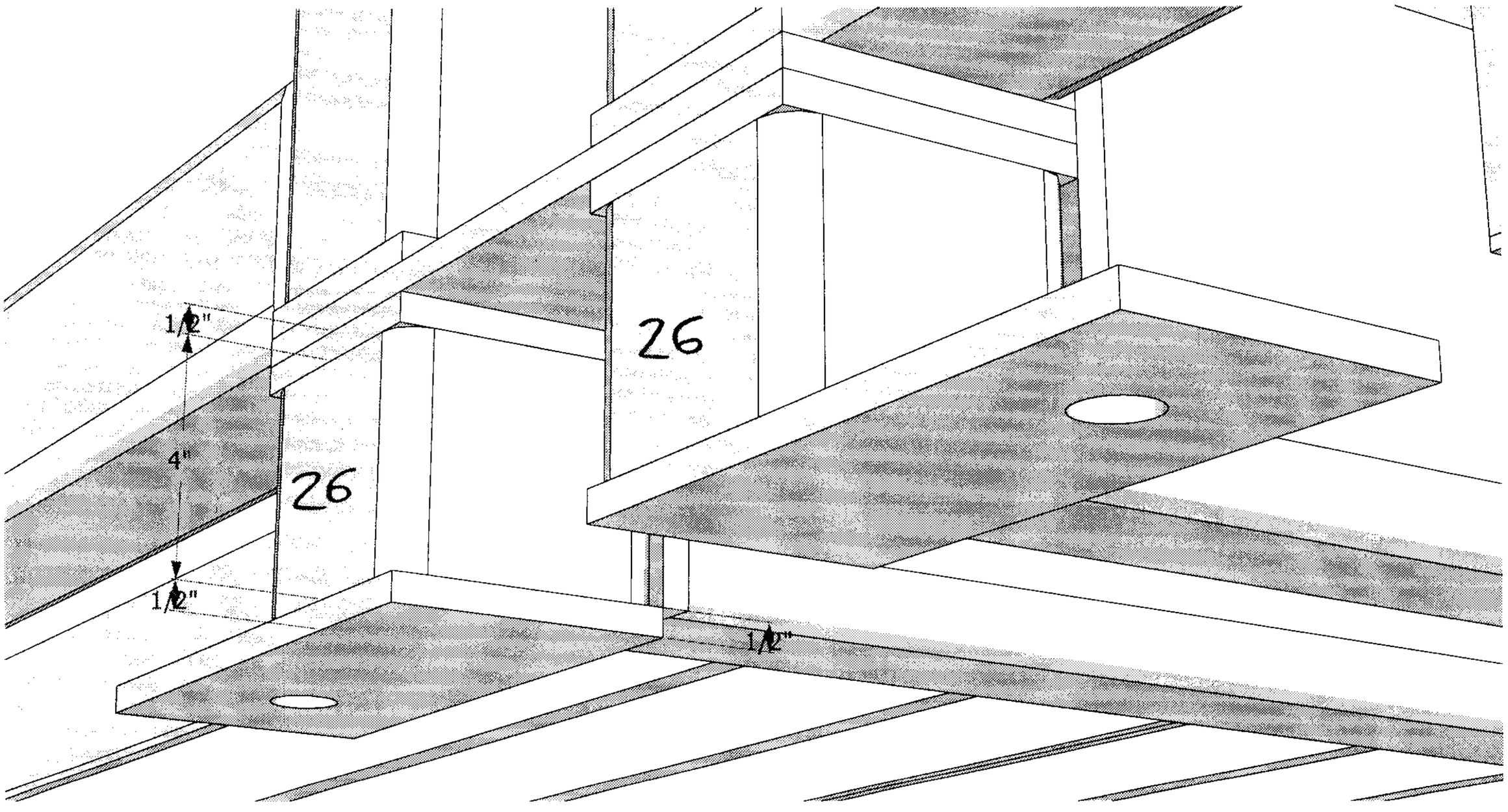



FIG. 50

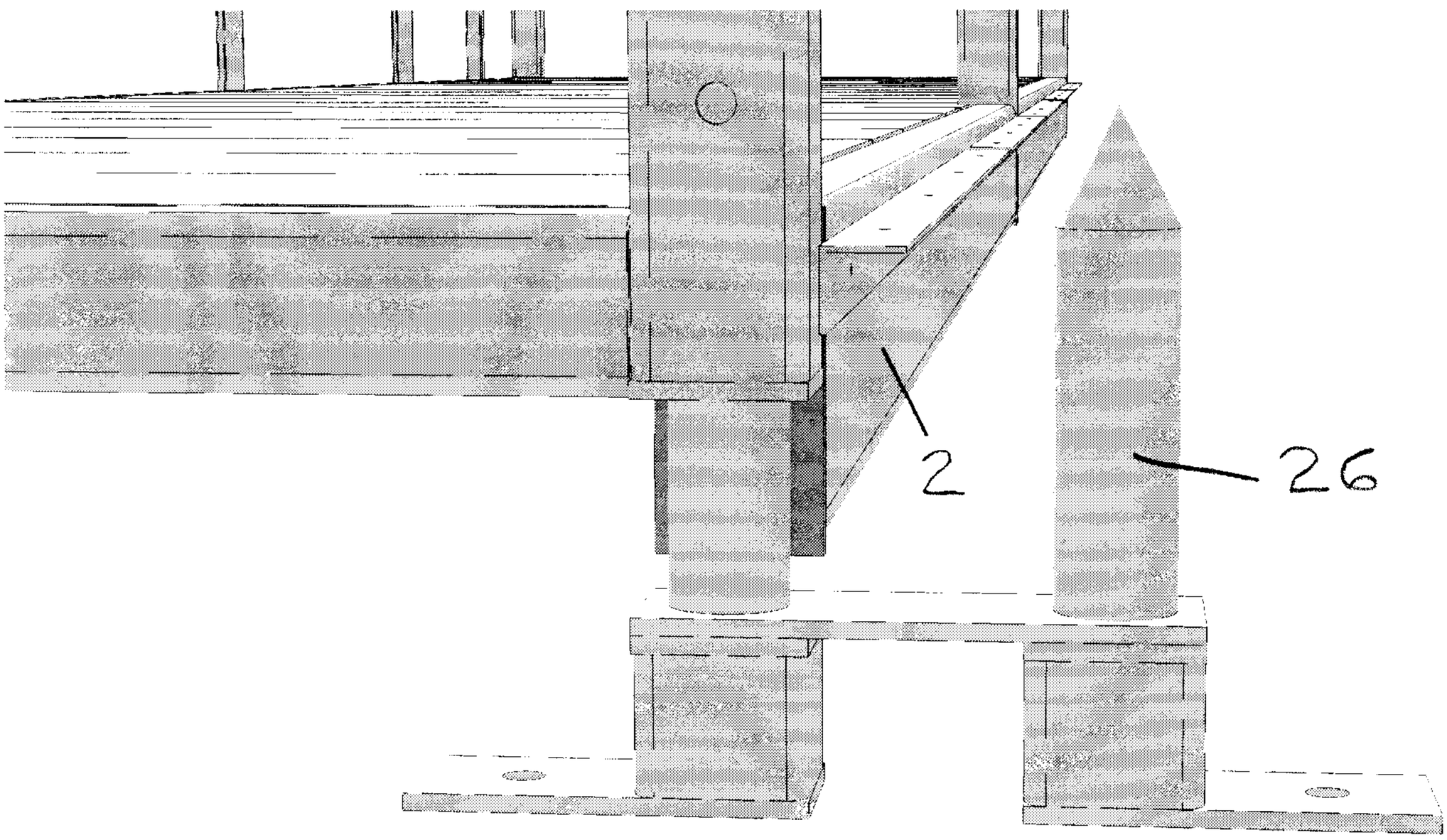



FIG 51

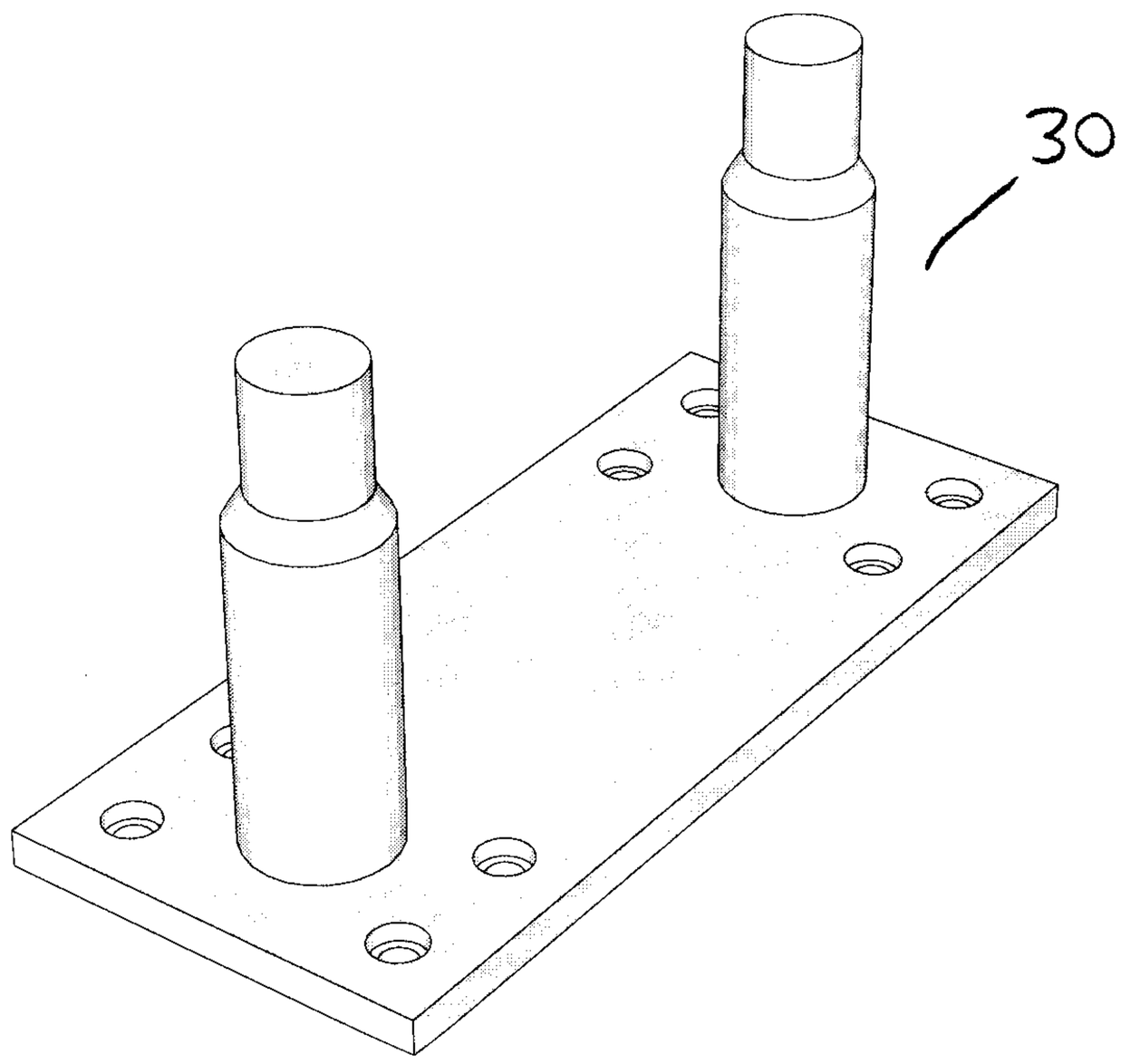



FIG 52

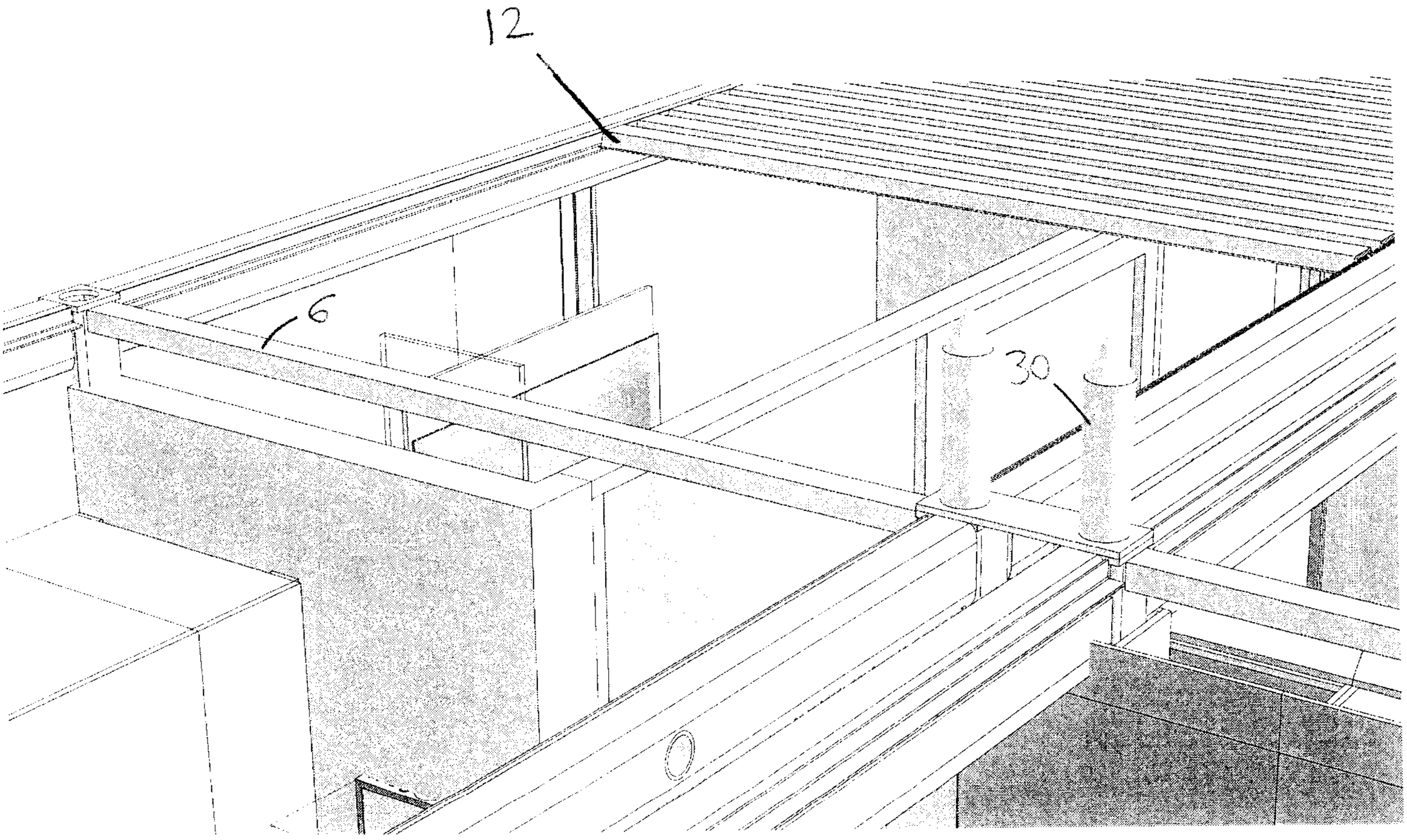



FIG. 53

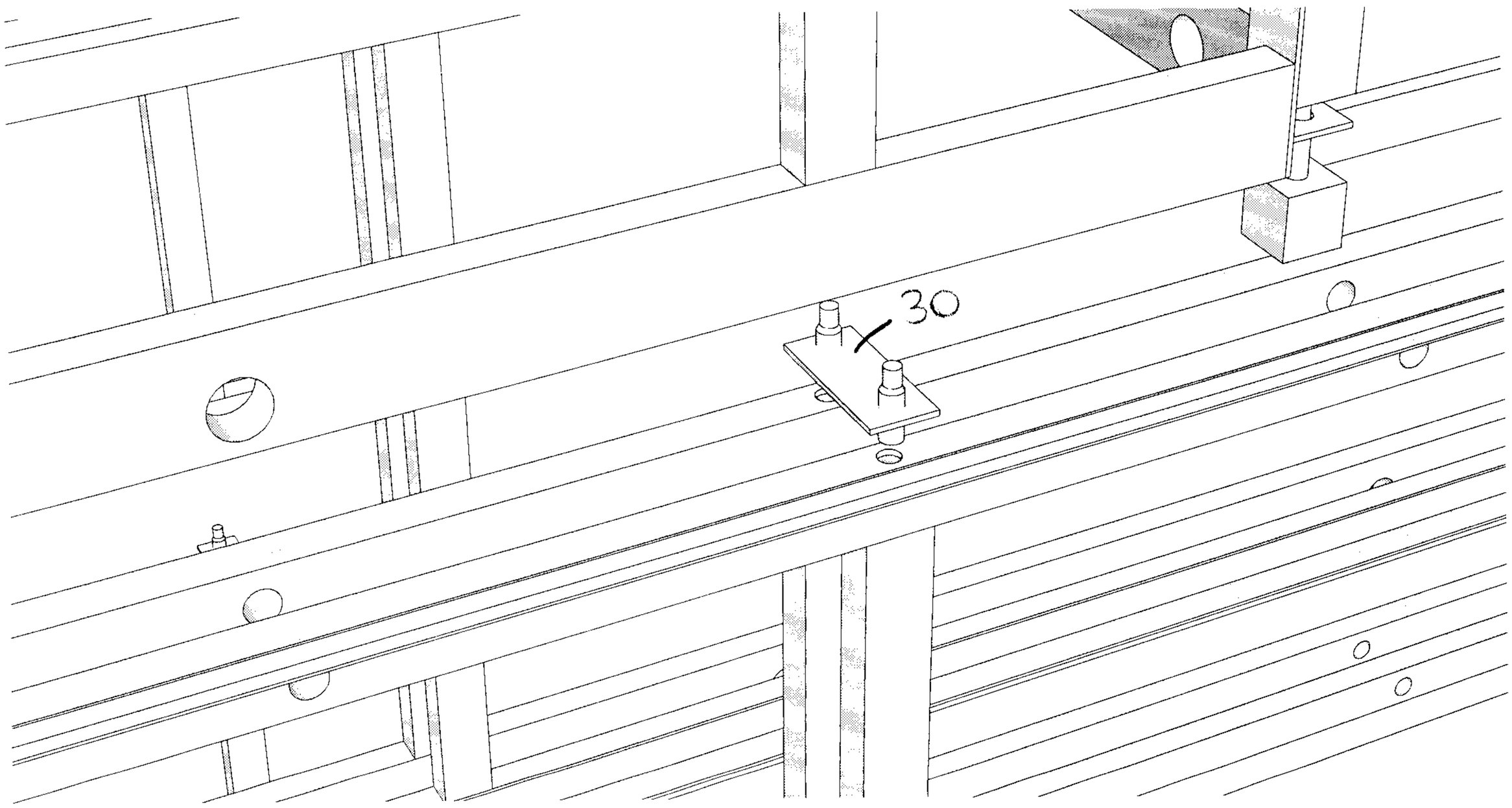



FIG. 54

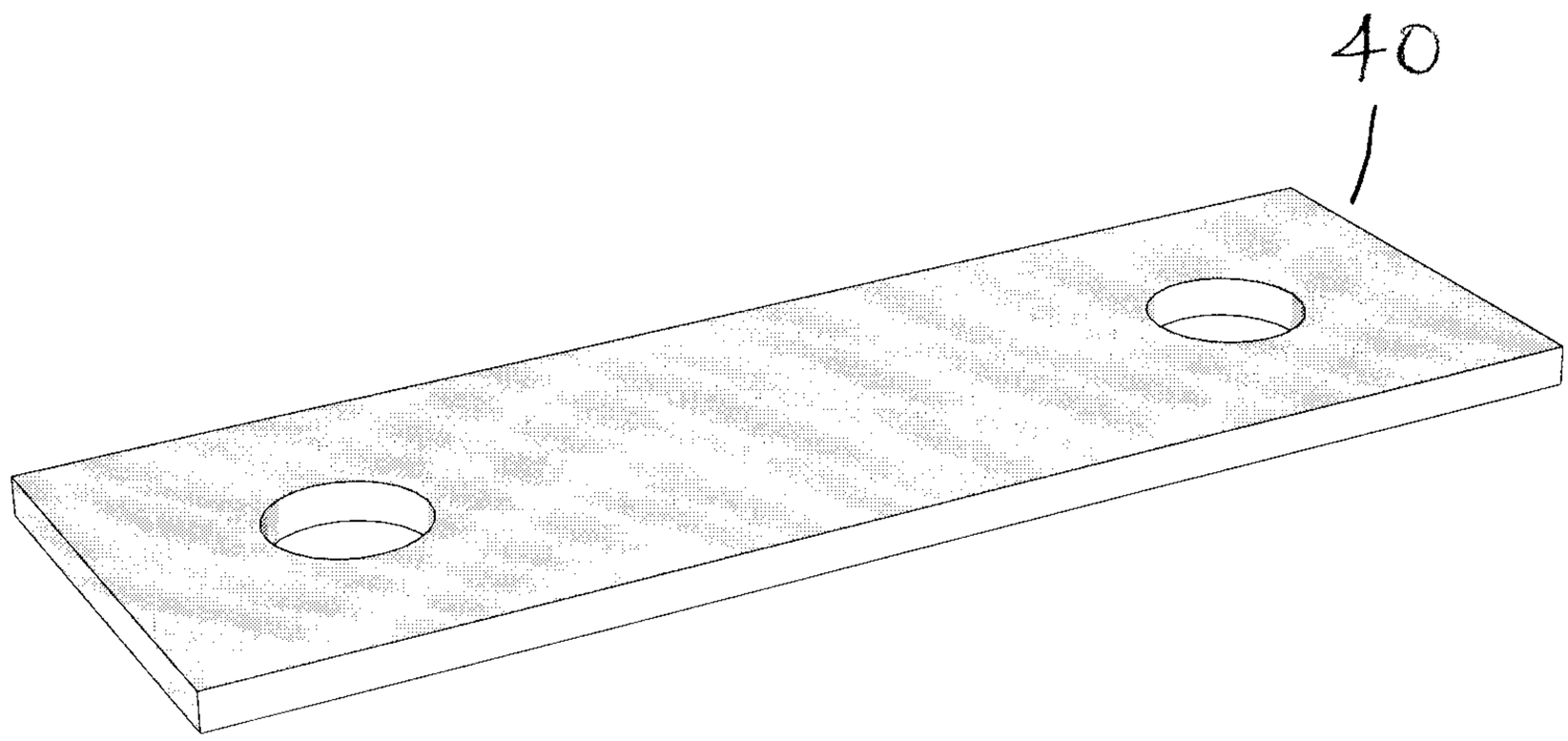



FIG. 55

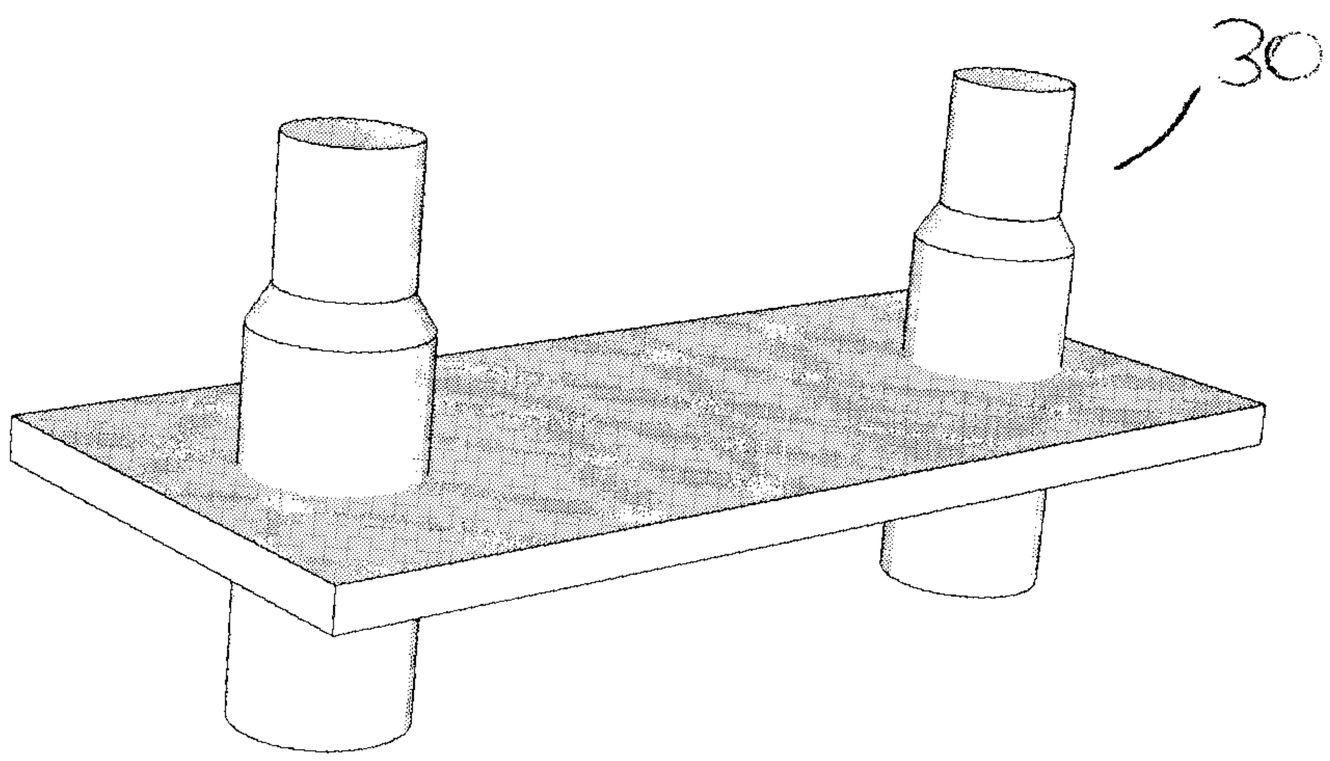



FIG.56

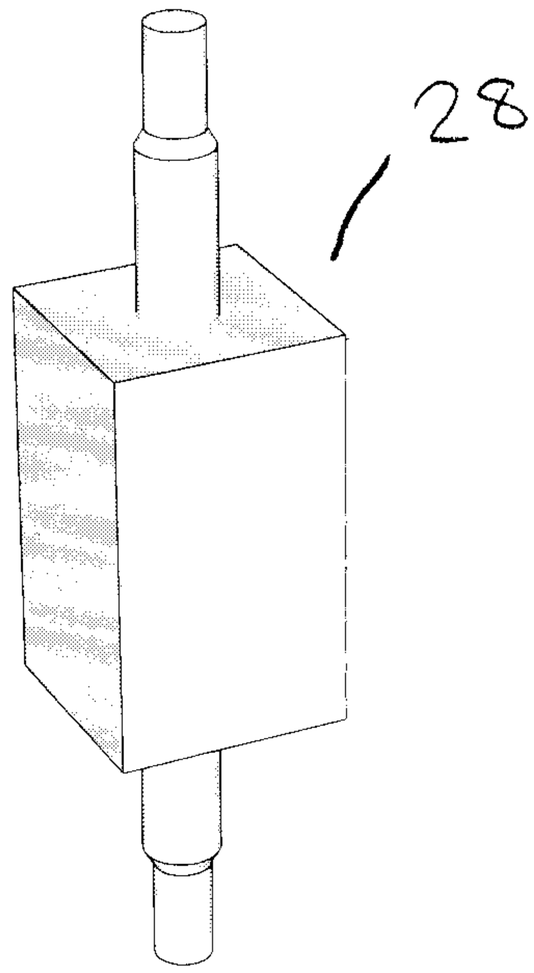



FIG. 57

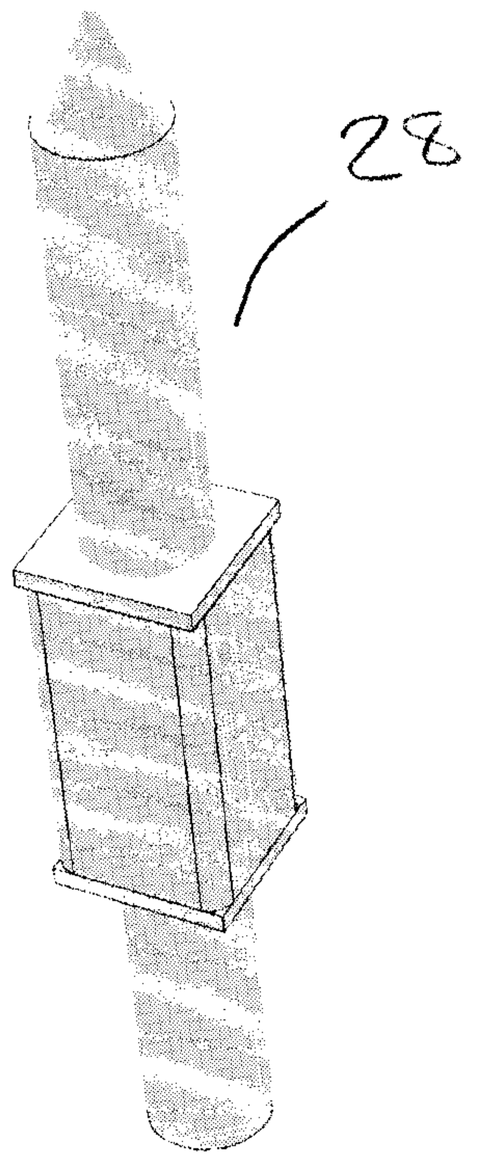



FIG. 58

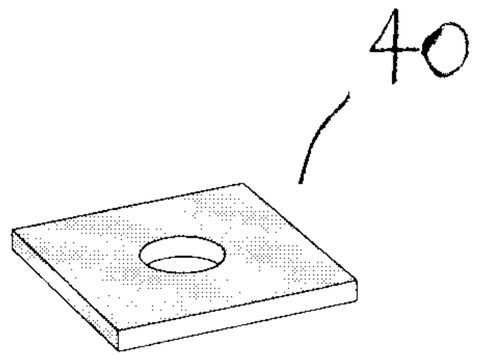



FIG. 59

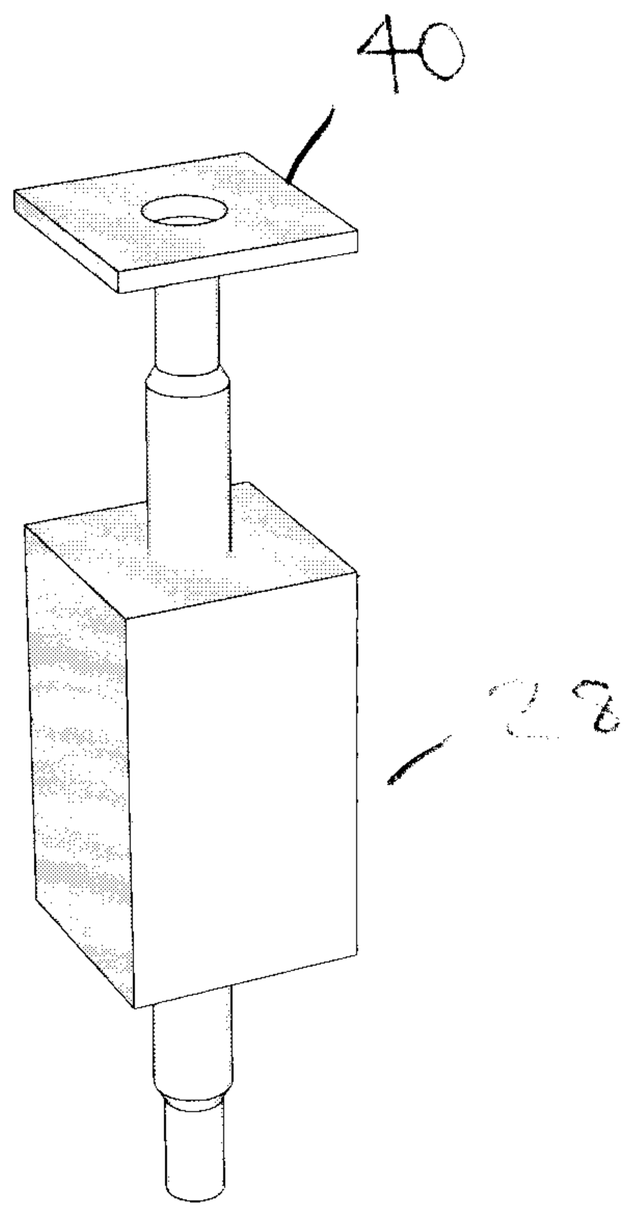



FIG. 60

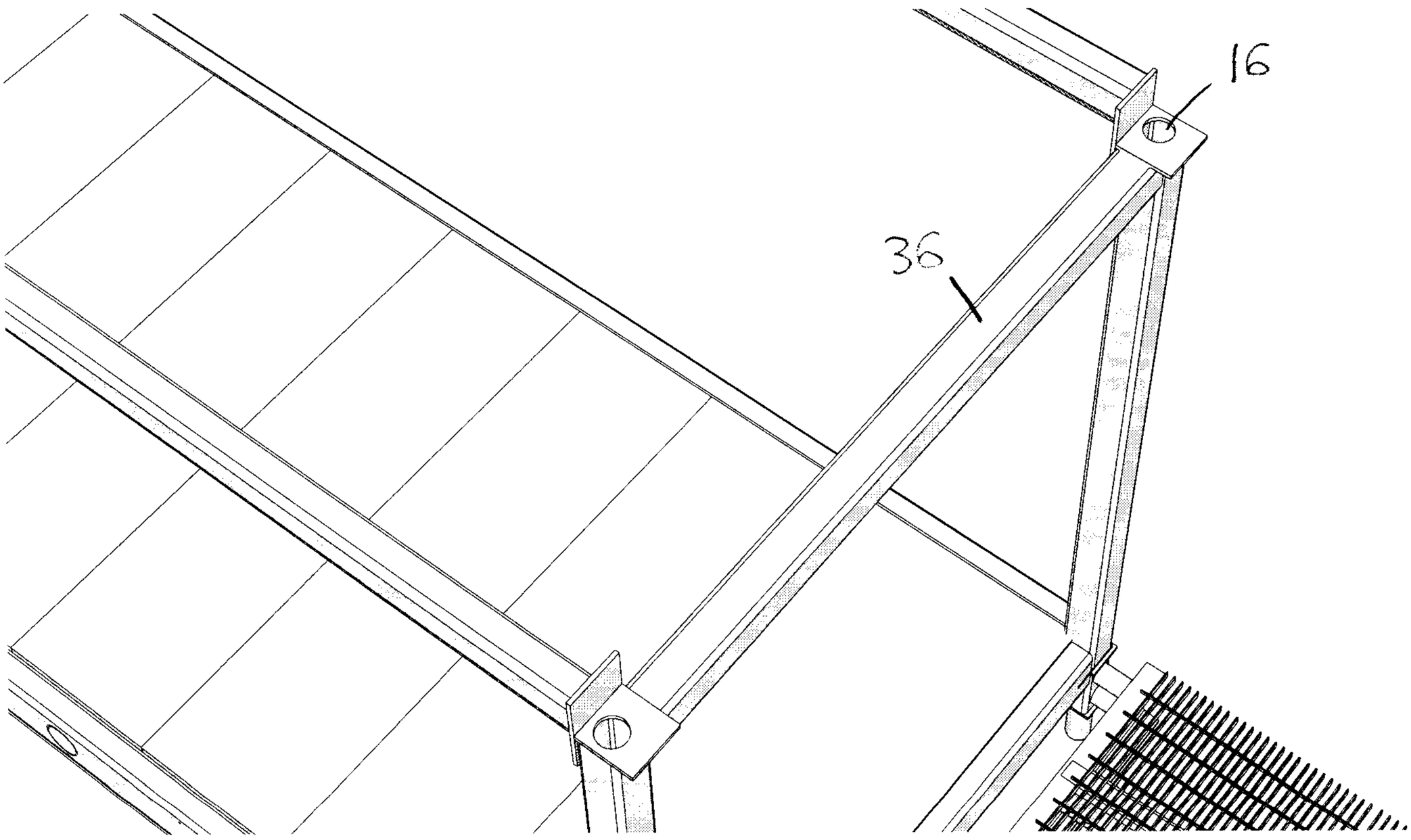



FIG. 61

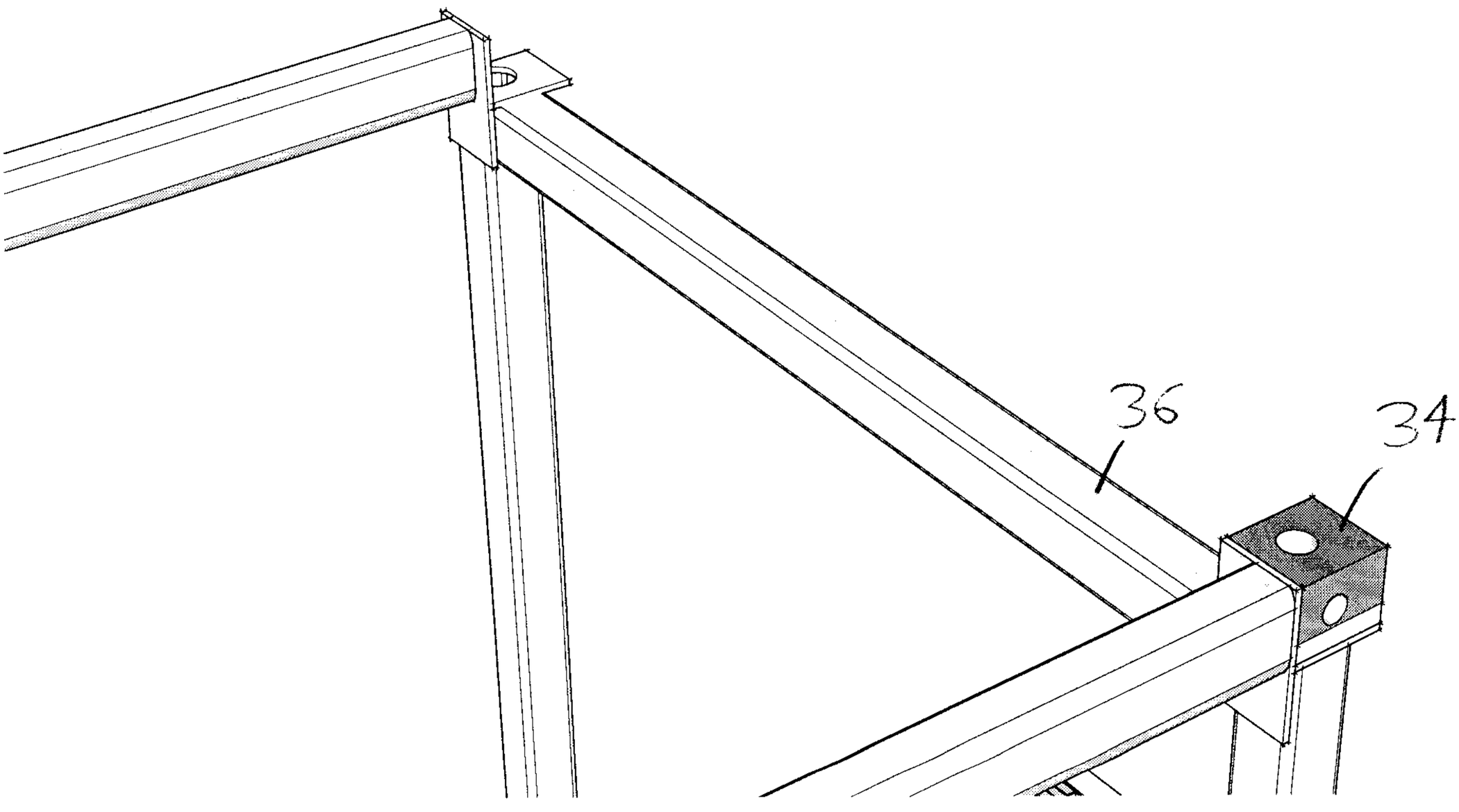



FIG. 62

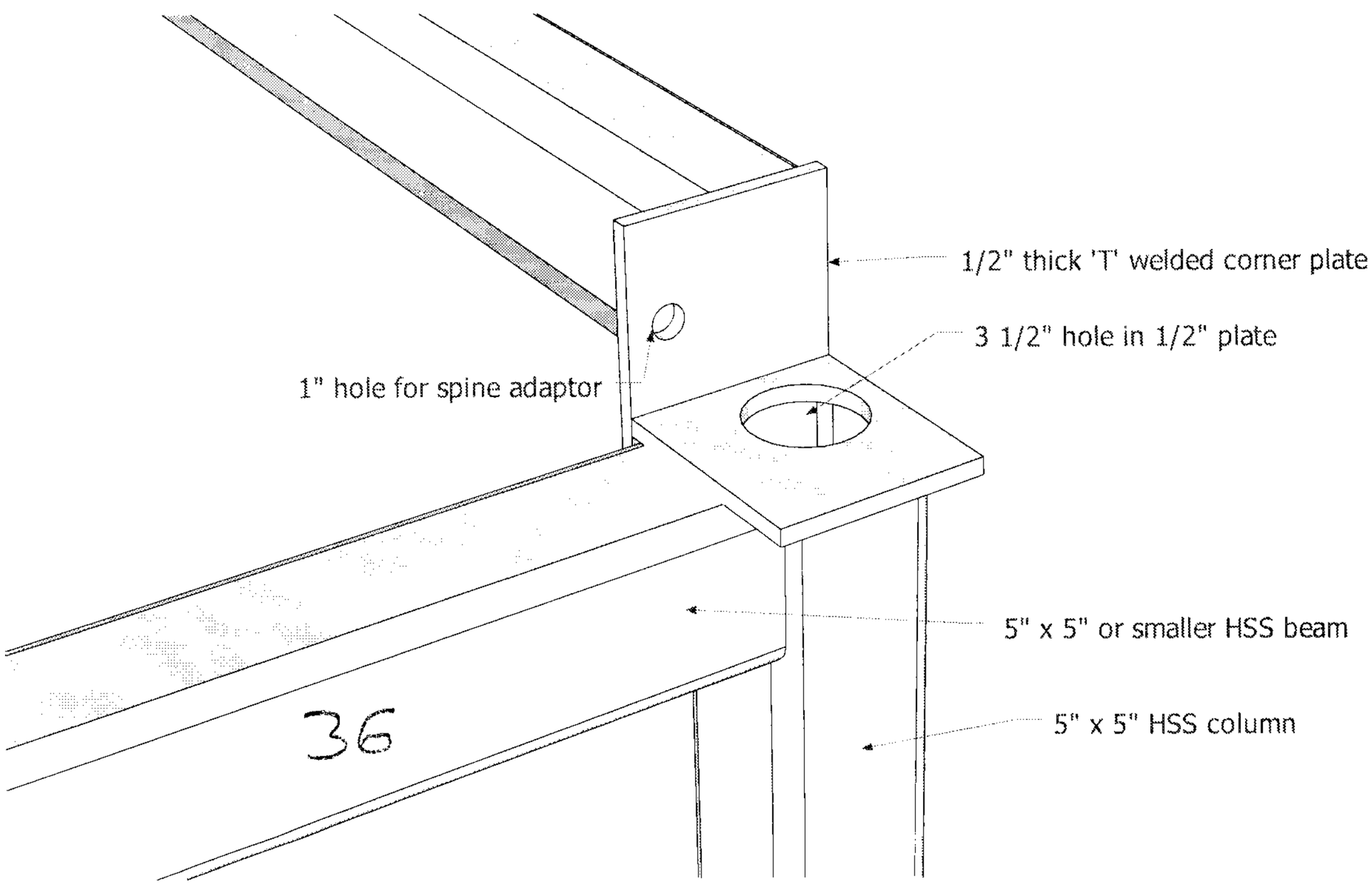

1/2" thick 'T' welded corner plate
3 1/2" hole in 1/2" plate
1" hole for spine adaptor
5" x 5" or smaller HSS beam
5" x 5" HSS column
36

FIG. 63

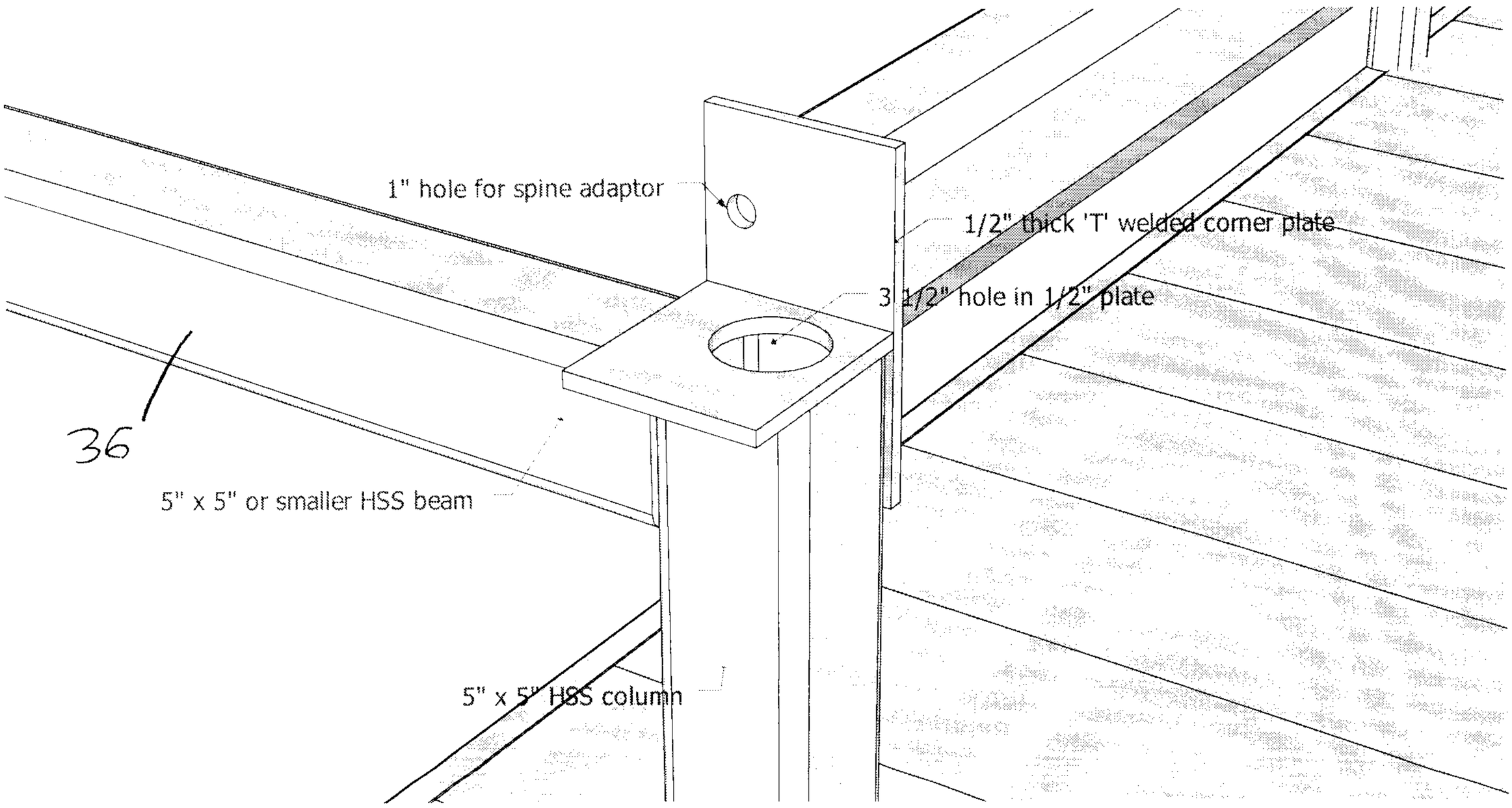

1" hole for spine adaptor
1/2" thick 'T' welded corner plate
3 1/2" hole in 1/2" plate
36
5" x 5" or smaller HSS beam
5" x 5" HSS column

FIG. 64

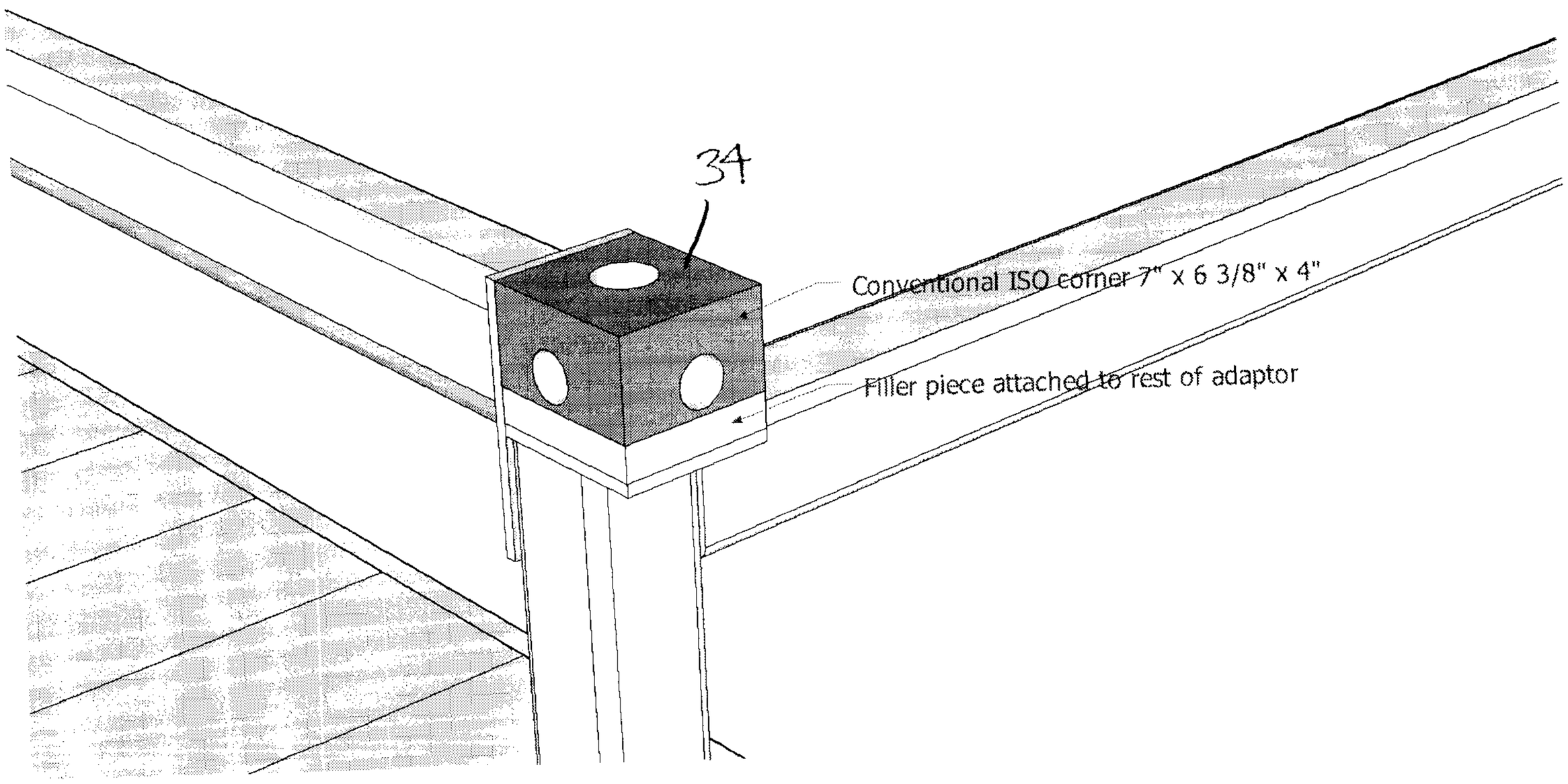

34
Conventional ISO corner 7" x 6 3/8" x 4"
Filler piece attached to rest of adaptor

FIG 65

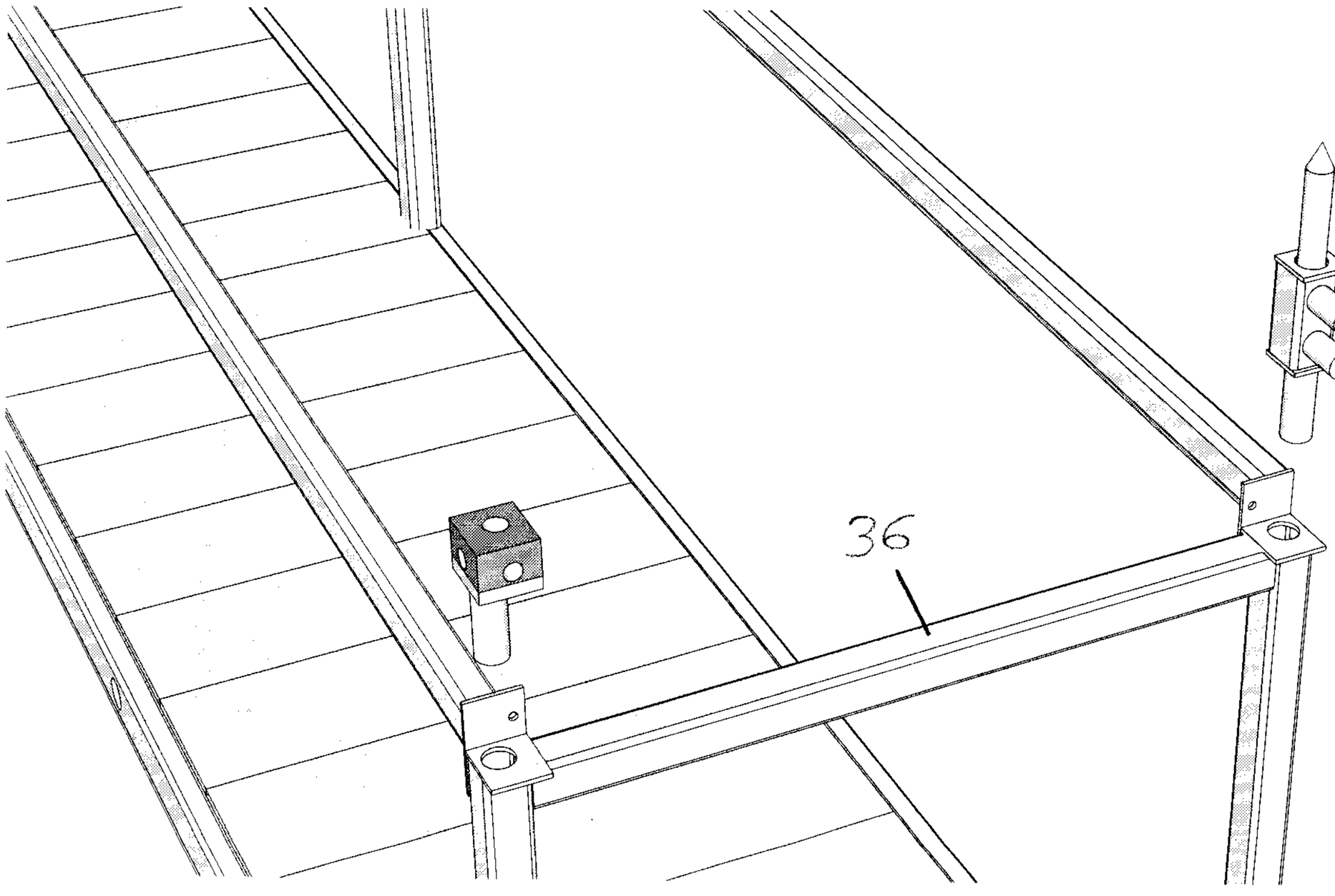



FIG. 66

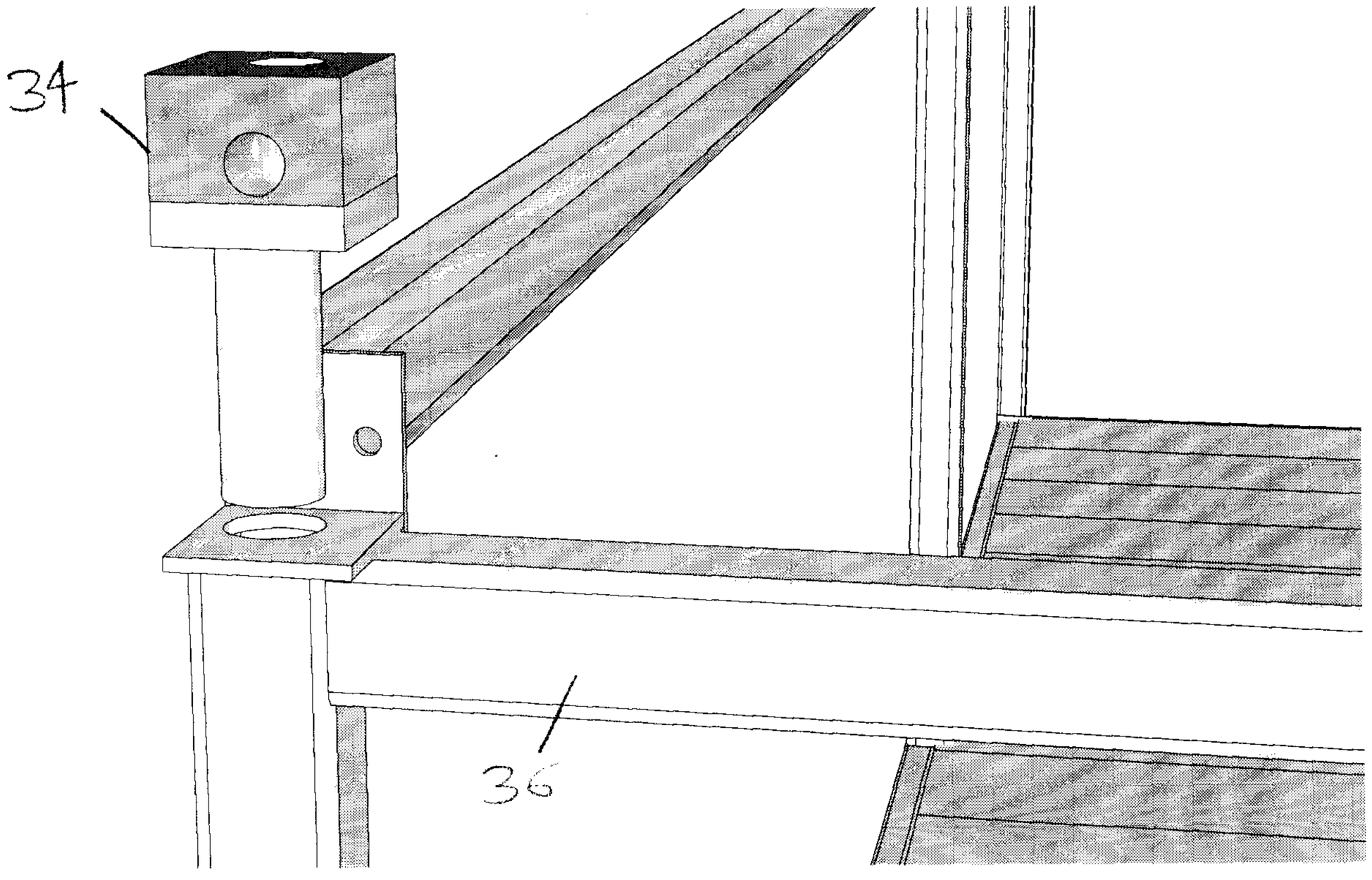



FIG. 67

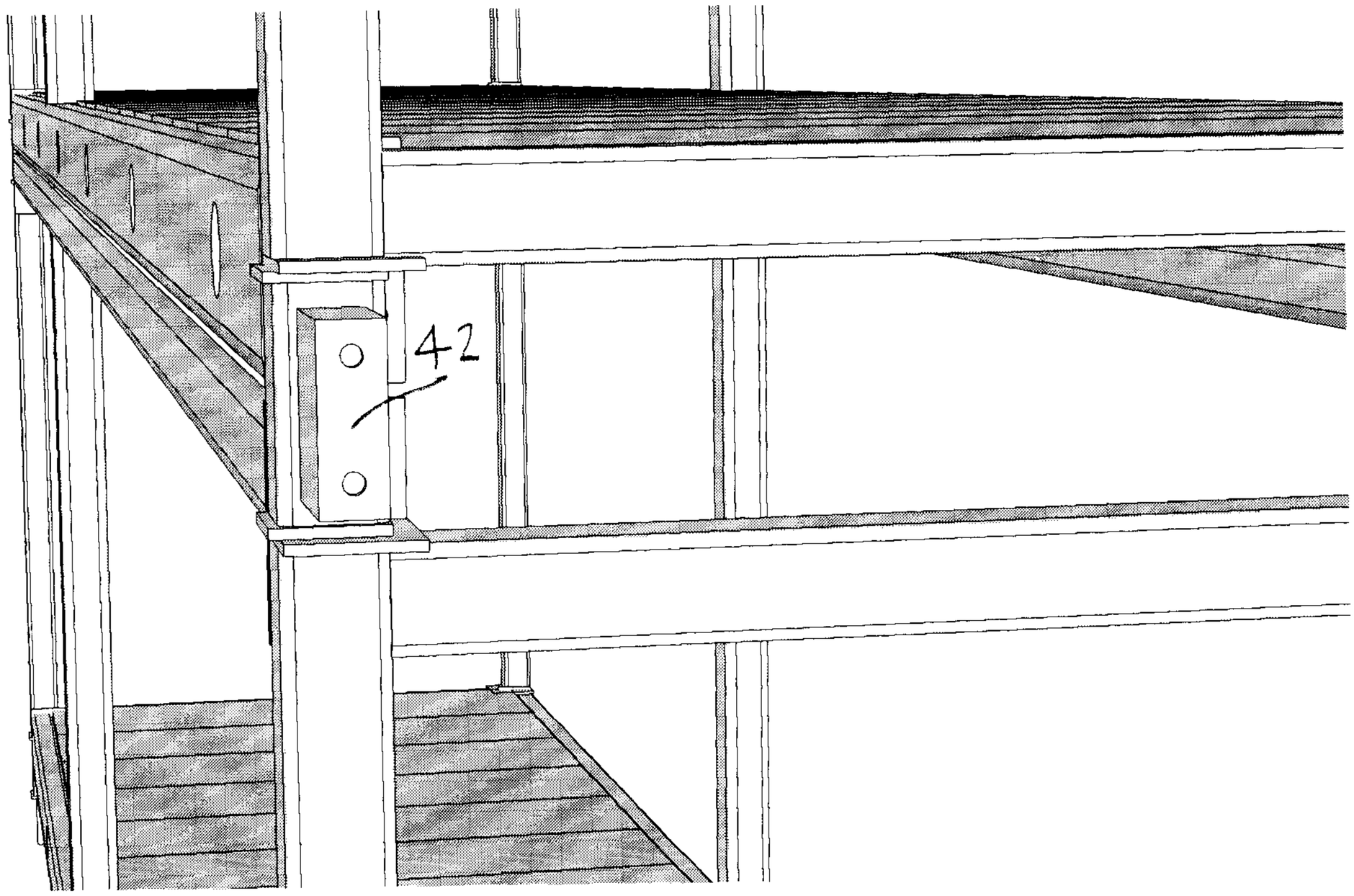



FIG. 6X

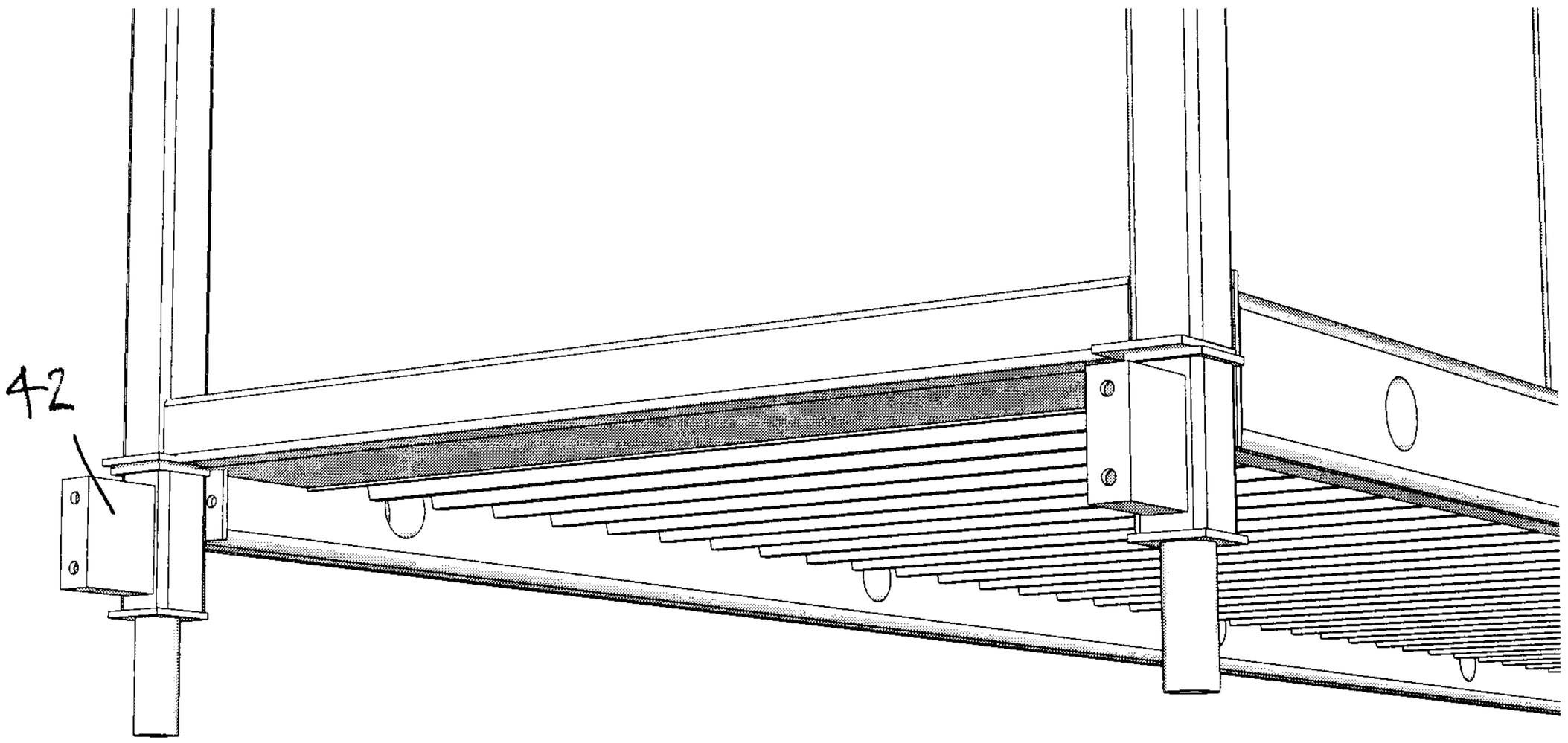



FIG. 69

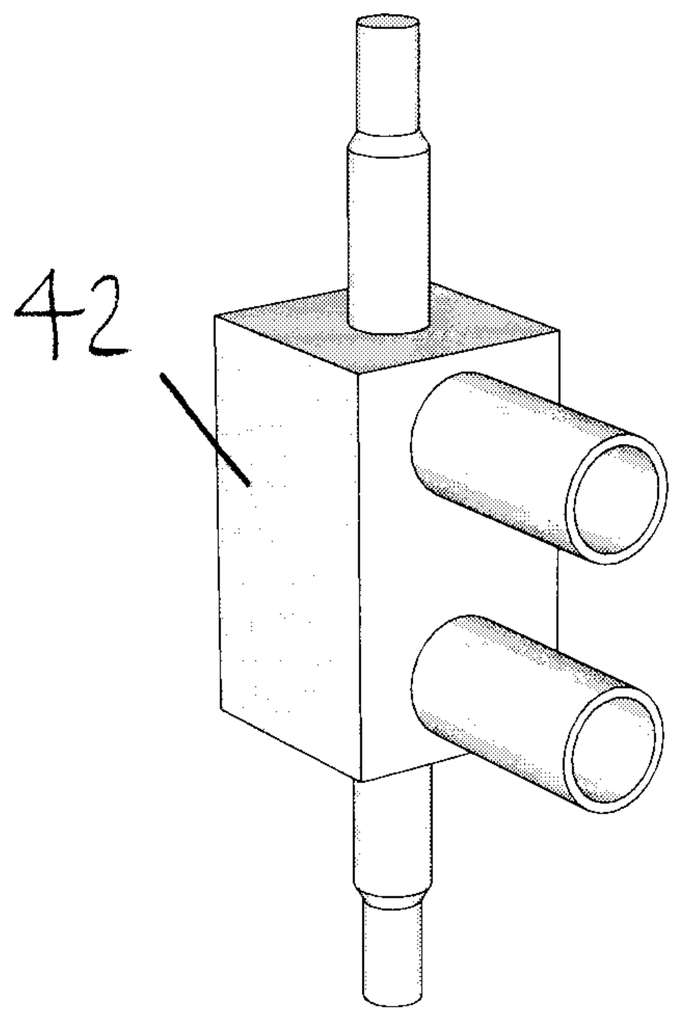



FIG. 70

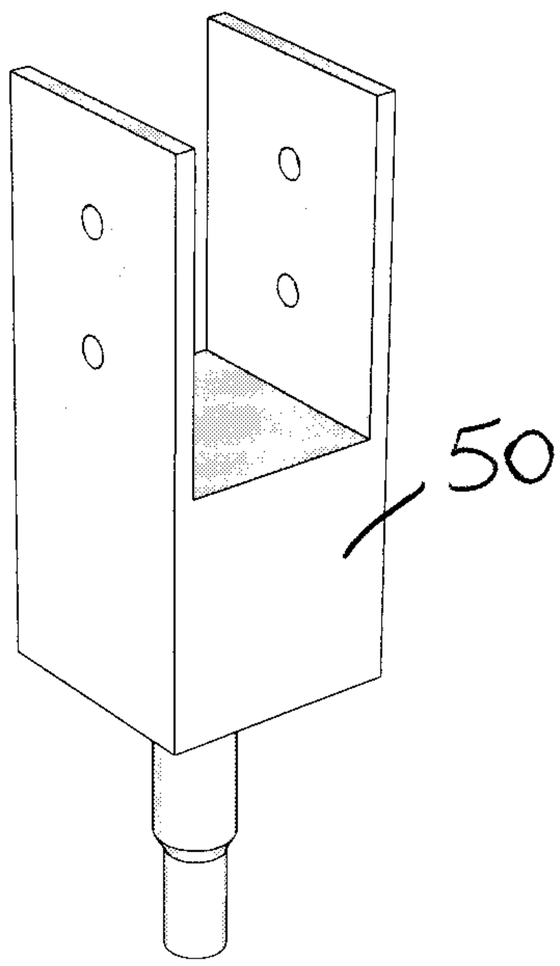



FIG. 71

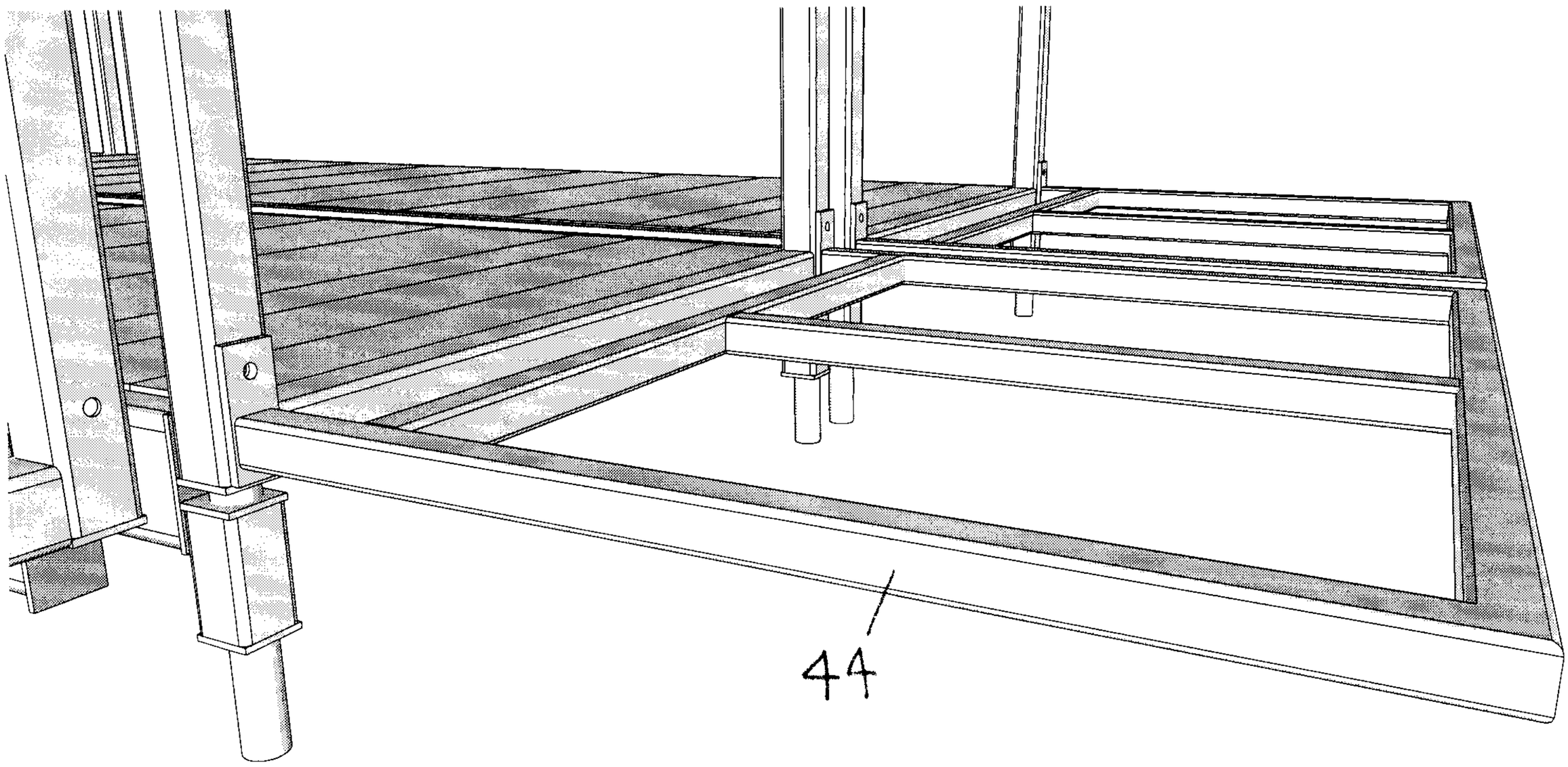



FIG 72

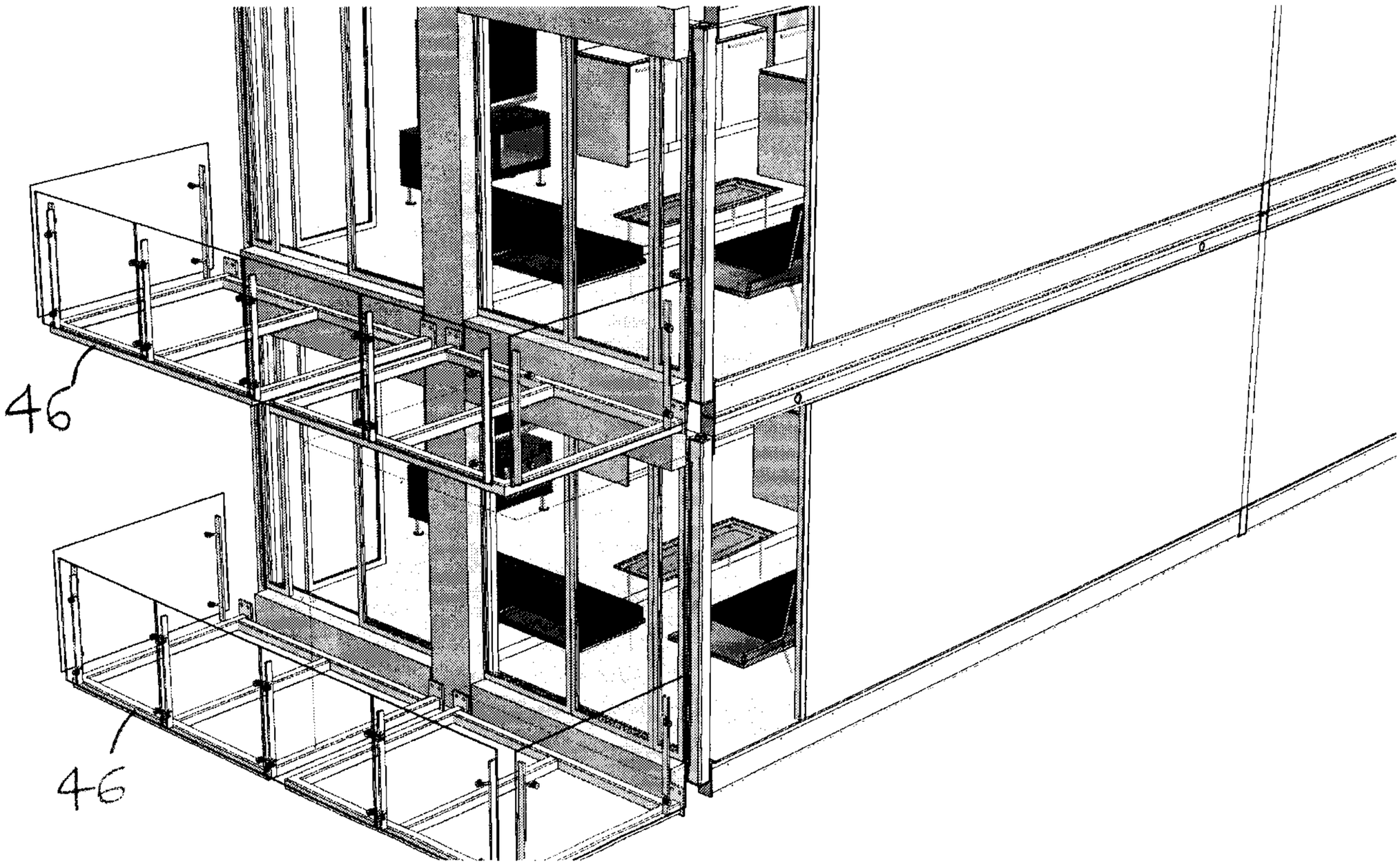



FIG. 73

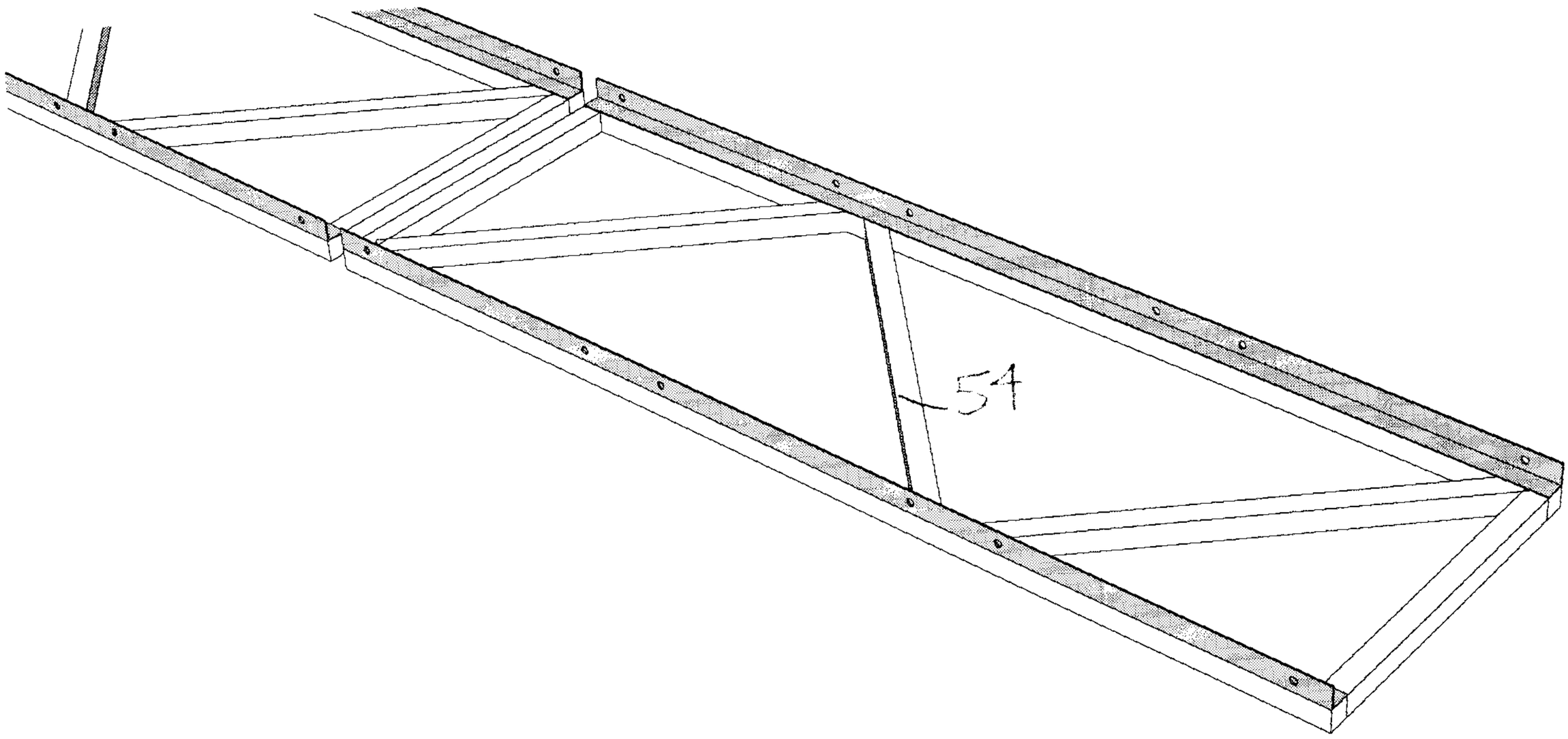



FIG 71

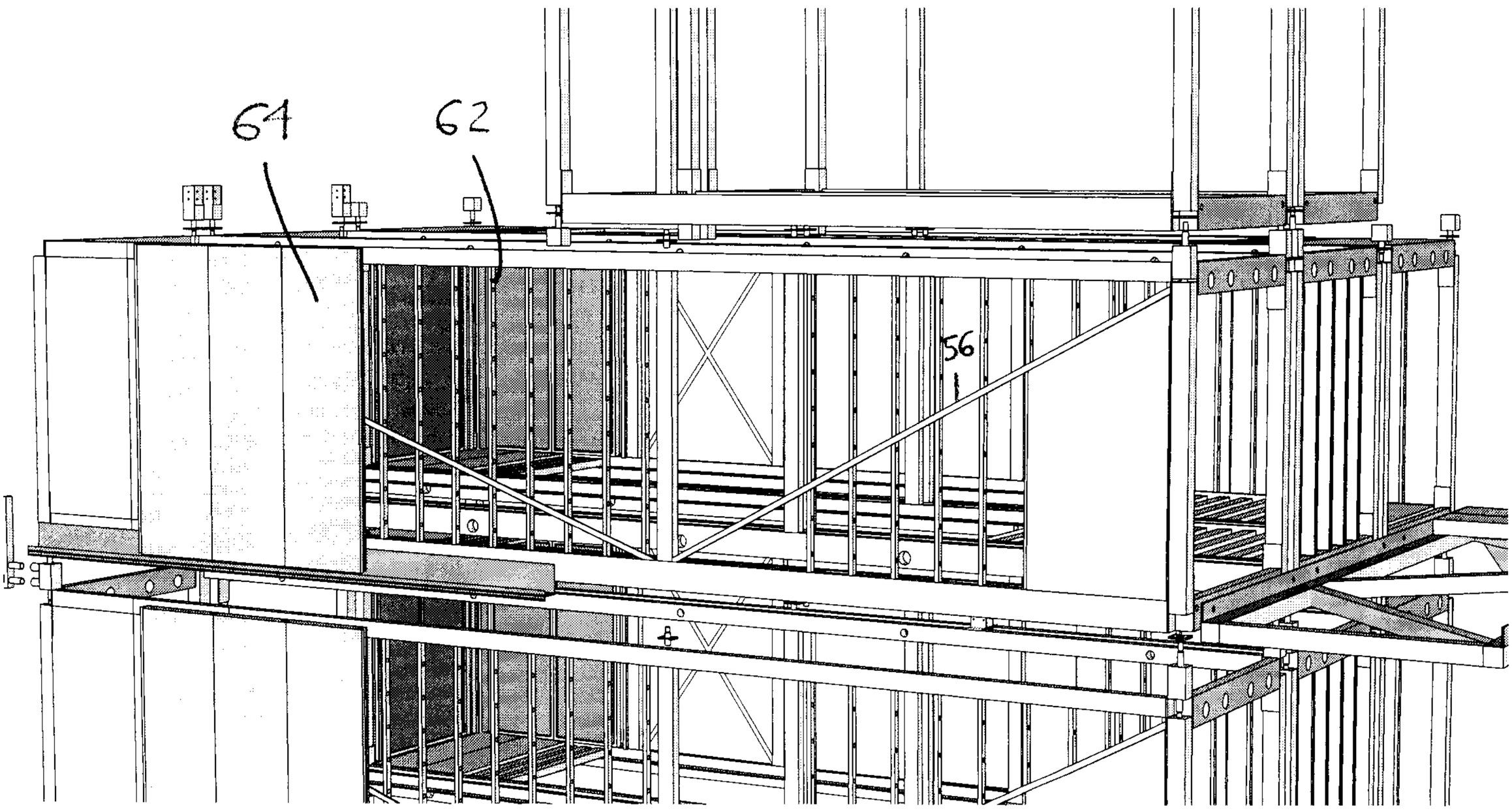



FIG 76

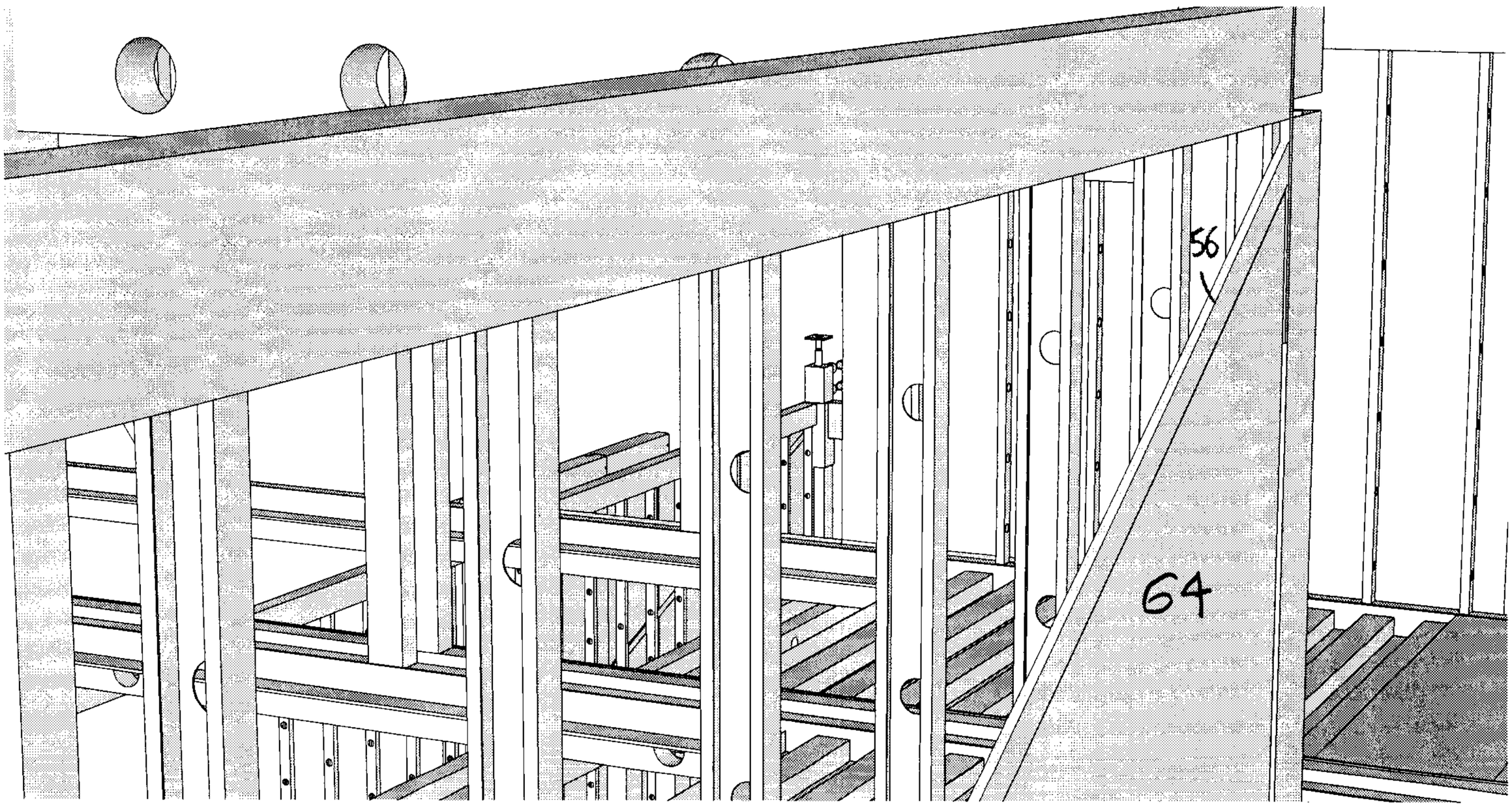



FIG. 77

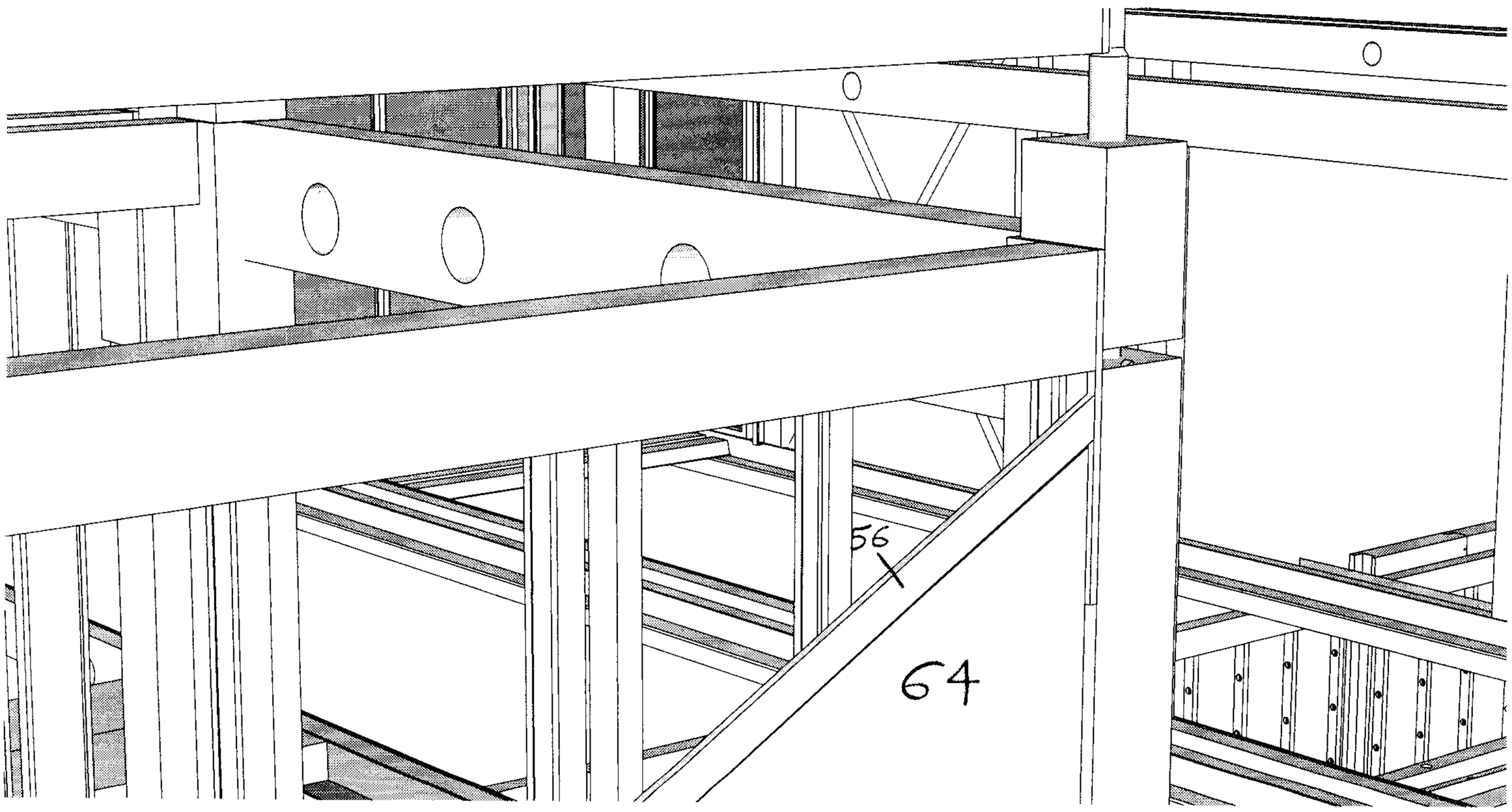



FIG 78

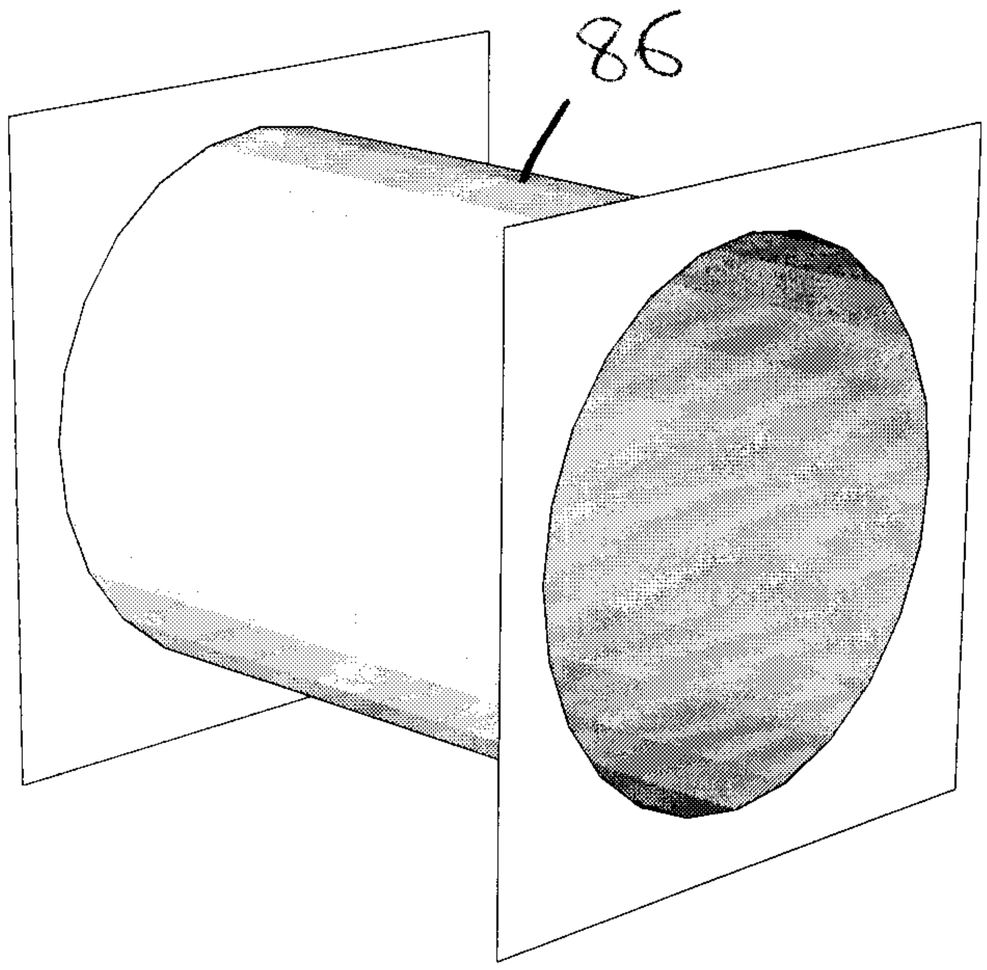



FIG 79

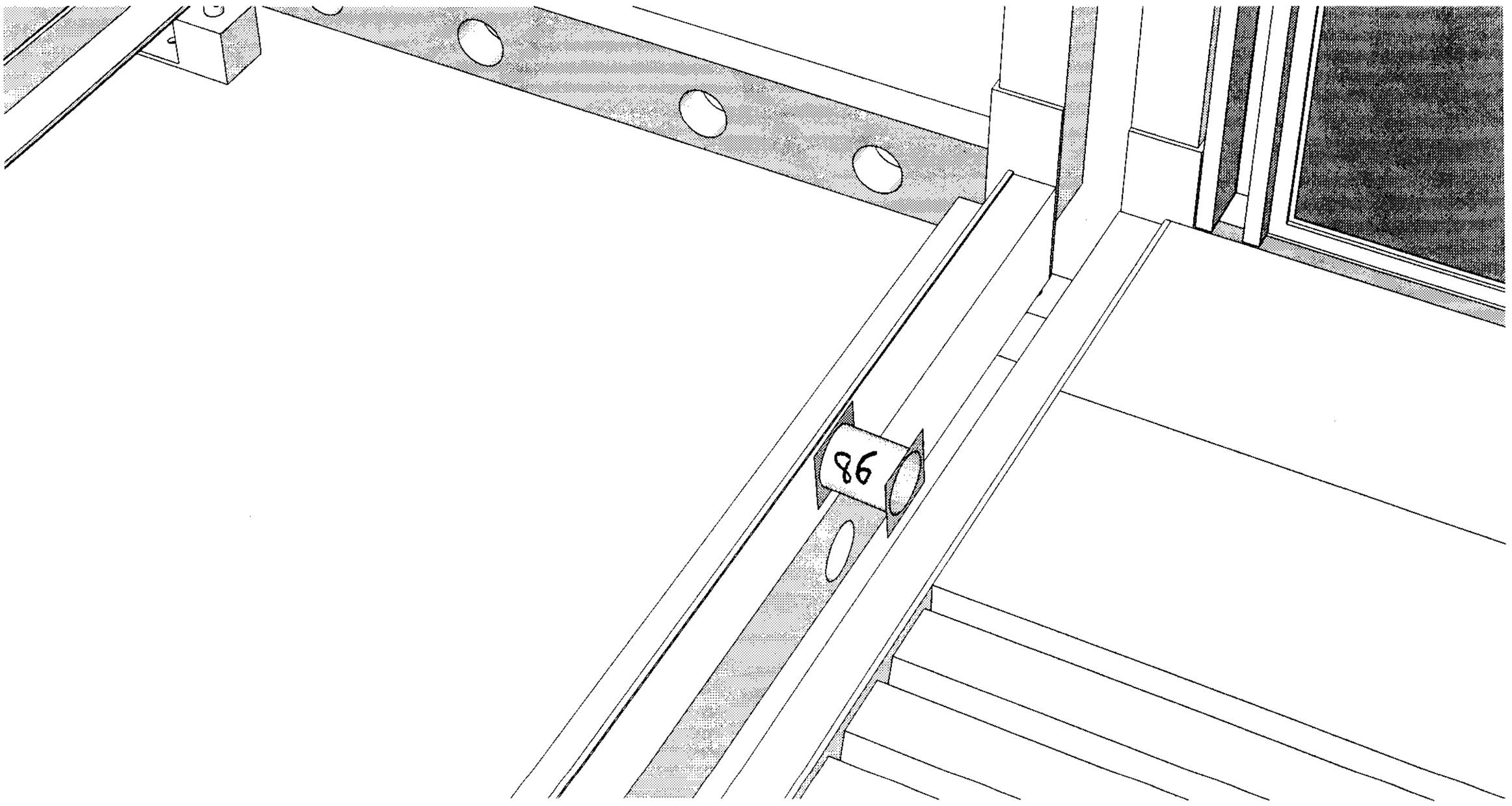



FIG. 80

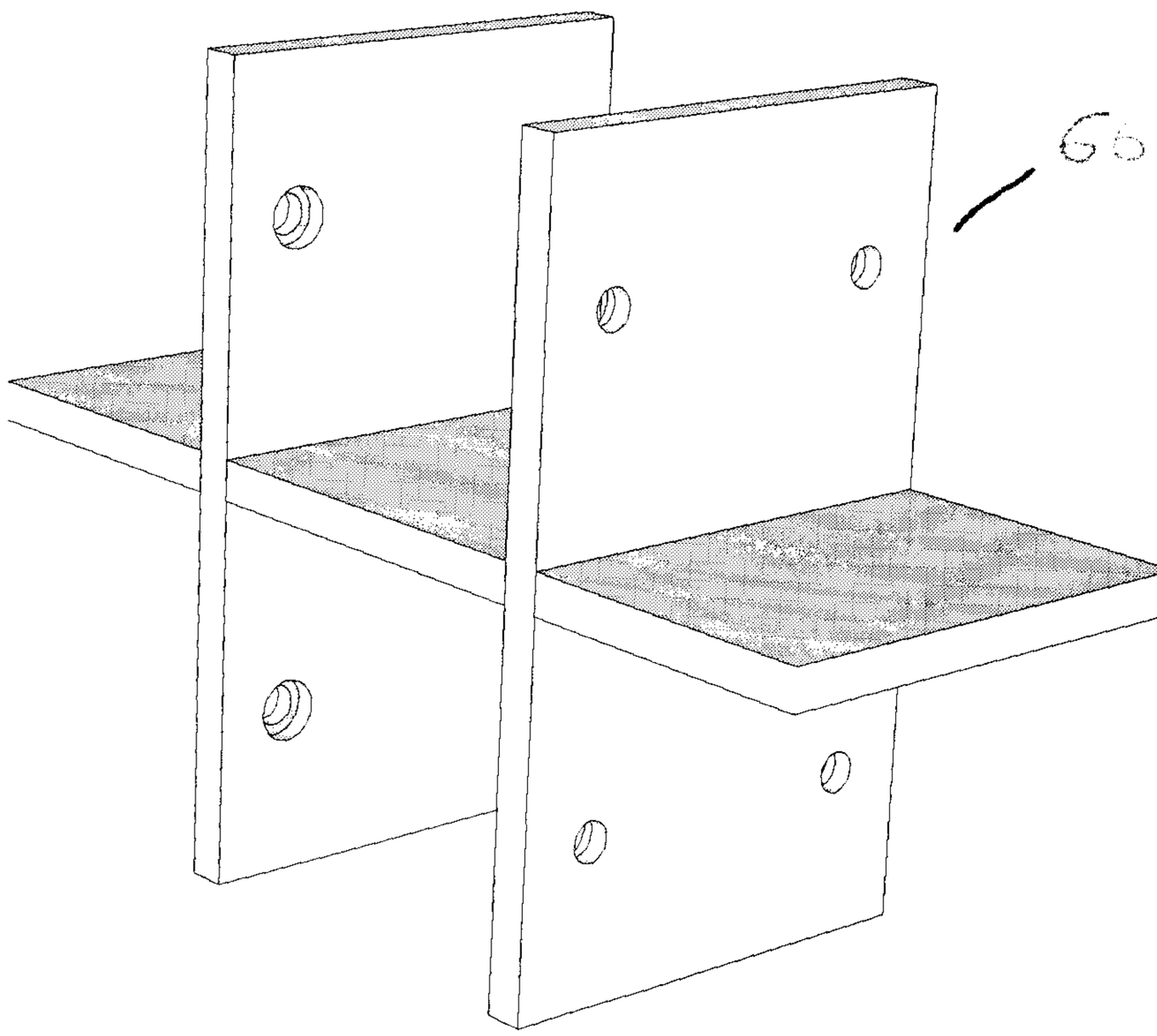



FIG 21

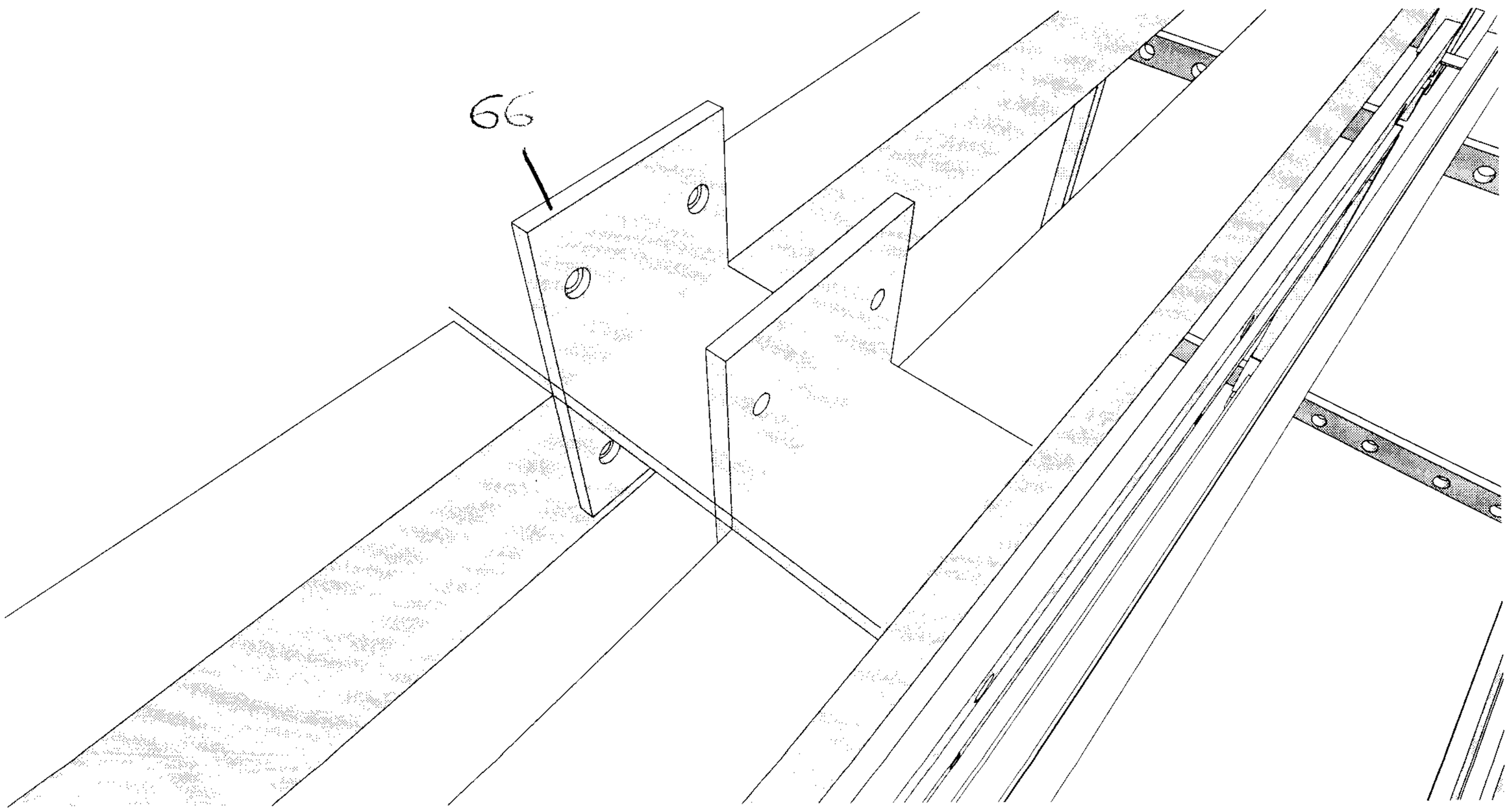



FIG. 8C

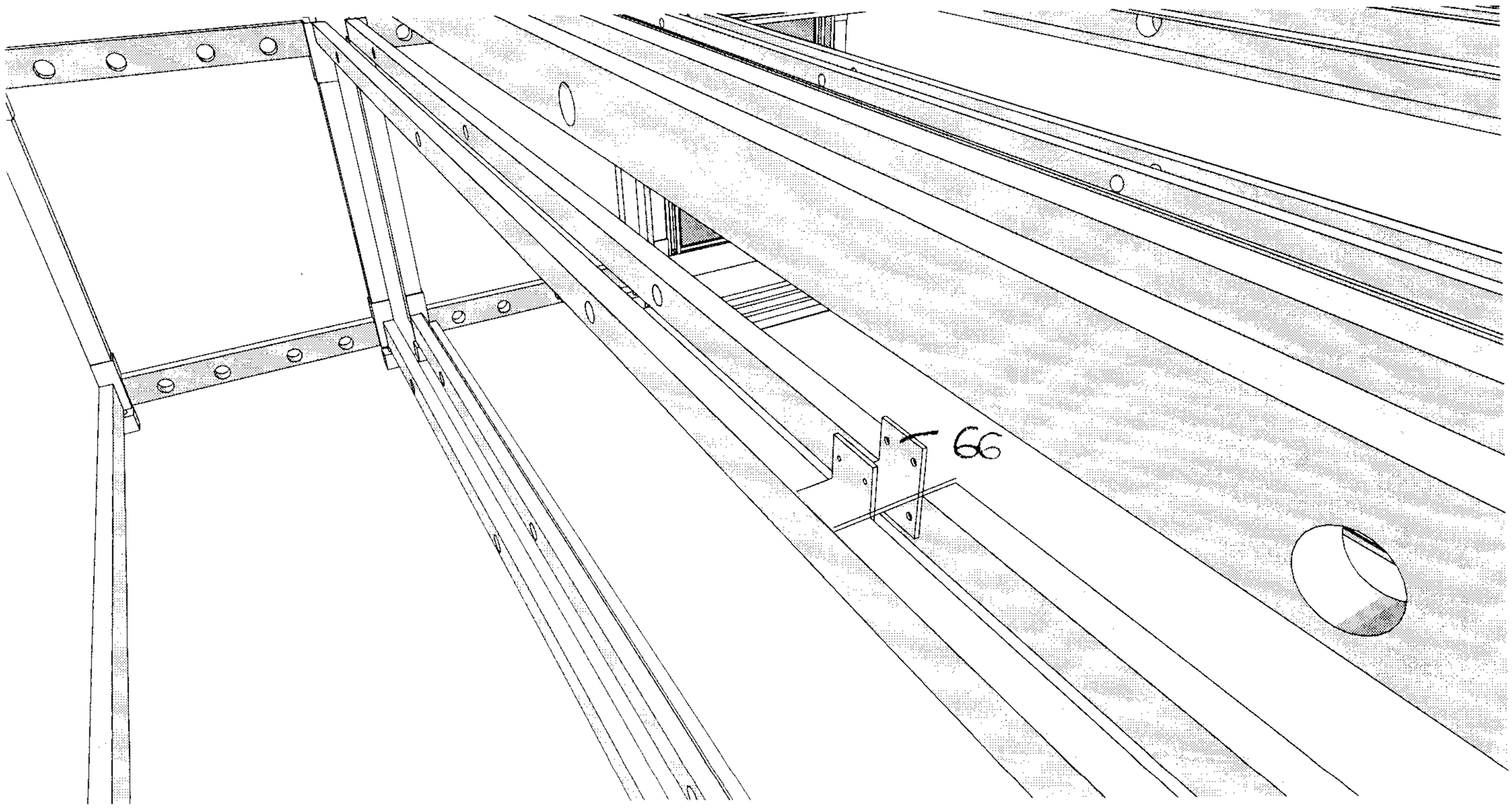



FIG 83

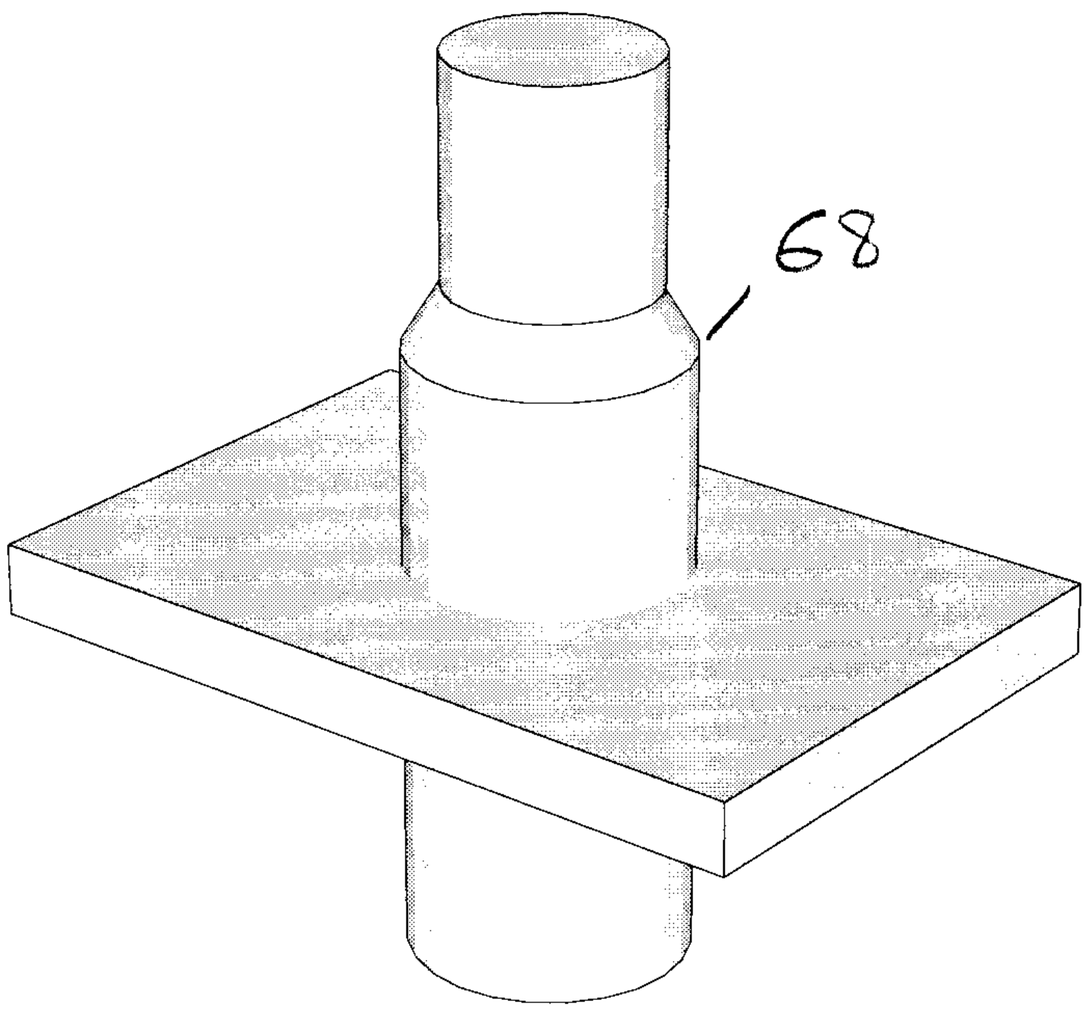



FIG 84

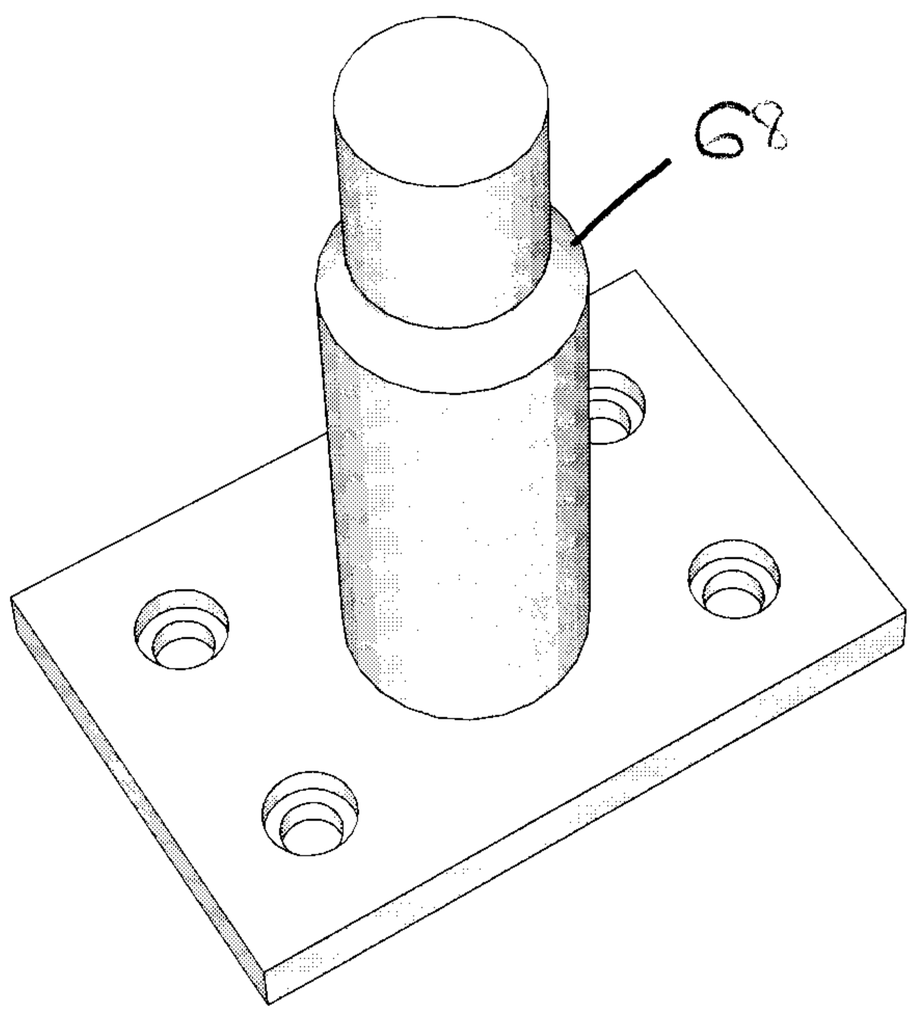



Fig 25

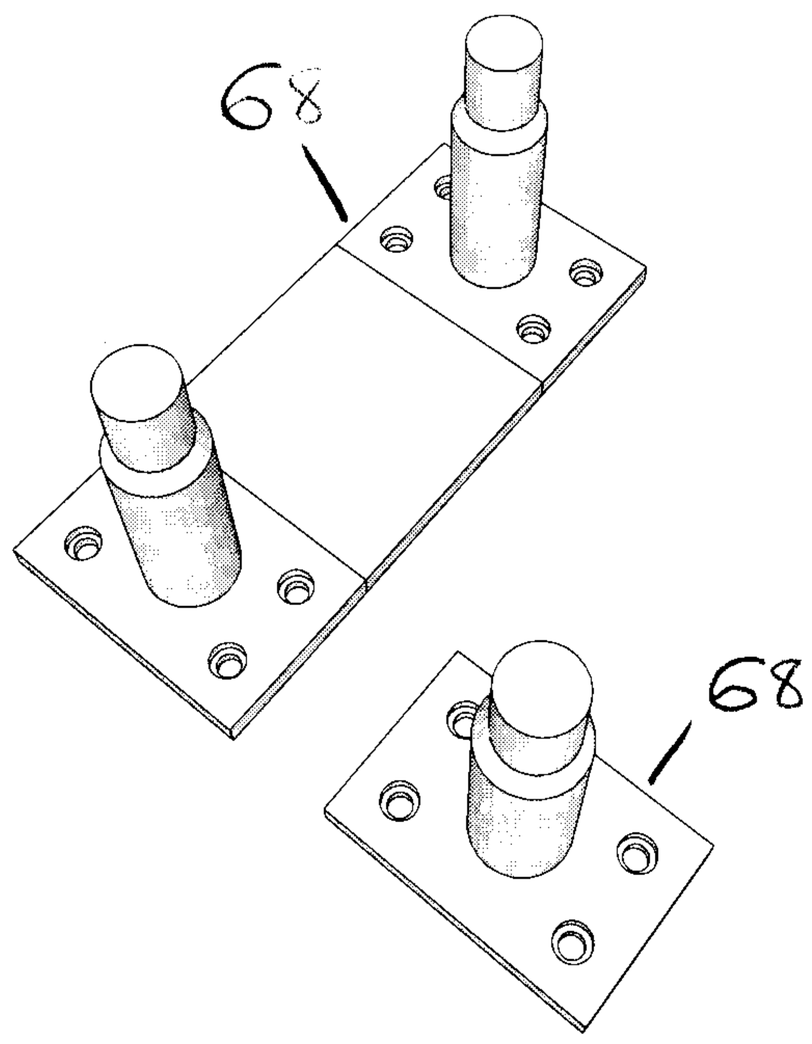



FIG. 86

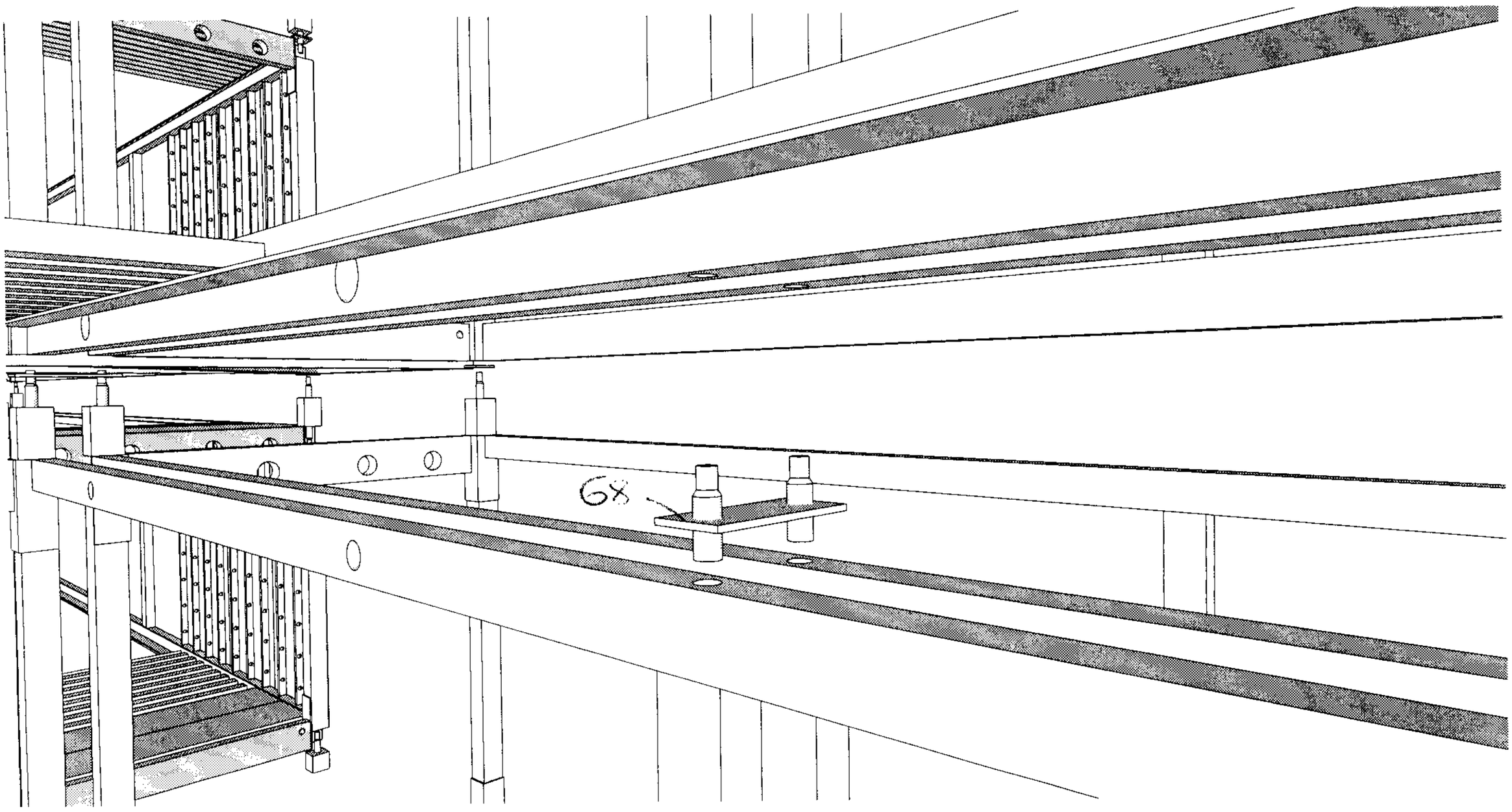



Fig. 87

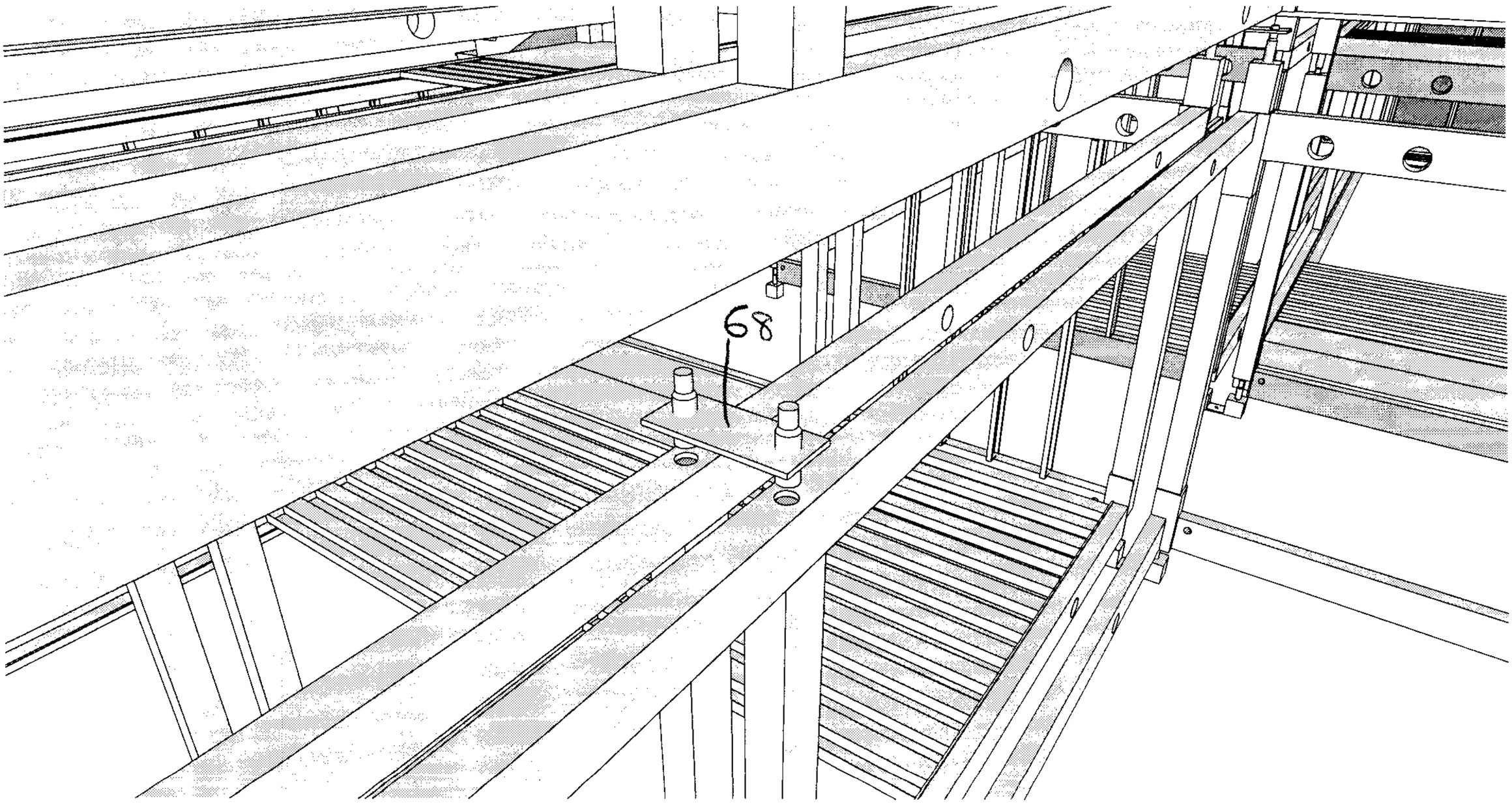



FIG 88

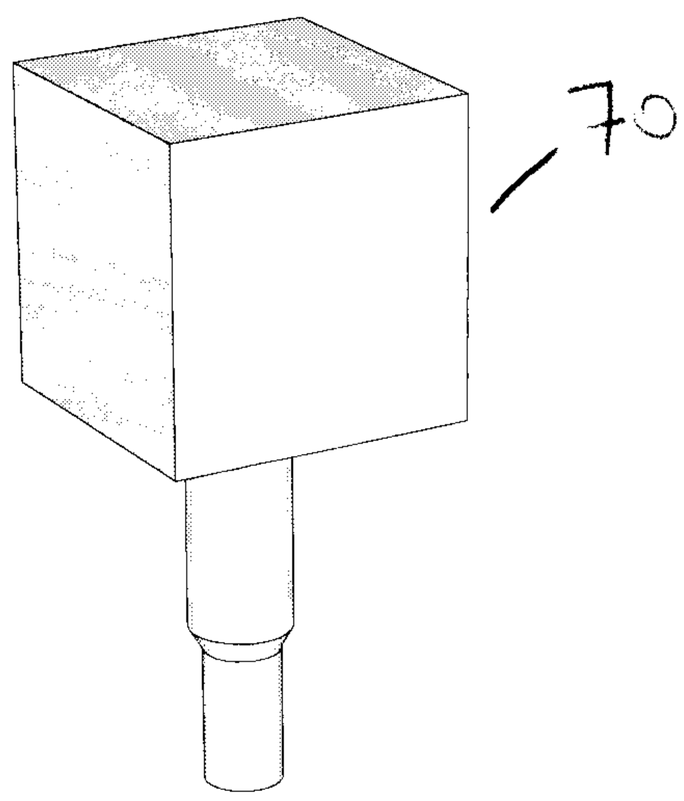



FIG. 89

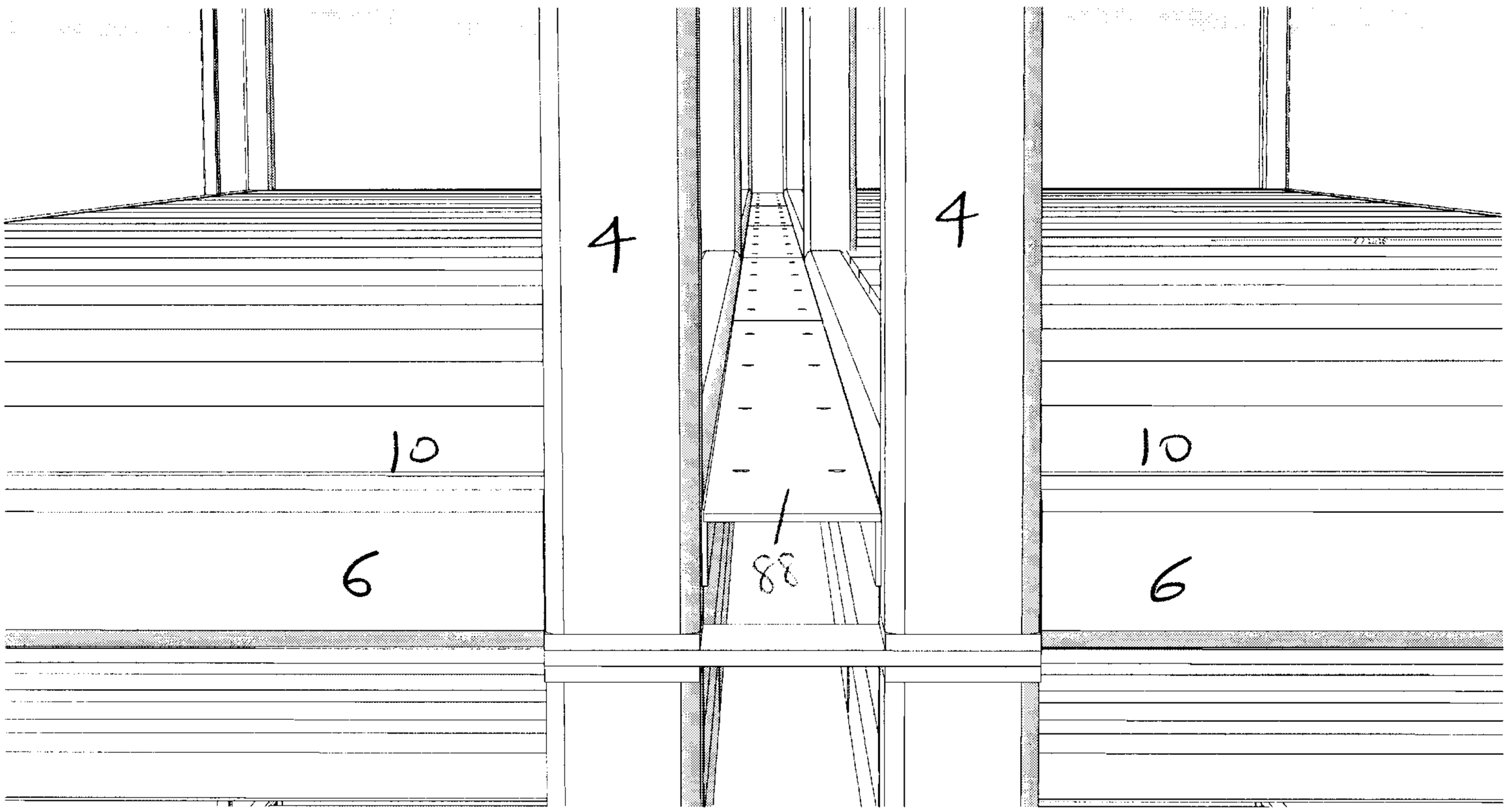



FIG 90

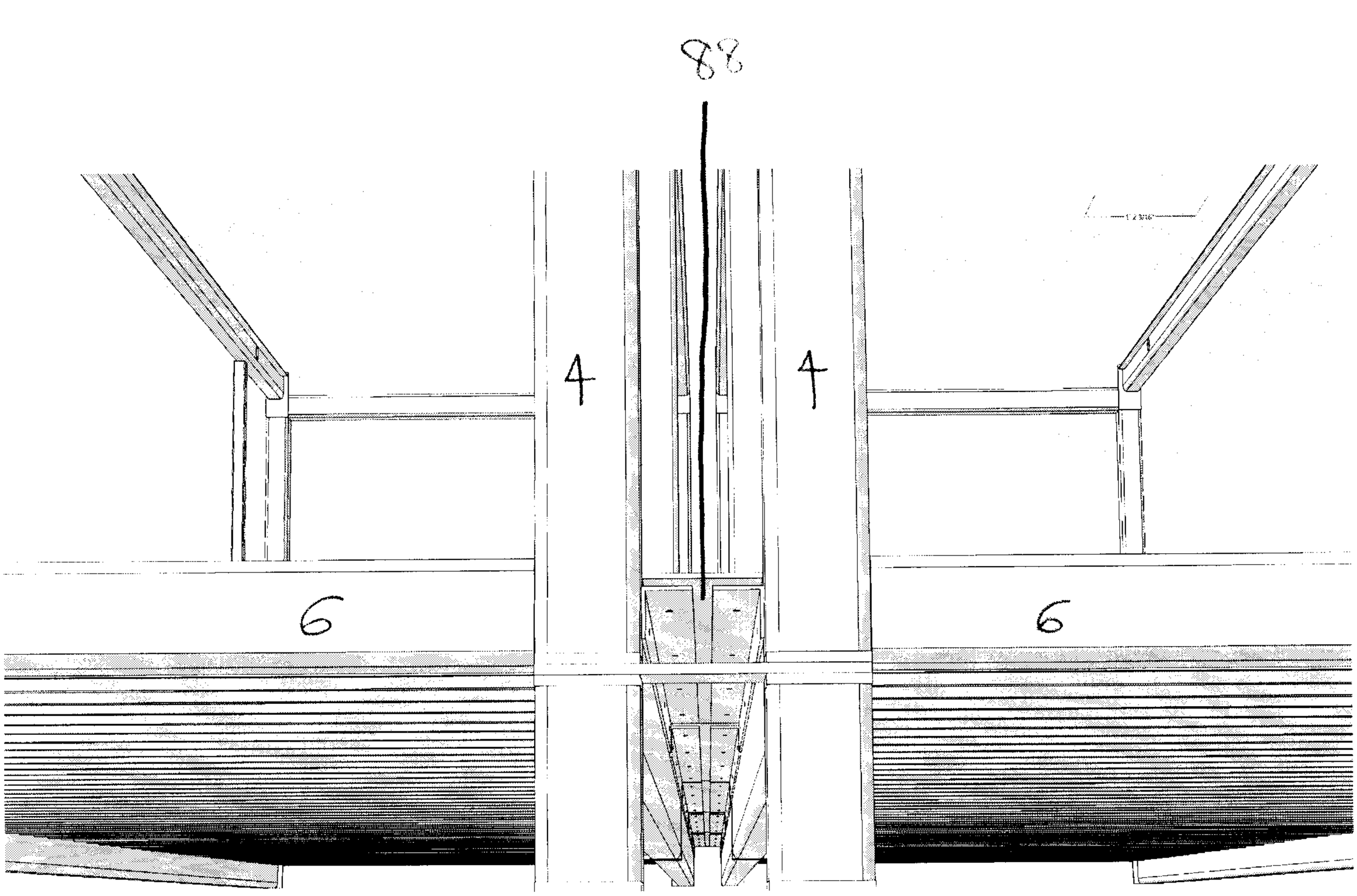



Fig. 91

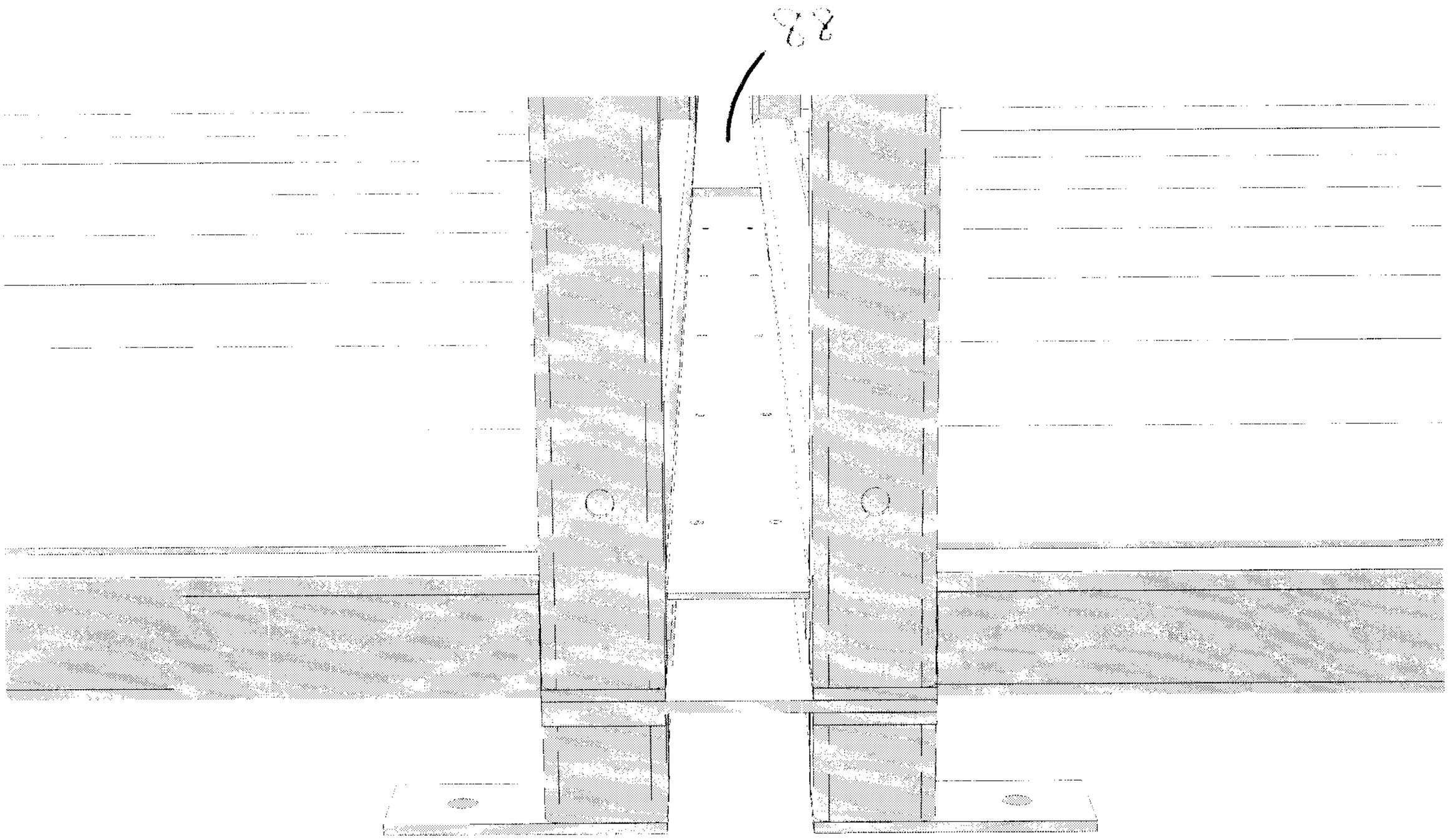



FIG 92

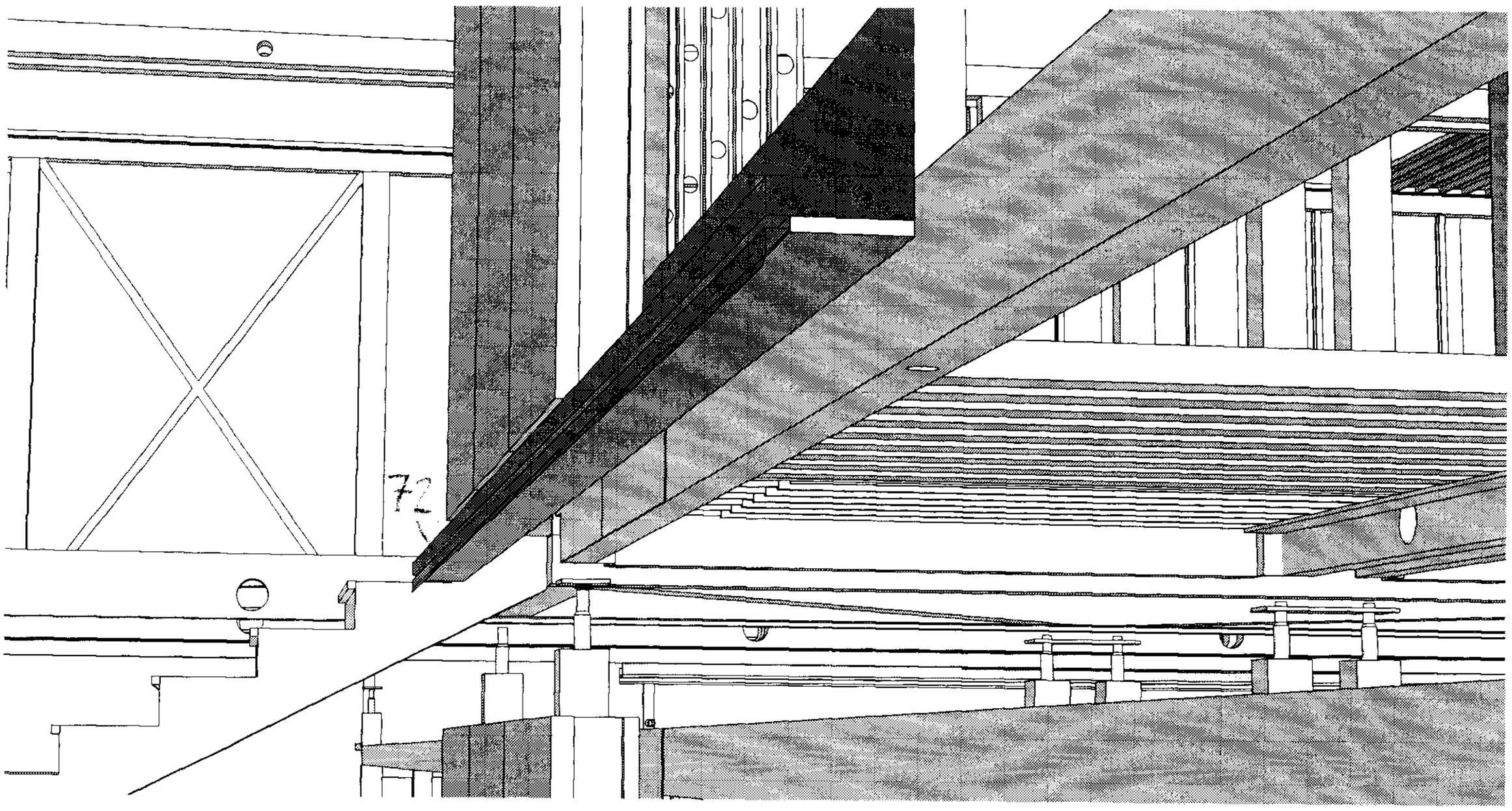



FIG 93

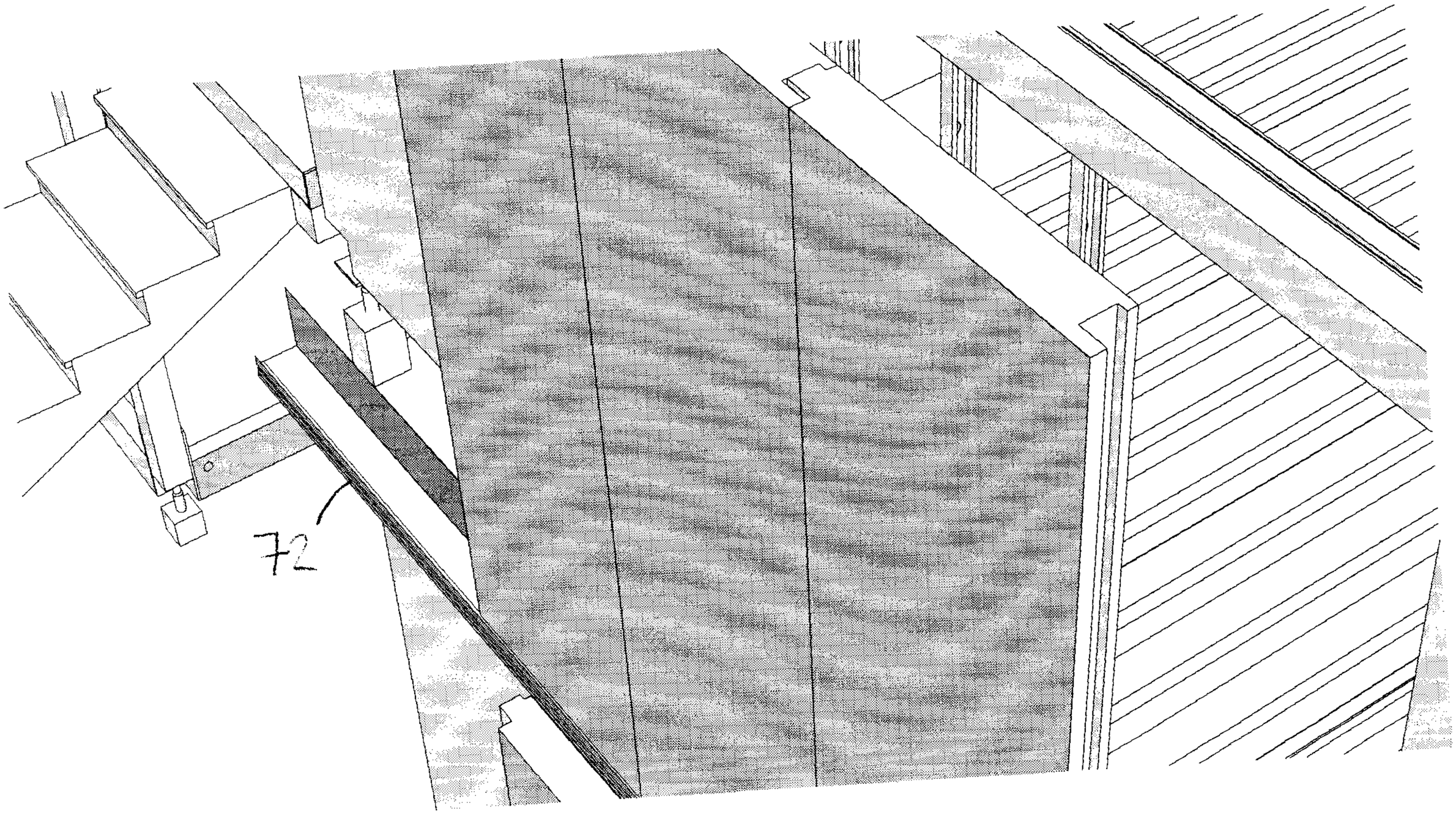



FIG. 14

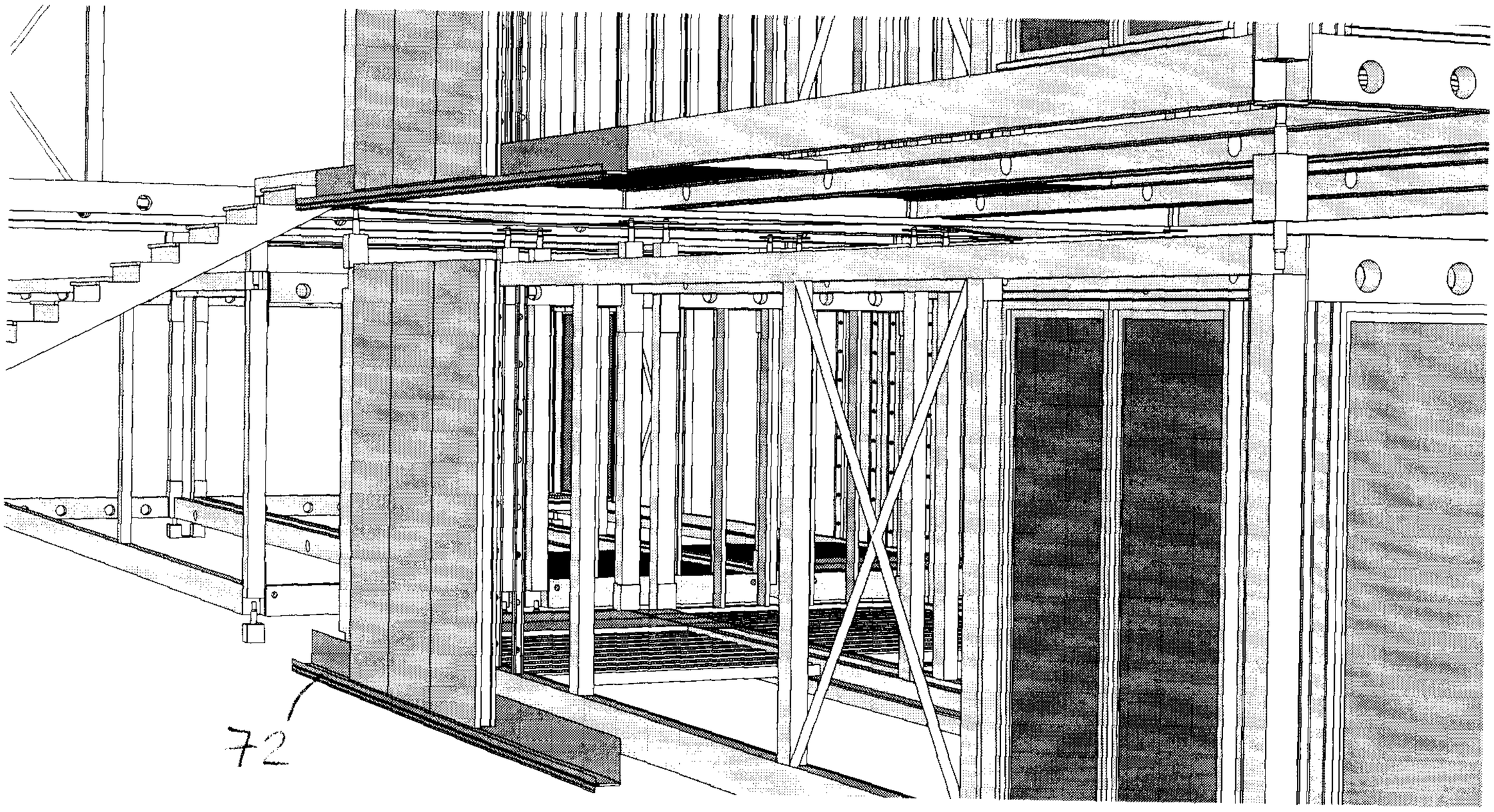



FIG. 95

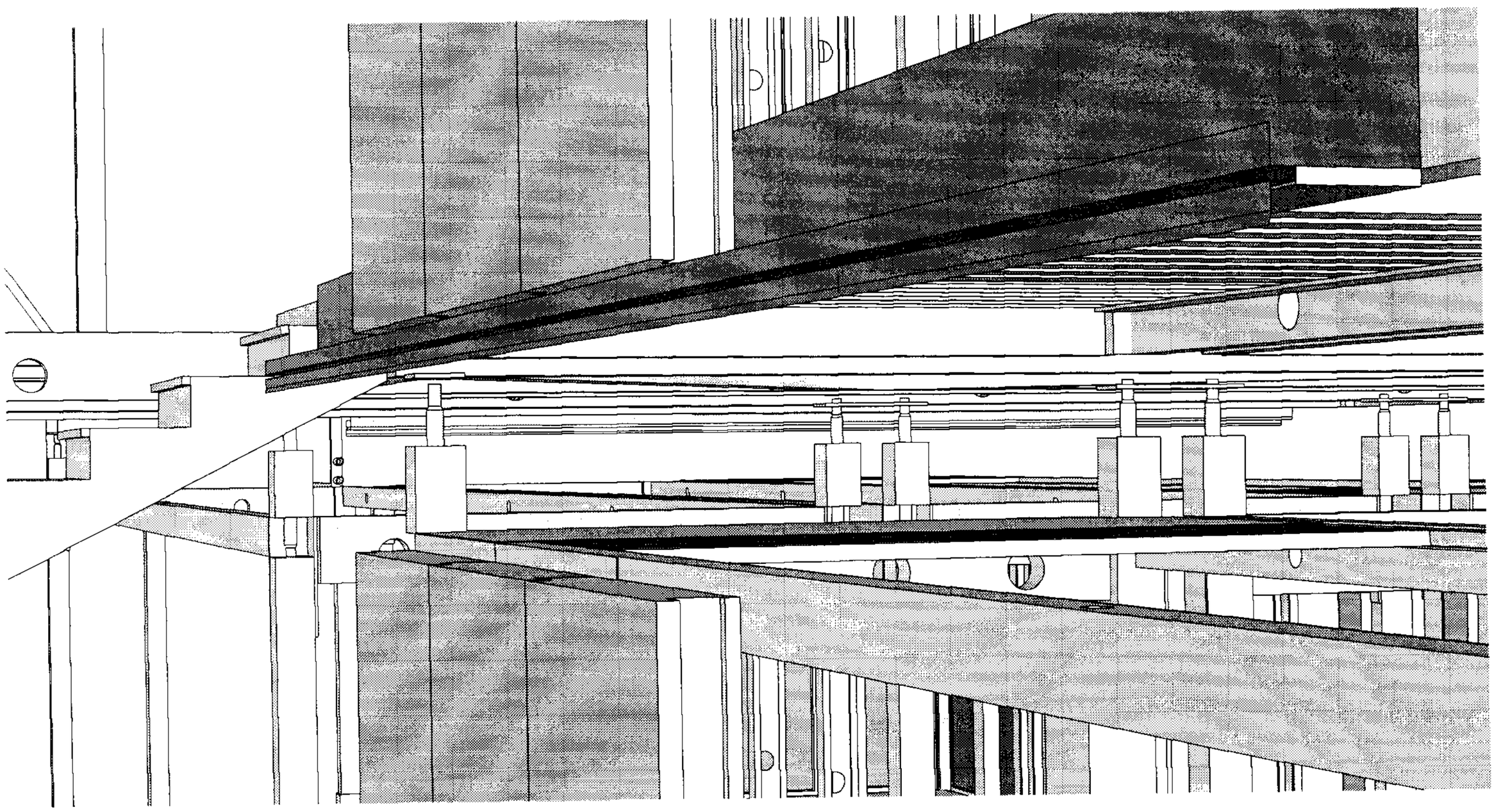


FIG. 96

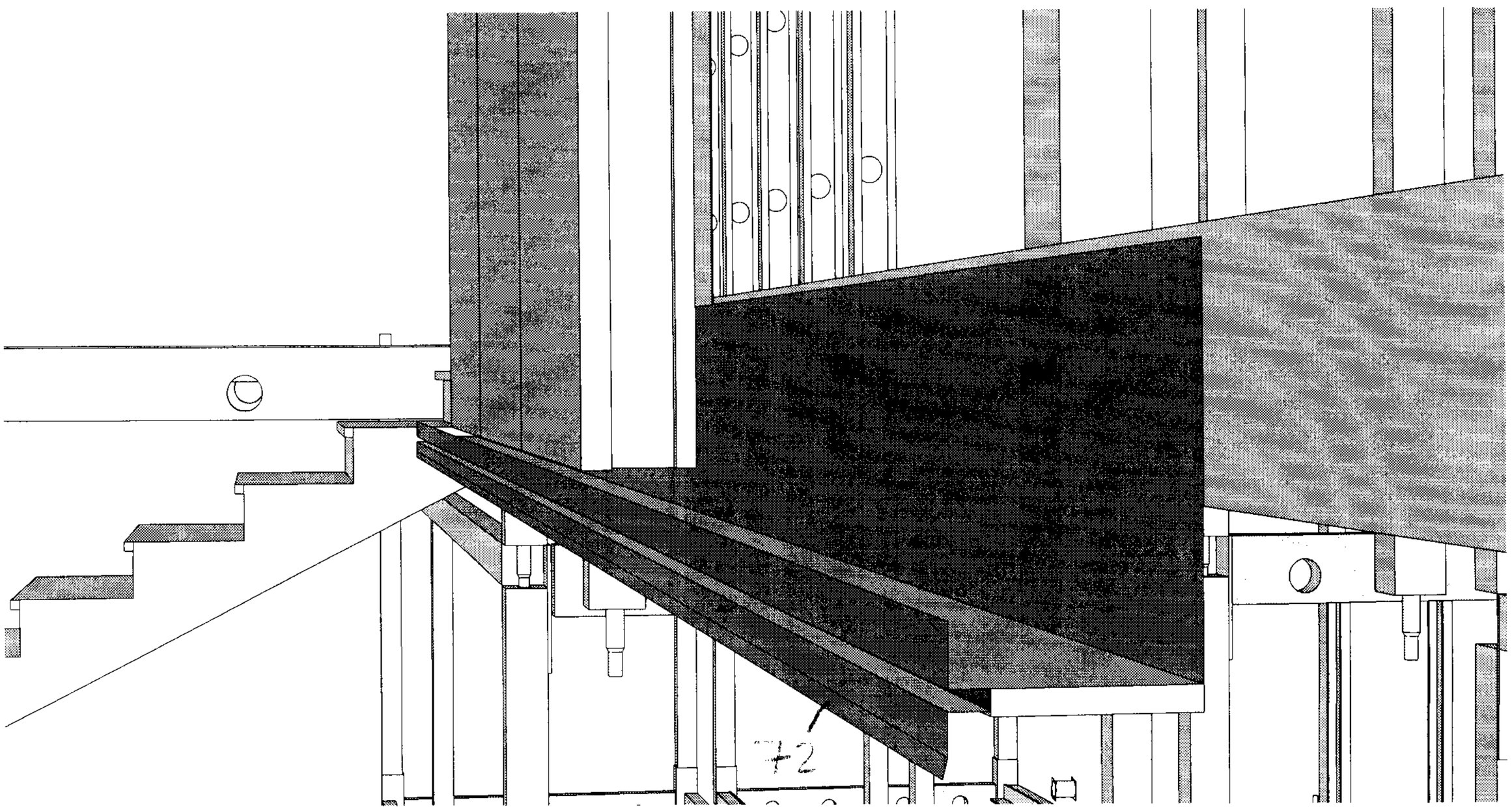



FIG. 97

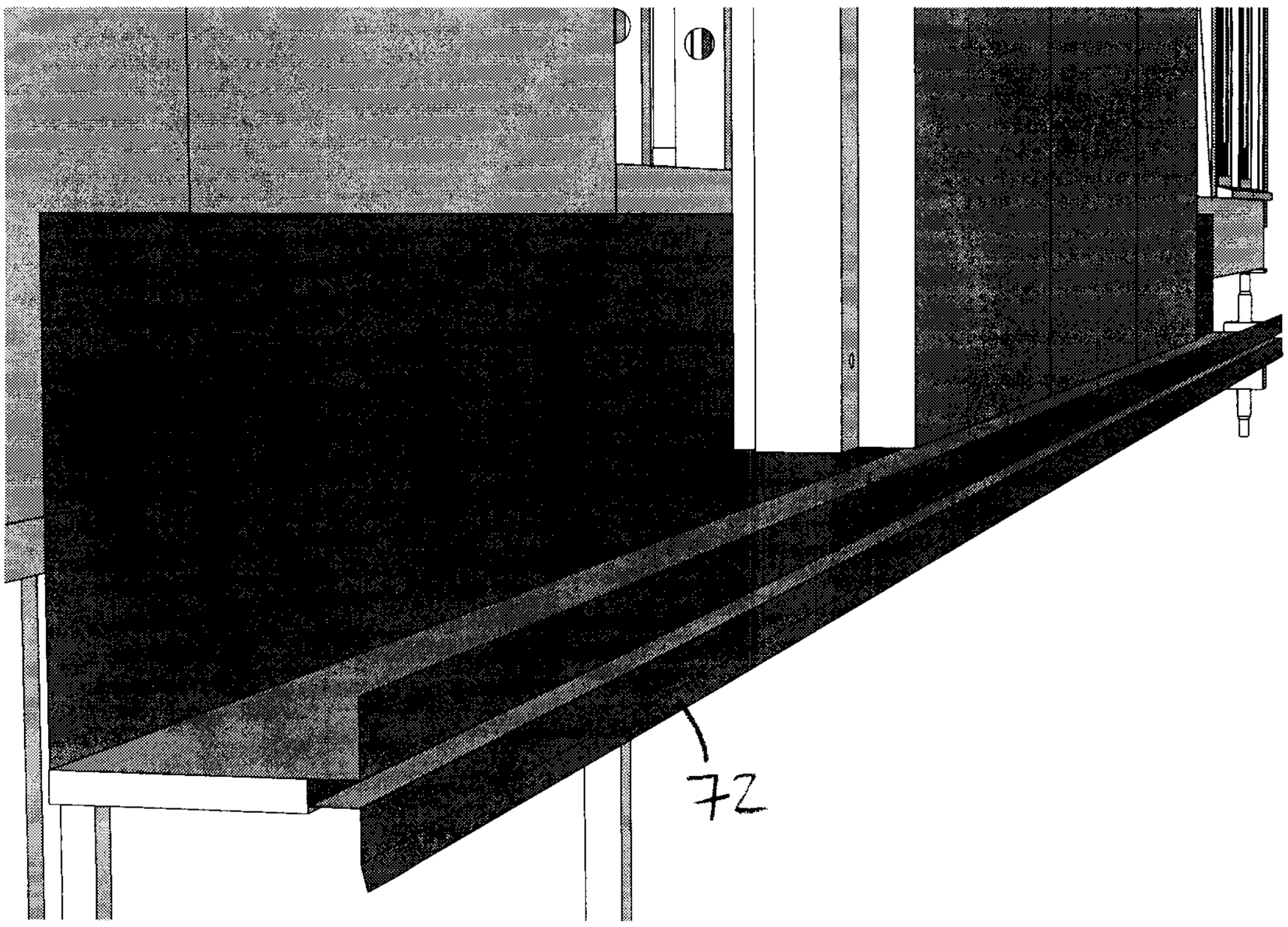



FIG 98

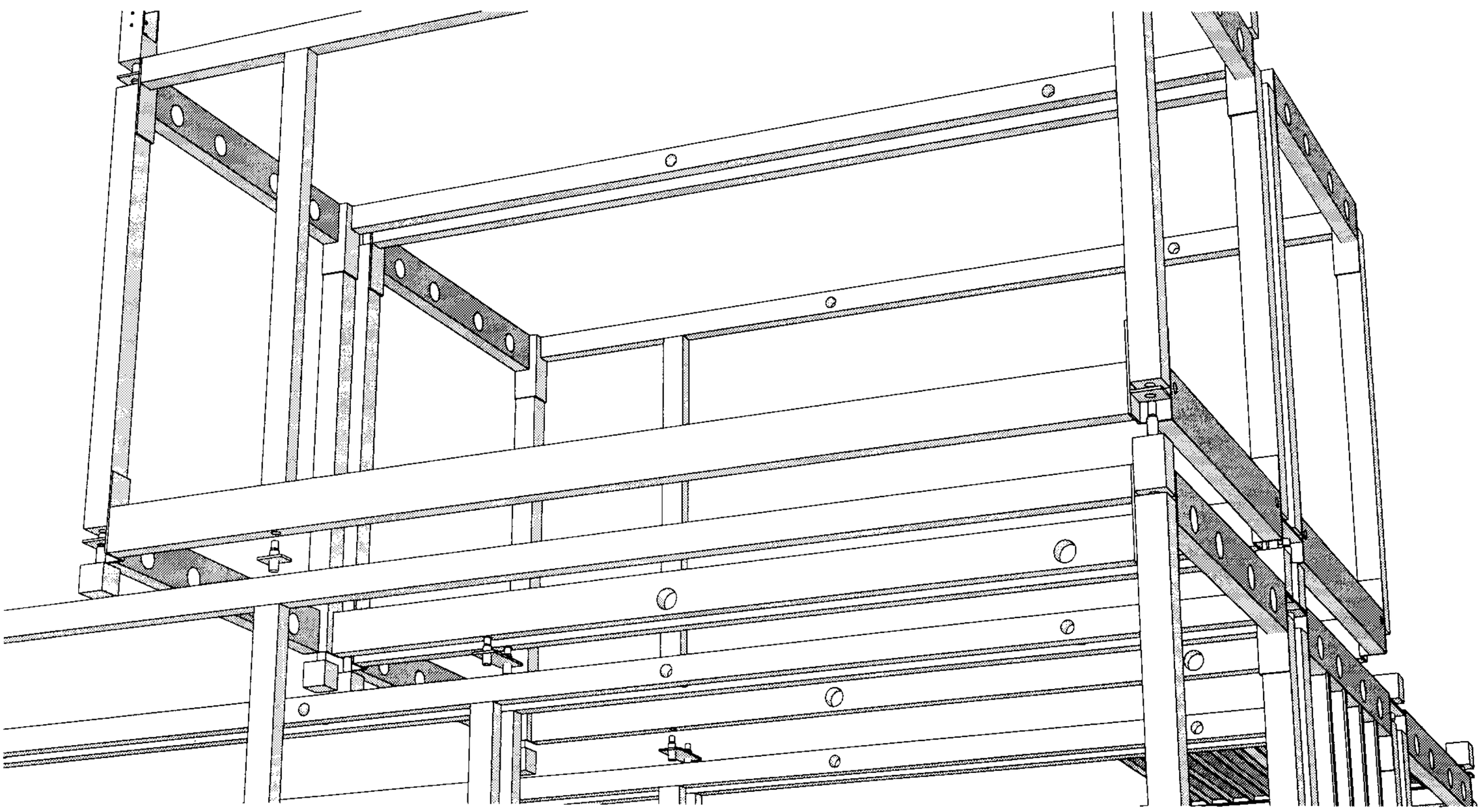


FIG.99

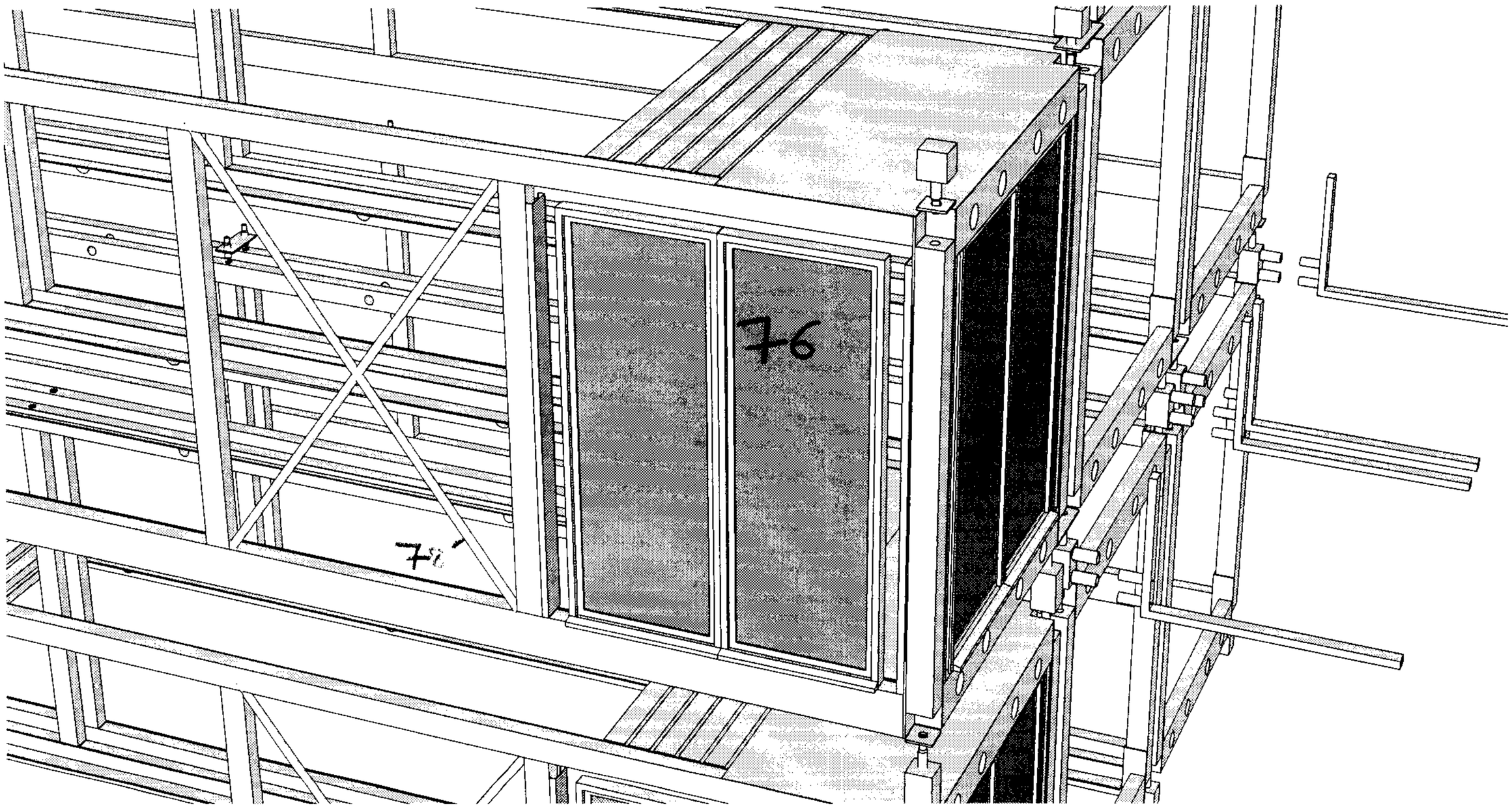



FIG 100

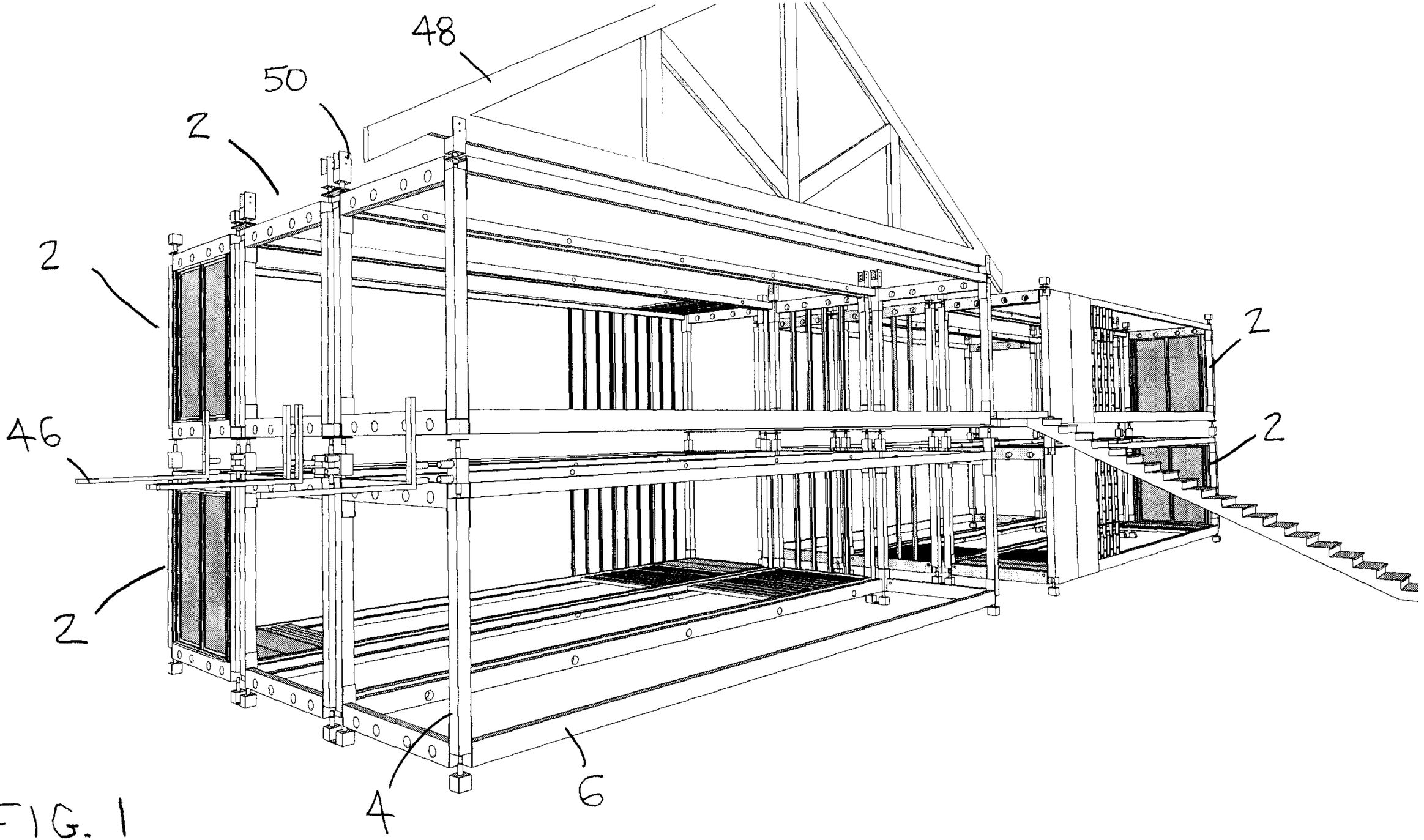



FIG. 1