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Ewing et al.

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(54) **METHOD OF MOUNTING A POWER DISTRIBUTION APPARATUS IN A RACK**

(75) Inventors: **Carrel W. Ewing**, Reno, NV (US); **Andrew J. Cleveland**, Reno, NV (US); **James P. Maskaly**, Sparks, NV (US); **Dennis W. McGlumphy**, Sun Valley, NV (US)

(73) Assignee: **Server Technology, Inc.**, Reno, NV (US)

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Related U.S. Application Data

(63) Continuation of application No. 11/715,521, filed on Mar. 7, 2007, now Pat. No. 7,312,980, which is a continuation of application No. 11/135,763, filed on May 23, 2005, now Pat. No. 7,196,900.

(60) Provisional application No. 60/624,287, filed on Nov. 1, 2004, provisional application No. 60/573,405, filed on May 21, 2004.

(51) **Int. Cl.**
H02B 1/34 (2006.01)

(52) **U.S. Cl.** **361/622**; 361/610; 361/626; 361/641; 175/50; 307/39; 307/41; 307/112; 307/113; 312/223.2; 312/265.3; 211/26

(58) **Field of Classification Search** ..... 361/622–628, 361/642–648, 727–732, 833, 836, 600–602; 307/39, 112, 10.1, 150, 29, 38, 41, 115, 125, 307/126, 141, 141.4, 143, 34, 11, 18, 32, 307/43; 337/186, 189; 312/223.1, 223.2, 312/233.3, 265.1, 265.3, 265.5; 174/48, 174/49, 50, 70 C, 72 C, 95, 72 R, 480, 481, 174/650; 248/200, 508, 510; 211/182, 189, 211/26, 162
See application file for complete search history.

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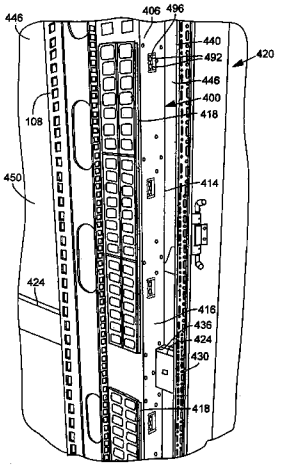
Primary Examiner—Michael V Datskovskiy
(74) *Attorney, Agent, or Firm*—Holland & Hart LLP

(57) **ABSTRACT**

Embodiments of a power distribution apparatus that is adaptable to be readily mounted within a variety of differing types of electronic equipment racks are herein described. One such embodiment provides power distribution apparatus having an upper mounting adapter. The upper mounting adapter may be attachable to a housing of the power distribution apparatus or may be integrally formed therein. Another embodiment provides power distribution apparatus having a lower mounting adapter. The lower mounting adapter may be attachable to the housing of the power distribution apparatus or may be integrally formed in the housing. A further embodiment provides power distribution apparatus having at least one mounting peg mounting in mating holes formed in a rack. The mounting pegs may be attachable to a housing of the power distribution apparatus or may be integrally formed therein. Other embodiments provide power distribution apparatus having rack mounting channels or access openings formed in at least one of a plurality of sides.

6 Claims, 15 Drawing Sheets



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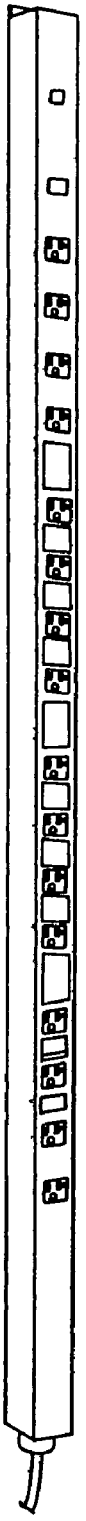

FIG. 1
(Prior Art)

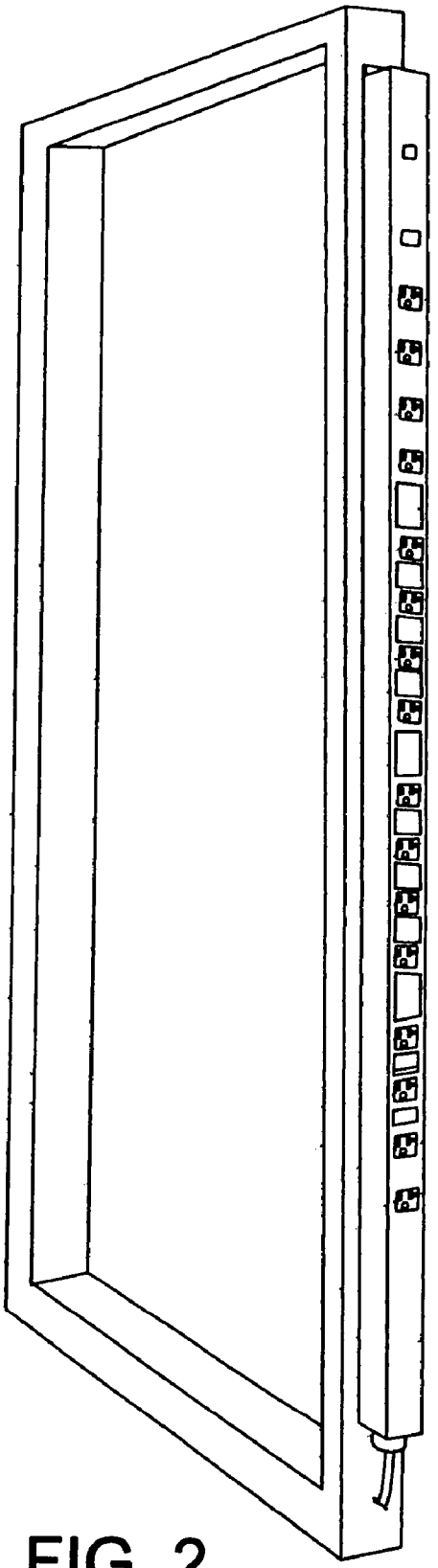

FIG. 2
(Prior Art)

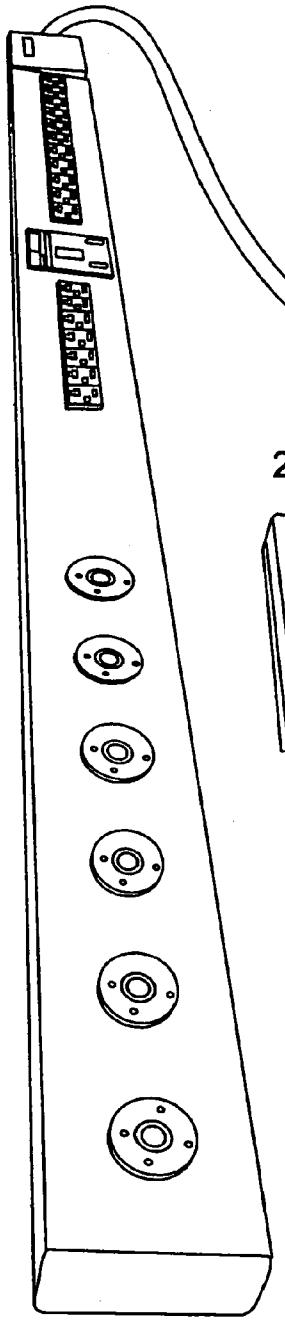

FIG. 3
(Prior Art)

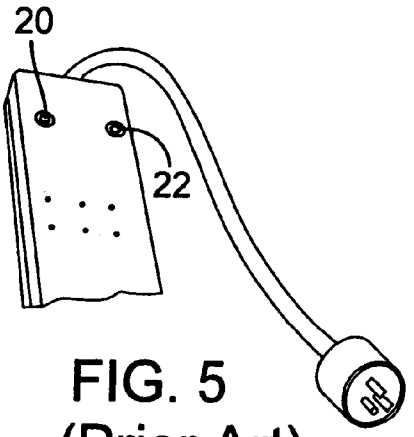

FIG. 5
(Prior Art)

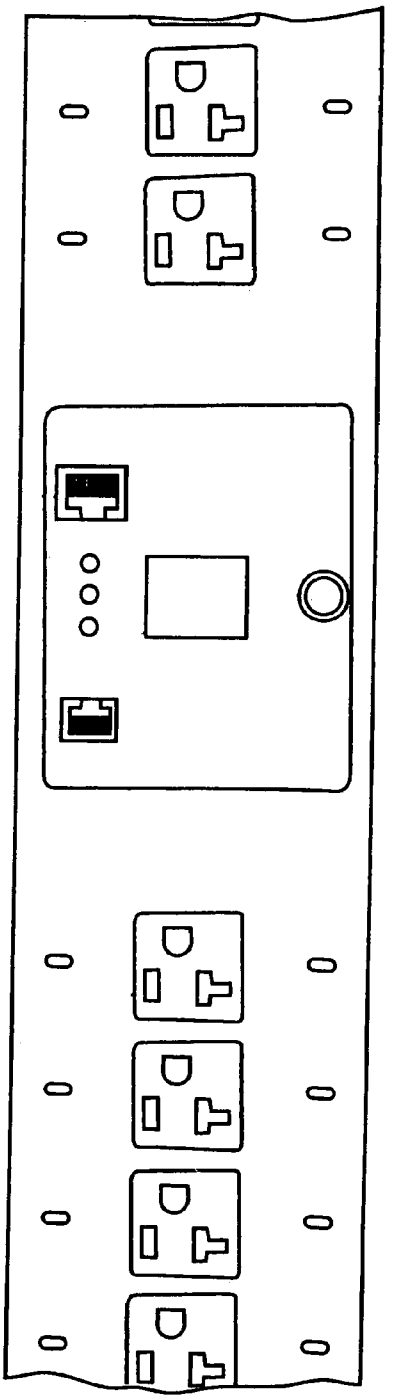

FIG. 4 (Prior Art)

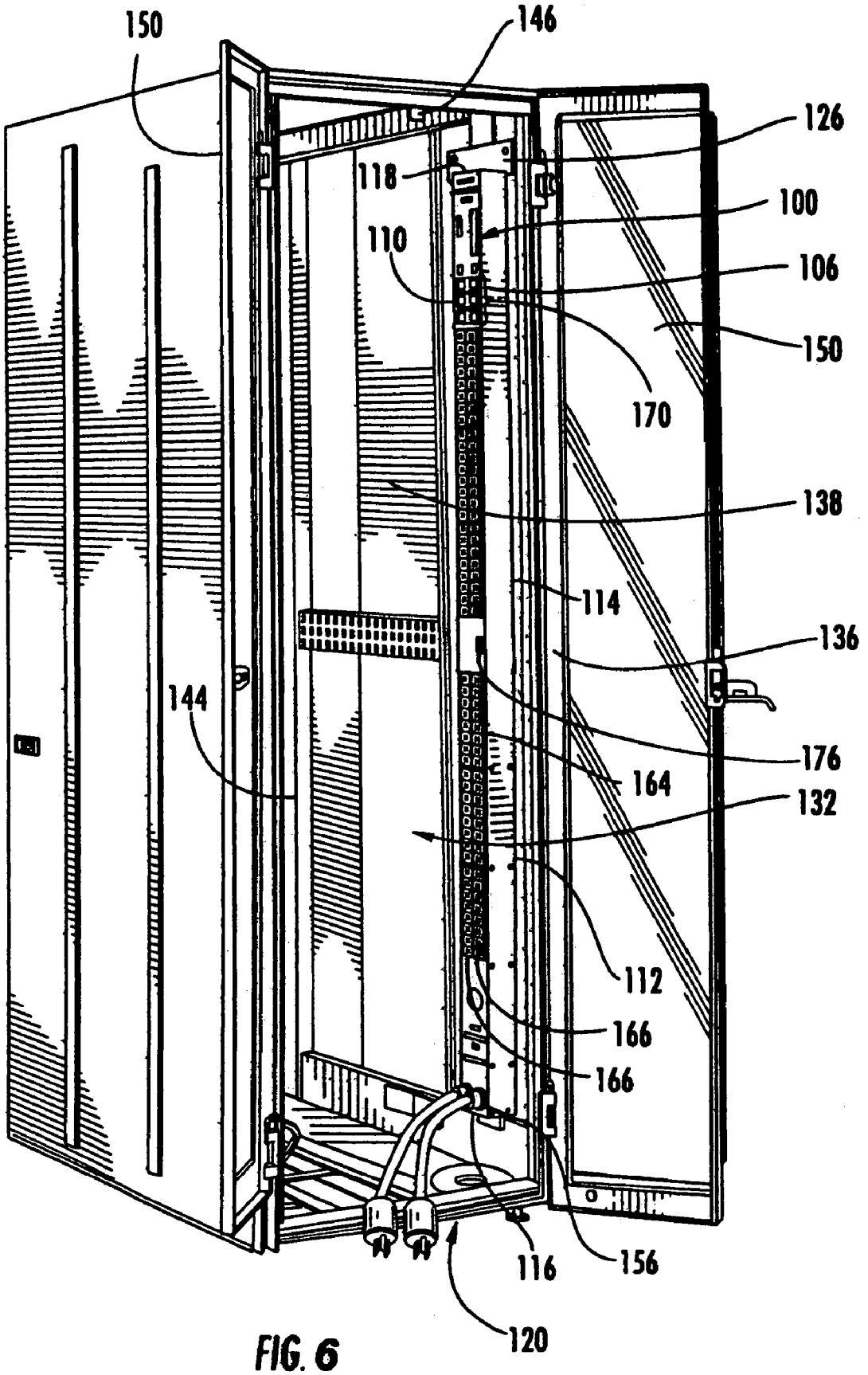
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FIG. 6

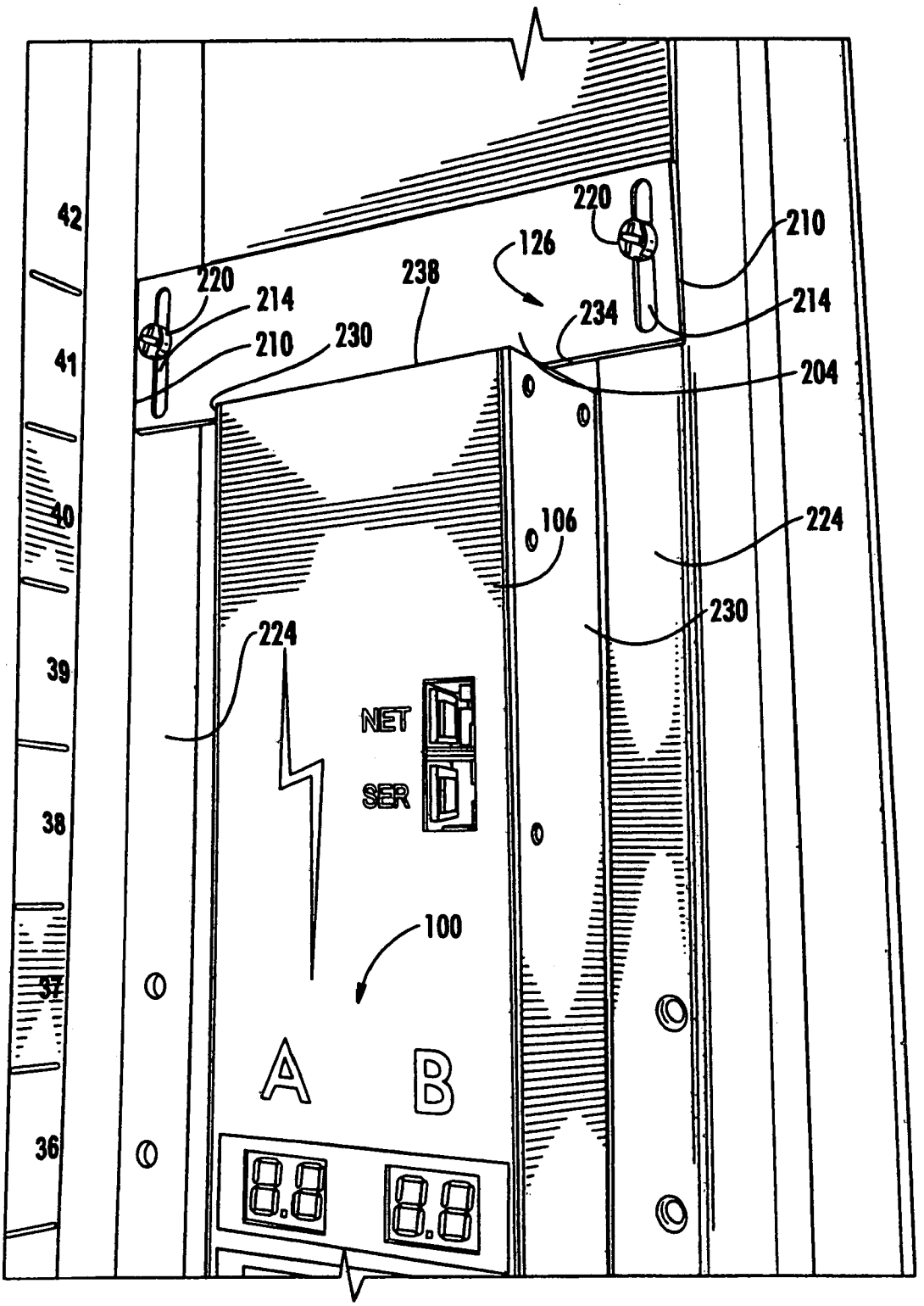
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FIG. 7

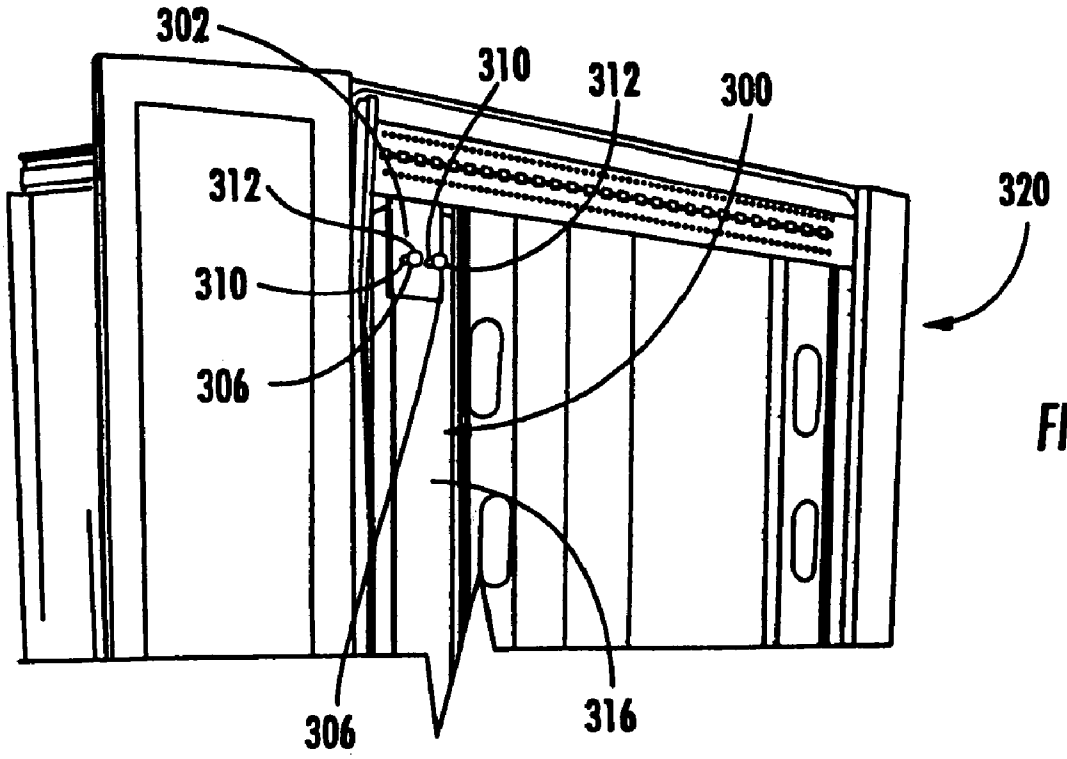

FIG. 8

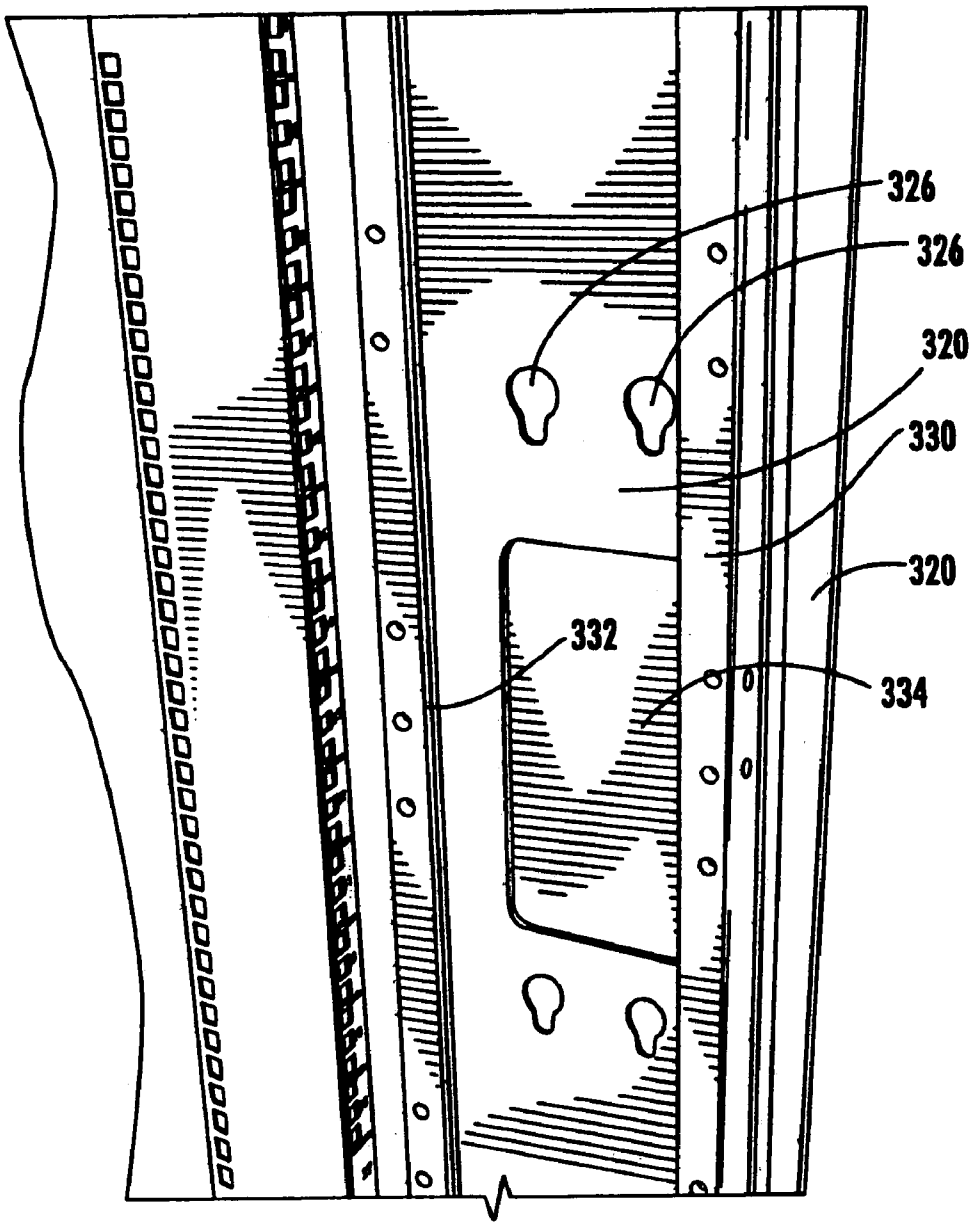

FIG. 9

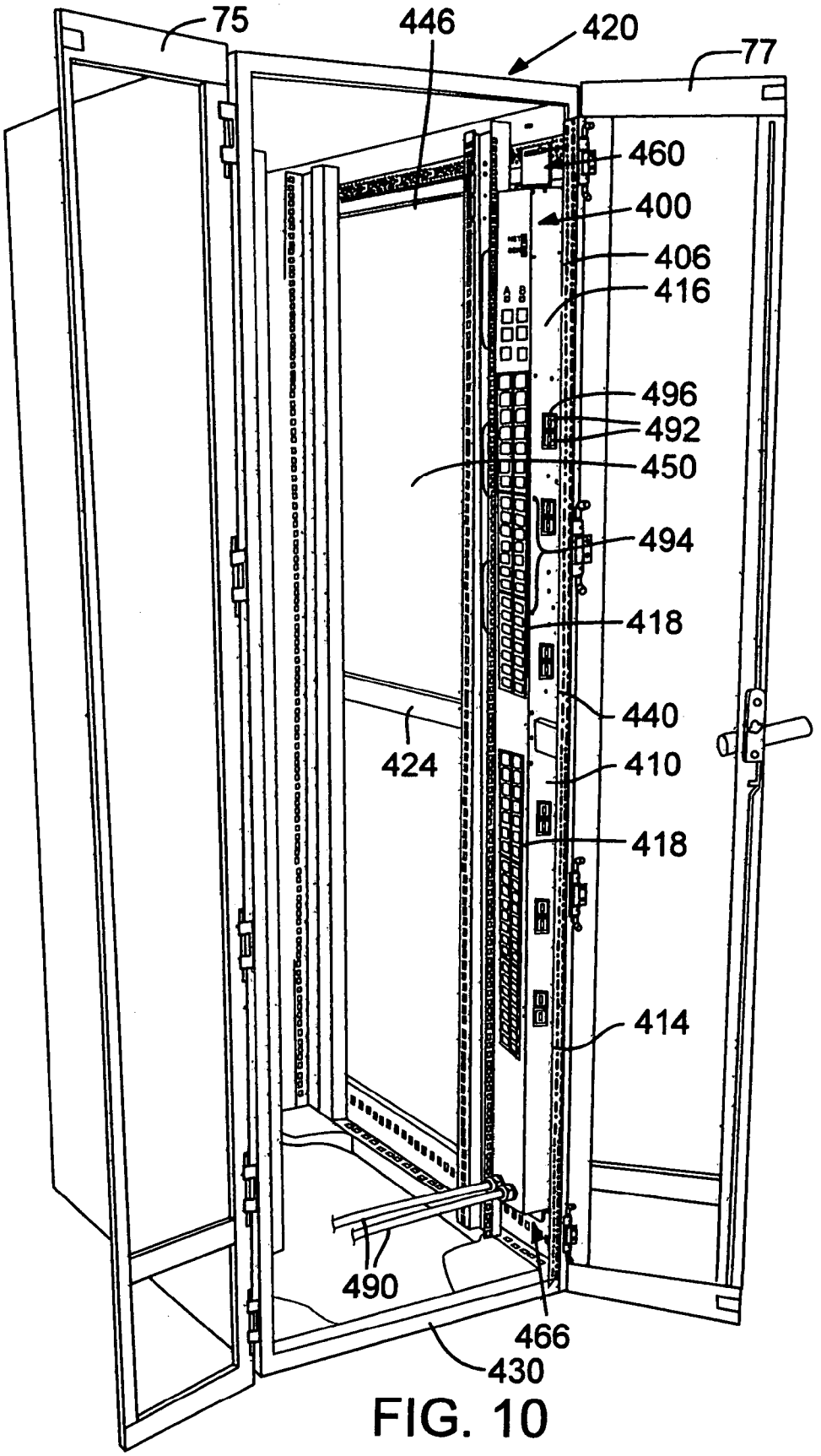
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FIG. 10

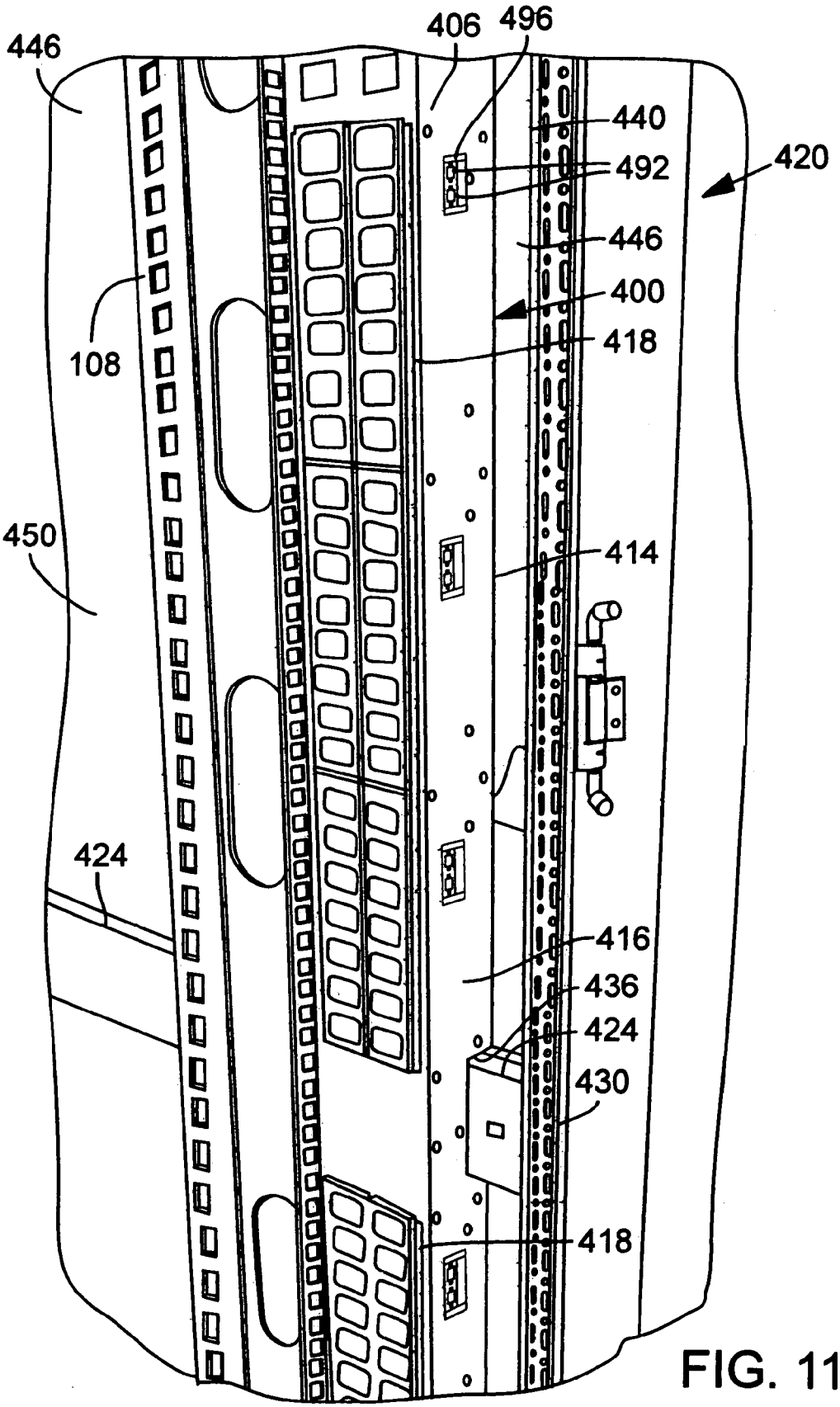
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FIG. 11

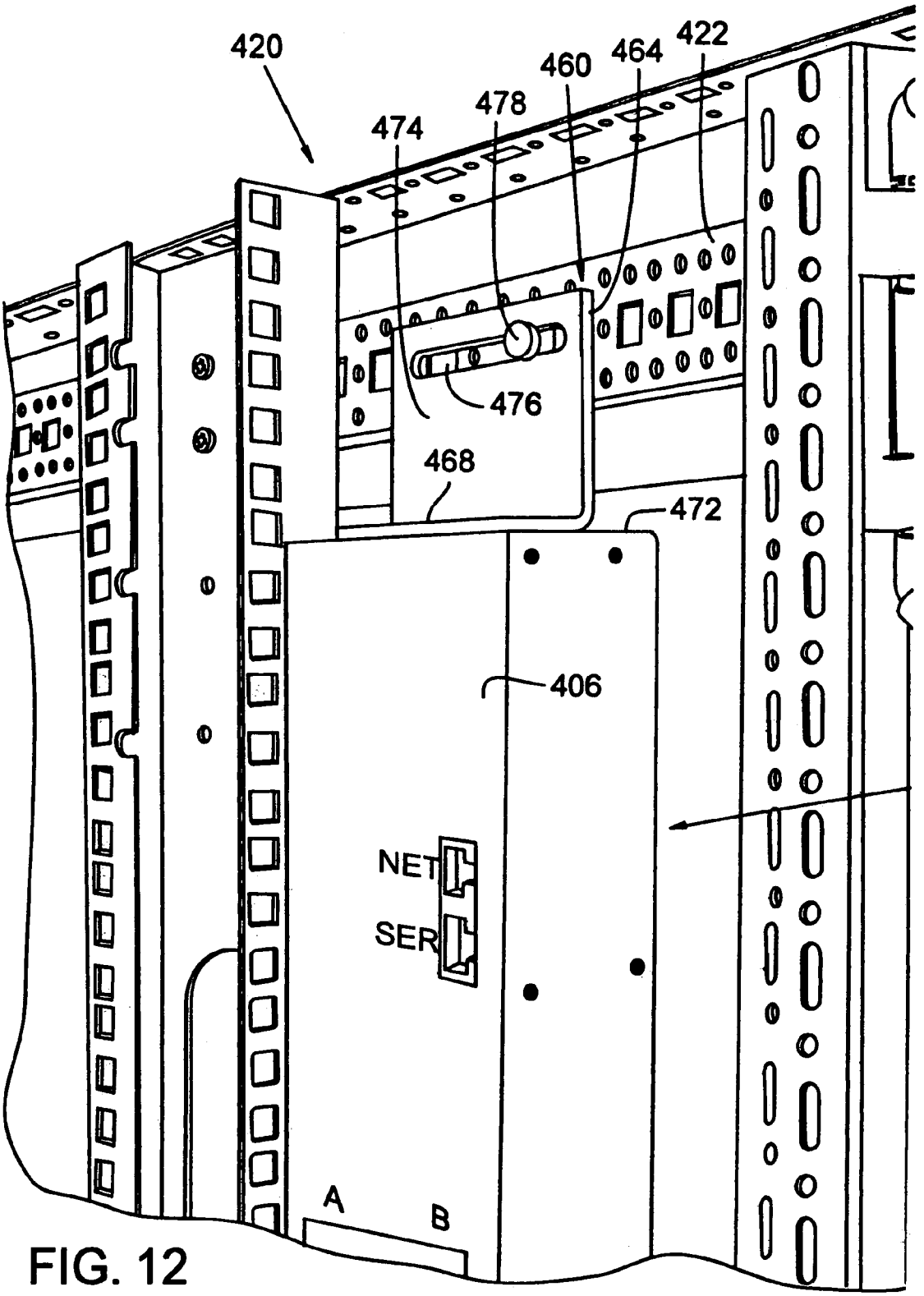

FIG. 12

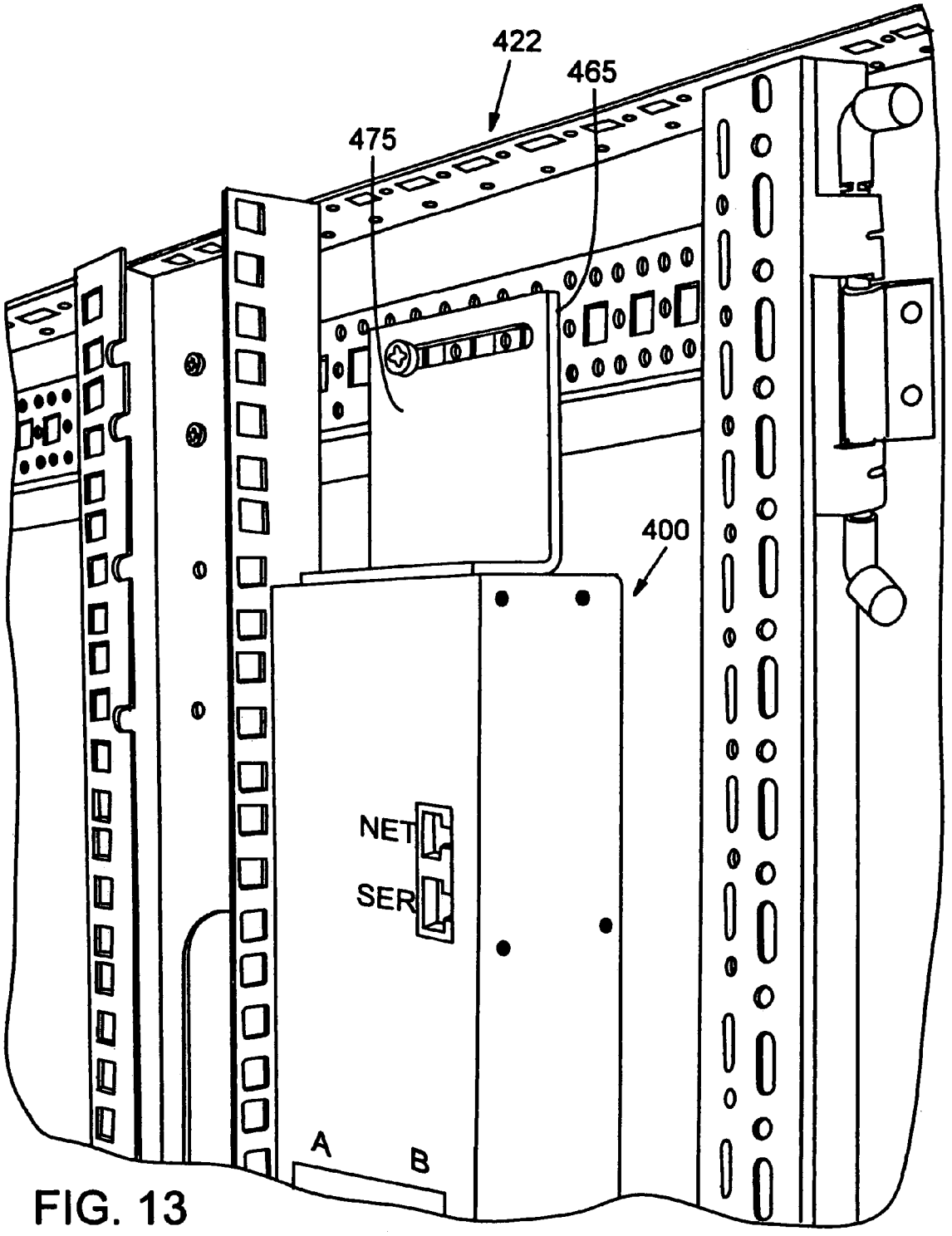

FIG. 13

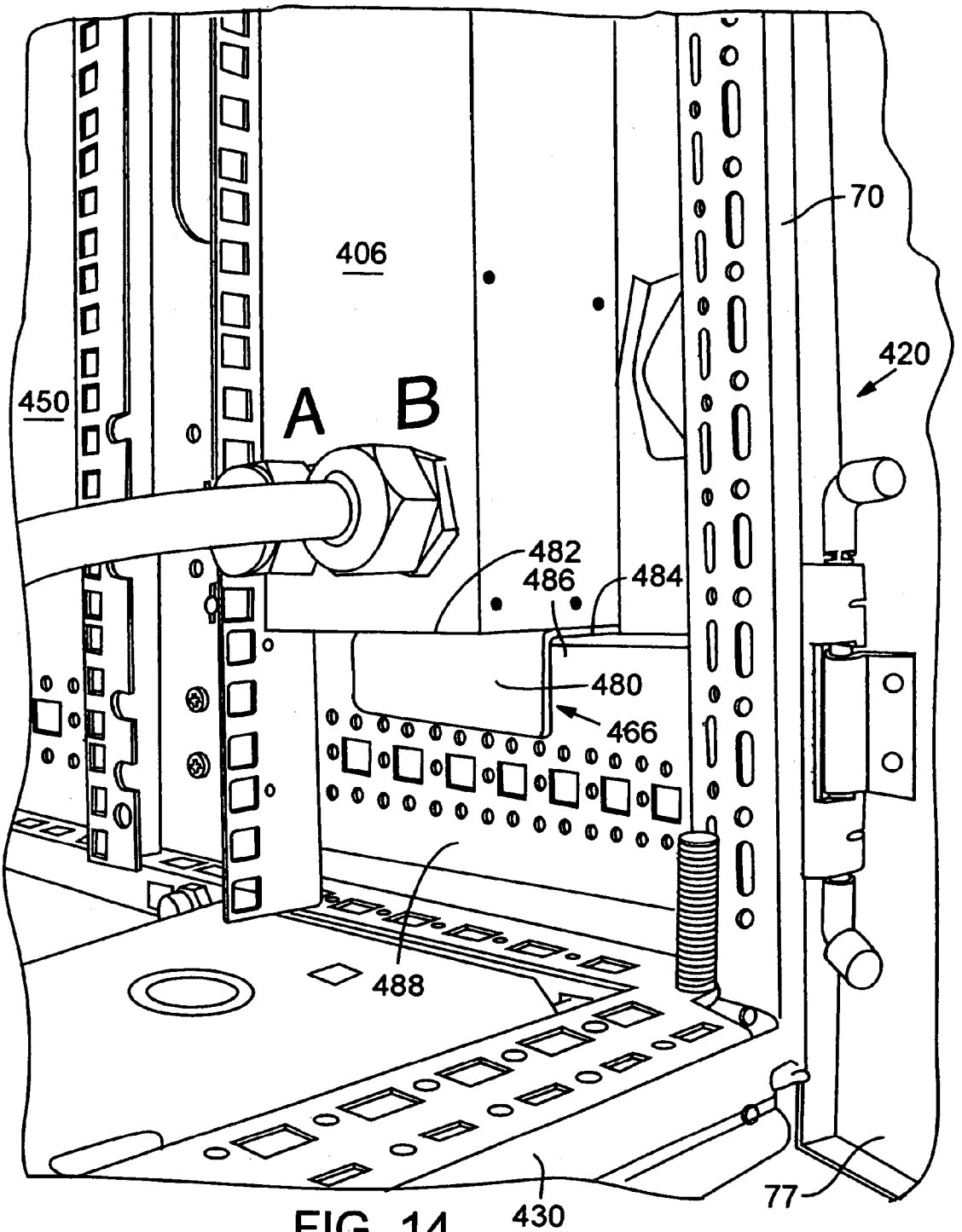

FIG. 14

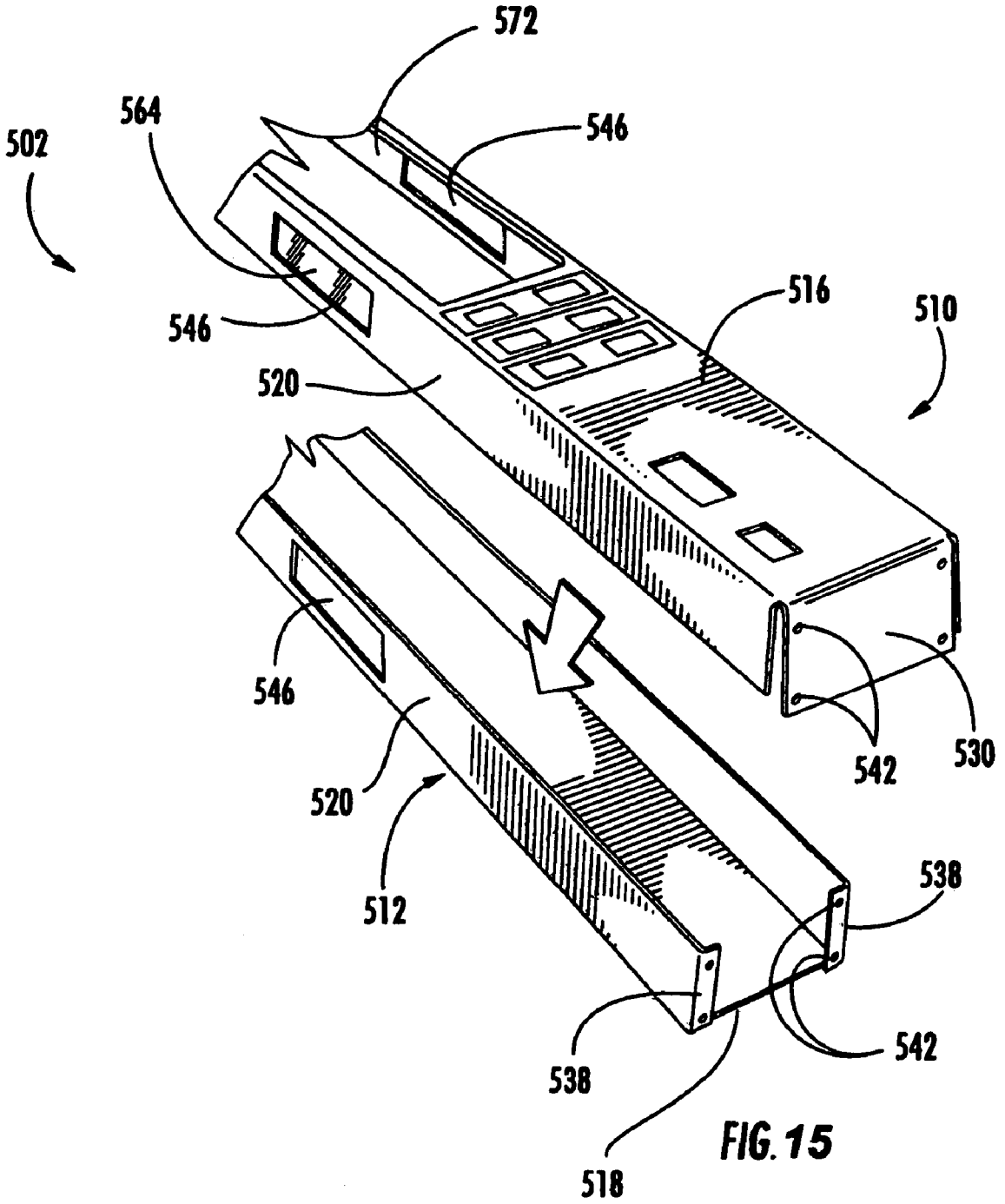
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FIG. 15

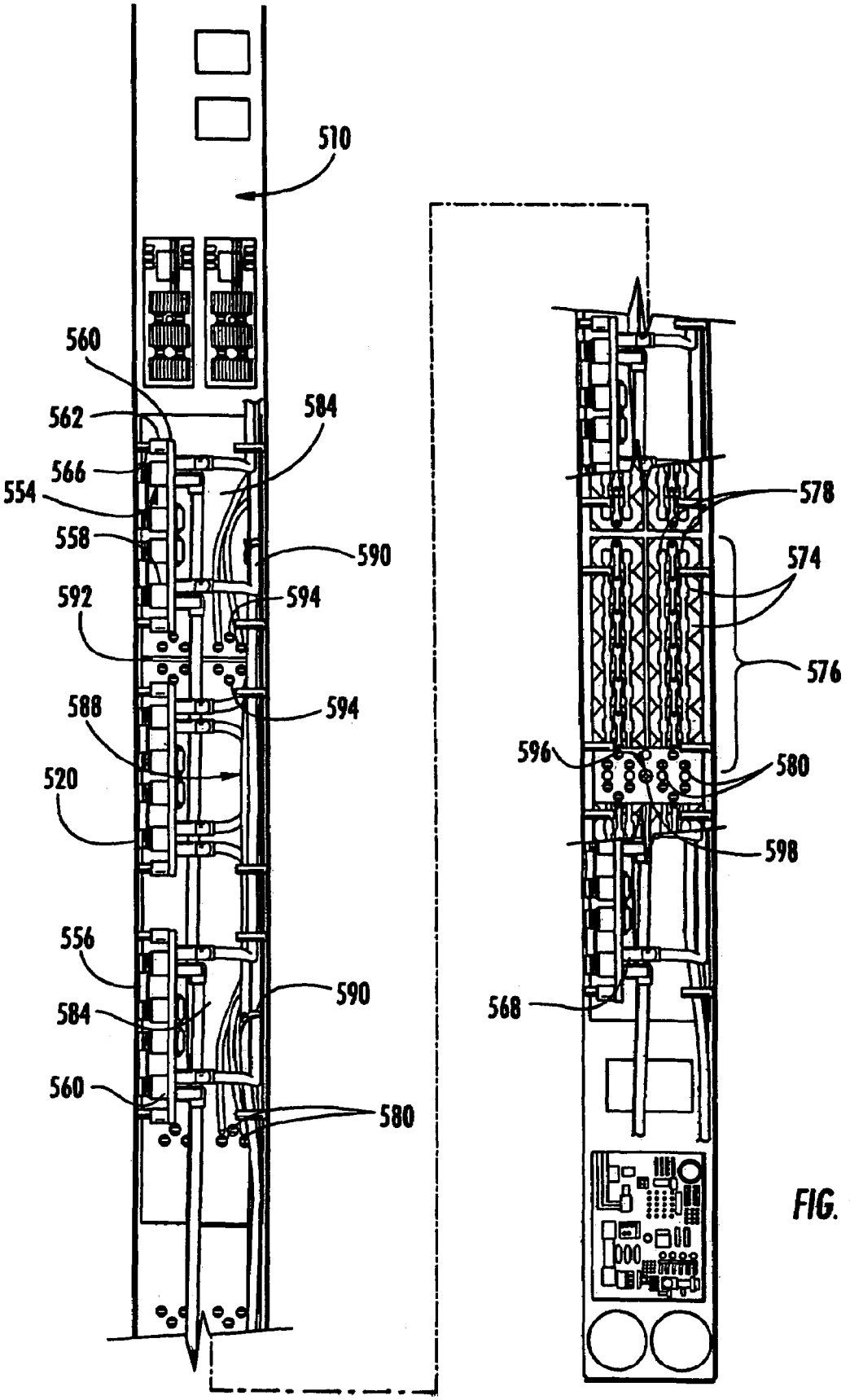
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FIG. 16

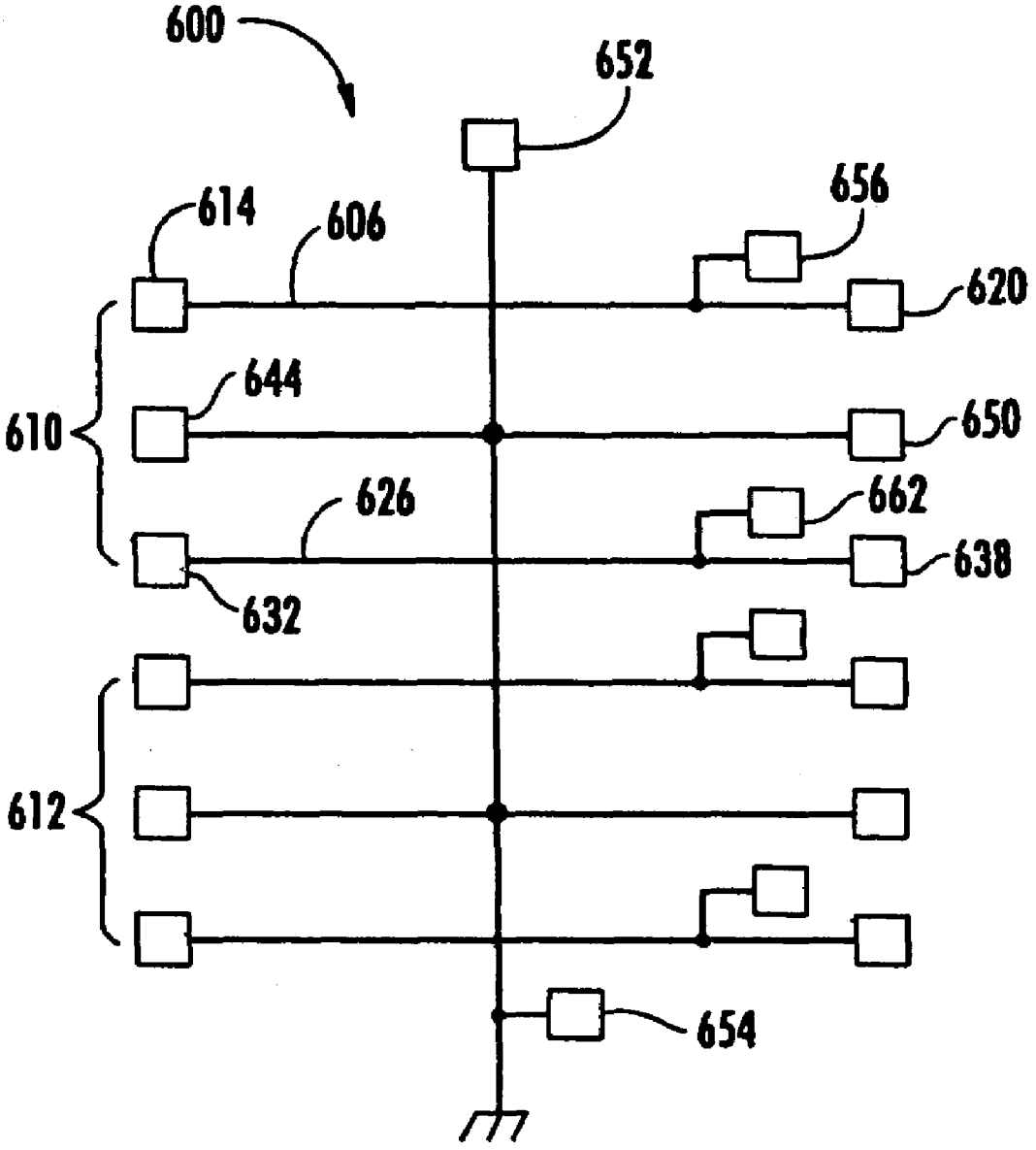

FIG. 17

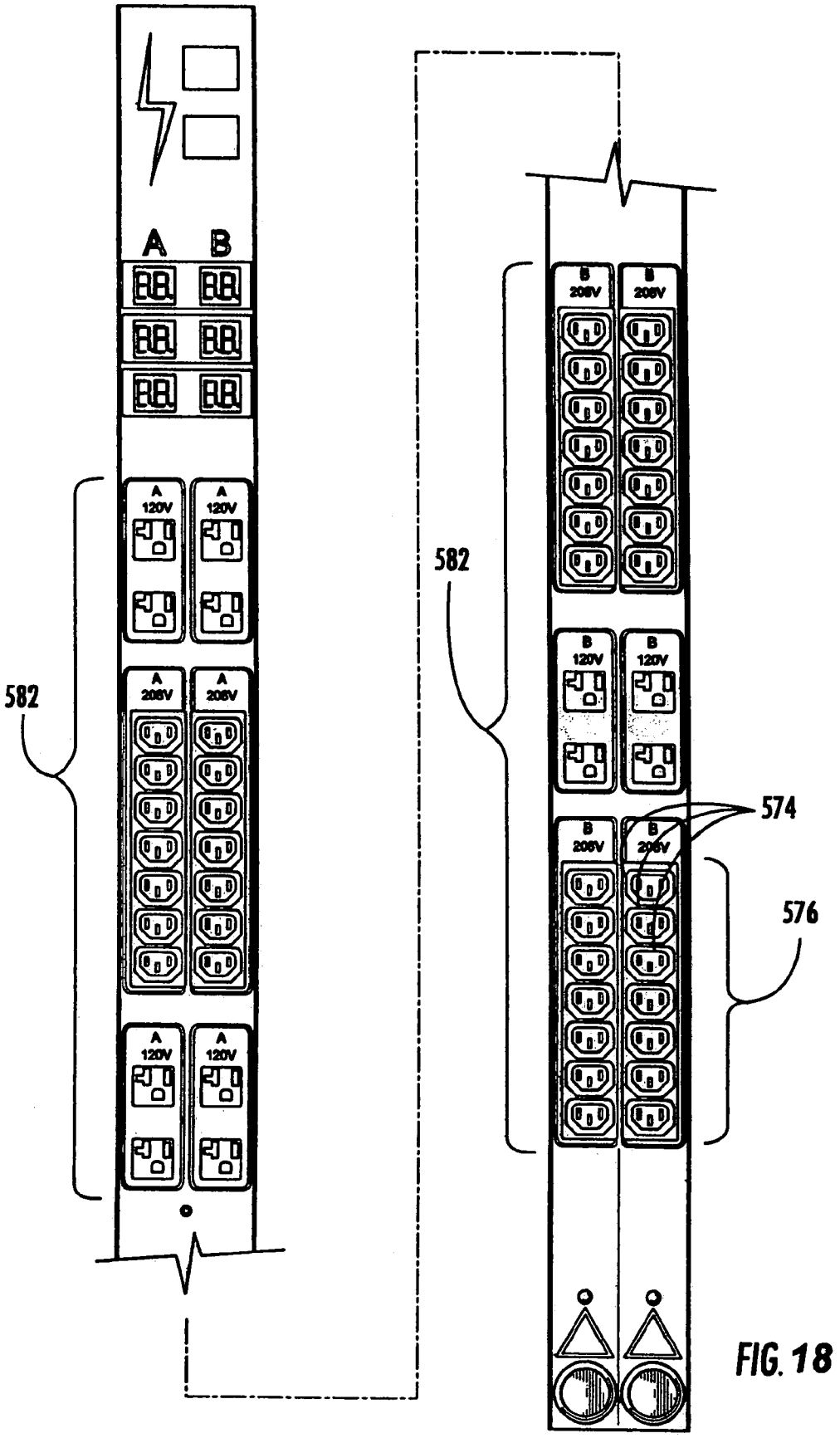

FIG. 18

METHOD OF MOUNTING A POWER DISTRIBUTION APPARATUS IN A RACK

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 11/715,521, filed Mar. 7, 2007, now U.S. Pat. No. 7,312,980 which is a continuation of U.S. patent application Ser. No. 11/135,763, filed May 23, 2005, which claims the benefit of U.S. Provisional Patent Application No. 60/573,405, filed May 21, 2004 (now U.S. Pat. No. 7,196,900), and U.S. Provisional Patent Application No. 60/624,287, filed Nov. 1, 2004. These applications are hereby incorporated by reference.

FIELD

The present invention relates to rack mountable power distribution apparatus. More particularly, the present invention relates to such power distribution apparatus that are adaptable to mount within a variety of differing types of electronic equipment racks (particularly cabinet racks) or in differing orientations within such racks.

BACKGROUND

Electronic equipment racks commonly consist of rectangular or box-shaped housings sometimes referred to as a cabinet or a rack. Electronic equipment is commonly mountable in such racks so that the various electronic devices are aligned vertically one on top of the other in the rack. Often, multiple such racks are oriented side-by-side, with each containing numerous electronic components and having substantial quantities of associated component wiring located both within and outside of the area occupied by the racks.

Power distribution units have long been utilized to supply power to the equipment in such racks, to remotely monitor and control the electronic equipment in such racks, and the supply of power to the power distribution unit. One particularly common such power distribution unit consists of an elongated box housing that has one or more power inputs and a number of power outputs extending along the longitudinal face of the unit. This power distribution unit is designed to mount vertically adjacent or secured to the external rear side of the rack. Typically, this power distribution unit is mounted to the exterior of a rear side of the rack. In this fashion, the power supplied to the unit is then distributed through horizontally extending power outputs to the horizontally co-aligned electronic components mounted in the rack.

An example of such a prior power distribution unit is shown in FIG. **1** and is sold under the trademark "Power Tower" by Server Technology, Inc., of Reno, Nev. FIG. **2** shows this prior art Power Tower power distribution unit secured to the outer edge of a generally rectangular rack to supply power to electronic components mounted within the rack.

Generally, power distribution units have been designed to be mounted in one particular rack configuration of the multiple configurations that are typically available. This can be inconvenient for users of power distribution units. For example, users who change from one type of rack to a different type of rack must often obtain new power distribution units that can be mounted in the new racks. This can be very expensive and time consuming. Because of the different mounting requirements, manufacturers typically must make, and suppliers must stock, separate power distribution units for each type of rack configuration. This can be very inefficient.

An example of a prior art power distribution unit designed for a particular mounting configuration is a power distribution unit made by American Power Conversion Corp. (APC) shown in FIGS. **3-5** that is designed to be mounted in only one type of rack, which is also made by APC. APC's rack is shown in FIGS. **6-10**. The APC unit has mounting disks or pegs, e.g., **20**, **22**, secured to the outer periphery of the back side of the APC unit. These mounting disks or pegs **20**, **22** slidably mount in mating slotted disk mounting apertures, e.g., **24**, **26**, in the rearward portion of the side of an APC rack (see FIGS. **8** and **9**).

The APC power distribution unit is therefore slidably mounted on or adjacent the rear side of the APC rack and remains slidably removable from the APC rack. The APC unit can be unintentionally jolted out of position on the APC rack by upward and downward movement of the rack, such as by accidental contact of an operator with the APC unit or in an earthquake of moderate intensity.

As noted above, the APC unit is not generally designed to be mounted to racks other than those made by APC, that is, racks having slotted apertures for receiving the mounting pegs of the APC power distribution unit. Similarly, the APC racks are typically not designed to accept power distribution units other than those made by APC. In addition, the APC units do not include fuses or circuit breakers that are accessible without removing the unit from a rack and opening the housing of the unit.

SUMMARY

In some embodiments, a power distribution apparatus (PDA), or power distribution unit, as it is sometimes referred to herein, is adaptable to be readily mounted within a variety of differing types of electronic equipment racks, particularly racks that provide at least a substantial box frame or housing within the periphery of which entire electronic units may be mounted.

The power distribution unit can include an upper mounting adapter that may be secured to an upper portion of a PDA and a rack. In some implementations, the upper mounting adapter comprises a bracket having a horizontal plate portion attachable to the upper portion of the PDA and a vertical plate portion attachable to the rack. The vertical plate portion may have a fastener opening, such as a slot, for allowing a fastener to pass therethrough and be received by the rack. In other implementations the upper mounting adapter comprises a plate vertically mountable to the rack, the plate abutting the PDA when the PDA is mounted to the rack, thereby securing the PDA against movement.

In some embodiments, a PDA has a bottom mounting adapter that may be secured to a bottom portion of the power distribution apparatus and a rack. In some implementations, the bottom mounting adapter is a U-shaped bracket having a horizontal plate with vertically downwardly extending plates at two opposing ends of the horizontal plate. The channel formed by the U-shaped bracket is adapted to abut a portion of the rack.

Some embodiments are directed to a PDA having a housing. The housing may have a mounting channel (or notch). The mounting channel may be formed in a side, typically the rear side, of the PDA and may allow the PDA to be mounted more closely to the side of a rack having a protrusion. The mounting channel is adapted to fit over the protrusion when the PDA is secured to the rack.

For example, as discussed above, some racks utilize support bars on the side of the rack, or otherwise have protrusions that can limit how closely prior PDAs can be placed to the rack. A housing with an appropriately configured channel may allow a PDA to be mounted more closely to a rack, particularly a peripheral side of a rack. In this way, the PDA occupies less of the interior of the rack and allows more room for electrical components and associated wiring. The mounting channel may serve other purposes, such as to help secure the PDA in position or render the rack more rigid.

Further embodiments can provide a PDA having a housing and a plurality of mounting pegs coupled to a side or face of the housing or within a mounting channel. The mounting pegs are configured to engage corresponding slotted mounting apertures in a rack. In certain embodiments, the mounting pegs are removable from the side of the housing. In at least one embodiment, the mounting pegs are removably secured to the housing with screws.

In yet further embodiments, a PDA having one or more fuses, circuit breakers, or circuit indicators facing outward from a side of the PDA other than the side of the PDA mounted to a rack. The fuses or other components of the PDA are thereby visible and accessible without removing the PDA from the rack. In certain embodiments, the PDA is readily adaptable to mount to either side of the rack and provide visibility of the one or more fuses, circuit breakers, or circuit indictors, regardless of the side of the rack to which the power distribution apparatus may be mounted.

Of course, some embodiments may contain one or more features described above. For example, at least one embodiment provides a power distribution apparatus having a mounting channel section and being useable with an upper mounting adapter, a lower mounting adapter, or mounting pegs. This embodiment can be highly adaptable and may be used in a variety of different racks. For example, one PDA may easily be adapted to be mounted a variety of racks, such as those manufactured by HP, IBM, and APC, which may reduce manufacturing costs, supplier inventory, and may allow customers to avoid having to purchase new PDAs when they change to a different style of rack. This embodiment may further include one or more fuses visible from the rear of the rack.

In some embodiments, the power distribution unit can also provide a high density power distribution unit, in which the number or power outlets provided exceeds twelve outlets and, in some implementations, provides multiple power inputs and at least twenty-one outlets per power input. One particular implementation is a polyphase, such as three-phase, power distribution unit, which may include two three phase power inputs and fourteen outlets per phase per power input.

The power outlets in the power distribution unit can extend vertically along a face of the unit, facing away from a side of, and toward the interior of, the rack when mounted in the rack. In this manner, wiring from rack-mounted equipment to the outlets in the power distribution unit may be oriented to remain within the confines of the periphery of the rack.

The PDA may be mounted in an electronic equipment rack. The rack may be of the type for mounting electronic equipment vertically, and may have doors on one or more side. At least certain embodiments allow wires of devices attached to the PDA to be kept within the external periphery of the rack, even if the sides of the rack are open.

There are other features and advantages of the various embodiments. They will become apparent as this specification proceeds. In this regard, it is to be understood that the scope of the present invention is not to be determined by whether a given embodiment includes all features or advantages recited herein or solves all problems or limitations in the prior art noted in this specification. The foregoing and other objects, features, and advantages of the invention will become more apparent from the following detailed description, which proceeds with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a prior power distribution unit.

FIG. **2** is a perspective view of the prior power distribution unit of FIG. **1** secured to the outer edge of a generally rectangular rack.

FIG. **3** is a perspective view of a prior power distribution unit.

FIG. **4** is a fragmentary top view of the prior power distribution unit of FIG. **3**.

FIG. **5** is a fragmentary perspective view of the prior power distribution unit of FIG. **3**.

FIG. **6** is a perspective view of a power distribution unit according to one embodiment mounted vertically within a cabinet rack of a first type.

FIG. **7** is an enlarged fragmentary perspective view of the power distribution unit of FIG. **6** showing, in particular, an upper mounting adaptor.

FIG. **8** is a perspective view of the back of the power distribution unit of FIG. **6** showing mounting pegs for securing the power distribution unit to the rack.

FIG. **9** a perspective view of a portion of the rack shown in FIG. **6**, showing mounting apertures for receiving the mounting pegs shown in FIG. **8**.

FIG. **10** is a perspective view of a power distribution unit according to one embodiment mounted vertically within a cabinet rack of a second type.

FIG. **11** is an enlarged fragmentary perspective view of the power distribution unit of FIG. **10** showing, in particular, a support brace channel penetrating the back side of the unit.

FIG. **12** is an enlarged fragmentary perspective view of the power distribution unit of FIG. **10** showing, in particular, an upper angled mounting bracket.

FIG. **13** is an enlarged fragmentary perspective view of the power distribution unit of FIG. **10** showing, in particular, an upper angled mounting bracket for mounting the power distribution unit in a cabinet rack of a third type.

FIG. **14** is an enlarged fragmentary perspective view of the power distribution unit of FIG. **10** showing, in particular, a lower mounting bracket.

FIG. **15** is a perspective view a portion of the housing of the power distribution units shown in FIGS. **6** and **10**, illustrating how top and bottom portions of the housing may fit together.

FIG. **16** is a top plan view of a portion of the housing of the power distribution units shown in FIGS. **6** and **10**, illustrating various components that may be included in the power distribution units and their arrangement in the housing.

FIG. **17** is a schematic wiring diagram of an embodiment of a power connection board useable in the power distribution units of FIGS. **6** and **10**.

FIG. **18** is a top plan view of a power distribution unit according to an embodiment of the present invention.

DETAILED DESCRIPTION

FIG. **6** illustrates a power distribution apparatus (PDA) **100** having a housing **106**. The housing **106** may be of any suitable dimension. The housing **106** is sized for mounting in a rack, such as rack **120**. The housing **106** is shown as a rectangular box, having longitudinally extending front **110** and back

faces **112**, two longitudinally extending lateral sides **114**, a first end **116**, and a second end **118**. Of course, shapes other than rectangular boxes could be used. The housing **106** may be made of a substantially rigid and durable material, such as metals or plastics. In at least one embodiment, the housing **106** is made of sheet metal.

The housing **106** may include an upper mounting adapter **126** for mounting the housing **106** to the rack **120**, which may be a rack manufactured by American Power Conversion Corp. of West Kingston, R.I., adjacent an electronic equipment mounting area **132** within the confines of the rack **120**. The housing **106** may thereby be securely mounted vertically within the rack **120**. In at least one embodiment, the rack **120** is secured adjacent the rearward edge **136** of one side wall **138** of the rack **120** that extends from the front face **144** of the rack **120** toward the rear face **146** of the rack **120**. The rack **120** may be coverable by one or more doors **150** (shown, however, as being open in FIG. **6**).

One or more power inputs **156** may be coupled to the housing **106**. In the illustrated embodiment, the power inputs are connected through the front face **110** of the housing **106**, proximate the first end **116** of the housing **106**. The power inputs **156** may be chosen to connect to a power supply (not shown) to provide a desired level of power to one or more electrical appliances (not shown). The power inputs **156** may be adapted to employ single phase power or polyphase power, including double or triple-phase power.

The housing **106** may have one or more outlet apertures **164** through which a plurality of power outlets **166** extend. As shown, the apertures **164** are rectangular openings in the front face **110** of the housing **106**. Each aperture **164**, and associated power outlets **166**, may represent a discrete power unit, or "branch." Each branch may be independently supplied with power, controlled, and wired. The power outlets **166** may provide the same or varying amounts of power, such as 120V or 240V, to connected devices (not shown).

One or more displays **170** may be provided on the housing **106**. As shown, six displays **170** are viewable on the front face **110** proximate the second end **118** of the housing **106**. The displays **170** may be LED displays, LCD displays, or any other suitable display device. The displays **170** may display information to a user, such as information regarding the status of the PDA **100** or the outlets **166**. In at least one embodiment, the displays **170** provide information regarding the amount of current drawn by one or more outlets **166**, including groupings of outlets **166**.

Power distribution apparatus **100** may also be provided with one or more communication connections **176**. The communication connections **176** may be used to send information from, and provide information to, the PDA **100**. For example, the communication connection **176** may be used to provide information over a network, such as the Internet, regarding the PDA **100** to a remote user. In other embodiments, the communication connection **176** may be used by service technicians to troubleshoot, program, or obtain data from the PDA **100**.

FIG. **7** presents a more detailed view of the upper mounting adapter shown in FIG. **6**. As shown in FIG. **7**, the upper mounting adapter **126** is a bracket having a planar rectangular plate **204**. Rectangular plate **204** is shown positioned vertically, with the length of the rectangular plate **204** extending horizontally. Adjacent each of opposing vertically extending sides **210** of the rectangular plate **204**, a fastener slot **214** extends vertically upwardly, parallel to each adjacent side **210** of the rectangular plate **204**. A fastener **220**, such as a screw, a nail, a bolt, or a pin, penetrates the fastener slot **214** and a mating horizontally extending fastener passage (not shown) drilled into the vertically extending cabinet rack side wall ridge **224** adjacent a vertical side **230** of the PDA **100**. In at least one embodiment, the fastener **220** is a self-tapping screw.

The lower horizontal edge **234** of the rectangular plate **204** abuts the horizontally extending top side **238** of the housing **106**. In this manner, the rectangular plate **204**, when secured in position by fasteners **220**, at least partially secures the PDA **100** to the rack **120**. Although the upper mounting adapter **126** has been shown and described as separate from the PDA **100**, the upper mounting adapter **126** could be integrally formed in, or coupled to, the PDA **100**.

With reference now to FIG. **8**, a PDA **300** may be provided with one or more mounting pegs **306**. In at least one embodiment, a pair of mounting pegs **306** are provided. In a further embodiment, at least two pairs of mounting pegs **306** are provided. The mounting pegs **306** may be secured to a housing **302** of the PDA **300** by inserting fasteners **310**, such as screws, nails, bolts, pins and the like, through fastener passages (not shown) in the housing **302**. Alternatively, the mounting pegs **306** may be integrally formed on the housing **302**. The mounting pegs **306** may be constructed from any suitable material, including metals, plastics, and rubber. The mounting pegs **306** may be shaped and sized as needed to mount to a particular rack **320**. The mounting pegs **306** may have a mushroom shaped end **312** in order to more securely anchor the PDA **300** to the rack **320**. As shown in FIG. **8**, the mounting pegs **306** are located on opposing sides of the same vertical point on the back side **316** of the housing **302** and extend horizontally therefrom.

As shown in FIG. **9**, the mounting pegs **306** may be used to secure the housing **302** to the rack **320** by placing the mounting pegs **306** through mounting apertures **326** in the rack **320**. In the embodiment shown in FIG. **9**, the mounting apertures **326** have an upside-down teardrop (thick-thin) shape, although other configurations could be used. The mounting pegs **306** and the upper mounting adapter **126** (FIGS. **6** and **7**) may be used to cooperatively secure the housing **302** to vertically extending side wall ridges **330**, **332** adjacent the planar vertical side wall **334** of the rack **320**.

In operation, the mounting pegs **306** slidably penetrate the mating slotted mounting apertures **312**. Note that the housing **302** is mounted using mounting pegs **306** and then secured into position using the upper mounting adapter **126** (FIGS. **6** and **7**). Using the upper mounting adapter **126** in conjunction with the mounting pegs **306** may result in a more secure attachment of the housing **302** to the rack **320** and reduce the chance that the housing **302** may be inadvertently dislodged from the rack **320**. This arrangement also can make the associated rack **320** more rigid and secure.

Another embodiment of a PDA **400** having a housing **406** is shown in FIG. **10**. The PDA **400** has the same basic external housing structure as the PDA **100** (FIGS. **6** and **7**) but is adapted for a particular rack **420**, such as that manufactured by Hewlett Packard Co. of Palo Alto, Calif. The rack **420** has a horizontally extending support arm **424** extending from the front side (not shown in FIG. **10**) to the rear side **430** of the rack **420**.

With reference to FIG. **11**, the housing **406** may be provided with a channel **436**. The channel **436** may be a U-shaped notch in the housing **406**. The channel **436** is shown located approximately in the middle of the housing **406**, between two outlet apertures **418**. The channel **436** is formed by U-shaped cut-out sections in both lateral sides **416** (one of which is shown in FIGS. **10** and **11**), thereby providing a recessed section in the back face **414** of the housing **406**. The channel **436** may be sized as desired to fit over a protrusion,

such as the horizontally extending rack support art **424** or otherwise possibly obstructing protrusion or element in the rack **420**.

As shown in FIGS. **10** and **11**, the channel **436** can allow the PDA **400** to be closely mounted to the rack **420**, even if the rack **420** has reinforcement bars **424** or other protrusions, in order to maximize available interior access space behind electronic equipment mounted in the rack. The location, shape, and size of the channel **436** can be varied as desired to accommodate a variety of racks and mounting configurations. Additionally, more than one channel **436** may be included in the housing **406**. When so mounted, the back side **440** of the housing **406** is relatively close to the side wall **446** of the rack **420**. The use of the channel **436** can therefore increase the amount of central wiring area in the rack **420** and may allow easier access to the electronic equipment (not shown) in the electronic equipment mounting area **450** in the rack **420**.

In the particular configuration shown in FIG. **10**, the power distribution apparatus **400** is adapted to receive and distribute power from two three phase power inputs **490**. This provides a total of six branches of power outlets—three phases of power per each of the two inputs **490**. Each such branch is fused by two fuses, e.g., **492**, one for each of the two sets of seven power outlets **494** supported by the branch. The two fuses **492** for the branch are visible through a polycarbonate window **496** removably mounted by screws (not shown), which penetrate mating passages (not shown) in the window **496** and the planar side wall **410** of the housing **406**. The polycarbonate window **496** thus faces the rear side **430** (including rear doors **75**, **77** when closed) of the rack **420** and is readily visible to an operator located adjacent the rear side **430** of the rack **420**.

The housing **406** is secured in position in the rack **420** by an upper mounting bracket **460** in cooperation with a lower mounting adapter **466**. With reference now to FIG. **12**, the upper mounting adapter **460** may include an angled mounting bracket **464** having a horizontal lower planar arm **468** abutting a coplanar upper planar side **472** of the housing **406**. An upper planar arm **474** extends vertically from, and perpendicularly to, the plane of the lower planar arm **468**. The upper planar arm **474** is shown having a transversely extending fastener slot **476** adjacent its upper edge. A fastener **478**, such as a nail, a pin, a bolt, a screw, or a self tapping screw, penetrates the fastener slot **476** and a mating passage (not shown) in the cabinet side structure **422** of the rack **420** in order to secure the upper angled mounting bracket **464** in the desired position with respect to the rack **420** and the power distribution apparatus **400**. In addition, lower arm fasteners (not shown), such as screws, bolts, nails, pins, etc., penetrate mating circular passages (not shown) in the lower planar arm **468** and the upper planar side **472** of the housing **406**.

For example, as shown in FIG. **13**, an angled mounting bracket **465** is configured to allow the PDA **400** to be mounted to a particular rack **422**, such as that manufactured by International Business Machines Corp. of Armonk, N.Y. The bracket **465** includes an upper planar arm **475** extending a length greater than the length of the upper planar arm **474** of angled mounting bracket **464** shown in FIG. **12**.

The upper mounting adapter **460** is shown as an integral component, including a concave bent (or curved) portion at the transition between the lower planar arm **468** and the upper planar arm **474**. However, rather than being of unitary construction, the upper mounting adapter **460** can be assembled from two or more pieces fastened together. In addition, the upper mounting adapter **460** could be integrally formed on the housing **406** without departing from the scope of the present invention. Furthermore, the dimensions of the upper mounting adapter **460**, such as the respective lengths of the upper planar arm **474** and the lower planar arm **468**, may be configured as desired to allow the PDA **400** to be mounted on a particular type of rack.

With reference to FIG. **14**, the lower mounting adapter **466** may be a vertically downwardly oriented U-shaped mounting bracket **480**. The lower U-shaped mounting bracket **480** may be secured to the lower planar side **482** of the housing **406**. The lower U-shaped mounting bracket **480** may be secured by one or more fasteners (not shown), such as two screws penetrating mating co-axial passages (also not shown) in the center horizontal planar section **484** of the U-shaped mounting bracket **480** and in the lower planar side **482** of the housing **406**. The U-shaped mounting bracket **480** provides a laterally and downwardly extending U-shaped channel **486** that mounts upon and surroundingly abuts the mating upwardly extending lower side arm **488** in the rack **420**. The housing **406** is thereby secured adjacent the rear side **430** (including rear doors **75**, **77** when closed) of the rack **420**, intermediate the electronic equipment mounting area **450** and the rear side **430**.

With reference now to FIG. **15**, certain embodiments of a PDA of the present application provide an upper housing portion **510** and a lower housing portion **512** that may be assumed to form a housing allowing convenient access to certain components of a PDA, such as the PDAs described in conjunction with FIGS. **6-14**. In at least one embodiment, the housing formed by the upper housing portion **510** and the lower housing portion **512** is adaptable to provide differing fuse and fuse window configurations.

As shown in FIG. **15**, the upper housing portion **510** and the lower housing portion **512** are substantially U-shaped. The upper U-shaped portion **510** forms the front face **516** and at least partially forms the lateral sides **520** of the housing. The lower U-shaped portion **512** forms the back face **518** and at least partially forms the lateral sides **520** of the housing.

The lower U-shaped portion **512** and the upper U-shaped portion **510** may be coupled by any suitable means. In the embodiment of FIG. **15**, the lower U-shaped portion **512** may slide over and matingly engage the upper U-shaped portion **510**. Each end of the upper U-shaped portion **510** may include a flap **530**. Each end of the lower U-shaped portion **512** may have U-shaped flanges **538** that matingly engage the outer portion of the flaps **530**. The upper U-shaped portion **510** and the lower U-shaped portion **512** are secured together by inserting fasteners (not shown) through fastener openings **542** in the ends of the upper U-shaped portion **510** and the ends of the lower U-shaped portion **512**. In at least one embodiment, the fastener openings **542** are threaded for receiving matingly threaded fasteners.

With continued reference to FIG. **15**, the upper U-shaped portion **510** has longitudinally distributed rectangular access openings **546** formed in both lateral sides **520**. The lower U-shaped portion **512** has longitudinally distributed rectangular access openings **546** formed in one lateral side **520**. The access openings **546** of the upper U-shaped portion **510** may be wider than the access openings **546** of the lower U-shaped portion **512** in order to provide access to standoff mount bases (not shown) which provide threaded fastener passages for threading mating screws (not shown) in order to mount fuse access windows or cover plates as described below.

The upper U-shaped portion **510** and the lower U-shaped portion **512** may be assembled so that the access openings **546** provide access to the interior of the housing, such as to fuse mounts **554** (FIG. **16**), on a selected lateral side **520** of the housing **506**. The access openings **546** may be covered by a protective covering **564**, such as a plastic or glass window. In

other embodiments, the access openings **546** may be covered by a metal plate. In at least one embodiment, the access openings **546** are covered with a Lucite window. The access openings **546** may be located anywhere on the housing **506**, and are located to allow visibility of, and easy access to, certain components, such as fuses (FIGS. **10** and **16**) when the PDA is in use. The components may thereby be observed, replaced, or otherwise serviced as desired without the need for removing the PDA from a rack.

Turning now to FIG. **16**, a PDA may have a wide variety of components assembled in the upper housing portion **510**. For example, a plurality of fuse assemblies **554** may be positioned in the upper housing portion **510**. A fuse **556** may be removed from, or installed into, a fuse assembly **554**. The fuse assembly **554** may have two clamp arms **558** to secure each fuse **556** and to place the fuse **556** in electrical communication with a circuit of the PDA. Each fuse assembly **554** may include a fuse board **560**. Other power interrupting devices, such as circuit breakers, may be utilized rather than the fuses **556**. Fuse boards **560** are positioned longitudinally along a lateral side **520** of the upper U-shaped portion **510**. Fuse boards **560** are substantially coincident with access windows **546** (FIG. **15**). Each fuse board **560** may be secured to the housing **506** by inserting fasteners (not shown), such as screws, through fastener openings (not shown) adjacent an access window **546**, through fuse mounts **566**, and into fastener mounts **562** on each fuse board **560**. The fuse boards **560** may have a plurality of connection terminals **568** for placing the fuses **556** in electrical communication with other components of the PDA.

As mentioned previously, during assembly, the lateral side **520** on which the interior of the housing **502** is to be accessible may be determined by aligning the access openings **546** (FIG. **15**) on lower U-shaped portion **512** with the access openings **546** (FIG. **15**) on the desired lateral side **520** of the upper U-shaped portion **510**. Of course, the lower U-shaped portion **512** may have access openings **546** on both lateral sides **520**, thereby providing access to the interior of the housing **502** on each lateral side **520**. In this embodiment, the protective coverings **564** (FIG. **15**) could be used to cover the access openings **546** not having fuse mounts **554**, or where access to the interior of the housing **502** is otherwise not required.

A plurality of power outputs **574** are mounted in the upper housing portion **510**. Each power output **574** may be part of an outlet gang **576**. As shown, three power rails or rods **578** are coupled to the back of each outlet gang **576**. Depending on the application, more or less power rails **578** could be used. Each of the power rails **578** runs substantially the length of the back side of a corresponding outlet gang **576** and is connected to each output **574** in the outlet gang **576**. Each power rail **578** may have a protrusion (not shown) that extends into a particular receptacle (not shown in FIG. **16**) of each power output **574** in an outlet gang **576**. Each receptacle may receive a prong (not shown) from a power cord (not shown) of an electrical appliance (not shown). The power rails **578** therefore serve to electrically couple each power output **574** in an outlet gang **576**. Each power rail **578** may correspond to a particular electrical component, such as a hot, neutral, or ground connection. The power rails **578** can be made from a conducting material, such as a conductive metal.

The use of the power rails **578** obviates individually wiring together multiple individual power outputs **574**. Although the power rails **578** are shown as parallel, linear rails, other configurations could be used. For example, the power rails **578** could be curved in order to accommodate an arcuate pattern of power outputs **574** if desired.

Each power rail **578** may be provided with at least one connecting prong **580**. The connecting prong **580** may be used to place a power rail **578**, and therefore a corresponding outlet gang **576**, in electrical communication with other electrical components. The connecting prongs **580** may be coupled to other electrical components by any suitable connecting means. In some embodiments, wires may be used as the connecting means. Of course, the present invention is not limited to power rails **578** having connecting prongs **580**. Any suitable means may be used for placing the power rails **578** in electrical communication with other electrical components.

An outlet gang **576** is shown covered by a planar layer of nonconductive material **584** that extends substantially across the width of the upper U-shaped portion **510**. More than one piece of the nonconductive material **584** may be used and the nonconductive material **584** may be shaped and sized as desired to insulate the electrical components of the PDA. The nonconductive material **584** may be any suitable material that substantially does not conduct electricity, such as plastics, rubber, and the like. In at least one embodiment, the nonconductive material **584** is Mylar. The nonconductive material **584** can be used to prevent unintended electrical communication between adjacent electrical components, such as between the outlet gang **576** and the fuse board **560**.

A plurality of wires **588** may be used to connect various components, such as the outlet gangs **576** and the fuse boards **560**. The wires **588** may be insulated wires, in order to help prevent unintended electrical contact between the wires **588** and the other components of the PDA. In addition, the wires **588** may be placed on the opposite side of the nonconductive material **584** from the outlet gangs **576** in order to help prevent such intended contact. The wires **588** are shown as laid out substantially along the side of the upper U-shaped portion **510** opposite the fuse boards **560**. The wires **588** may be secured together by fasteners **590**, such as locking plastic bands.

The power outputs **574** and other electrical components of the PDA may be connected by various electrical connectors, such as various types of wires. In certain embodiments, including the embodiment of FIG. **16**, the electrical connector may be a power connection board **592**. The power connection board **592** may be used to connect at least two electrical components. For example, the power connection board **592** may be placed between, and used to connect, two outlet gangs **576**, as shown in FIG. **16**. The power connection board **592** may be an at least semi-rigid component capable of placing at least two electrical components in electrical communication. In certain embodiments, the power connection board **592** is a printed circuit board. In at least one embodiment, the power connection board **592** is a four-layer printed circuit board.

The power connection board **592** may have a number of holes **594** extending therethrough. The holes **594** may be lined with a conducting material, such as a conductive metal. In at least one embodiment, a connecting prong **580** of a power rail **578** associated with an outlet gang **576** can engage a hole **594**. If desired, the connecting prong **580** may be further secured to the connector **592**, such as by soldering. As shown in FIG. **16**, nonconductive material **584** may be placed between the connecting prongs **580** and the power connection board **592**. The connecting prongs **580** may extend through openings (not shown) in the nonconductive material **584**.

The power connection board **592** may be coupled to the upper U-shaped portion **510** of the housing **506**. In one embodiment, the power connection board **592** is provided with a fastener hole **596**. A fastener **598**, such as a screw, a

nail, a pin, a bolt, etc., may be inserted through the fastener hole **596** and securely received by a mount (not shown) on the upper U-shaped portion **510**.

A schematic diagram of a printed circuit board **600** useable in this embodiment is shown in FIG. **17**. Each layer of the printed circuit board **600** may correspond to a single electrical component. For example, when the circuit board **600** is used for power transmission, one layer may correspond to a "hot" electrical connection, one layer may correspond to neutral connection, and one layer may be a ground connection. The use of an entire layer of the printed circuit board **600** for each connection may allow for larger amounts of electricity to flow through the printed circuit board **600**.

FIG. **17** shows two power inlets, **610** and **612**, connected to circuit board **600** for distributing power to two outlet gangs **576**. Lead **606** of power inlet **610**, which may be an AC line power connection, is shown connected to connection point **614**. Connection point **614**, as well as other connection points, may be a pad. The pad may be an annular ring surrounding a hole in the circuit board **600**. The annular ring may be made from a conducting material, such as a conductive metal.

A power rail **578** (FIG. **16**) of a first outlet gang **576** (FIG. **16**) may also be connected to pad **614**. Pad **614** is in electrical communication with pad **620** through the circuit board **600**. In turn, pad **620** may be connected to a power rail **578** of a second outlet gang **576**. Similarly, lead **626** of power inlet **610**, which may be an AC line power neutral connection, may be connected to pad **632**. A power rail **578** of the first outlet gang **576** may also be attached to pad **632**. Pad **632** is in electrical communication with pad **638**. Pad **638** may be connected to a power rail **578** of the second outlet gang **576**. Pads **644** and **650** may be ground connections for their respective outlet gangs **576** and be grounded through pads **652** and **654**. Leads **606** and **626** may be connected to a fuse board **560** (FIG. **16**) through pads **656** and **662**, respectively. Additional outlet gangs **576**, other electrical components, or additional power inlets, such as power inlet **612**, may be connected in a similar manner.

As illustrated in FIG. **18**, a plurality of power outlets **574** pass through various outlet apertures (not shown). The apertures are rectangular openings in the front face of the housing. One or more apertures, and the associated power outlets **574** extending therethrough, may represent a discrete power unit, or "branch" **582**. Each branch **582** may be independently supplied with power, controlled, and wired.

The power outlets **574** may be individual outlets or part of an outlet gang **576**, single components having multiple power outlets **574**. Suitable outlet gangs are type 0909 ganged outlets available from Shurter, Inc., of Santa Rosa, Calif. The ganged outlets **576** are shown as linear arrangements of the power outlets **574**, which may be arranged in columns or rows. Each branch may include one or more ganged outlets **576**. As shown, two ganged outlets **576** may be placed side-by-side, providing two columns of outlets **574** longitudinally extending down the front face of the PDA.

The ganged outlets **576** may be configured to deliver the same or different amounts of power to their corresponding power outlets **574**. For example, one ganged outlet **576** may provide 120V power while another ganged outlet **576** may provide 240V power. Of course, the present invention is not limited to any particular power configuration. In addition, the ganged outlets **576** may have varying numbers of power outlets **574**. The ganged outlets **576** may be used exclusively in the PDA or in conjunction with individual outlets **574**.

The power distribution units described above have been described as being in the form of single phase or three phase power distribution devices. A given rack, however, can utilize a power distribution unit that supports either single or three phase power depending on the application involved.

It can thus be seen that certain embodiments provide PDAs that are readily and easily adaptable to be utilized in differing orientations in a cabinet rack and in differing types of cabinet racks. The PDAs are securely mounted in the various cabinet racks and relatively unlikely to be unintentionally jolted out of position in the rack. The PDAs may provide single or polyphase power and associated features, including environmental monitoring, remote control, communications network access, and current monitoring displays. The PDA may also be relatively lighter in weight than correspondingly functioning prior PDAs, which typically include substantially increased quantities of wiring.

Having illustrated and described the principles of the disclosed embodiments, it will be apparent to those skilled in the art that the embodiments can be modified in arrangement and detail without departing from such principles. In view of the many possible embodiments, it will be recognized that the described embodiments include only examples and should not be taken as a limitation on the scope of the invention. Rather, the invention is defined by the following claims. We therefore claim as the invention all possible embodiments and their equivalents that come within the scope of these claims.

We claim:

1. A method of mounting a power distribution apparatus in a rack comprising:

selecting a rack from amongst a plurality of racks;

selecting a U-shaped bracket from amongst a plurality of different types of mounting adapters for mounting the power distribution apparatus in the selected rack;

securing the selected mounting adapter to the power distribution apparatus; and

fitting the U-shaped bracket over a portion of the rack.

2. A method as in claim **1** and further comprising orienting the power distribution apparatus such that an electrical component within the power distribution apparatus is visible without removing the power distribution apparatus from the rack.

3. A method as in claim **1** and further comprising inserting a fastener through a passage in the selected mounting adapter and through a passage in the rack to secure the power distribution apparatus to the rack.

4. A method of mounting a power distribution apparatus in a rack comprising:

selecting a rack from amongst a plurality of racks;

selecting at least one of a plurality of different types of mounting adapters for mounting the power distribution apparatus in the selected rack;

securing the selected mounting adapter to the power distribution apparatus;

securing the selected mounting adapter to the selected rack; and

fitting a channel in the power distribution apparatus over a protrusion in the rack.

5. A method as in claim **4** and further comprising inserting a fastener through a passage in the selected mounting adapter and through a passage in the rack to secure the power distribution apparatus to the rack.

6. A method as in claim **4** and further comprising orienting the power distribution apparatus such that an electrical component within the power distribution apparatus is visible without removing the power distribution apparatus from the rack.

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