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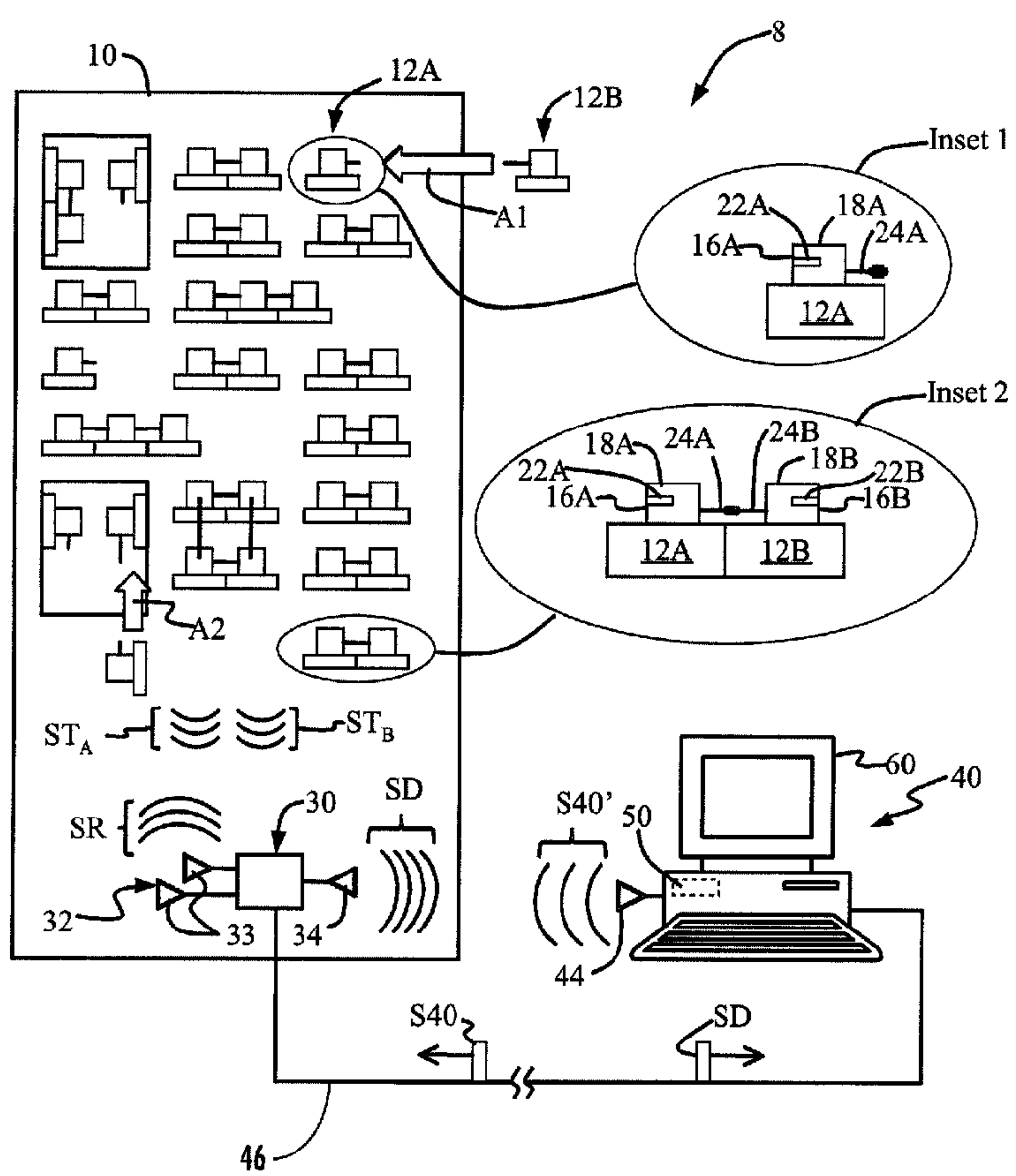
(54) Titre : SYSTEMES RFID ET PROCEDES DE DETECTION ET/OU D'ORIENTATION AUTOMATIQUES DE LA CONFIGURATION PHYSIQUE D'UN SYSTEME COMPLEXE

(54) Title: RFID SYSTEMS AND METHODS FOR AUTOMATICALLY DETECTING AND/OR DIRECTING THE PHYSICAL CONFIGURATION OF A COMPLEX SYSTEM



(57) Abrégé/Abstract:
A radio-frequency identification (RFID)-based configuration detection system for automatically detecting, directing, and/or configuring the physical configuration of a complex system constituted by a set of one or more types of mateable components. The

(57) Abrégé(suite)/Abstract(continued):
RFID configuration detection system utilizes a set of mateable RFID tags arranged so that each mateable component includes at least one mateable RFID tag. Each RFID tag includes information about its associated component and is arranged so that when the components are mated, their associated RFID tags also are mated. The system uses at least one RFID reader to read RFID tag signals from the RFID tags. The RFID tag signals provide information about mating status of the component, as well as information about components themselves. An information processing system operably connected to the RFID reader receives and process information concerning the number and type of mated connections and thus the configuration. Changes to the configuration, such as mated connections being unmated, can be tracked to provide real-time configuration information.

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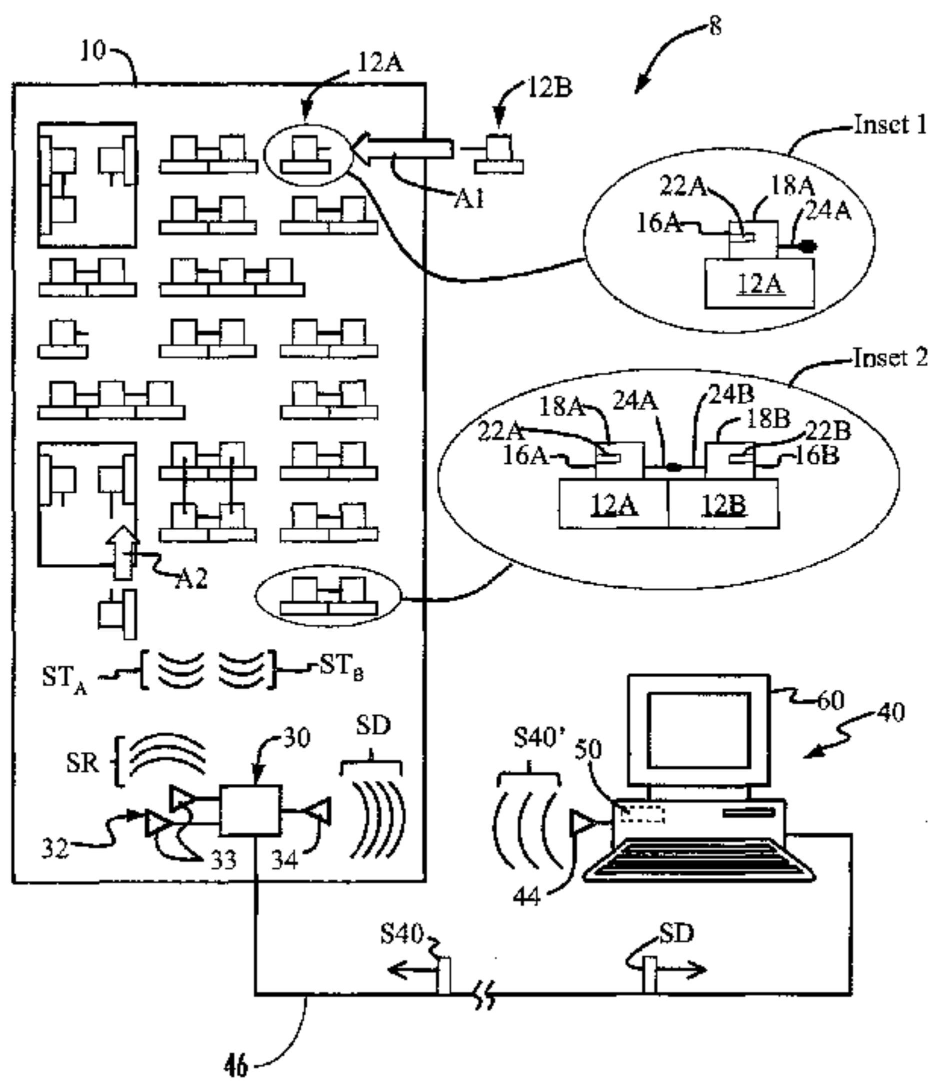
(54) Title: RFID SYSTEMS AND METHODS FOR AUTOMATICALLY DETECTING AND/OR DIRECTING THE PHYSICAL CONFIGURATION OF A COMPLEX SYSTEM

FIG. 1



(57) **Abstract:** A radio-frequency identification (RFID)-based configuration detection system for automatically detecting, directing, and/or configuring the physical configuration of a complex system constituted by a set of one or more types of mateable components. The RFID configuration detection system utilizes a set of mateable RFID tags arranged so that each mateable component includes at least one mateable RFID tag. Each RFID tag includes information about its associated component and is arranged so that when the components are mated, their associated RFID tags also are mated. The system uses at least one RFID reader to read RFID tag signals from the RFID tags. The RFID tag signals provide information about mating status of the component, as well as information about components themselves. An information processing system operably connected to the RFID reader receives and process information concerning the number and type of mated connections and thus the configuration. Changes to the configuration, such as mated connections being unmated, can be tracked to provide real-time configuration information.

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RFID SYSTEMS AND METHODS FOR AUTOMATICALLY DETECTING AND/OR DIRECTING THE PHYSICAL CONFIGURATION OF A COMPLEX SYSTEM

RELATED APPLICATIONS

[0001] The present application claims priority to U.S. Provisional Patent Application Serial No. 61/011,194, filed on January 15, 2008 and entitled "RFID SYSTEMS AND METHODS FOR AUTOMATICALLY DETECTING AND/OR DIRECTING THE PHYSICAL CONFIGURATION OF A COMPLEX SYSTEM," which is incorporated herein by reference in its entirety.

BACKGROUND

Field of the Disclosure

[0002] The technology of the disclosure relates generally to the use of radio-frequency identification (RFID) systems, and in particular is directed to RFID-based systems and methods for automatically detecting, directing, and/or configuring the physical configuration of a complex system, such as a telecommunications system.

Technical Background

[0003] Typical telecommunications data centers include large numbers of optical and electrical cable connections that join various types of network equipment. Examples of network equipment include electrically-powered (active) units such as servers, switches and routers, and unpowered (passive) units such as fanout boxes and patch panels. This network equipment is often installed within cabinets in standard (e.g., 19") equipment racks. Each piece of equipment typically provides one or more adapters where optical or electrical patch cables can be physically connected to the equipment. These patch cables are generally routed to other network equipment located in the same cabinet or to another cabinet.

[0004] A common issue in telecommunications data center management is determining the current configuration of all the optical and electrical links among all the network hardware equipment. The configuration of optical and electrical links can be completely determined if the physical locations of all connected patch cable connectors on installed network equipment are known.

[0005] Another issue is that some equipment is capable of being installed in any one of multiple orientations when only one particular orientation is correct or desirable. For example, a patch cable that contains a transmit optical fiber and a receive optical fiber needs to be connected to the corresponding adapter in the proper orientation or "polarization" so that the transmit/receive process can occur.

[0006] Information about the physical location and orientation of the adapters and their parent patch panels in data center cabinets is presently manually recorded and added to the network management software database after the adapters and patch panels are installed. This process is labor-intensive and prone to errors. Additionally, any changes made to the physical configuration of any network equipment must be followed up with corresponding changes to the network management software database, which delays providing the most up-to-date information about the system configuration. Furthermore, errors from manual recording and entry of configuration data tend to accumulate over time, reducing the trustworthiness of the network management software database. In addition, the need to connect a given connector or install a given piece of equipment in only one of a number of possible orientations also leads to errors in the system's physical configuration, as mentioned above. Finally, it is better to know of an incorrect connection as soon as it is made, rather than sometime later when a problem arises (e.g., loss of a connection or loss of data), and when the source of the problem is more difficult to diagnose.

SUMMARY OF THE DETAILED DESCRIPTION

[0007] A first aspect disclosed in the detailed description is a radio-frequency identification (RFID) system for detecting, directing, and/or configuring a configuration of a complex system having a set of one or more types of mateable components. The system includes a set of mateable RFID tags arranged so that each mateable component in the set includes at least one mateable RFID tag. The mateable RFID tags include information relating to their associated mateable components and are arranged so that the mating of components results in the mating of the corresponding RFID tags. The RFID system includes at least one RFID reader adapted to read an RFID tag signal sent from at least one RFID tag in a mated pair of RFID tags, wherein the at least one RFID tag signal contains information about the mated components. The RFID system also includes an information processing system operably connected to the at least one

RFID reader. The information processing system is adapted to receive and process information therefrom to establish a number and type of mated connections that constitute the complex system configuration. The information processing system is also optionally adapted to provide directions for configuring the system so that an end-user can configure the complex system.

[0008] A second aspect disclosed in the detailed description is an RFID configuration detection system for detecting, directing, and/or configuring a configuration of a complex system having a set of one or more types of mateable components. The RFID system includes at least one mateable RFID tag associated with each mateable component in the set of mateable components and having an antenna electrically connected to an integrated circuit (IC) chip. The IC chip is adapted to store information that includes information relating to its associated mateable component. The at least one mateable RFID tag is arranged relative to its associated component such that mating two mateable components causes the corresponding at least one mateable RFID tag associated with the two mateable components to mate and exchange the information stored therein, and to communicate information regarding their mated status via at least one wireless RFID tag signal. The RFID system includes at least one RFID reader adapted to receive the at least one wireless RFID tag signal from each mated pair of components. The RFID system also includes an information processing system operably connected to the at least one RFID reader. The information processing system is adapted to receive therefrom and process said mated status information to determine the complex system configuration. The information processing system is also optionally adapted to provide directions for configuring the system so that an end-user can configure the complex system.

[0009] A third aspect disclosed in the detailed description is an RFID-based method of detecting and/or directing a configuration of a complex system having a set of one or more types of mateable components. The method includes providing each mateable component in the set with at least one mateable RFID tag that includes information about its associated mateable component, including arranging the at least one mateable RFID tag so that when two mateable components mate, the corresponding mateable RFID tags mate and exchange information about their respective mateable components. The method also includes mating a number of mateable components so as to cause the corresponding mateable RFID tags to mate and exchange information about their respective mateable component. The method further includes, for each pair of mated components, generating at least one RFID tag signal that includes information relating to the mated components. The method further includes receiving and processing the at least one RFID tag signal from each pair of mated components to determine the complex system configuration.

[0010] The method optionally includes directing a change in the system configuration by causing an RFID tag to attract the attention of a system end-user with respect to a first mateable component, and then indicating to the system end-user to connect a second mateable component to the first mateable component.

[0011] Additional features and advantages of the invention will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the invention as described herein, including the detailed description that follows, the claims, as well as the appended drawings.

[0012] It is to be understood that both the foregoing general description and the following detailed description present embodiments of the invention, and are intended to provide an overview or framework for understanding the nature and character of the invention as it is claimed. The accompanying drawings are included to provide a further understanding of the invention, and are incorporated into and constitute a part of this specification. The drawings illustrate the various exemplary embodiments of the invention, and together with the description serve to explain the principals and operations of the invention.

Brief Description of the Figures

[0013] **FIG. 1** is a schematic diagram of an example embodiment of an RFID configuration detection system as shown in operable relation with a generalized example of a complex system having a number of juxtaposed mateable components;

[0014] **FIG. 2A** is a close-up schematic diagram of an example embodiment of two mateable RFID tags used in the RFID configuration detection system of **FIG. 1**, prior to the tags being mated;

[0015] **FIG. 2B** is a schematic diagram similar to that of **FIG. 2A,** but with the two RFID tags mated;

[0016] **FIG. 3** is a perspective diagram of an example embodiment of a complex system in the form of a telecommunications system cabinet having a number of mateable components that include a cabinet with an equipment rack that holds rack-mountable housings, which in turn house various other types of telecommunications system components;

[0017] **FIG. 4** is a perspective diagram similar to **FIG. 3**, illustrating an example embodiment wherein the cabinet includes rail RFID tags arranged along both front vertical rails of the equipment rack to provide RFID tag connection redundancy as well as orientation information of the rack-mountable housing when mounted in the equipment rack;

[0018] **FIG. 5A** is a perspective diagram similar to **FIG. 3**, illustrating the addition of patch-panel components to the rack-mounted housings, wherein the patch-panel components include patch-panel RFID tags that mate with the corresponding housing RFID tags;

[0019] **FIG. 5B** is a close-up front view of an example embodiment of a patch-panel component that includes two patch-panel RFID tags, and wherein each adapter in the patch panel has an associated adapter RFID tag;

[0020] **FIG. 5C** is a close-up perspective schematic diagram similar to **FIG. 5A**, showing in greater detail how the patch-panel RFID tags mate with the housing RFID tags, and how the housing RFID tags mate with the rail RFID tags;

[0021] **FIG. 6A** is a perspective diagram similar to **FIG. 5A**, illustrating the addition to the system of a jumper cable connected to two adapters of different patch panels;

[0022] **FIG. 6B** is a close-up side view of the jumper cable and one of its connectors prior to the connector being inserted into an adapter of the patch panel and the jumper RFID tag mating with the adapter RFID tag;

[0023] **FIG. 6C** is similar to **FIG. 6B**, illustrating the jumper cable connector mated with the patch-panel adapter, and the jumper RFID tag mated with the adapter RFID tag, and also showing the subsequent transmission of RFID tag signals from the two RFID tags to the RFID reader;

[0024] **FIG. 7** is similar to **FIG. 6A**, and shows the addition to the telecommunications cabinet of another component in the form of rack-mounted electronics;

[0025] **FIG. 8** is a schematic diagram similar to **FIG. 7**, and shows a sample telecommunications cabinet with a single jumper cable joining two adapters on two different patch panels of two different housings;

[0026] **FIGS. 9A**, **9B** and **9C** illustrate example embodiments of how individual RFID tags on various system components are provided with unique ID numbers *N* that include both a product serial number and a physical location in the complex system;

[0027] **FIG. 10A** is a schematic close-up side view similar to **FIG. 6B**, showing the jumper cable connector prior to being connected (mated) to a patch-panel adapter, wherein the adapter has associated therewith four adapter RFID tags arranged on respective sides of the adapter;

[0028] **FIG. 10B** is a front-on view of the adapter of **FIG. 10A,** along with the four associated adapter RFID tags arranged so that a given mating between the jumper RFID tag and one of the adapter RFID tags provides information regarding the orientation of the jumper connector relative to the adapter; and

[0029] **FIG. 11** shows an example of displaying the detected configuration of the example telecommunications system cabinet in the process of being configured.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0030] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings, in which some, but not all embodiments of the invention are shown. Indeed, the invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Whenever possible, like reference numbers will be used to refer to like components or parts.

[0031] The detailed description discloses systems for and methods of automatically detecting the physical configuration of the components of a relatively complex apparatus, piece of equipment, appliance, device, instrument, tool, mechanism, system, etc. (collectively referred to hereinafter as a "complex system"). A related aspect includes directing the configuration of the complex system, and in particular the re-configuration of the system. Here, a "complex system" means a system having a number of mateable components that, because of their sheer numbers and/or the character of how the components mate, manually tracking the different possible system configurations can be tedious and/or can be relatively difficult and can lead to errors in the system configuration. In an example embodiment, what constitutes a "complex system" is not a function of the number of components *per se*, but rather is a function of the importance of achieving the proper mating connection among different system components, and the adverse consequences associated with making one or more improper connections. Thus, in embodiments disclosed herein, a system having just a few mateable components can be considered a "complex system" if manually tracking the configuration of the mateable components is problematic due to their location and/or if the adverse consequences to the system are considered severe if the configuration is improper or if the configuration changes due to a component failure or other unintended reason.

[0032] In an example embodiment, the systems and are described in connection with complex systems based on telecommunications system apparatus. Such apparatus includes components in the form of various types of network equipment, including the associated optical and electrical links in a data center application. Each system component (e.g., a piece of network equipment such as patch cable connectors, adapters, patch panels and rack-mounted housings, electronics and optical/electrical equipment, etc.) is provided with one or more RFID tags that are able to detect physical mating with RFID tags on other network equipment.

[0033] In another example embodiment, the RFID tags (which are also referred to in the art as "RFID transponders") include a switch (e.g., a push-button-type switch) that electrically connects/disconnects and activates/deactivates the RFID antenna so that a person (e.g., a technician) installing components into the complex system can selectively activate the RFID tags during the process. In another embodiment, the switch provides a latchable signal to the integrated circuit (IC) as an IC input rather than or in addition to connecting or activating the antenna. For example, the technician can activate the RFID tag to generate a signal representative of the type of component to which the RFID tag is attached, and where the component is to be connected. An example of such an RFID tag is described in U.S. Patent Application Serial No. 11/590,377 filed October 31, 2006 and entitled "Radio Frequency Identification Transponder for Communicating the Condition of a Component," which is incorporated herein by reference in its entirety.

[0034] Generally speaking, the term "component" as used herein is intended to be widely construed to include, for example, a piece of equipment, device, tool, apparatus, connector, structure, element, constituent, module, part, unit, machinery, gear, etc. that makes up the complex system and that plays a role in determining the complex system configuration. In example embodiments, some components of the complex system need not be considered when detecting the system configuration. What constitutes a component that needs to be considered when detecting the system configuration will depend on the nature of the complex system and the end-user's needs with regard to what constitutes operable and non-operable states of the complex system. For example, in the discussion below, a telecommunications system cabinet is considered, wherein the cabinet has a frame. In certain instances, the frame can be considered a "component" because it supports an equipment rack and may be worth identifying as a specific frame amongst a host of such frames in a central office. On the other hand, the frame as a component may not be considered relevant by the end-user as compared to detecting other components, such as jumper cables, when there is only one frame in a particular closet, for example. Thus, in the discussion and in the claims, a "set" of mateable components is considered, wherein the set can include some or all of the total number of components that constitute the complex system, as the case may be.

[0035] In the discussion below and in the figures, numbers presented in *italics* represent identification (ID) numbers *N* that generally include information having at least one piece of data relating to the component to which it is attached, such as for example, one or more serial numbers, relative locations, orientations, etc. In an example embodiment, the ID numbers *N* are stored and processed by the RFID configuration detection system in order to detect and communicate (e.g., display) the configuration of the complex system.

[0036] An example application of embodiments disclosed herein is described below in connection with telecommunications applications. However, the methods of detecting and/or directing the physical configuration of the complex system using mating RFID tags that exchange information (e.g., in the form of unique component ID numbers *N*) and that communicate their mating status can be used to automatically determine the configuration of any complex system having physically mateable components, and to direct the configuration (including the re-configuration) of the complex system.

[0037] Reference is now made in detail to certain embodiments, examples of which are illustrated in the accompanying drawings. Whenever possible, like or similar reference numerals are used throughout the drawings to refer to like or similar parts. The exemplary embodiments employ RFID technology that allows for automatically detecting and communicating the physical configuration of a complex system such as a telecommunications system. It should be understood that the embodiments disclosed herein relating to telecommunications systems are merely examples, each incorporating certain benefits. Various modifications and alterations may be made to the following examples within the scope of the present invention, and aspects of the different examples may be mixed in different ways to achieve yet further examples. Accordingly, the true scope of the invention is to be understood from the entirety of the present disclosure, in view of but not limited to the embodiments described herein. For example, in the example embodiments below, only a single RFID reader and antennas at the top and bottom of the racks or cabinets are shown and described for the sake of illustration. However, embodiments include configurations wherein one, two, or even more antennas are arranged in each shelf unit and/or wherein each shelf is completely independent of its rack and has one or more readers and one or more antennas associated therewith as needed to establish the configuration-detecting and/or configuration directing functionalities of the present invention as described in detail below.

[0038] **FIG. 1** is a schematic diagram of an example embodiment of an RFID configuration detection system ("RFID system") **8** according to embodiments disclosed herein, which is an RFID system capable of automatically detecting and communicating the physical configuration of a complex system. RFID system **8** also can be used to direct the configuring of the complex system, and in particular, the reconfiguring of the complex system. In an example embodiment, the physical configuration includes the presence or absence of various parts independent of their connectivity. For example, RFID system **8** of some embodiments may be configured to serve one or more other functions, such as the function of asset/inventory management, in addition to its configuration detection and configuration directing functions. RFID system **8** is shown interfaced with an example complex system **10** that includes a set of one or more different types of components **12**. For the sake of illustration, the set of components **12** include a number (e.g., a subset) of one or more different types of first components **12A** (see, e.g., **Inset 1**) and a number (e.g., a subset) of one or more different types of second components **12B** that are mateable with one, some or all of the first components (see, e.g., **Inset 2**).

[0039] Each first component **12A** has associated therewith (e.g., fixed thereto) a first RFID tag **16A.** First components **12A** are all shown schematically as being the same, though in practice a variety of different types of first components are typically included in complex system **10**. Each component **12A** is configured to mate with (e.g., mechanically, electrically or optically connect to) or otherwise be placed in operable relationship with a corresponding second component **12B** that has associated therewith (e.g., fixed thereto) a second RFID tag **16B**. RFID tags **16A** and **16B** are configured to mate (i.e., electrically connect) when first component **12A** mates with or is otherwise arranged in operable relationship to its counterpart second component **12B**.

[0040] For example, in the case where complex system **10** is a telecommunications cabinet as discussed below, components **12A** and/or **12B** may be, for example, rack-mountable electronic devices, rack-mountable electrical/optical devices, rack-mountable housings, patch panels, jumper cables, switches, routers, servers, and the like. These components may need to be arranged in the system in a select manner, e.g., a select orientation, and with select connections.

[0041] Note that the terms "first" and "second" components are used in the present example for the sake of convenience. The various components could also include "third" components that mate with the second components, "fourth" components that mate with the third components, etc. Thus, the invention can include embodiments wherein three or more RFID tags may all communicate to each other rather than just two tags in a point-to-point topology, e.g., on a common bus or star configuration, such as shown schematically in some of the components and RFID tags in complex system **10** of **FIG. 1**.

[0042] RFID tags **16A** and **16B** (which are referred to collectively as "RFID tag **16**" when discussing properties common to each tag) are discussed in greater detail below. Each RFID tag **16** includes a substrate **18**, an IC chip **20** (not shown in **FIG. 1**; see **FIGS. 2A** and **2B**), an antenna **22,** and electrical contact members **24**. Each RFID tag **16** is adapted to store information in IC chip **20**. In an example embodiment, this information includes at least one piece of data relating to the RFID tag's **16** associated component **12**. Each RFID tag **16** is also adapted to mate with an RFID tag of an associated component (via contact members **24**) and share and store information when the two related components **12A** and **12B** are brought into their operable (or in some cases, an inoperable) configuration in complex system **10**.

[0043] With continuing reference to **FIG. 1**, RFID system **8** further includes at least one RFID reader **30** that has an RFID antenna system **32** with at least one antenna element **33**. RFID reader **30** also optionally includes a second antenna system **34** for transmitting wireless data signals **SD**. RFID reader **30**, and in particular RFID antenna system **32**, is preferably arranged relative to complex system **10** so that it can receive RFID tag signals **ST** from all of the RFID tags **16** used to monitor the configuration of the complex system. In an example embodiment, this involves strategically arranging a plurality of antenna elements **33** throughout complex system **10**. In an example embodiment, RFID reader **30** is configured to switch between antenna elements **33** so that it can selectively interrogate and/or receive RFID tag signals **ST** from RFID tags **16** located in different regions of complex system **10**. In an example embodiment, multiple RFID readers **30** and multiple antenna elements **33** are used to provide RF coverage of complex system **10**.

[0044] With continuing reference to **FIG. 1**, RFID system **8** further includes an information processing system **40**, such as a computer, operably connected to RFID reader **30** and adapted to store and process information from RFID reader **30**. In an example embodiment, information processing system **40** includes a wireless antenna **44** (e.g., a wireless card) that receives wireless data signals **SD** from RFID reader **30** and that can transmit RF wireless communication signals **S40** to RFID reader **30** (e.g., to elicit the transmission of information from the RFID reader). In an example embodiment, information processing system **40** includes a wire (e.g., an Ethernet cable) **46** connected to RFID reader **30** for wired communication with RFID reader **30** via electronic data signals **SD** and/or electronic communication signals **S40**.

[0045] Information processing system **40** can include a database unit **50** adapted (e.g., via database unit software stored on a computer-readable medium) to store and process information, particularly information about RFID tags **16** provided to the information processing system **40** from RFID reader **30**. In an example embodiment, database unit **50** includes basic (e.g., background or general) information about complex system **10**, such as its overall structure, the number of components **12** that constitute the system, the different types of components making up the system, orientation information about orientation-sensitive components, etc. In an example embodiment, this basic information is inputted into database unit **50** (e.g., manually, or via an external computer-readable medium such as a compact disk or so-called "memory stick") prior to any configuration-status information being received from RFID reader **30**. In an example embodiment, information processing system **40** includes a display **60**, such as a standard liquid crystal display (LCD) monitor or personal digital assistant (PDA), to provide two non-limiting examples, that displays (e.g., using graphics and/or alphanumerics) the system configuration information stored in database unit **50**.

[0046] With continuing reference to **FIG. 1**, consider now one of the second components **12B,** such as for example a second piece of telecommunications network equipment (e.g., a patch panel), being installed into complex system **10** so as to mate with one of the first components **12A**, as illustrated by arrow **A1** (see also see **Inset 2**). This installation may involve, for example, placing a telecommunications network component into a rack-mounted housing **12H** (not shown in **FIG. 1**; see **Fig. 3**), as illustrated by arrow **A2**, and as discussed in an example embodiment below. While first component **12A** mates with second component **12B**, the RFID tag **16B** on second component **12B** electrically mates with RFID tag **16A** of first component **12A** via respective contact members **24B** and **24A**, as illustrated in **Inset 2**.

[0047] RFID tags **16** are configured to store information in IC chip **20,** such as ID numbers *N,* and exchange these numbers with its mated RFID tag. RFID tags **16** are also configured to transmit some or all of this information via a wireless RFID tag signal **ST** (i.e., RFID tag signals $\mathbf{ST_A}$ and $\mathbf{ST_B}$ for RFID tags **16A** and **16B**, respectively) transmitted by antenna **22**. In an example embodiment, RFID reader **30** is adapted to transmit RF wireless reader signals **SR**, which in an example embodiment are used to interrogate (poll) one or more RFID tags **16**. In another example embodiment, reader signals **SR** are used to write information to one or more RFID tags **16**, or to activate a signaling device **27**, such as a light (e.g., a light emitting diode (LED), on one or more of the RFID tags **16** (see **FIG. 2B**). RFID reader **30** also transmits the pairs of RFID tag ID numbers N (e.g., ID numbers N_A and N_B for mated RFID tags **16A** and **16B**) for all mated components **12** to information processing system **40** using (wireless and/or wired) data signals **SD**.

[0048] Database unit **50** within information processing system **40** stores and processes the information about complex system **10**. In an example embodiment, database unit **50** combines the information received from RFID reader **30** with previously stored basic information about complex system **10** to map all received RFID tag ID numbers N to known component types. Using the pairs of RFID tag ID numbers N, information processing system **40** automatically determines the relative positions (and optionally the component orientation of orientation-sensitive components) of the mated components **12**. As mentioned above, this information can then be displayed on display **60** to provide a user with a (real-time) view of the configuration of complex system **10**.

[0049] For example, where complex system **10** is a part of a telecommunications network, information processing system **40** automatically indicates which patch panel is attached to which port on a given rack-mounted housing. This information is recorded in database unit **50** without it ever having to be manually entered. In an example embodiment, information processing system **40** also immediately detects when other components **12** (e.g., patch cables, patch panels, housings, switches, routers, and servers in the case of a telecommunications application) are added or removed from complex system **10** (e.g., from any data center cabinets), and automatically updates database unit **50** to reflect any changes in the configuration of complex system **10**. This method leverages the pre-configuration of all RFID tags **16** at manufacture time and also provides a real-time configuration status of complex system **10**.

[0050] In an example embodiment where a component **12** includes more than one RFID tag **16** (e.g., a patch panel with twelve adapters, where each adapter has its own RFID tag), a standardized ID number scheme is used for each RFID tag so that its physical position *P* in complex system **10** (or its position relative to another component) can be determined via its ID number *N*. In addition, for components having orientation sensitivity, the RFID tag information allows the database unit software to determine if the orientation of the installed component is correct.

[0051] **FIG. 2A** is a schematic diagram of an example embodiment of two mateable RFID tags **16A** and **16B** according to embodiments disclosed herein, prior to the RFID tags being mated. RFID tag substrate **18** supports RFID (IC) chip **20** and RFID antenna **22**, which is electrically connected to IC chip **20**. IC chip **20** is configured to store information, such as the above-mentioned ID number *N*, which in turn may include one or more pieces of data, such as a serial number, component type, component manufacturer, manufacturing date, installation date, location, lot number, performance parameters (such as attenuation measured during installation), identification of what is at the other end of the component, etc. In an example embodiment, such information is preloaded onto IC chip **20** at manufacture time, or is loaded onto IC chip **20** using RFID reader **30** and reader signals **SR**.

[0052] In an example embodiment, contact members **24A** are "pogo pins" electrically connected to IC chip **20A**, while contact members **24B** are in the form of contact pads or contact slots electrically connected to IC chip **20B** and adapted to mate with contact members **24A** to establish an electrical connection between IC chips **20A** and **20B**, as shown in **FIG. 2B**. This allows IC chips **20A** and **20B** to exchange information, such as their respective ID numbers *N*, as well as a status indicator (e.g., a bit sequence) that indicates that RFID tags **16A** and **16B** are mated. In an example embodiment, this information is provided to RFID reader **30** in response to subsequent RFID reader polls via reader signals **SR**. This embodiment is preferred when RFID tags **16** require a polling signal from RFID reader **30** to power the IC chip **20**. In another example embodiment where IC chips **20** do not rely on an incoming signal for power, the RFID tags **16** automatically transmit this information when they are mated.

[0053] When RFID tags **16A** and **16B** are disconnected, in an example embodiment their disconnected state is saved in their respective IC chips **20A** and **20B** to indicate that they are disconnected from one another. This "disconnect" state is communicated to RFID reader **30** on subsequent RFID reader polls via reader signals **SR** or is transmitted by the RFID tags **16** at or near the time when the disconnection occurs. This disconnect state can also be displayed using signaling device **27** on one or both of the RFID tags **16** associated with disconnected components **12**.

[0054] **FIG. 3** is a perspective diagram of an example embodiment of a complex system **10** in the form of a telecommunications system cabinet **12C**. Cabinet **12C**, which itself is considered a "component," includes an outer support frame **12F** that supports right and left inner front vertical rails **102R** and **102L** (hereinafter, "right and left front rails") with respective right and left front faces **103R** and **103L**. Support frame **12F** also supports right and left inner rear vertical rails **104R** and **104L** (hereinafter, "right and left rear rails"), and includes a top panel **108** and a bottom panel **110**. Support frame **12F** and top and bottom panels **108** and **110** define a frame interior **120** with a front opening **124**. In an example embodiment, support frame **12F** includes a frame RFID tag **16F** that includes information about the support frame (e.g., its serial number, its location, its installation date, the types of components it supports, etc.).

[0055] In an example embodiment, front and rear rails **102** and **104** include support brackets (not shown) and define an equipment rack **12R** that supports one or more telecommunications network-related components **12** such as, for example, rack-mountable housings **12H** configured to be stored in a stacked fashion within frame interior **120**. In one example embodiment, each rack-mountable housing **12H** includes a front **141**, a top panel **142**, a bottom panel **144**, and right and left side panels **146R** and **146L** that define an open housing interior **148**.

[0056] RFID system **8** includes one or more "rail" RFID tags **16R** mounted on front right **102R** (e.g., on front surface **103R**). RFID system **8** also includes one or more "housing" RFID tags **16H** mounted on each housing **12H**. In an example embodiment, at least one of the housing RFID tags **16H** is mounted on one of the housing side panels **146R** or **146L** so as to mate with a corresponding rail RFID tag **16R** when housing **12H** is supported within equipment rack **12R** of cabinet **12C**. Other housing RFID tags **16H** are shown arranged on housing top panel **142** as well as within housing interior **148** for mating with RFID tags on individual patch panels, as discussed below.

[0057] In an example embodiment, all rail RFID tags **16R** in RFID system **8** are programmed at the time of manufacture with the aforementioned unique ID numbers *N*. In an example embodiment, ID numbers *N* indicate, for example, both a serial number *N* for the component and the relative position *P* of the component RFID tag. For example, ID numbers N_R for rail RFID tags **16R** indicate each RFID tag's **16R** relative position along front rail **102R**. This also allows each rail **102** to be automatically associated with a cabinet ID number N_C of the cabinet **12C** (or frame ID number N_F of the frame **12F**) in which it is installed. Likewise, in an example embodiment, all housing RFID tags **16H** are programmed at the time of manufacture with unique identification numbers N_H that indicate both the housing serial number and the position of the RFID tag P_H on the housing (e.g., its relative location along the top panel **142**).

[0058] In an example embodiment, at least one RFID reader **30** is included within, on or near cabinet **12C**. In one example embodiment, RFID reader **30** is mounted on frame top panel **108** (as illustrated in **FIG. 3**) or on frame bottom panel **110**. RFID reader antenna system **32** is preferably arranged to optimize RFID tag communication. In an example embodiment, antenna system **32** includes two or more antenna elements **33** arranged in different locations within, on or around cabinet **12C** to ensure that RFID reader **30** can read RFID tag signals **ST** from all RFID tags **16** of RFID system **8** associated with the complex system **10** defined by cabinet **12C**, and to transmit RFID reader signals **SR** to one or more of the RFID tags. Also, as discussed above, in an example embodiment, RFID reader **30** is configured to switch between antenna elements **33** so that it can selectively interrogate RFID tags **16** with RFID signals **SR** and/or receive RFID tag signals **ST** from RFID tags **16** located within different regions of cabinet **12C**.

[0059] An example embodiment of RFID system **8** provides various RFID tags **16** arranged such that if a given component **12** of complex system **10** is not installed in its proper orientation, the corresponding RFID tags **16** cannot mate. For example, with reference to **FIG. 3**, if housing **12H** were mounted upside down in cabinet **12C**, the corresponding rail RFID tags **16R** and the housing RFID tags **16H** would not mate because there are no rail RFID tags on left front vertical rail **102L**. Failure to generate at least one RFID tag signal **ST** upon installing housing

12H would indicate an incorrect housing orientation and thus an incorrect configuration for cabinet **12C**.

[0060] In an alternate example embodiment illustrated in **FIG. 4**, rail RFID tags **16R** are provided on both right and left front vertical rails **102R** and **102L**. In this case, the corresponding rail RFID tags **16R** and housing RFID tags **16H** mate when the housing is added to equipment rack **12R**, but each housing RFID tag **16H** is programmed to indicate if it is on the top or bottom of the particular housing. The redundant rail RFID tags **16R** provide information about the installation of housing **12H** even with the failure of one of the rail RFID tags, or if there is tag-mating failure on one end of the housing. In an example embodiment, this same redundancy method is applied to some or all of the other components, such as the modules within the housing, or even adapters within the modules.

[0061] When housing **12H** is installed in cabinet **12C**, the housing RFID tag **16H** on side panel **146R** automatically mates with the corresponding rail RFID tag **16R** on front vertical rail **102R**, and the RFID tags **16** exchange information. When the mated RFID tags **16R** and **16H** are polled by reader signal **SR** from RFID reader antenna system **32**, in an example embodiment both RFID tags **16** respond with respective RFID tag signals **ST** that include the identification number of their mating RFID tag **16** (see e.g., **FIG. 1**) and optionally a status indicator (e.g., a bit sequence) that indicates that RFID tags **16H** and **16R** are mated.

[0062] **FIG. 5A** is a schematic diagram similar to **FIG. 3**, but showing the insertion of patch panels **12P** in rack-mounted housings **12H** that are already installed within equipment rack **12R** of cabinet **12C**. Patch panels **12P** include at least one patch-panel RFID tag **16P**. Patch panel **12P** includes an array of adapters **12A**, with each adapter having associated therewith an adapter RFID tag **16A**, as illustrated in the close-up front-on view of patch panel **12P** of **FIG. 5B**.

[0063] **FIG. 5C** is a close-up schematic diagram similar to **FIG. 5A**, showing more details of how patch-panel RFID tags **16P** mate with the corresponding housing RFID tags **16H**, and how rail RFID tags **16R** on right front vertical rail **102R** mate with the corresponding housing RFID tags **16H**. In **FIG. 5C**, adapters **12A** are omitted for ease of illustration. Housing **12H** in **FIG. 5C** is shown as having a top front flange **147** and two side front flanges **149** that facilitate mounting the housing in equipment rack **12R**. Top front flange **147** includes a number housing RFID tags **16H** (three such RFID tags are shown). Right-side front flange **149** includes another housing RFID tag **16H**. When a patch panel **12P** is mounted to front **141** of housing **12H**, the patch-panel RFID tag **16P** mates with the corresponding housing RFID tags **16H** on top front flange **147**. Likewise, when housing **12H** is mounted into equipment rack **12R** of cabinet **12C**, housing RFID tag **16H** on right-side front flange **149** mates with rail RFID tag **16R** on face **103R** of vertical right front rail **102R**.

[0064] As illustrated generally in **FIG. 1**, when the RFID tags **16** are polled by RFID reader signal **SR**, the mated RFID tags respond by transmitting an RFID tag signal **ST** that includes the ID number *N* of their mating RFID tag. Further, as shown in **FIG. 5A**, housing **12H** may include additional housing RFID tags **16H** on a bottom panel **144** to provide a way to detect whether the orientation of the inserted patch panel is incorrect (i.e., installed upside-down).

[0065] **FIG. 6A** is a schematic diagram of RFID system **8** and complex system **10** similar to that shown in **FIG. 5A**, illustrating the addition to cabinet **12C** of another component in the form of a patch cable (or "jumper" cable) **12J** that enables a communication link between two adapters **12A** on two separate patch panels **12P**. Jumper cable **12J** includes a cable section **231** and connectors **232A** and **232B** at the cable's opposite ends. In an example embodiment, each connector **232A** and **232B** of jumper cable **12J** respectively includes a jumper RFID tag **16JA** and **16JB** integrated therewith or otherwise fixed thereto, as shown in the close-up side view of the jumper cable and adapter array **230** of **FIG. 6B**. In an example embodiment, jumper RFID tags **16J** are programmed at the time of manufacture with a unique identification number N_J that indicates both the jumper cable serial number and the specific connector type used on the jumper cable.

[0066] With reference now to **FIG. 6C**, when jumper connector **232A** is installed in a patch panel adapter **12A**, its jumper RFID tag **16JA** automatically mates with the corresponding adapter RFID tag **16A** of patch panel **12P**. When the mated RFID tags **16JA** and **16A** are polled by RFID reader signal **SR** from RFID reader **30**, one or both RFID tags respond with transmitting respective RFID tag signals **ST** (i.e., $\mathbf{ST_{JA}}$ and/or $\mathbf{ST_A}$) that include the ID number *N* of their mating RFID tag. In an alternative example embodiment, only one of the mated RFID tags (**16JA** or **16A**) transmits a RFID tag signal **ST** that includes both ID numbers N_J and N_A and optionally a status indicator (e.g., a bit sequence) that indicates that RFID tags **16JA** and **16A** are mated.

[0067] **FIG. 7** is similar to the view of RFID system **8** and cabinet **12C** of **FIG. 6A**, and shows the addition to equipment rack **12R** of another rack-mounted component in the form of rack-mounted electronics **12E**. Like the previous components added to cabinet **12C**, rack-mounted electronics **12E** includes an electronics RFID tag **16E** configured to mate with a corresponding rail RFID tag **16R** on right front face **103R** of right front vertical rail **102R**. In an example embodiment, electronics RFID tag **16E** is programmed at the time of manufacture with a unique identification number N_E that can be used to determine features of rack-mounted electronics **12E** using the database unit software, which in an example embodiment relating to a telecommunications system includes network management software. When the mated RFID tags **16E** and **16R** are polled by a signal **SR** from the RFID reader antenna, in an example they each respond by transmitting respective RFID tag signals **ST** (i.e., $\mathbf{ST_E}$ and $\mathbf{ST_C}$) that include the ID number N_C and N_E of their mating RFID tag, and optionally a status indicator (e.g., a bit sequence) that indicates that RFID tags **16E** and **16R** are mated.

[0068] Now presented is an example showing how RFID system **8** can be used to automatically detect the physical configuration of a telecommunications data center having components such as cables, fibers and like equipment such as described above, and to direct the configuration of the system. **FIG. 8** is a schematic diagram similar to **FIG. 5A**, showing a sample cabinet **12C** wherein a single jumper cable **12J** joins two adapters **12A** on two different patch panels **12P** in two different housings **12H**. Each component **12** includes one or more RFID tags **16** with a unique ID number *N*.

[0069] **FIGS. 9A**, **9B** and **9C** illustrate an example embodiment of how individual RFID tags **16** on various system components **12** of complex system **10** of **FIG. 8** have unique ID numbers *N* that include, for example, a product serial number and a physical location of the RFID tag **16** in complex system **10**. In **FIGS. 9A**, **9B** and **9C**, the ID numbers *N* for the various components **12** are shown in *italics*. In cases where a particular ID number *N* is not explicitly shown, it can be inferred from neighboring labeled RFID tags.

[0070] For example, with reference to **FIG. 9A**, the eighteen rail RFID tags **16R** located on right front rail **102R** of frame **12F** have corresponding ID numbers N_C = { *1-1, 1-2,...1-18*}. Likewise, the eight housing RFID tags **16H** on the lower-most housing **12H** have corresponding cabinet ID numbers N_H = {*22-1, 22-2,...22-8*}, while the three housing RFID tags **16H** on the upper-most housing **12H** have housing ID numbers N_H = {*21-0, 21-1,...21-4*}.

[0071] With reference now to **FIG. 9B**, the two jumper RFID tags **16JA** and **16JB** associated with respective connectors **232A** and **232B** have jumper ID numbers N_J = {*4001-1,* *4001-2*}. Likewise, with reference now to **FIG. 9C**, the twelve adapter RFID tags **16A** associated with adapters **12A** on upper-most patch panel **12P** have patch-panel ID numbers N_A = {*301-1, 301-2,...301-12*}, while the twelve adapter RFID tags **16A** on the lower-most patch panel **12P** have adapter ID numbers N_A = {*302-1, 302-2,...302-12*}. Likewise, the upper-most patch-panel **12P** has two patch-panel RFID tags with ID numbers N_P = {301-0, 301-13}, while the lower-most patch-panel **12P** has two patch-panel RFID tags with ID numbers N_P = {302-0, 303-13}.

[0072] An example embodiment of RFID system **8** of the present invention uses RFID tags **16** to confirm that orientation-sensitive components **12** have been correctly installed into complex system **10**. **FIG. 10A** is a schematic side view of connector **232A** of jumper cable **12J** being connected to an adapter **12A** of patch panel **12P**, wherein the adapter **12A** includes four adapter RFID tags **16A** arranged on respective sides of the adapter **12A**. **FIG. 10B** is a front-on view of adapter **12A** and the four associated adapter RFID tags **16A**. Adapter RFID tags **16A** include information about their respective positions relative to adapter **12A** (i.e., top, bottom, left side, right side). In the case where it is possible to insert jumper connector **232A** into adapter **12A** in more than one orientation, the arrangement of adapter RFID tags **16A** allows for one of the four adapter RFID tags **16A** to mate with the jumper RFID tag **16JA**. In the example shown in **FIG. 10A** and **FIG. 10B**, it is assumed that four different orientations are possible. In general, the arrangement of RFID tags **16** in **FIG. 10A** and **FIG. 10B** to establish orientation involves two or more RFID tags **16**. This method allows for RFID system **8** to detect whether a given component—here, jumper cable **12J**—is correctly installed in complex system **10**. If incorrectly installed, database unit **50** (or signaling device **27**) flags the improper connect condition and in an example embodiment, conspicuously indicates the improper connect condition so that an end-user can immediately spot the incorrect connection and take corrective action (e.g., insert connector **232A** into adapter **12A** in its proper orientation). This is one of the ways in which RFID system **8** facilitates configuring a complex system such as complex system **10**.

[0073] When all of components **12** are finally installed in complex system **10** and RFID reader **30** has identified the set of all mated RFID tags **16**, the component configuration information is provided to an end-user of complex system **10** (or an end-user of RFID system **8**, as the case may be). In an example embodiment, information about the component configuration of complex system **10** is displayed on display **60** of information processing system **40**. In an example embodiment, information processing system **40** includes a graphics driver and uses graphics to display a representation of complex system **10** on display **60**.

[0074] **FIG. 11** shows an example display **60** that displays graphic and/or alphanumeric information about the configuration of the above-described example complex system **10** in the form of telecommunications cabinet **12C**. Display **60** shows the various network-related components **12C** and a list of mated RFID tags **16** obtained by RFID tag reader **30**. The information shown on display **60** is provided by database unit **50** and is based on ID number information provided by RFID reader **30** and so is presented in *italics* in **FIG. 11** for the sake of illustration. The physical configuration, and hence the physical location, of each component **12** in complex system **10** can be inferred from the complete set of neighboring labeled RFID tags that are found to be mated to each other.

[0075] An example of providing a progressive summary of the evolving configuration of complex system **10** as based on individual mated RFID tag data of the type that might be communicated via display **60** of information processing system **40** via the operation of the network management software operating in database unit **50** is as follows:

1-6 ←→ 21-0

- Housing *21* is mounted in Cabinet *1*, Rack position *6*.

21-1 ←→ 301-0

- Patch panel *301* is mounted in Housing *21*, Patch panel position *1*, in Cabinet *1*, Rack position *6*.

301-7 ←→ 4001-1

- Jumper *4001* Connector *1* is mounted in Patch panel *301*, Adapter position *7*, in Housing *21,* Patch panel position *1*, in Cabinet *1*, Rack position *6*.

1-14 ←→ 22-0

- Housing *22* is mounted in Cabinet *1*, Rack position *14*

22-1 ←→ 302-0

- Patch panel *302* is mounted in Housing *22*, Patch panel position *1*, in Cabinet *1*, Rack position *14*.

302-6 ←→ 4001-2

- Jumper *4001* Connector *2* is mounted in Patch panel *302*, Adapter position *6*, in Housing *22*, Patch panel position *1*, in Cabinet *1*, Rack position *14*.

[0076] Based on this information, the configuration of any component **12** in complex system **10** can be determined. For example, it is possible to determine how a specific jumper cable **12J** is configured, and this information may be displayed on display **60** as follows:

- Patch panel *301*, Adapter position *7*, in Housing *21*, Patch panel position *1*, in Cabinet *1*, Rack position *6*
  with
- Patch panel *302*, Adapter position *6*, in Housing *22*, Patch panel position *1*, in Cabinet *1*, Rack position *14*.

[0077] This particular telecommunication-based example utilizes a method that incorporates detection of a jumper cable to adapters, adapter attachment in patch panels, patch panel attachment to housings, and housing attachment to cabinets. While this hierarchical approach is well-suited for many communications network equipment applications, including data center management, there are other applications where a non-hierarchical interconnection of mating RFID tags is desirable. For example, consider determining the physical configuration of a two-dimensional array of components. RFID tags can be positioned on the four sides of each component, and arranged to mate with corresponding tags on neighboring components. In addition, similar approaches could be used in applications other than communications network equipment applications. For example, similar approaches could be used to assure proper assembly of complex mechanical, electrical, and optical structures, as well as complex structures that employ combinations of electrical, mechanical and optical components.

[0078] As discussed above, RFID tags **16** can include switches that allow for the RFID tag **16** to transmit information to RFID reader **30** about the component **12** to which the particular RFID tag **16** is attached. Thus, in an example embodiment, the method includes actively managing the configuration of complex system **10** as the complex system **10** is being configured, for example, by an on-site technician. This method includes, for example, activating the RFID tag **16** for a given component (for example, a component **12A** of **FIG. 1**) prior to mating the component **12** with another component (for example, a component **12B** of **FIG. 1**). The RFID reader **30** receives this RFID tag signal and consults information processing system **40**, which tells the RFID reader **30** to which component **12B** the component **12A** is supposed to be mated. RFID reader **30** then transmits a signal to the corresponding RFID tag **16B**, which in an example embodiment includes signaling device **27**, such as a light, which is activated by the RFID reader signals via IC chip **20**. This shows the technician to which component **12B** the component **12A** in hand is to be connected.

[0079] When the proper connection is made, confirmation is carried out as described above by both RFID tags **16A** and **16B** transmitting the other tags ID number N to RFID reader **30**, which information is then transmitted to information processing system **40**. If the particular components **12A** and **12B** are not supposed to be connected, then information processing system **40** sends a signal to RFID reader **30** that indicates an incorrect connection. RFID reader **30** then sends a signal to one or both RFID tags **16A** and **16B** to cause signaling device(s) **27** to be activated in a manner that indicates a connection error (e.g., blinking red lights).

[0080] Embodiments of the present invention have a number of advantages, particularly relating to the application to complex telecommunications systems. By standardizing the RFID tag-to-tag mating hardware, the same method for detecting installed network components can be applied to all types of data center network equipment, including components from different companies and manufacturers. Further, the ability to automatically monitor the configuration of a complex telecommunications system can be used to help guide the system installers to achieve the proper system configuration in less time and with fewer errors in the final system.

[0081] In an example embodiment, the database unit software includes network management software adapted to determine the current (i.e., real-time) physical configuration of a data center network using information from mated RFID tag pairs on network equipment. Thus, the system configuration can be constantly updated as changes are made to the system, such as components being mated (connected) and unmated (disconnected). This eliminates the need to manually record and enter physical location data on network equipment into network management software both during system set-up as well as during system maintenance or when changing the system configuration for any reason. It also ensures that the network management software database is completely accurate, even while new network equipment is being added or removed.

[0082] Another advantage of the embodiments disclosed herein is that the RFID configuration detection system can be set up to track the correct orientation of orientation-sensitive components and can be configured to provide detection redundancy should one of the RFID tags fail or should two tags fail to properly mate.

[0083] Many modifications and other embodiments of the invention set forth herein will come to mind to one skilled in the art to which the invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings.

[0084] Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. It is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

What is claimed is:

1. A radio-frequency identification (RFID) system for detecting and/or directing a configuration of a complex system having a set of one or more types of mateable components, comprising:

a set of mateable RFID tags arranged so that each mateable component in the set includes at least one mateable RFID tag, wherein the at least one mateable RFID tag includes information relating to their associated mateable components and are arranged so that the mating of components results in the mating of the corresponding mateable RFID tags;

at least one RFID reader adapted to read an RFID tag signal sent from at least one RFID tag in a mated pair of RFID tags, wherein the RFID tag signal contains information about the mated components; and

an information processing system operably connected to the at least one RFID reader and adapted to receive and process information therefrom to establish a number and type of mated connections that constitute the complex system configuration.

2. The system of claim 1, wherein at least one of the mateable RFID tags is adapted to transmit an RFID tag signal that indicates an unmated status when two mated RFID tags become unmated.

3. The system of claim 1, wherein at least one mateable component includes two or more mateable RFID tags arranged so as to indicate an orientation of the at least one mateable component when mated with another mateable component.

4. The system of claim 1, including a database unit operably connected to a display operable to display information about the complex system configuration.

5. The system of claim 1, wherein:

the complex system is a telecommunication system, and wherein the set of mateable components includes one or more components selected from the group of components comprising: patch panels, patch-panel adapters, jumper cables, housings, equipment racks, and a cabinet;

the mateable RFID tags include unique ID numbers for each telecommunication system component; and

the information processing system includes basic information about the telecommunication system that is combined with configuration-status information provided by the at least one RFID reader in order to detect and communicate the telecommunication system configuration.

6. A radio-frequency identification (RFID) configuration detection system for detecting and/or directing a configuration of a complex system having a set of one or more types of mateable components, comprising:

at least one mateable RFID tag associated with each mateable component in the set of mateable components and having an antenna electrically connected to an integrated circuit (IC) chip, the IC chip being adapted to store information that includes information relating to its associated mateable component, wherein the at least one mateable RFID tag is arranged relative to its associated component such that mating two mateable components causes the corresponding at least one mateable RFID tag associated with the two mateable components to mate and exchange the information stored therein, and to communicate information regarding their mated status via at least one wireless RFID tag signal;

at least one RFID reader adapted to receive the at least one wireless RFID tag signal from each mated pair of components; and

an information processing system operably connected to the at least one RFID reader and adapted to receive therefrom and process said mated status information to determine the complex system configuration.

7. The system of claim 6, wherein at least one of the mateable components is orientation sensitive and has associated therewith one or more mateable RFID tags arranged so as to establish a mating orientation when the at least one orientation-sensitive component is mated with another mateable component.

8. The system of claim 6, wherein the stored information in each IC chip includes a unique identification (ID) number relating to the associated mateable component.

9. The system of claim 6, wherein the information processing system includes a database unit adapted to store said mated status information on an ongoing basis to provide a real-time status of the complex system configuration.

10. The system of claim 9, wherein the information processing system includes a display operably coupled to the database unit and adapted to display information relating to the configuration of the complex system.

11. The system of claim 6, wherein the complex system includes a telecommunications network, and wherein the mateable components are selected from the group of mateable components comprising: a cabinet, an electronics rack, a rack-mountable electronic device, a rack-mountable electrical/optical device, a rack-mountable housing, a patch panel, a jumper cable, a switch, a router, and a server.

12. The system of claim 6, wherein the at least one RFID reader includes an antenna system having one or more antenna elements arranged relative to the complex system so as to detect RFID tag signals from different regions of the complex system.

13. The system of claim 12, wherein the at least one RFID reader is adapted to generate polling signals that elicit the RFID tag signals from the mated RFID tags.

14. A radio-frequency identification (RFID)-based method of detecting and/or directing a configuration of a complex system having a set of one or more types of mateable components, comprising:

providing each mateable component in the set with at least one mateable RFID tag that includes information about its associated mateable component, including arranging the at least one mateable RFID tag so that when two mateable components mate, the corresponding mateable RFID tags mate and exchange information about their respective mateable components;

mating a number of mateable components so as to cause the corresponding mateable RFID tags to mate and exchange information about their respective mateable component;

for each pair of mated components, generating at least one RFID tag signal that includes information relating to the mated components; and

receiving and processing the at least one RFID tag signal from each pair of mated components to determine the complex system configuration.

15. The method of claim 14, wherein the generating of the at least one RFID tag signal includes, for at least one pair of mated components, generating one RFID tag signal from each mated RFID tag.

16. The method of claim 14, further including displaying the complex system configuration.

17. The method of claim 14, wherein the mateable RFID tags are polled periodically to elicit RFID tag signals to provide updated information about the complex system configuration.

18. The method of 14, wherein at least one of the types of mateable components is orientation sensitive, and further including:

arranging the at least one mateable RFID tag relative to the orientation-sensitive component so that a component orientation can be deduced when the orientation-sensitive component is mated with another component.

19. The method of claim 14, further including directing a change in the complex system configuration by:

causing an RFID tag to attract the attention of a system end-user with respect to one or more of the mateable components; and

indicating to the system end-user to connect at least one of the other mateable components to said one or more mateable components.

20. The method of claim 14, further including transmitting an RFID tag signal that indicates when two mated components become unmated.

1/15

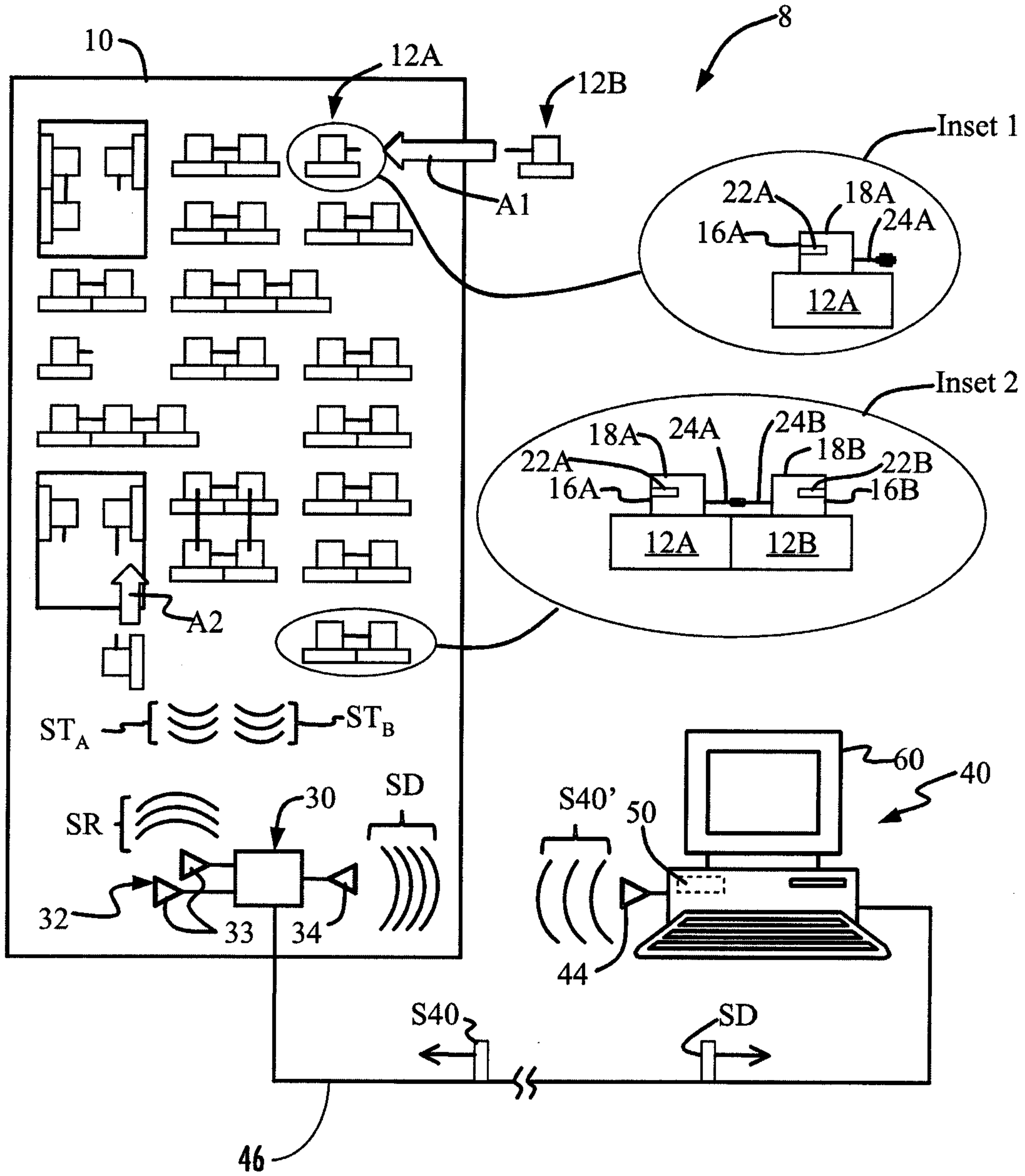

8
10
12A
12B
A1
Inset 1
22A
18A
16A
24A
12A
Inset 2
18A
24A
24B
18B
22A
22B
16A
16B
12A
12B
A2
ST_A
ST_B
SR
30
SD
32
33
34
60
40
S40'
50
44
S40
SD
46

FIG. 1

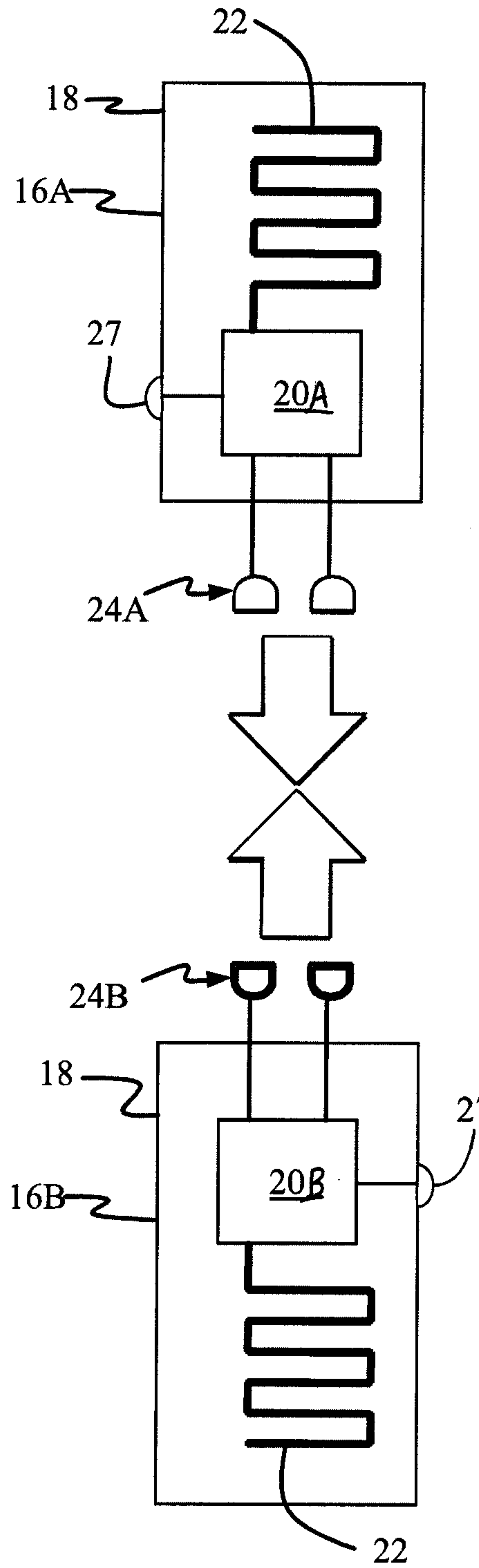

22
18
16A
27
20A
24A
24B
18
16B
20B
27
22

FIG. 2A

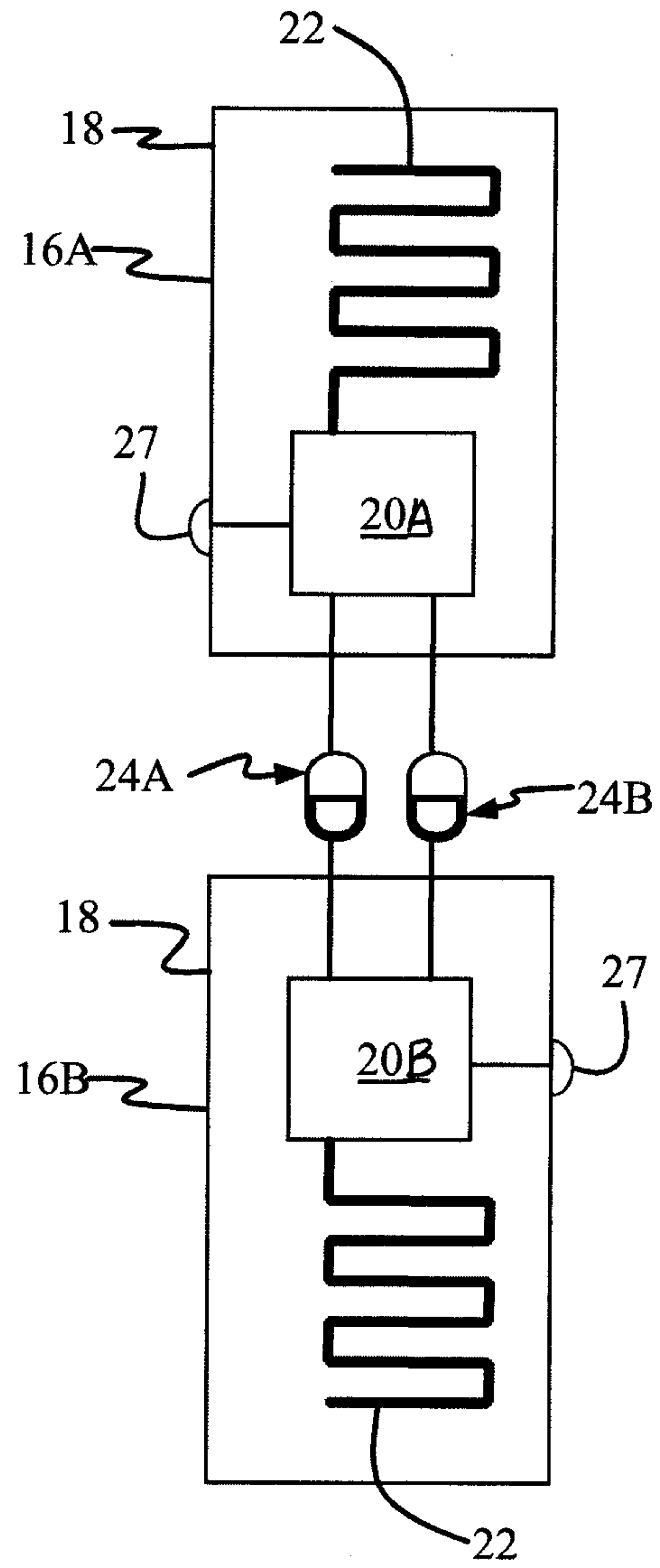

22
18
16A
27
20A
24A
24B
18
27
16B
20B
22

FIG. 2B

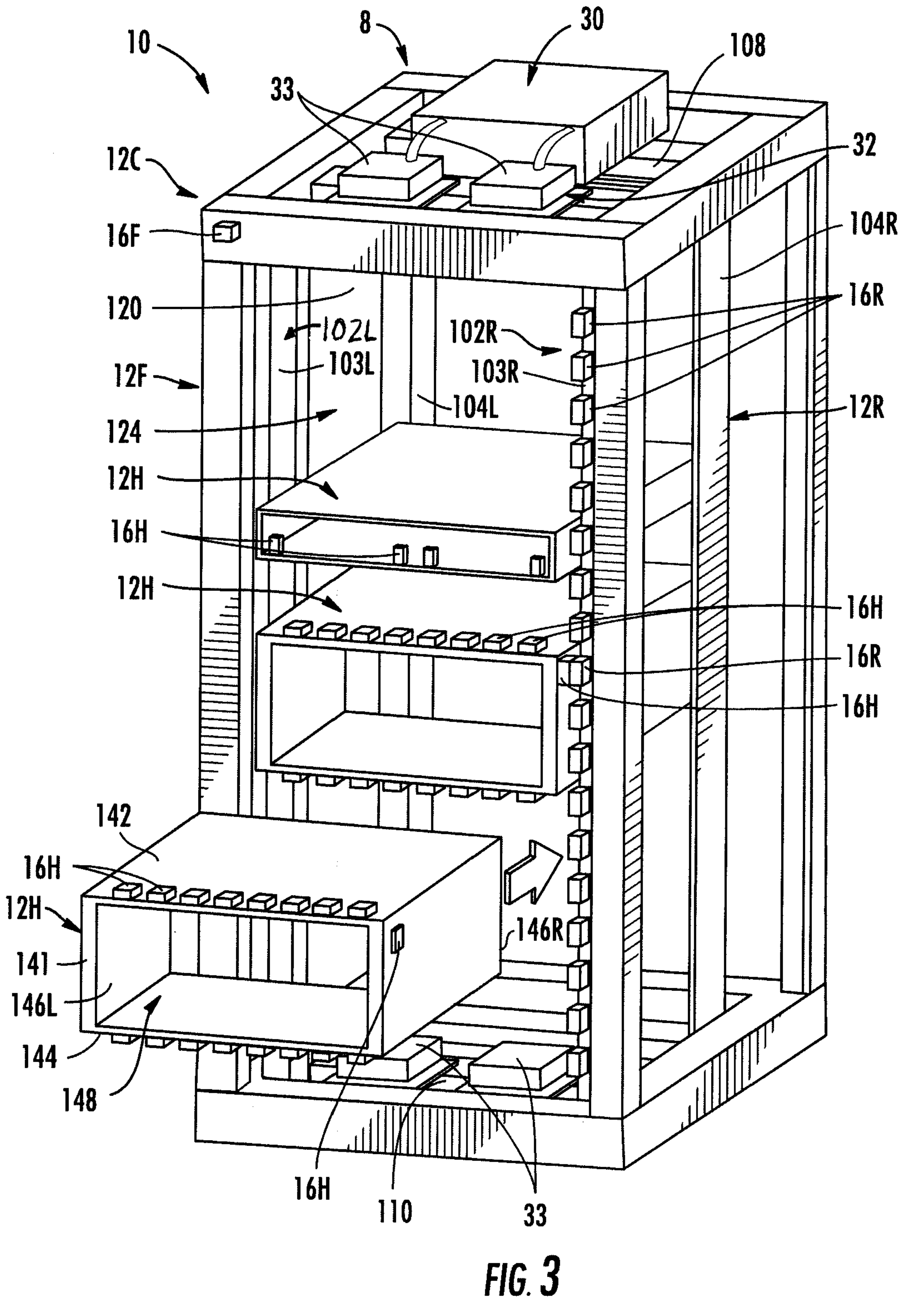

10
8
30
108
33
32
12C
16F
104R
120
102L
102R
16R
103L
103R
12F
104L
12R
124
12H
16H
12H
16H
16R
16H
142
16H
12H
146R
141
146L
144
148
16H
110
33

FIG. 3

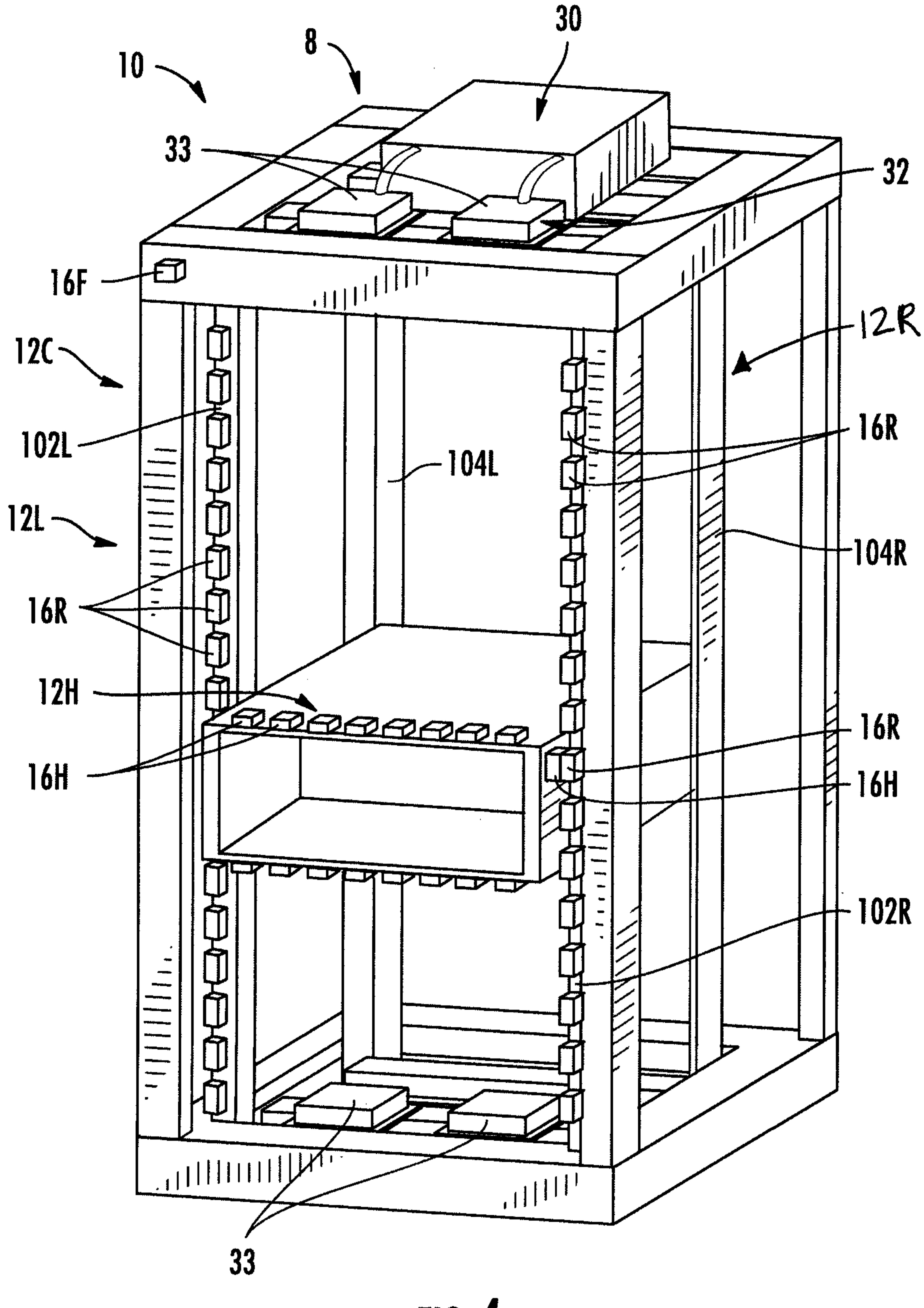

30
8
10
33
32
16F
12R
12C
102L
16R
104L
12L
104R
16R
12H
16R
16H
16H
102R
33

FIG. 4

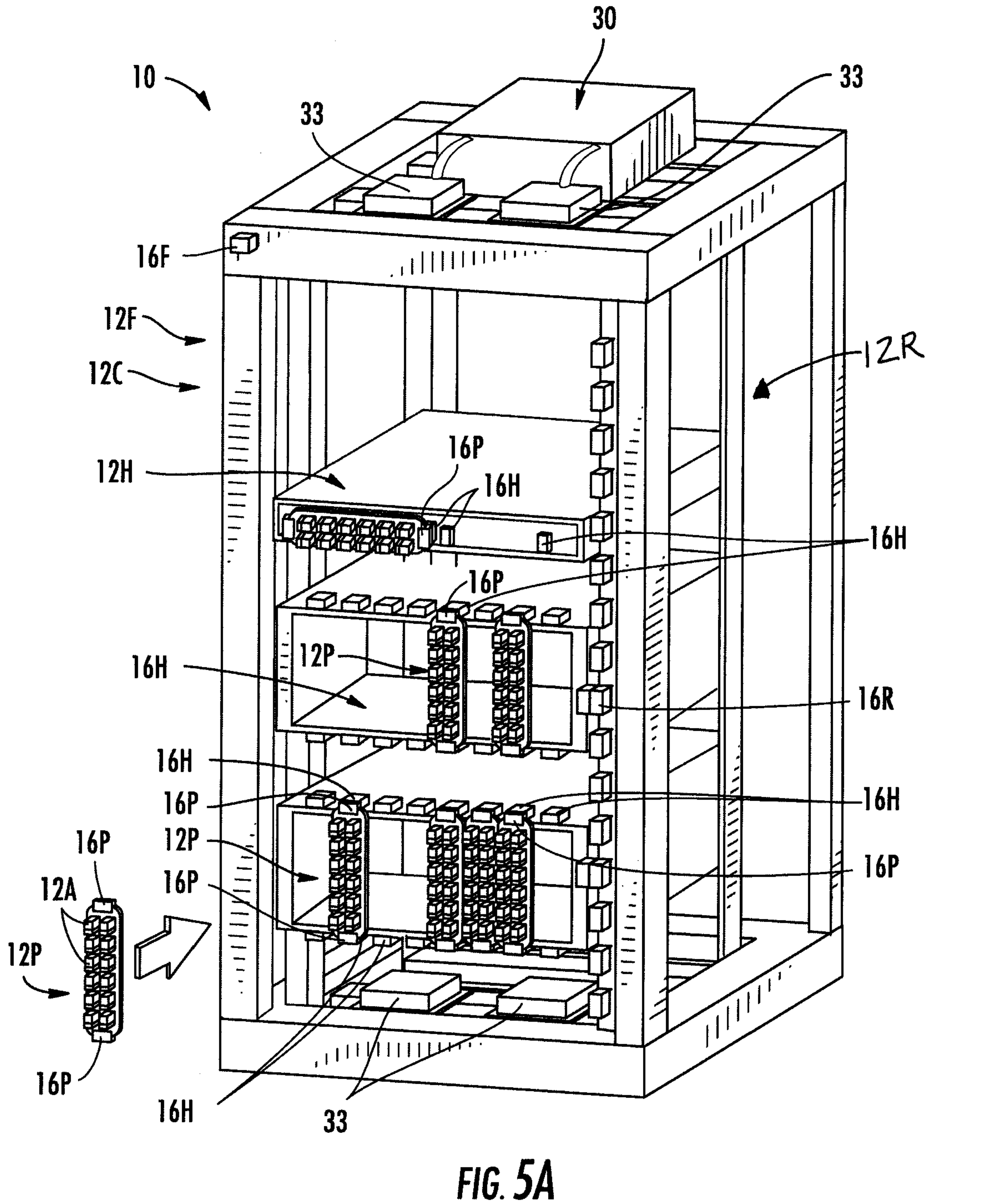

30
10
33
33
16F
12F
12C
12R
12H
16P
16H
16H
16P
16H
12P
16R
16H
16H
16P
12P
16P
16P
16P
12A
12P
16P
16H
33

FIG. 5A

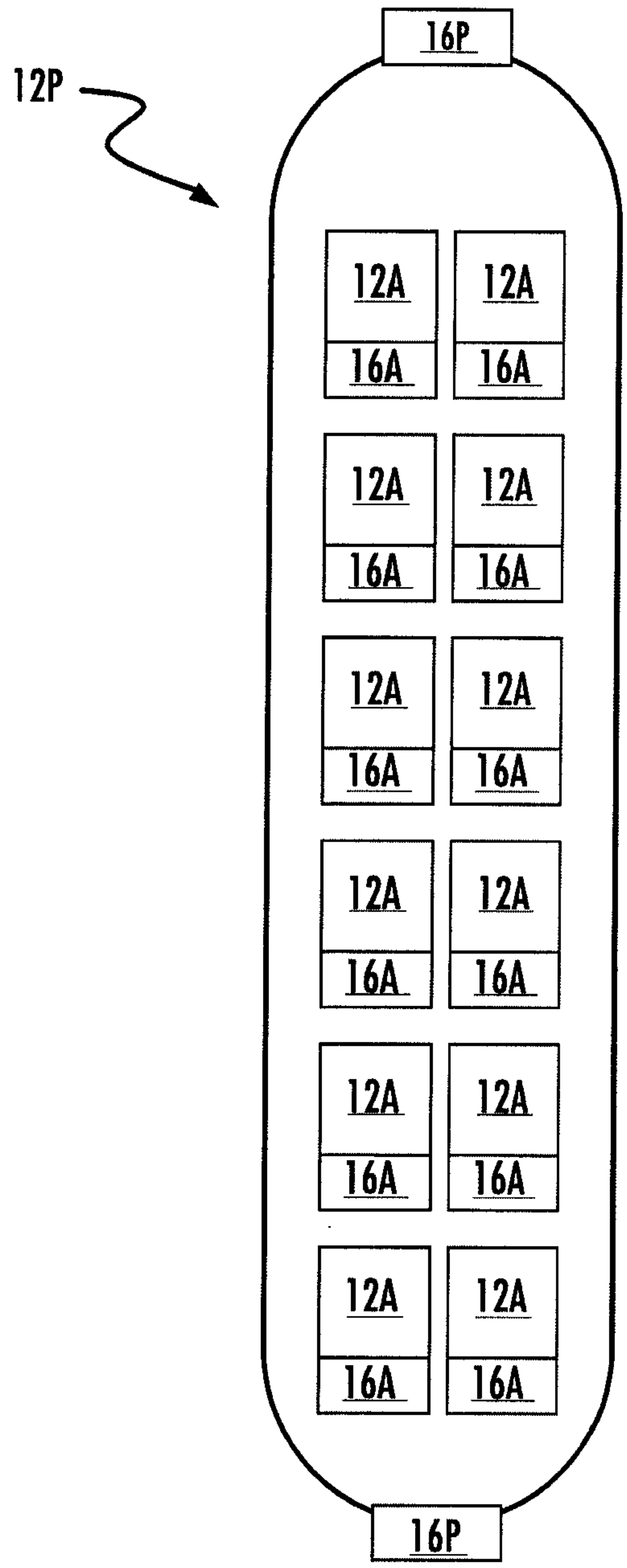

12P
16P
12A
16A
12A
16A
12A
16A
12A
16A
12A
16A
12A
16A
12A
16A
12A
16A
12A
16A
12A
16A
12A
16A
12A
16A
16P

FIG. 5B

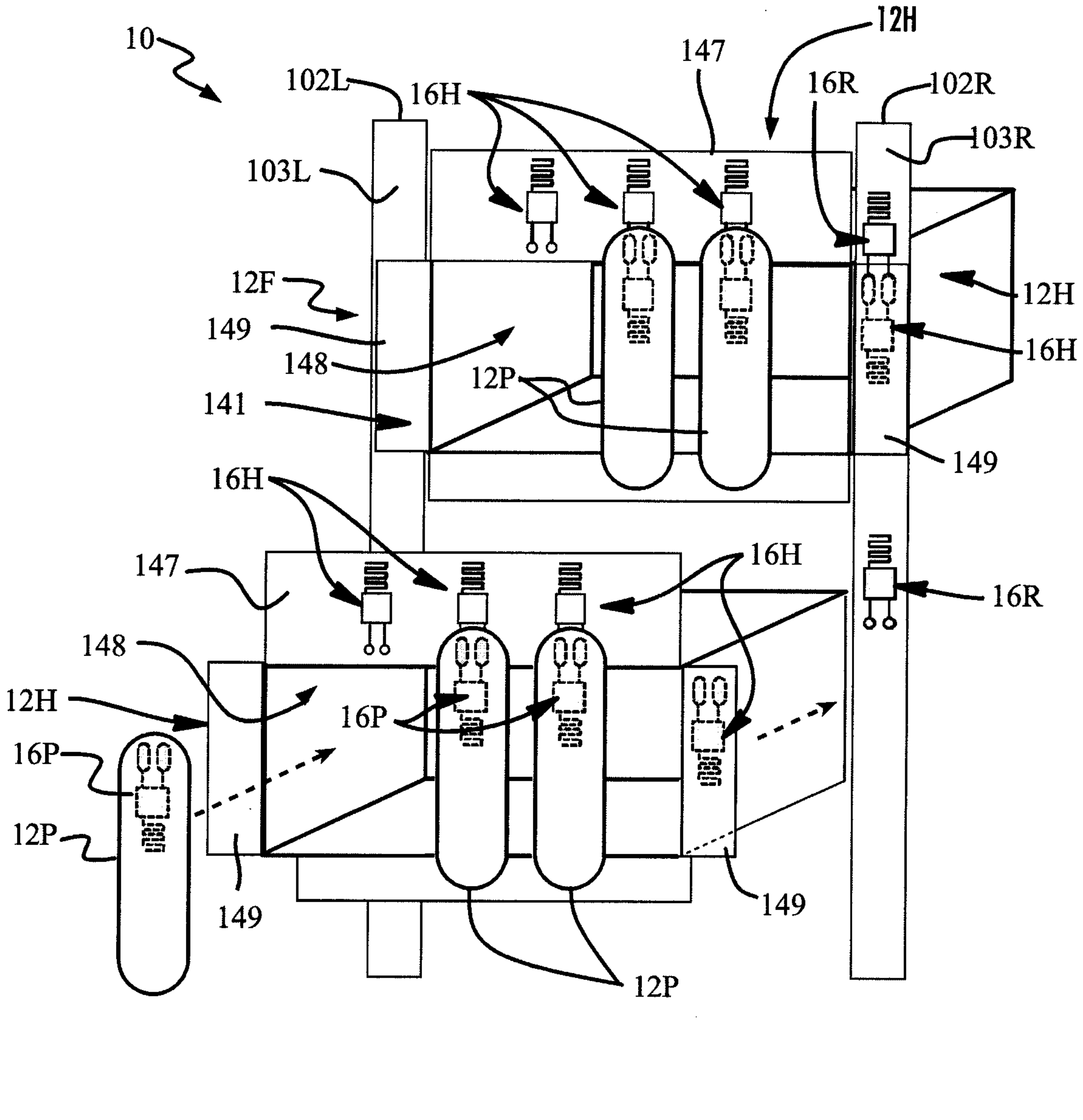

10
102L
16H
147
12H
16R
102R
103R
103L
12F
149
148
12P
141
12H
16H
149
16H
147
16H
16R
148
12H
16P
16P
12P
149
149
12P

FIG. 5C

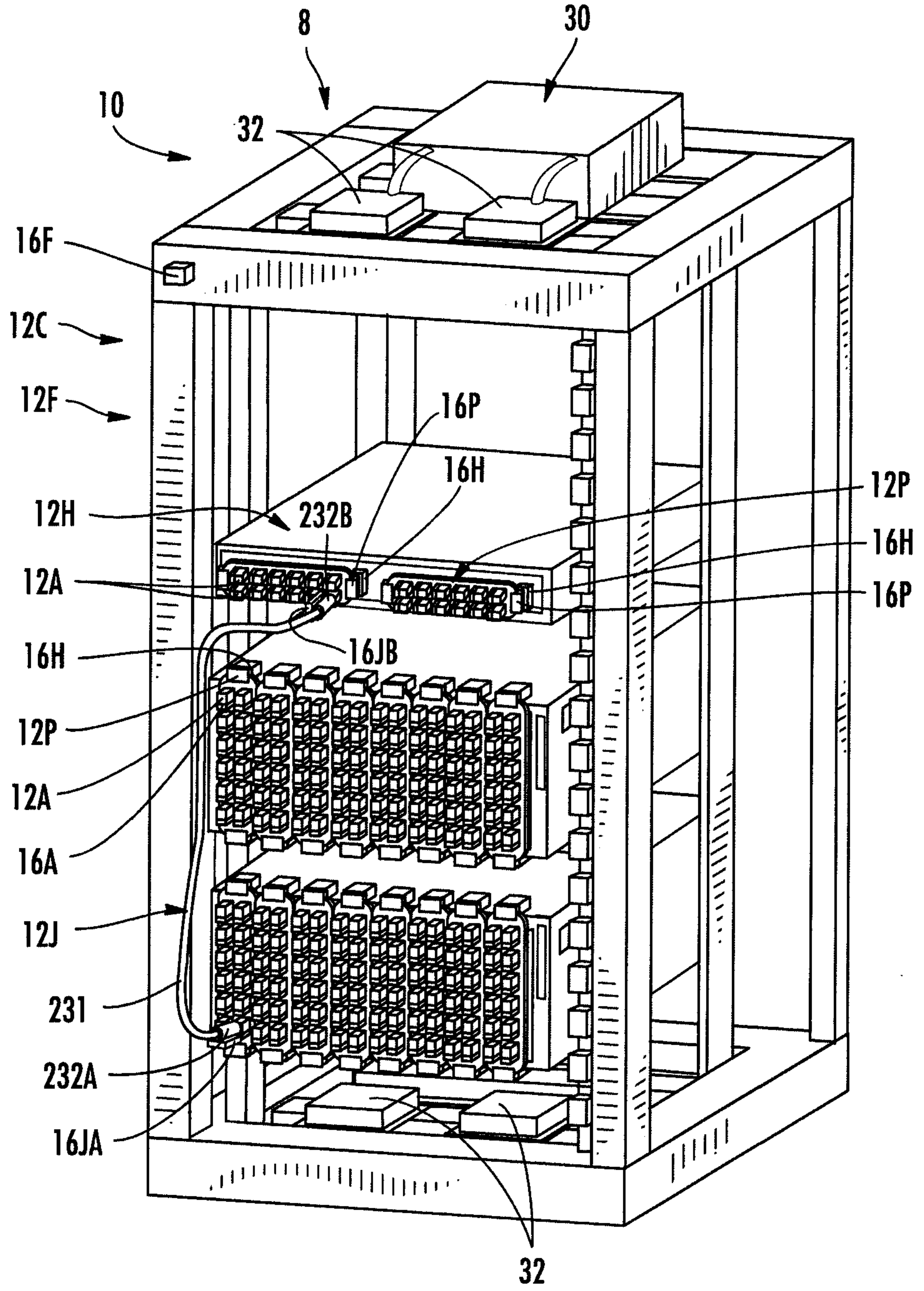

8
30
10
32
16F
12C
12F
16P
16H
12P
12H
232B
16H
12A
16P
16JB
16H
12P
12A
16A
12J
231
232A
16JA
32

FIG. 6A

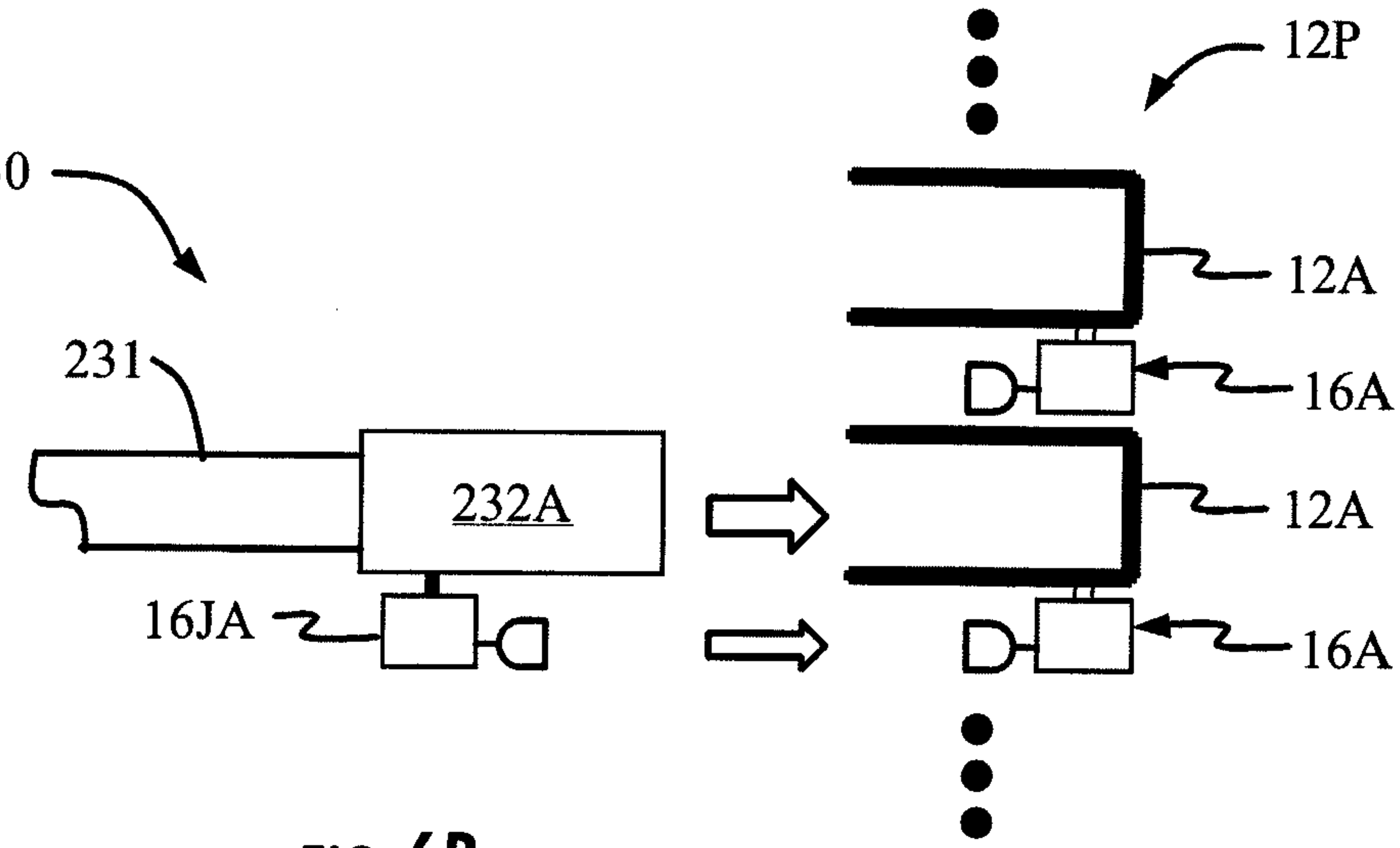

12P
230
12A
231
16A
232A
12A
16JA
16A

FIG. 6B

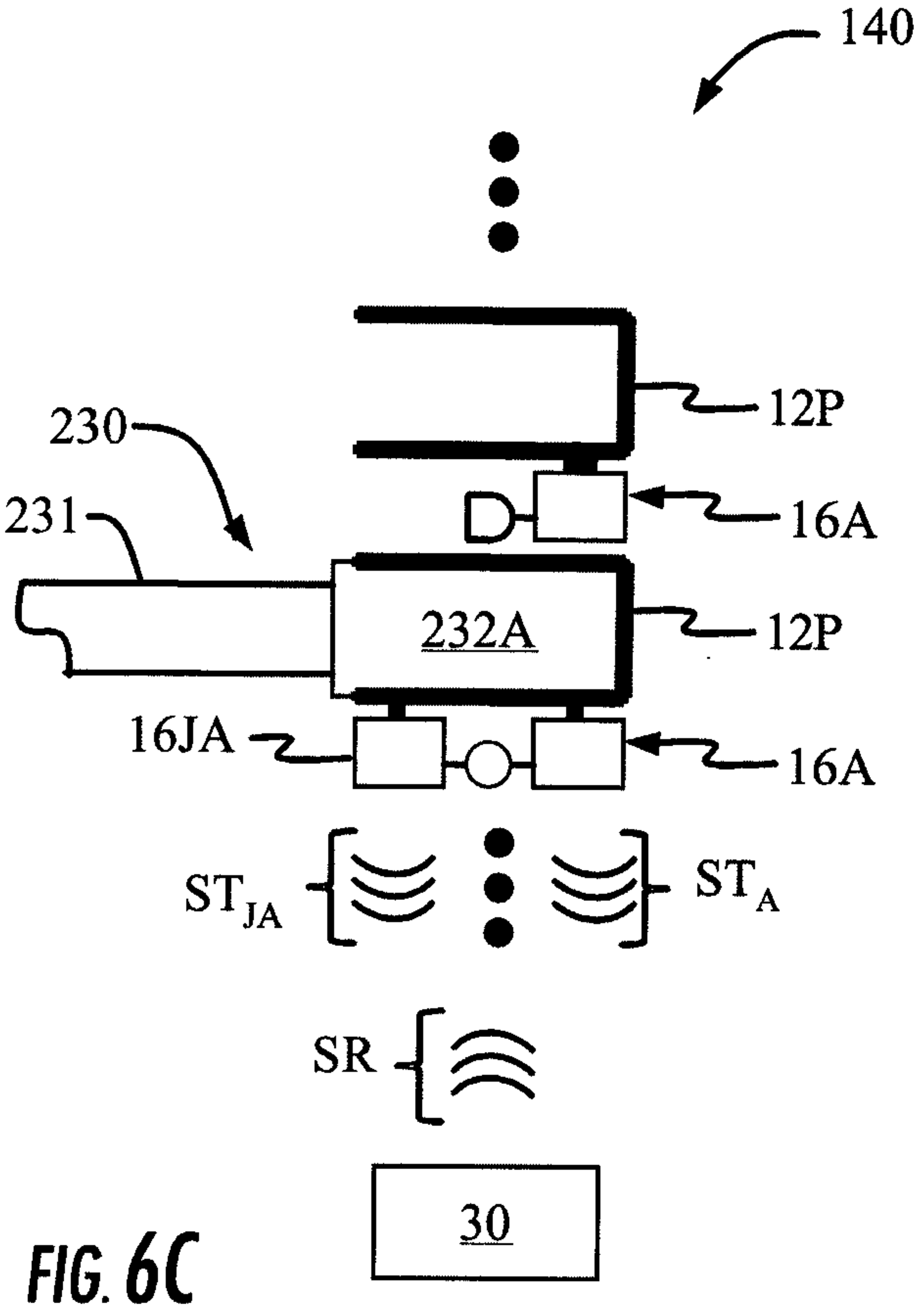

140
12P
230
16A
231
232A
12P
16JA
16A
ST_{JA}
ST_A
SR
30

FIG. 6C

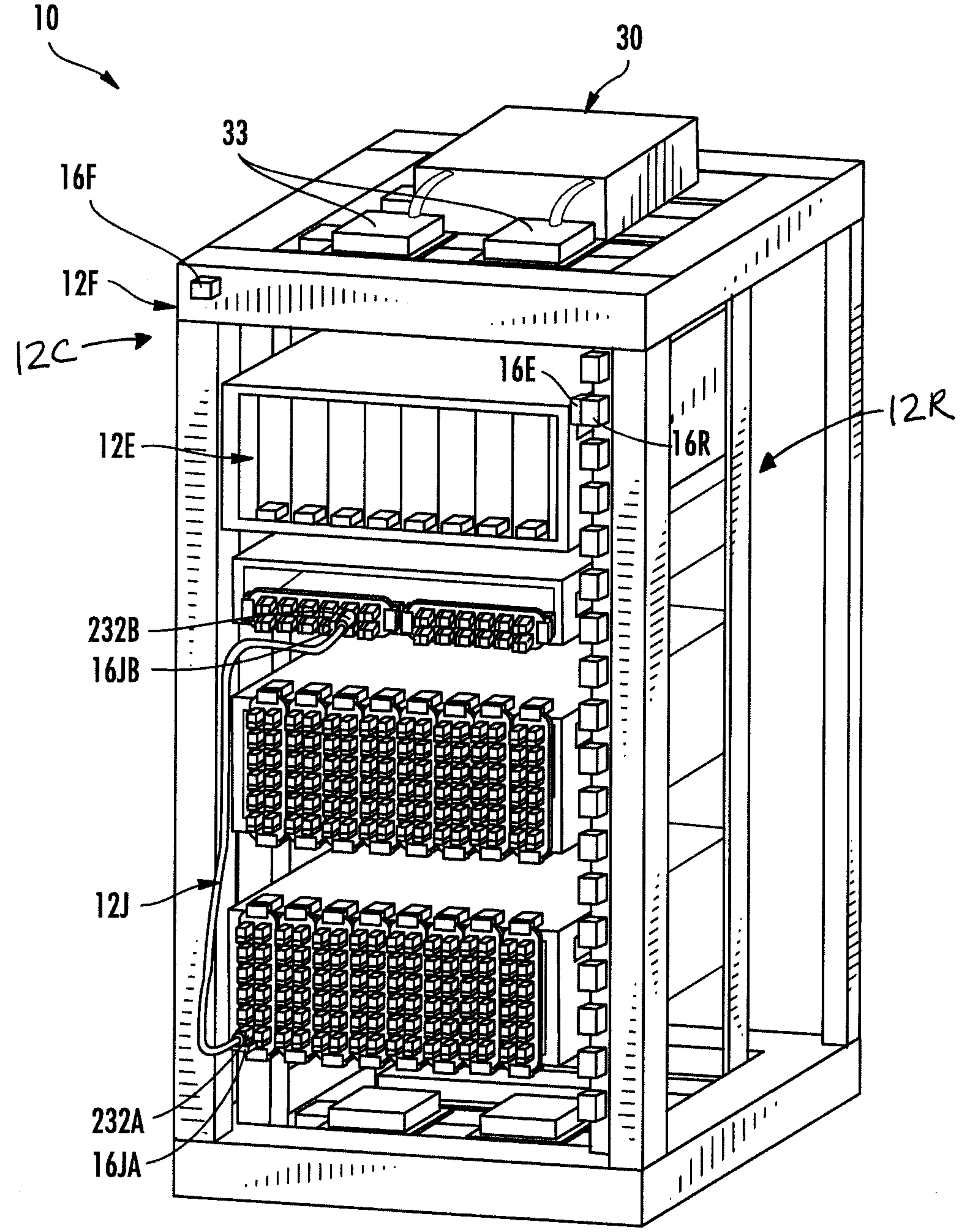


FIG. 7

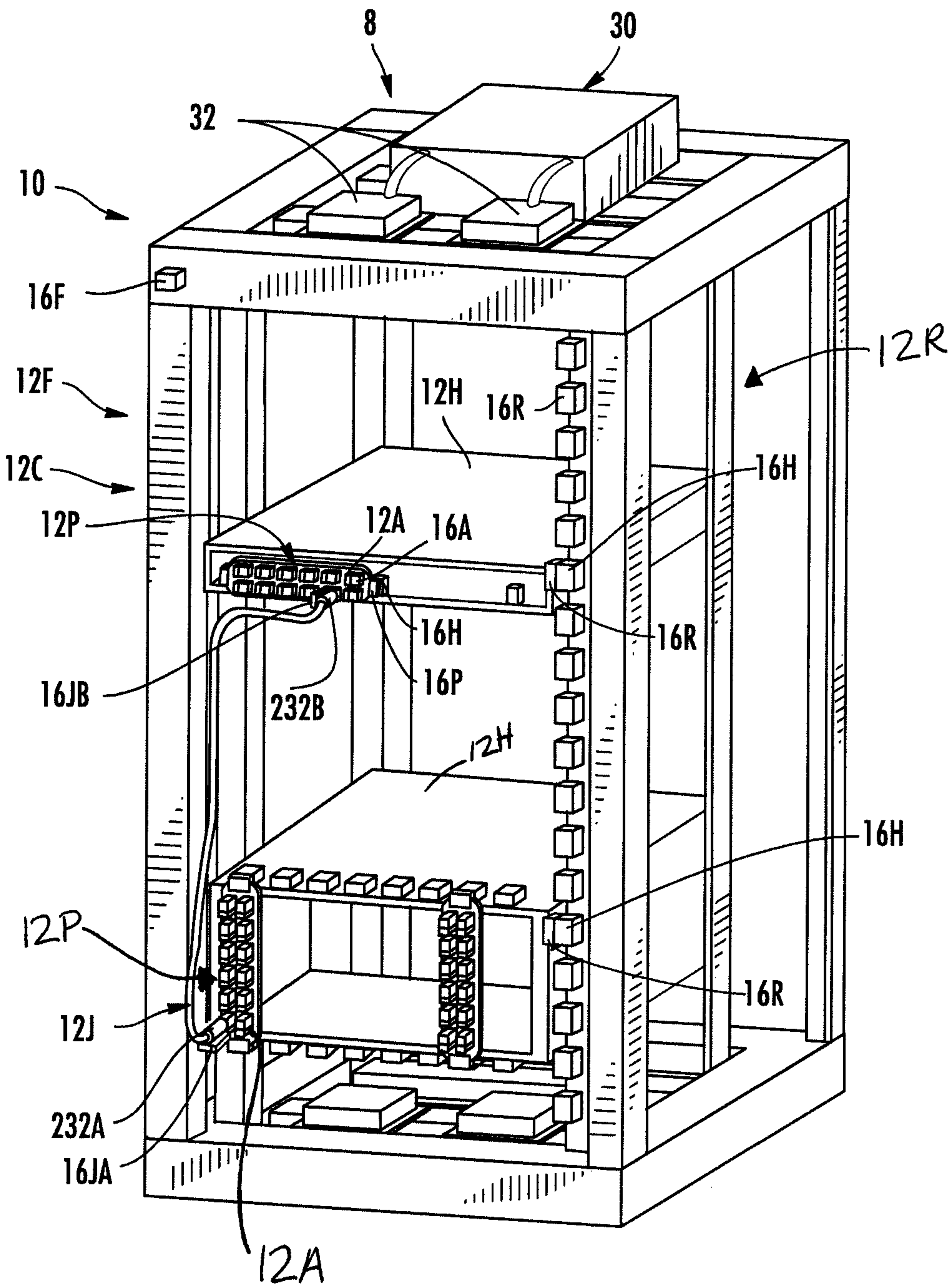

8
30
32
10
16F
12F
12C
12P
12H
16R
12R
16H
12A
16A
16R
16H
16JB
232B
16P
12H
16H
12P
16R
12J
232A
16JA
12A

FIG. 8

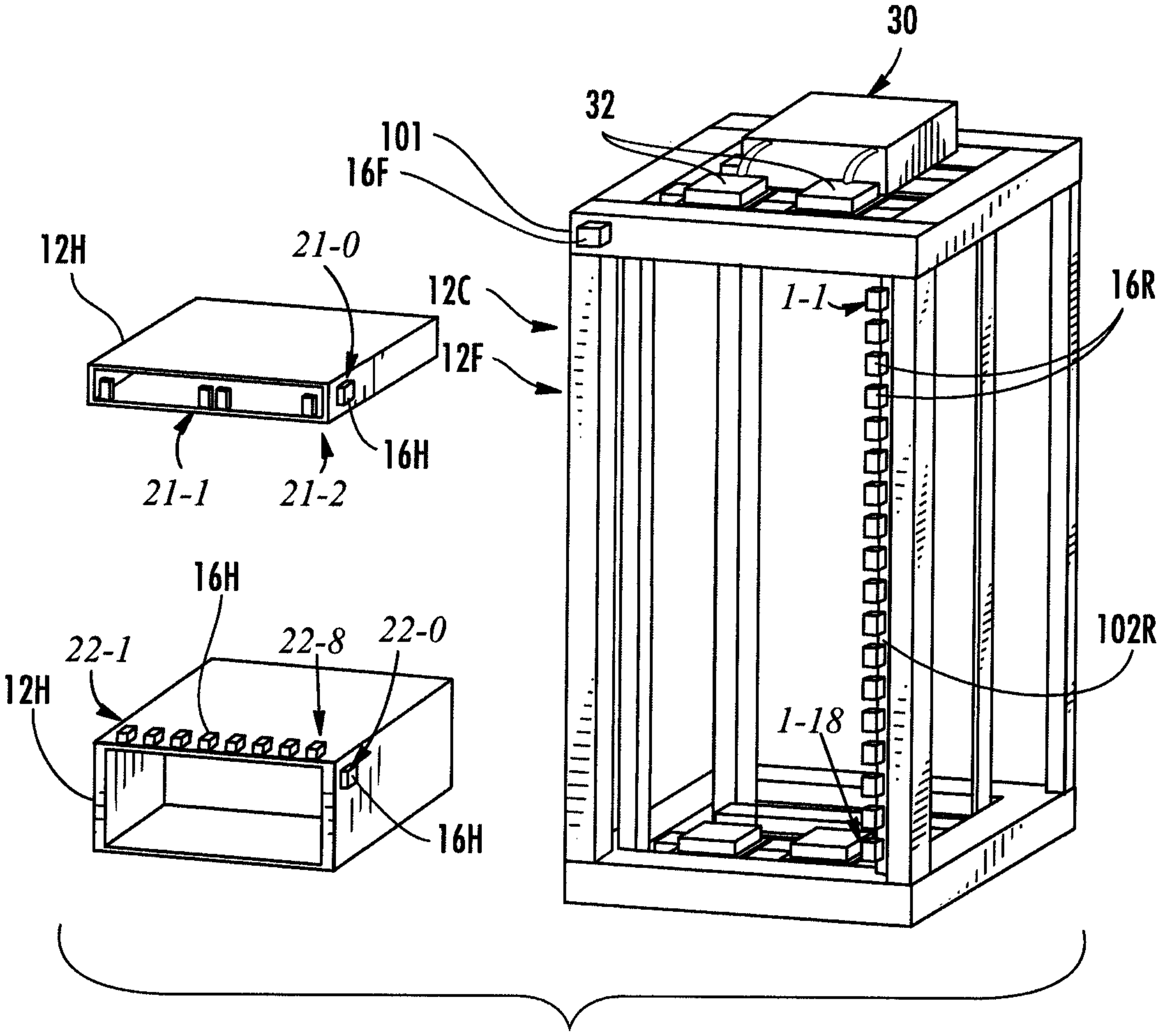

30
32
101
16F
12H
21-0
12C
1-1
16R
12F
16H
21-1
21-2
16H
22-1
22-8
22-0
12H
102R
1-18
16H

FIG. 9A

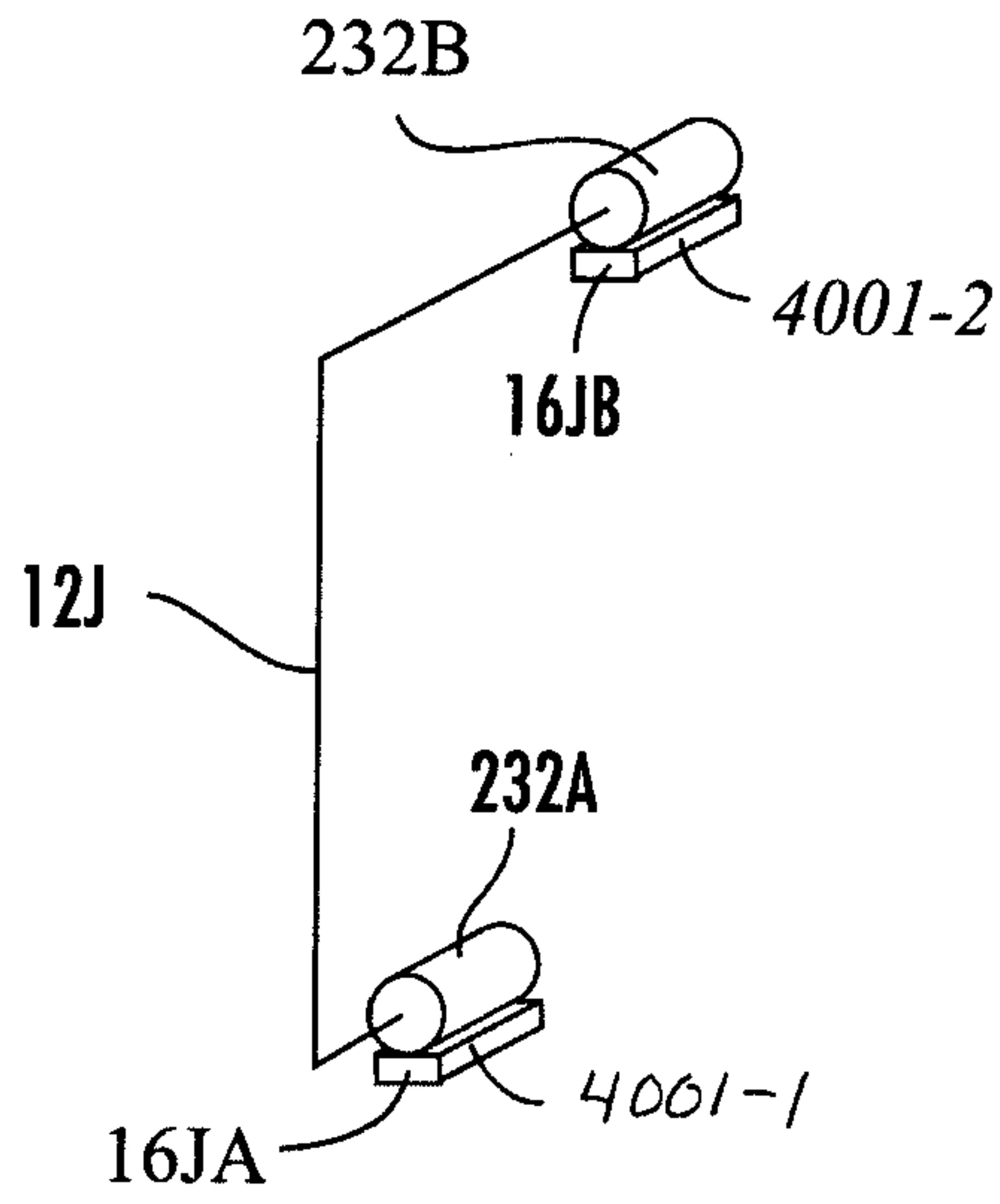

232B
4001-2
16JB
12J
232A
4001-1
16JA

FIG. 9B

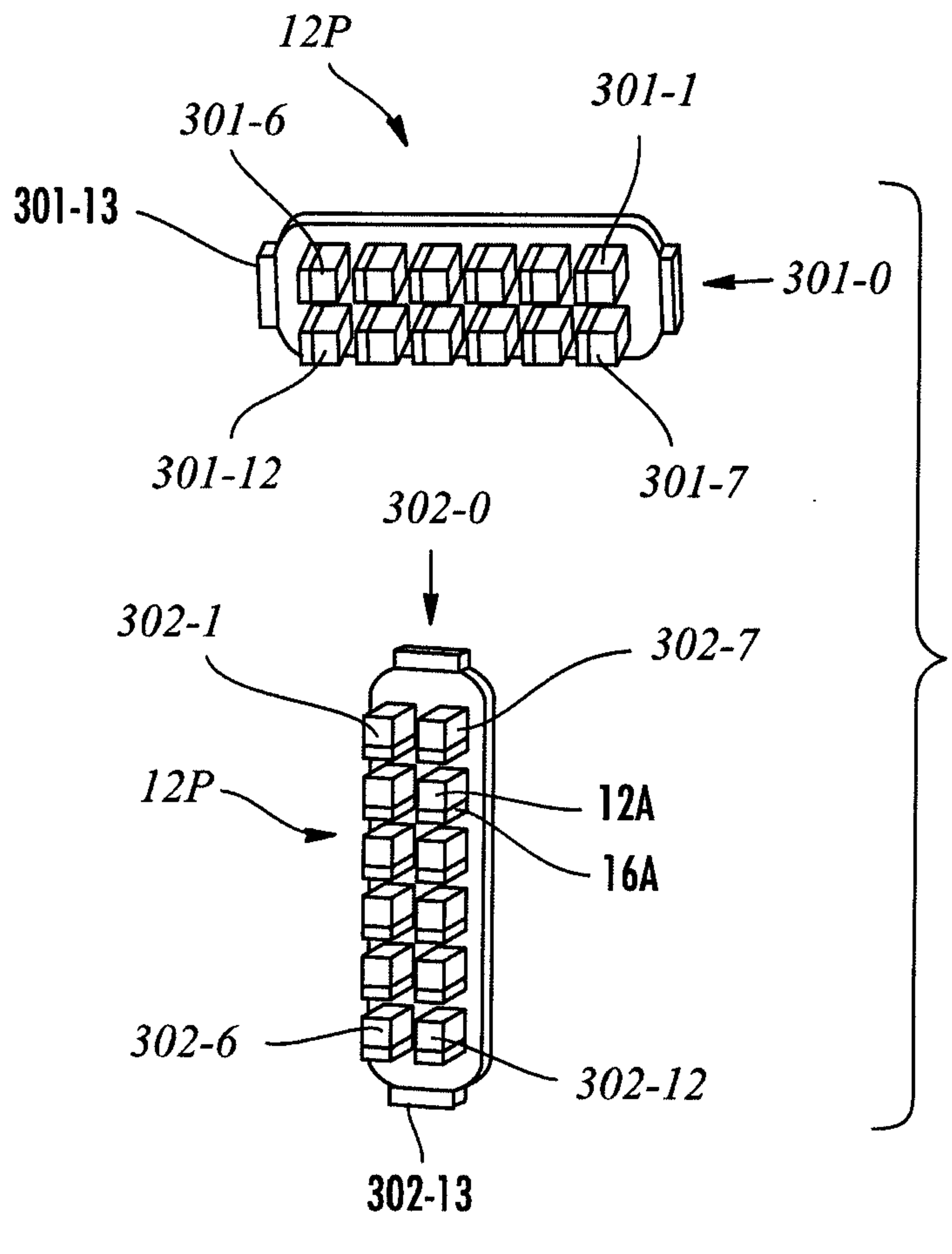

12P
301-6
301-1
301-13
301-0
301-12
301-7
302-0
302-1
302-7
12P
12A
16A
302-6
302-12
302-13

FIG. 9C

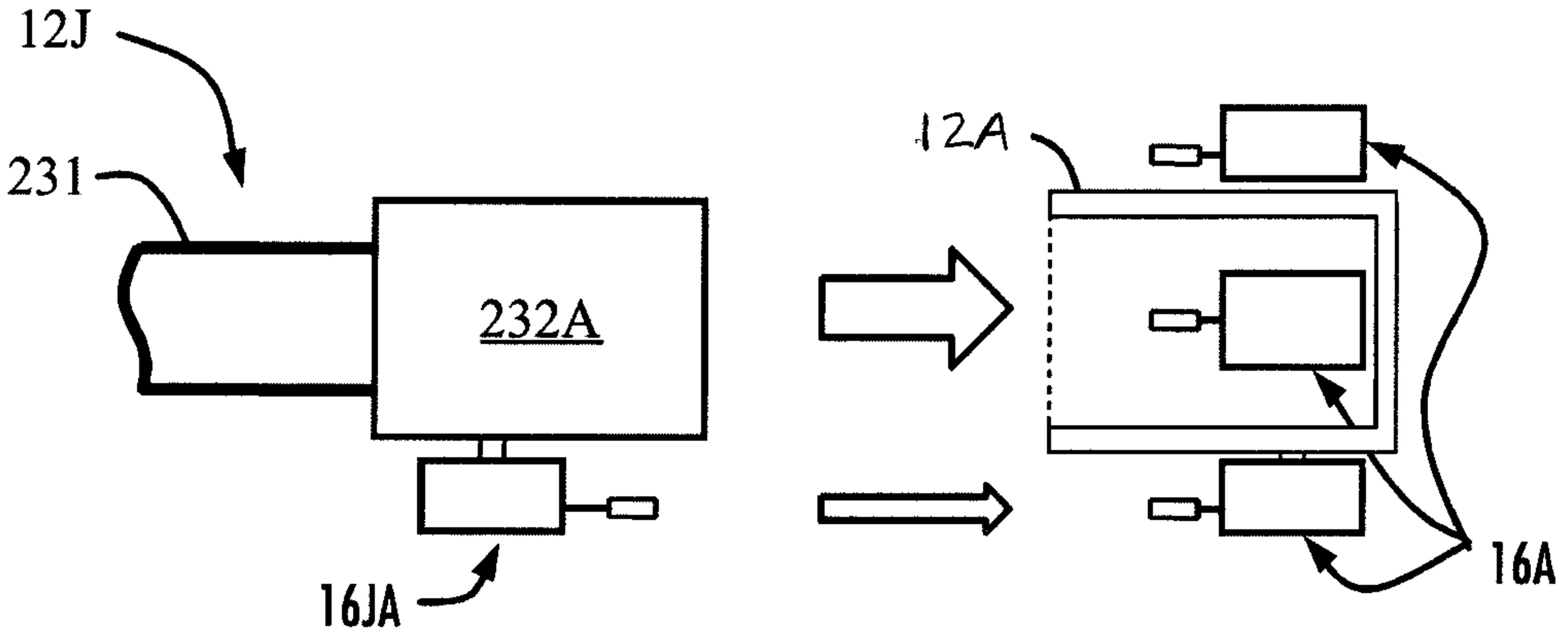


FIG.10A

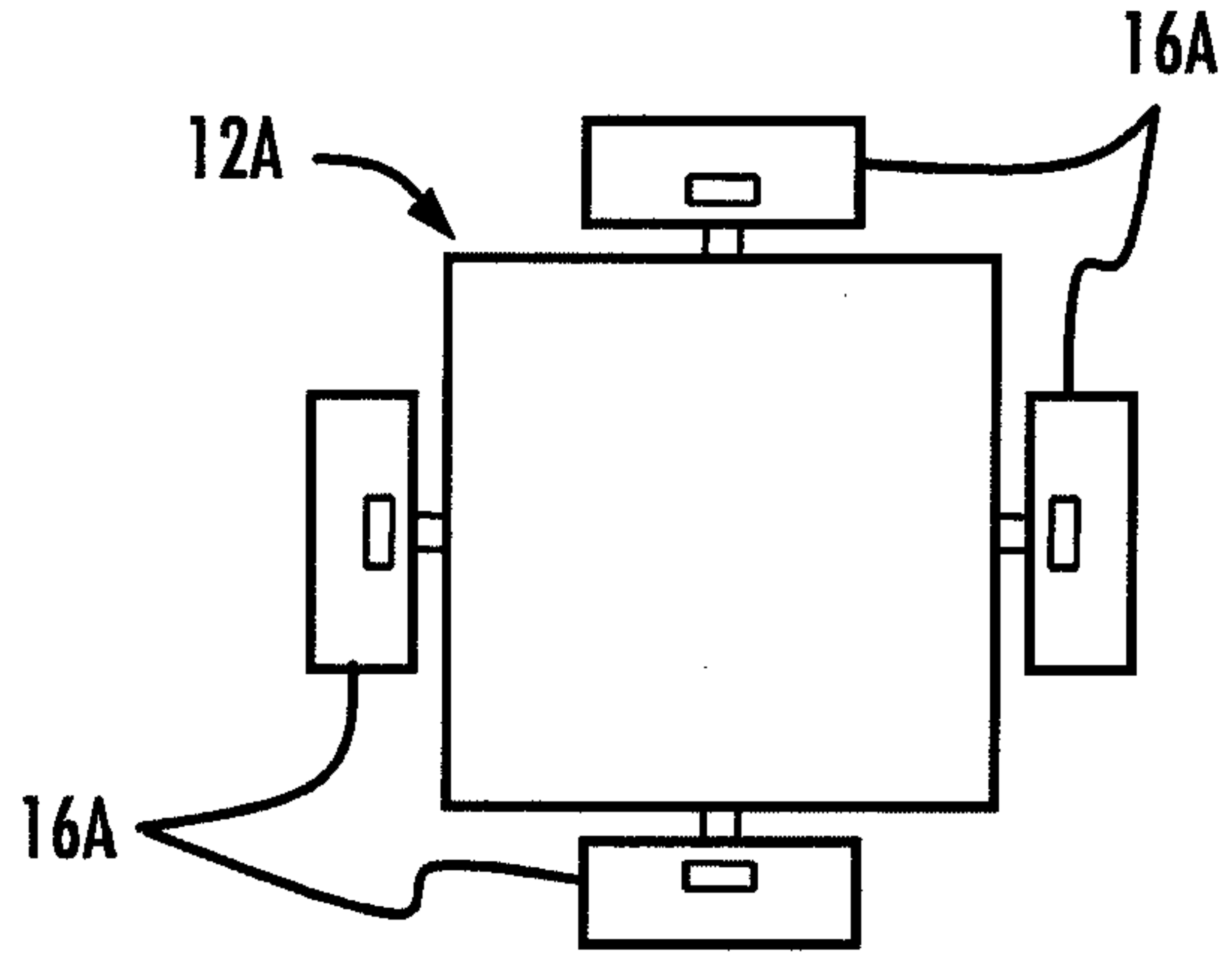


FIG.10B

60

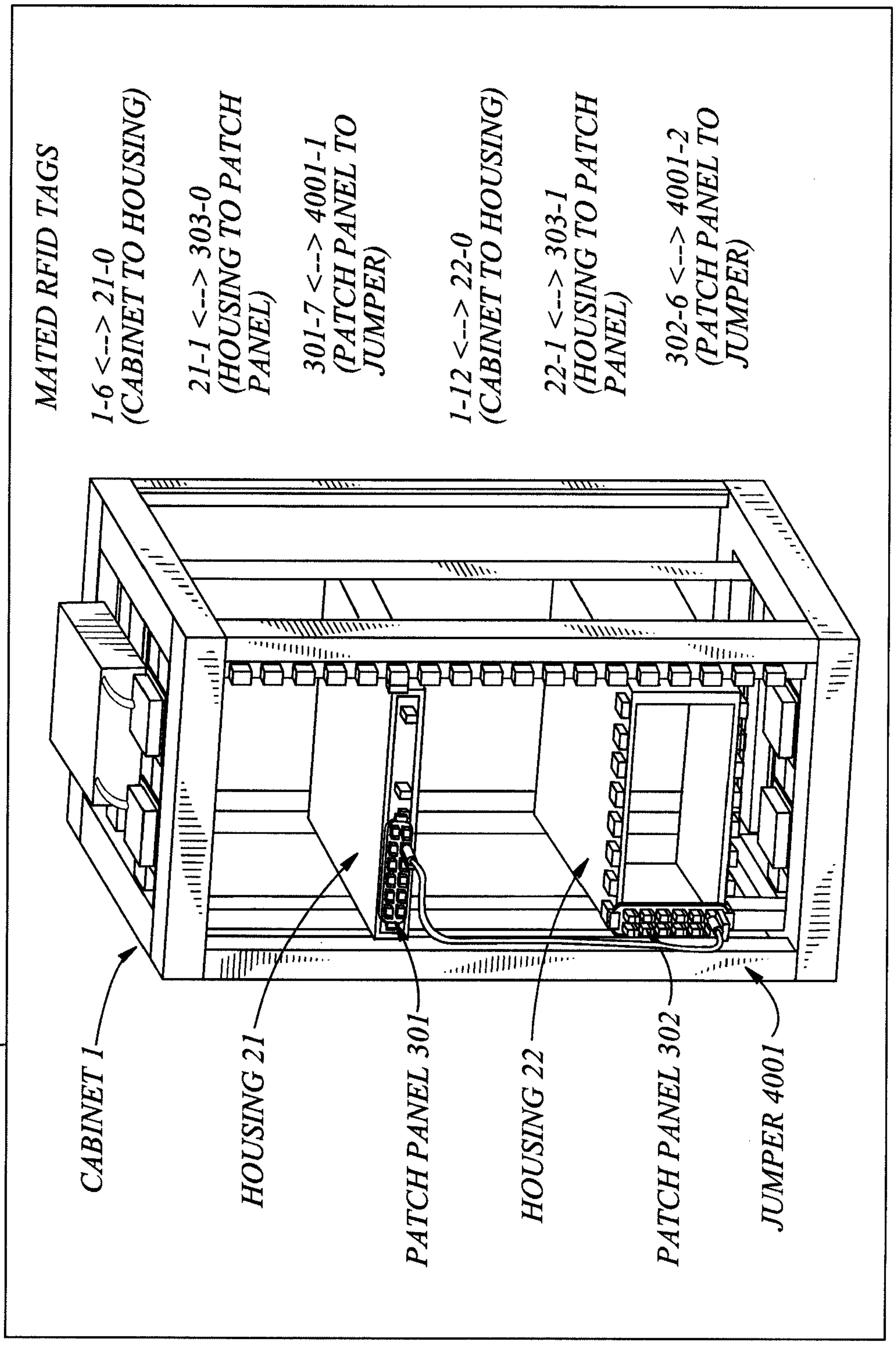
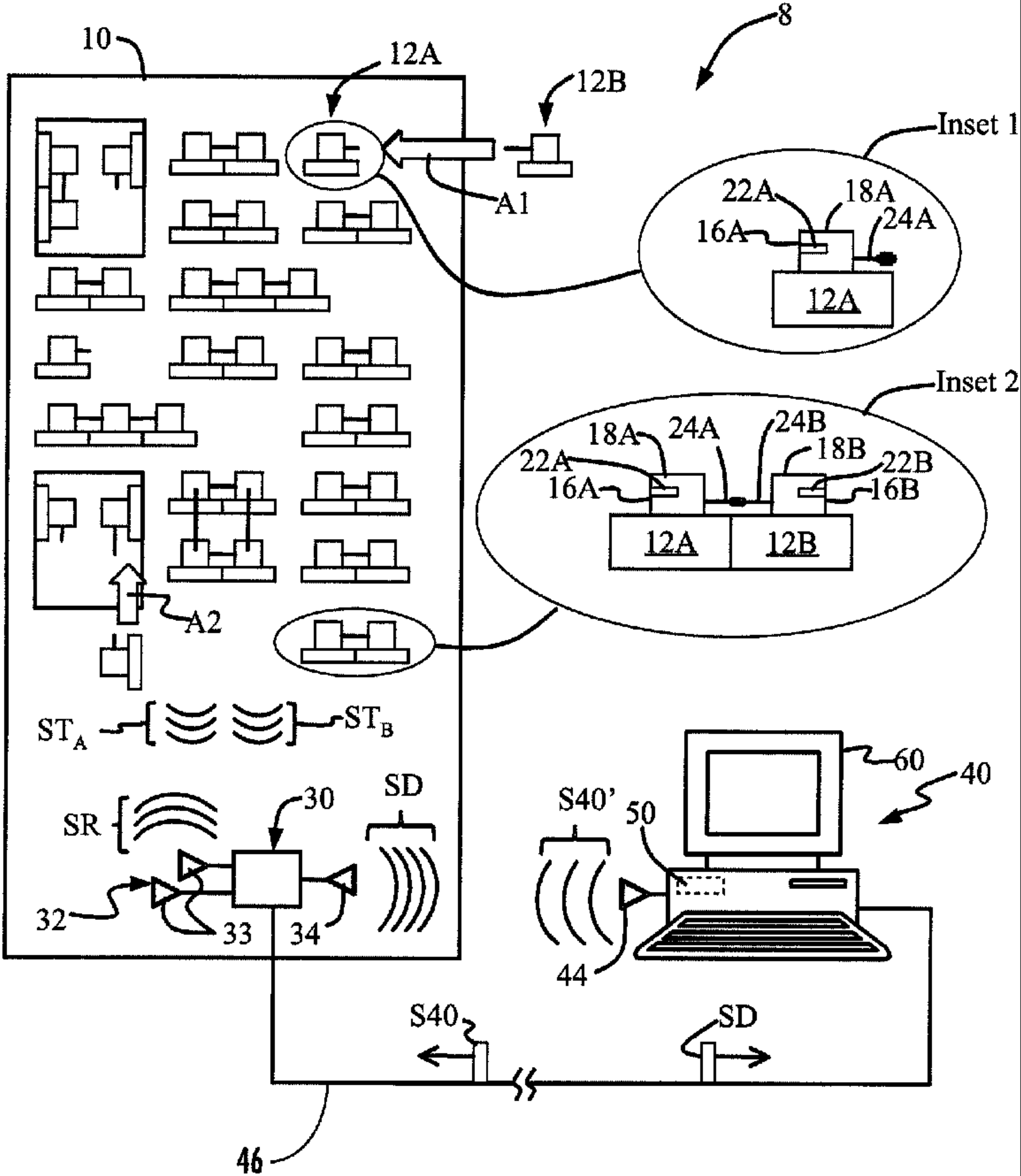

MATED RFID TAGS
1-6 <--> 21-0
(CABINET TO HOUSING)
21-1 <--> 303-0
(HOUSING TO PATCH PANEL)
301-7 <--> 4001-1
(PATCH PANEL TO JUMPER)
1-12 <--> 22-0
(CABINET TO HOUSING)
22-1 <--> 303-1
(HOUSING TO PATCH PANEL)
302-6 <--> 4001-2
(PATCH PANEL TO JUMPER)
CABINET 1
HOUSING 21
PATCH PANEL 301
HOUSING 22
PATCH PANEL 302
JUMPER 4001

FIG. 11



8
10
12A
12B
Inset 1
A1
22A
18A
16A
24A
12A
Inset 2
18A
24A
24B
18B
22A
22B
16A
16B
12A
12B
A2
ST_A
ST_B
SD
SR
30
60
40
S40'
50
32
33
34
44
S40
SD
46